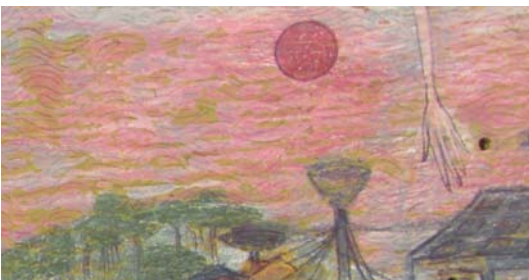
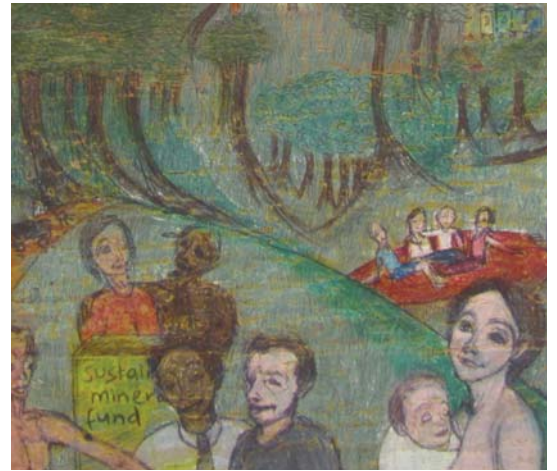


Vision 2040



Advantage Australia: resource governance and innovation for the Asian Century

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EXECUTIVE SUMMARY

The minerals sector and Australia are vulnerable. Reviewing the 160-year history of Australian mineral development indicates that local and international factors have all been influential in constraining or sustaining mining, including economics, geology and social forces. Research undertaken through the Mineral Futures Collaboration Cluster indicates that, in future, environmental and social factors will be important to both mining productivity and defining the role which mining plays more broadly within the Australian economy.

Australia occupies an unusual position as a developed country, by being a net importer, whose capacity for international trade is increasingly reliant on a single industry sector (mining) that produces comparatively low-value commodities. Despite commitments to developing value-added mineral products in Australia over past decades, the contemporary reality is stark. Rather than thriving exports of steel and electricity, Australian exports are dominated by unprocessed bulk commodities of iron ore and coal. These and other mineral exports have followed the pattern of other export commodities (wool, wheat, sugar), in that they have comparatively low requirements for labour, are comparatively cheap and simple to transport, and are supported by high levels of foreign investment.

Looking ahead, Australia faces uncertainties over future levels of commodity demand in a resource constrained world and increased competition from overseas for market share. Back on the ground, the quality of our remaining mineral resource stock is in decline, costs of production and transport are rising, along with community concerns and environmental pressure, while social licence to operate¹ is becoming more difficult to establish and maintain. Moving beyond the mineral sector, it is increasingly apparent that the macroeconomic consequences of the recent 'boom' are affecting the prospects of other key industry sectors such as agriculture, tourism, education and manufacturing. Imperative, is the need for Australia to prevent the 'Dutch disease' progressing towards the 'Resource Curse'. This requires effective management of resources and the sector in contrast to countries who have exhausted profitable mineral resources and proceeds from mining without making a transition to other sources of economic development. Meanwhile, China, Japan and Europe are focussed on becoming resource efficient economies where recycling plays a greater role.

Australia must rethink how it uses its resources to deliver long term benefit in the decades ahead. Developing a long-term strategy for managing minerals and mineral wealth should be a national priority. This report proposes a National Minerals Strategy, as a means of positioning Australia for advantage in the Asian Century and to secure prosperity for the present and future.

Mining and Australia are vulnerable

Bulk commodities dominate exports – rather than high value-added goods

The future is uncertain for market share and demand

Increased mining investment is pursued despite crowding out value adding sectors

Resource management for the Asian Century merits a National Strategy

¹ A social license refers to the ongoing tacit support received by a mining operation from the local community and other stakeholders.

National Mineral Account: taking stock, measuring impact, being accountable

Initiating a National Mineral Account will provide key data needed in areas including: exploration activities and outcomes; site-based performance indicators for mining and mineral processing operations across *economic, social, environmental dimensions*. Not only will this facilitate regional assessment of cumulative impacts and benefits, it will complement existing national-scale data on resource stocks, production and export volumes; price and currency trends. The collection and integrated analysis of such data is of critical importance to policy formation and informed governance at the regional and national scale. If key stocks, flows and indicators are not monitored, it will be difficult to substantiate the scale and character of benefits and impacts from mining and mineral processing activities, and existing externalities may further constrain the social licence required for mining to occur effectively in Australia. A timely response to resolving conflicts about benefits and impacts is also of critical importance to harnessing the value of existing markets, at a time when new mineral domains in other countries are emerging.

Better strategy requires better information from a new National Mineral Account

Vision 2040: getting ahead, staying ahead and benefiting future generations

Maximising benefits to present and future generations from Australia's mineral resources will involve sharing present benefits transparently across regions, and that sufficient revenues from the current boom are invested in new platforms for economic development and innovation within and beyond mining, for example through sovereign wealth funds. Vision 2040 is a collaborative vision for Australia's mineral future developed as part of this research. It puts the long-term sustainability of the national community at the forefront of mineral futures development policy with a focus on (i) transformational technology development for mining and remediation – including through links with renewable energy, and (ii) leveraging value from increasing manufacturer and consumer interests in environmentally ethical and socially responsible supply chains through the development of *Brand Australia: responsible minerals*

Vision 2040: maximising long term benefit

To achieve this objective, *Vision 2040* proposes a nationally co-ordinated, strategic and deliberative approach to developing mineral resources in the context of a future global economy. A National Minerals Strategy would involve extensive consultation with citizens, industry and governments. It would add value to existing policy initiatives by integrating with other national initiatives and harmonising approaches across States. Elements of the strategy are elaborated in the box overleaf.

Delivering benefits from Vision 2040 through a National Minerals Strategy

In conclusion, this report strongly recommends for the development of a National Minerals Strategy to complement the work undertaken for the recent white papers on Energy and the Asian Century including the current country strategies being developed. In this way, Australian governments, industry and citizens can work collectively to ensure that mineral resources are used wisely to advantage Australia in the Asian century.

Advantage Australia

FOUNDATIONS FOR A NATIONAL MINERALS STRATEGY

1. Positioning for long-term development –

A strategy for mineral development as a bridge to a resilient economy

A National Minerals Strategy will provide a long-term approach to promote innovation within mining and allied sectors that delivers ongoing advantage from Australia's resources in the Asian century.

2. Global leadership – *Supporting environmentally and socially responsible supply chains*

Policy makers and companies can achieve a competitive advantage for Australia by leading the development of standards and practice for responsible minerals, such as is occurring with the Steel Stewardship / Responsible Steel initiative. Further benefit could come from developing new business models and services to generate value along the supply chain of mining, manufacturing, recycling.

3. Informing industry, government and community – *Better data to inform long term decision making*

A National Mineral Account must be initiated for site and regional data on economic, social and environmental impacts to underpin analyses of regional and national benefit.

4. Responding to challenges – *Transformational technology and innovation*

Supporting the research, development and commercialisation of technologies that make a 'step change' in the environmental and social performance of mining and mineral production and services to mining.

5. Labour and skills – *High value skills for a high value industry: Addressing shortages in high value and transferable skills, addressing negative impacts of different workforce configurations (including Fly-In-Fly-Out and Drive-In-Drive-Out), and increasing expertise in managing responsible supply chains.*

6. Excellence in delivery of product and services – *Focusing on our strengths and extending our skills*

Supporting Australian ingenuity: growing exports of mining software and sustainable mining services including development and deployment of regenerative mine remediation practices, technologies, and financing.

7. Strengthening our competitiveness – *Positioning research and development for future success*

Evaluating 'social licence in design' as a pre-development assessment of new technology development to ensure that new technologies better meet community expectations. Support technologies which deliver net positive benefits, i.e. 'more good', rather than just 'less harm'.

8. Facilitating investment and best practice governance – *One-stop-shop for co-ordinated development*

Governance structures to coordinate across states and territories and drive progress in increasingly sustainable management of resources. Harmonising systems for licensing projects and regulations across jurisdictions. Progress full implementation of Extractive Industries Transparency Initiative. Invest in future skills that assist transition to an economy based on renewable resources.

9. Measuring our performance – *Tracking progress towards 2040: Improving our understanding and management of regional scales of inflation, benefit sharing, and cumulative impacts through:*

- Creating greater transparency through increased public reporting on performance in economic, social and environmental sustainability.
- Hypothecation of mineral revenues through a sovereign wealth fund.

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1 INTRODUCTION

Examining Australia's mineral future in the "Asian Century" is a national imperative. The task is urgent, complex and will require sustained support to be successful. At present, thinking about the future of minerals and metals is dominated by discussions of economic forecasts for investment and sale prices, and growth projections for export volumes and revenue. Despite the growing evidence of unintended impacts from a multi-speed economy, and a strong currency affecting other sectors, there is little discussion of how Australian resources will contribute to national prosperity over the long-term. In a presentation related to the White Paper *Australia in an Asian Century*, Dr Ken Henry (2012) warned:

"I should make a cautionary remark about both our natural and created endowments, and the capabilities that have been constructed upon them. None of this should be taken for granted. Our abundant natural resource endowments are not inexhaustible, even though earlier generations of Australians – and the present one, largely – have acted as if they were" (p9).

Importantly, while Ken Henry is right in pointing out that Australia's natural resource endowments are exhaustible in a physical sense, an examination of Australia's mineral development history demonstrates that mineral resource booms in Australia have peaked several times, not because they have been 'physically exhausted' but due to shifts in a range of techno-economic, social and environmental variables. Today, Commonwealth and State governments view rising production as desirable given the contribution which royalties and taxes make to annual revenue. However, it is now clear that growth in per capita steel consumption in China is slowing, while concerns from stakeholders outside of the mining industry regarding the balance of costs and benefits (social, economic and environmental) are growing in terms of extent (number and distribution of conflicts) and their capacity to influence the mineral industry's 'social licence to operate'. Together with easing international commodity prices, these developments suggest a need for a more strategic national governance approach in relation to Australia's mineral future.

It may also be useful for discussions regarding Australian mineral futures need to sit more broadly within a policy context that can objectively evaluate the current and future role of mineral and other sectors in providing export income streams for Australia. A key question is how can the development of Australia's mineral endowment support a transition towards a '*sixth wave of innovation for a resource constrained world*' (Bradfield Moody and Nogrady, 2010) capable of aligning Australia with wider sustainable development goals?

This report challenges to the idea that exporting large quantities of bulk mineral commodities will remain a sustainable development pathway for Australia long-term. In seeking to promote responsible mineral resource development in Australia, it aims to promote a broader discussion about current and future transitions in the Australian economy. Ultimately this paper arrives at a governance framework for a National Minerals Strategy seeking to deliver long-term ecological, social and economic benefit for the Australian community.

1.1 Overview of document

This work is part of the Mineral Futures Collaboration Cluster – a three-year program of research (2009-2012) funded by CSIRO and five university partners within the CSIRO Minerals Down Under Flagship. Specifically it is part of the Project 1 ‘Commodity Futures’ program of work.

Other research is being undertaken concurrently on:

- ‘Technology Futures’ (Project 2) which includes (i) the impacts of automation and remote teleoperation and (ii) constructive technology assessment including social licence in design and
- ‘Regions in Transition’ (Project 3) exploring case studies of affected resource-rich communities in Western Australia (Mid West and Boddington) and Queensland (Surat Basin).

An overview of the document is provided in Figure 1. Following this introduction, Section 2 provides an overview of the benefits that have been drawn from exploiting Australia’s mineral resources during the past and at present, before calling into question whether Australia is doing enough to secure long-term benefits for the future. Section 3 further explores the present and future challenges to mineral production in Australia, in the context of changes to terms of global trade. Section 4 outlines changes to reserves and production for key mineral commodities – iron, coal, copper, gold, lithium – and explores future opportunities in the context of social and environmental constraints. Section 5 outlines the conclusions that have been drawn from the milestone report *Vision 2040: Innovation in mining and Minerals* which was a key part of the Commodity Futures research project, drawing on the input of more than one hundred stakeholders. Section 6 introduces opportunities for sustainable mineral resource management and finally section 7 provides key recommendations for the foundation of a National Minerals Strategy.

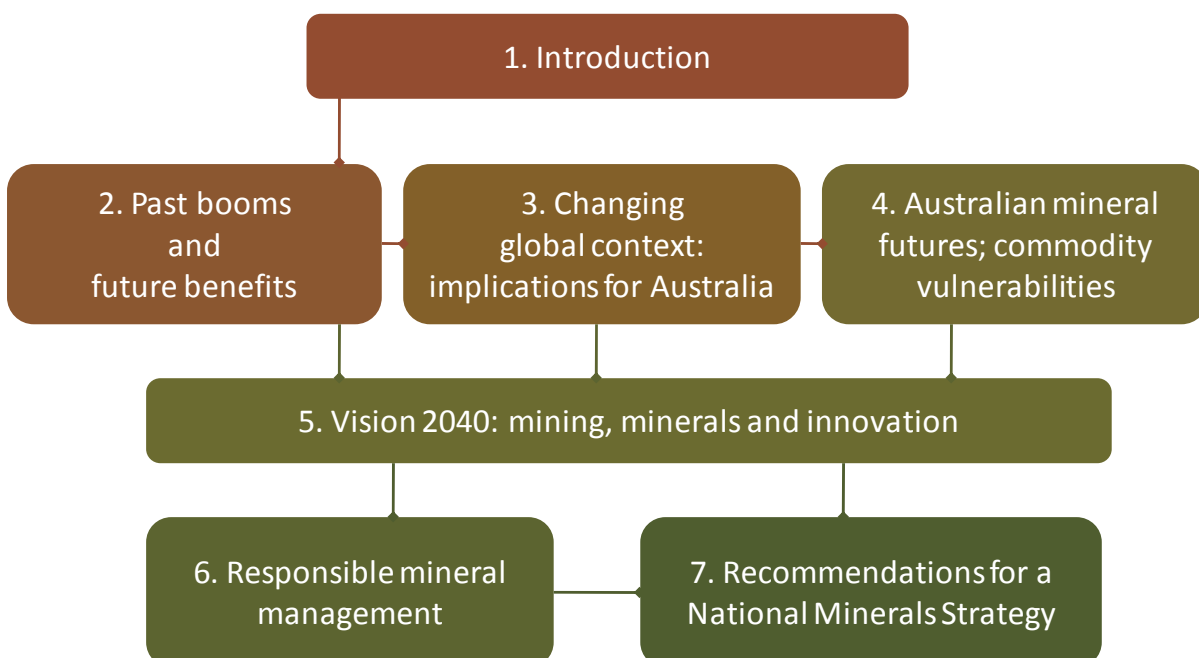


Figure 1: Overview of document

2 PAST, PRESENT AND FUTURE BENEFIT FROM MINERALS

CHAPTER TWO OUTLINE

This section explores factors affecting past, present and future benefit from minerals (section 2.1) and reviews historical minerals booms in Australia (section 2.2) – highlighting that factors affecting competition and changing demand for resources have caused booms to end, rather than physical resource depletion. Contested views about mining and minerals in Australia are then explored (section 2.3), together with the current economic challenges of a resource dependent economy (section 2.4), namely: the increasing dependence of Australia’s export earnings on continued high prices for mineral commodities; and secondly, the often detrimental direct and indirect effects of this dependence on other sectors of the economy. Finally section 2.5 examines future uncertainties relating to increased competition from overseas producers and softening demand.

2.1 Past, present and future benefit

The question of whether Australia’s export prosperity will continue to be tied to the minerals sector can to some extent be answered by the subsequent analysis of past trends. *Economically beneficial* periods of mining have historically occurred when available technologies, labour, transport options, and the necessary capital investments, were made available when mineral commodities were themselves in demand.

However, research undertaken by the Mineral Futures Collaboration Cluster (Giurco *et al.*, 2009; Giurco *et al.*, 2010; Prior *et al.*, 2012a) has identified a number of key challenges to the idea that exporting large quantities of bulk mineral commodities can remain a sustainable development pathway for Australia in the longer-term. These key challenges include: (a) the inevitable progression from high-quality/more-accessible ore bodies, to lower quality/less-accessible ore bodies; (b) increasingly high public expectations directed towards the mineral industry in terms of economic, environmental and social performance; and (c) the extent to which Australia’s increasing dependence on the mining sector makes it vulnerable to negative macroeconomic consequences.

Ensuring that mineral development in Australia is *environmentally, socially and economically* sustainable in the longer-term will require a substantially different approach to thinking about innovation moving forward (Mason *et al.*, 2011a).

Box 1. Changing social licence

Changing attitudes toward the social responsibilities of companies, and changes to the conventional benefits and impacts from mining appear to be having an increasingly significant impact on the ability of mines and processing operations to function. A recent report exploring the concept and application of social licence to operate (SLO) interviewed representatives from the Australian minerals industry and its representative bodies, who described the effect of not having SLO as ranging from “complaints from neighbours leading to political impositions or licence restrictions, blockades and community protests” (Lacey *et al* 2012). The report characterises SLO as “...having the acceptance and approval (and perhaps support and consent) of local communities to operate.” Social licence to operate is embedded within “Enduring Value”, the Mineral Council of Australia’s code of practice, and interviewees participating in the SLO study indicated that their view of SLO’s importance in the future was that it was likely to be “core business” and “perhaps even a condition of formal legal approval.”

This broader level analysis points to the fact that sustaining benefits into the future will depend on what is done to ensure that ongoing development does not come at a net cost to the national community, and that governance arrangements facilitate wise investments from the proceeds of the current ‘boom’ for innovations and transitions that will support the needs of future generations.

2.2 Historic trends: actions and decisions shape the future

Historically, Australian resources booms have begun and ended due to shifting variables such as: demand within international commodity markets; shifts from *high-quality/easily-accessible* ore bodies to *lower quality/less-accessible* ore bodies; labour and transport availability; and the level of public and private investments in exploration, infrastructure and technology (Battellino, 2010), rather than through the physical depletion of Australia’s mineral resource stocks. Accordingly, the extent to which mineral deposits can be relied upon to deliver benefit is therefore not only determined by resource volumes, but also by the extent to which patterns of development seeking to derive benefit from these stocks, can be sustained under changing social, economic and environmental circumstances (See Table 1 below).

Table 1: Overview of significant boom periods in Australia*

Boom	Description	Challenges	Decline
1850s	Centred on the gold rush in Victoria. Much of the wealth was exported (to UK) but much also remained in Australia, creating civic infrastructure in major towns and cities such as Ballarat, Bendigo and Melbourne. Atypical compared with later booms in that it was not accompanied by a large increase in mining investment. Large amounts of capital were not readily available and surface alluvial mining was well suited to large inputs of labour and little input of capital.	Rapidly expanding population, worker conditions, taxation/costs of mining licences lead to Eureka Stockade. What we now call ‘Dutch Disease’ was also present (e.g. wages for shepherds doubled from 1850 to 1853).	Alluvial gold deposits, which were easily accessible with the technology of the day, were largely exhausted in Australia, at a time when such deposits were being found in large numbers in California (international competition).
1890s	Centred on minerals in WA, but also Qld, and Broken Hill in NSW. Development of ‘no-liability’ company made it easier to access capital.	Tariffs were imposed to protect local industries (which continued into 20th century). Export of wool and grain stagnated.	Rising costs, falling prices and falling profits meant capital for more complex, or equipment-intensive mining, dried up.
1960s - early 1970s	Mineral and energy boom comprising coal, iron ore mining and bauxite and oil discovery. Surplus current account of balance of payments.	Capital and technology intensive. Wage rises and centralised wage fixing across economy. Inflation rose, tariffs cut, but import quotas imposed to protect manufacturing.	High inflation in Australia and globally, investment fell, commodity prices stagnated. Boom ended.
Late 1970s - early 1980s	Focussed on coal, oil and gas following oil price shock of late 70s. Short lived.	Mining boom lead to euphoria about future of Australia, higher wage demands, rising inflation.	Ended with Australia following global economy to recession in 1982/83
2005 on	Broad based, but iron ore, coal, gas feature strongly. Strong Chinese demand. High terms of trade (prices for exports). First boom with floating exchange rate.	‘Dutch disease’ recognised. Tourism, manufacturing, education hurt by high dollar. Social and environmental pressures (Prior et al., 2012a).	Historically high prices are waning in 2012, although volumes are still increasing.

*Table expanded from Battellino, 2010 citing various authors.

2.3 Contested views: mining, externalities and benefits for Australia

Consultations between the Mineral Futures Collaboration Cluster and Australian mineral industry stakeholders between 2010-2011, identified a number of contested views relating to the role that mining might play in providing benefits for Australia's future (Mason, *et al.*, 2011a). The competing narratives coming out of this consultation process are important, as they point to key differences in the expectations of governments, the minerals sector, and members of the public, in terms of Australia's capacity to derive benefit from minerals longer-term, and what constitutes acceptable 'trade-offs' between environmental, social and economic benefits and costs (Prior *et al.* 2012b).

The first narrative identified in the consultation process presented the mining industry as the 'golden goose' that will continue to provide for Australia's future as long as it is undisturbed. Under this view there was a perceived need to 'protect natural resource industries' so that they could remain Australia's main economic engine. In contrast to the first narrative, an alternative narrative cast the mining industry as a conduit through which Australia's finite mineral endowment or 'family silver' could be sold for an optimal financial return. Under this narrative there was a perceived need to protect Australia's *natural resources*, or conserve their value in some form (rather than selling them too cheaply), as an inheritance that should be maintained for future generations. Within both narratives, there is an acceptance that financial capital is being derived in exchange for degrading natural capital, but that this trade-off is both necessary and acceptable. However, accepting that current cost/benefit trade-offs will remain sustainable over the longer-term, resulting in positive net gains for Australia, conflicts with other views emerging from the public consultation process.

Members of the public and other stakeholders raised concerns about the wider impacts of mining and mineral processing operations, citing both historical examples and pointing to potential future risks, within a narrative where the mineral industry was viewed as a 'bad tenant', with the potential to cause more damage than economic benefits can justify. When assessing the costs and benefits of mining, people with this view were accounting for social, environmental and economic impacts traditionally perceived to be 'externalities' by the mining sector. This included consequences for local and regional communities that have attracted significant attention in recent years, particularly with respect to techniques that affect the quality and/or availability of water, or the productive capacity of land. As Smith (2009) explained in a NSW Parliamentary briefing paper:

"Mining contributes enormously to the Australian and NSW economy. The minerals industry is NSW's largest export industry, accounting for export revenue of \$11.1 billion in 2006-07, which is 39% of total NSW exports. However, this is not without cost. Environmental groups and some sectors of the community would like to see greater environmental protection of natural features from the environmental impacts of coal mining, particularly subsidence. Similarly, the potential impact of mining on water resources of the State has created conflict in agricultural communities. With estimated Australian coal reserves of some 200 years, this debate seems far from over" (iv).

These narratives and the conflicts they embody indicate that a future for mining in Australia may ultimately rely upon reconciling these contested views, in order to secure and maintain what is referred to by the mining industry as a 'social license to operate' (see Box 1). Looking ahead, it seems a third narrative is needed where knowledge, innovation and human capital are recognised as

important as mineral resources in underpinning future prosperity.

Australia occupies an unusual position as a developed country, in that it is a net importer of goods, whose capacity for international trade is increasingly reliant on a single industry sector producing comparatively low-value commodities. In the absence of alternatives for generating export income, a failure to secure the necessary ‘*social licence to operate*’ could have serious economic consequences. Accordingly, efforts to demonstrate how resource development could deliver more equitable outcomes for a wider range of stakeholders would need to be a fundamental guiding principal for a more strategic approach to Australia’s mineral future.

2.4 Present challenges: the negative consequences of a resource dependent economy

Unintended consequences are identified here in two key areas: (a) the increasing dependence of Australia’s export earnings and government budgets on continued high prices for mineral commodities; and (b) the direct and indirect effects of this dependence for other sectors of the economy.

Table 2 outlines shifting Australian export values between 2006–07 to 2010–11, when revenues derived from mining more than doubled to \$136 billion, and the sector’s contribution to total Australian exports rose to 55%, up from 37% in 2006–07. Over the same period, manufacturing exports remained stable in absolute terms, but fell from 51% to 34% as a proportion of total export value (ABS, 2012).

Table 2: Value of Exports by Industry of Origin (ABS, 2012)

Years	Mining \$m	Manufacturing \$m	All Industries \$m	Share of total exports	
				Mining %	Manufacturing %
2006–07	61 882	85 141	168 099	36.8	50.6
2007–08	72 832	88 260	180 857	40.3	48.8
2008–09	117 646	92 279	230 829	51.0	40.0
2009–10	99 693	79 799	200 720	49.7	39.8
2010–11	135 604	84 067	244 595	55.4	34.4

Based on these trends, Australia meets Maxwell’s (2006, p17) criteria for a mineral dependent economy, which is defined as a country having a significant dependence on the non-renewable resources sector, “*where minerals and energy account for 25 per cent or more of a country’s merchandise exports*”. Consequently, there are increasing concerns that the economic benefit being derived from the current period of high demand supports the mining sector to the potential detriment of other sectors of the economy, while growing unsustainable economic dependencies within government budgets and economic outlooks.

For example, a recent Reserve Bank of Australia Discussion Paper discussed the implications of the most recent boom period for ‘*directly affected industries, regional areas, as well as the rest of the economy*’. According to Connolly and Orsmond (2011), a number of significant benefits can be seen to have flowed from this growth period: through the payment of taxes and royalties; and the boost to Australian incomes through the ownership of mining equities. However, generating these benefits has also led to unintended negative consequences associated with price pressures for non-tradable goods and services (such as skilled labour costs and the prices of raw materials for the construction industry), alongside a large increase to the real exchange rate, impacting other trade exposed

industries (such as manufacturing and tourism). As a recent report from Treasury explains:

“Over the past decade, the Australian dollar (AUD) has appreciated strongly against the US dollar (USD), rising from less than US \$0.50 in 2001 to a peak of over US \$1.10 in 2011. While the rise can be attributed to a number of factors, the mining boom has been the key driver of the appreciation over this period (Garton et al., 2012)”.

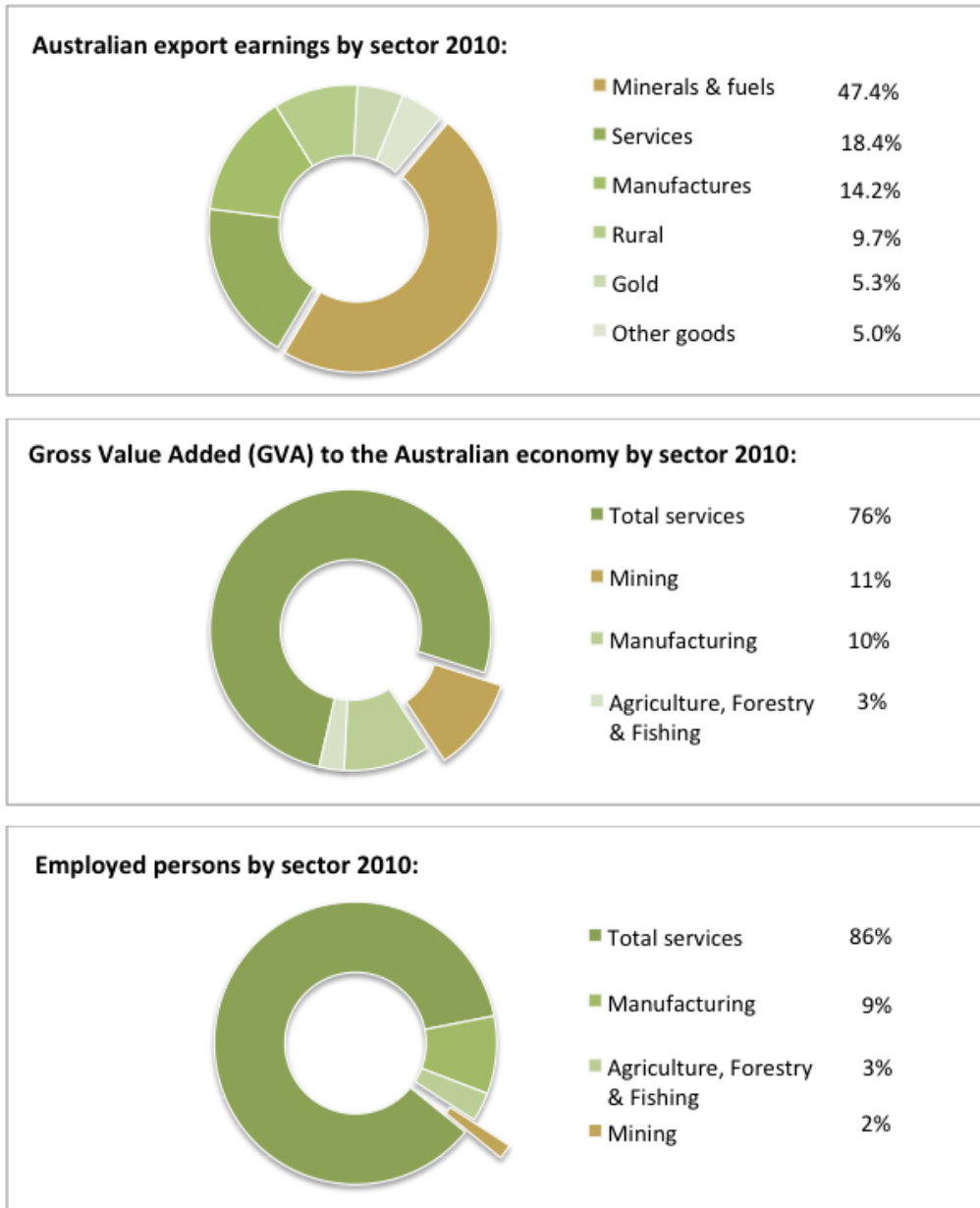
Looking ahead, Connolly and Orsmond (2011) suggest that ongoing mining investments ‘*still in prospect*’ are likely to further increase the effects of mining on the non-mining sectors of the economy, and as the economy moves closer to full employment:

“[...] additional demands for labour and other inputs from the domestic economy and the distribution of mining revenues have the potential to spill over into further changes in input and non-tradable prices. This is likely to be a challenging environment for policy as it attempts to ensure continued containment of overall demand and inflation pressures (p50)”.

Accordingly, this has been reflected in the Reserve Bank of Australia’s recent positions on official interest rates with a view to managing the negative effect of the appreciating currency.

Although mining contributes significantly to total export values, it is a relatively smaller contributor to total GVA, and total employment compared to other sectors of the Australian economy (Figure 2).

Figure 2: Australian export earnings, GVA and employment by sector in 2010*



*Adapted from Department of Foreign Affairs and Trade (2011)

Present concerns relating to the long-term national interest of a resource dependent economy for other important sectors of the Australian economy, alongside long-term productivity declines across most Australian industry sectors including mining (Figure 3), call for a broader and more detailed assessment of the extent to which Australia's current approach towards economic development aligns with longer-term sustainable development trajectories for the nation. As can be seen, the largest drops in multi-factor productivity from 1990s to 2000s occur in mining, utilities and rental hiring. The mining effect is partly a result of new capital expenditure yet to begin production and partly from declining ore grades (Topp et al. 2008).

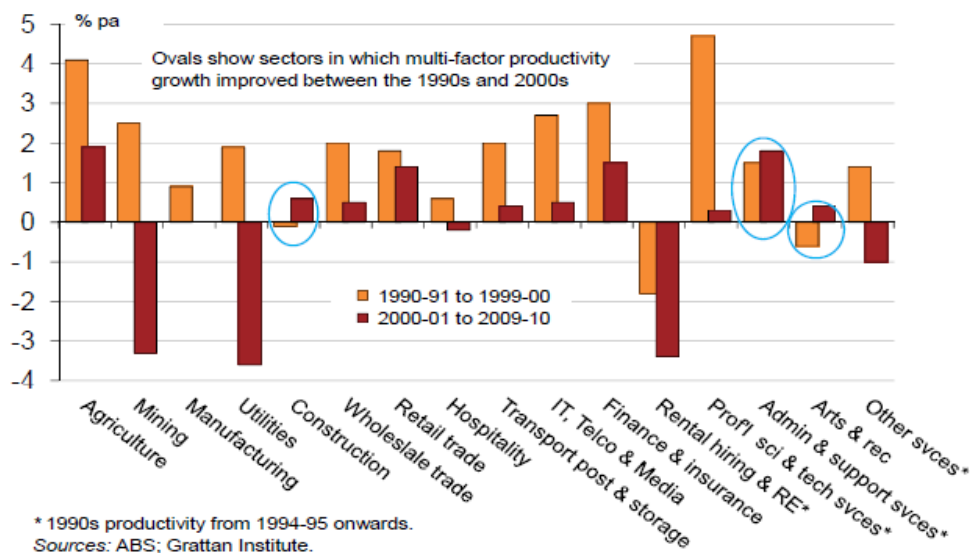


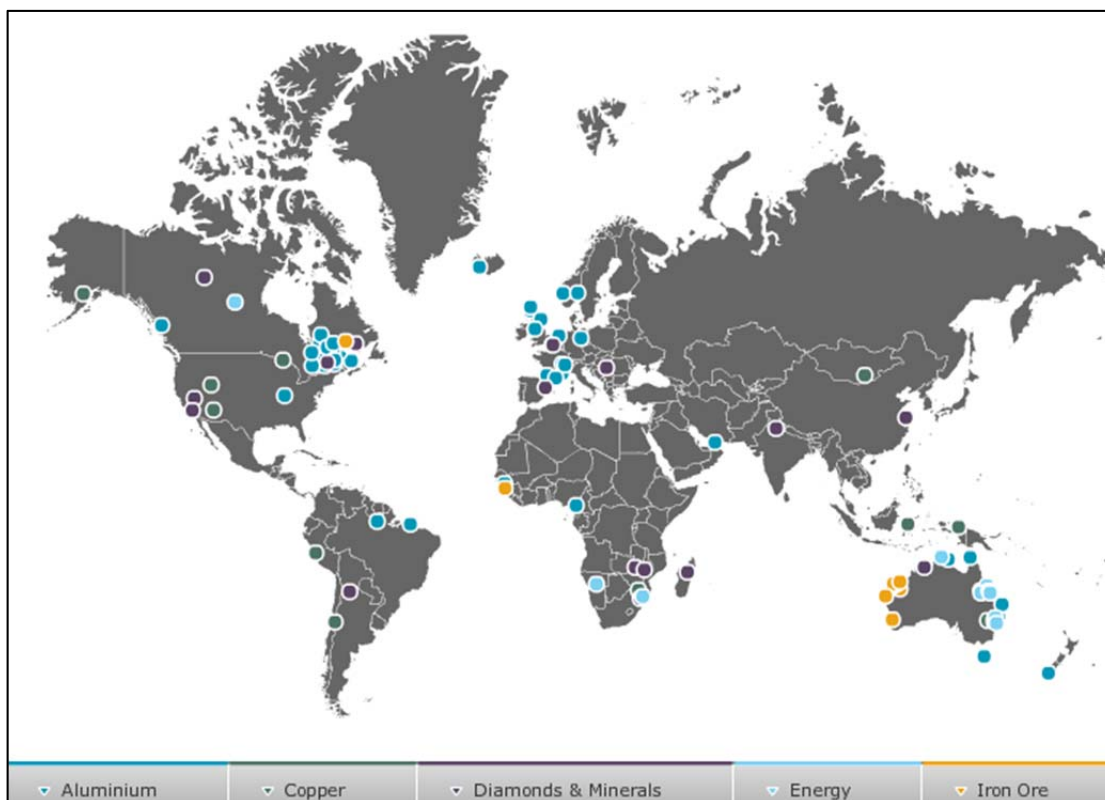
Figure 3: Multi-factor productivity growth by sector, 1990s & 2000s (Eslake and Walsh, 2011)

2.5 Future uncertainties: economic resilience under changing circumstances

Future uncertainties around the economic resilience of Australia's current mineral resource boom are identified here across three key areas: (a) new countries are moving to begin production; (b) that Australian investment in mining is nearing its 'peak' alongside downward trends in commodity prices and rising operating costs; and (c) that uncertainties are growing in relation to the sustainability of Australia's terms of trade with China.

Firstly, while prices for many mineral commodities have been high in recent years, fuelled by growth in Asia and China in particular, more countries are now also moving to take advantage of this unprecedented situation. Accordingly, Australia has become just one of the many countries that international companies such as BHP Billiton and Rio Tinto choose to invest in (Figure 3). Accordingly, Australian iron ore exports for example, the key mineral commodity driving the current boom, now face increased competition from new mining operations in Africa, with further operations financed by China expected to come online in three to four years (Hurst 2012; Potts, 2012).

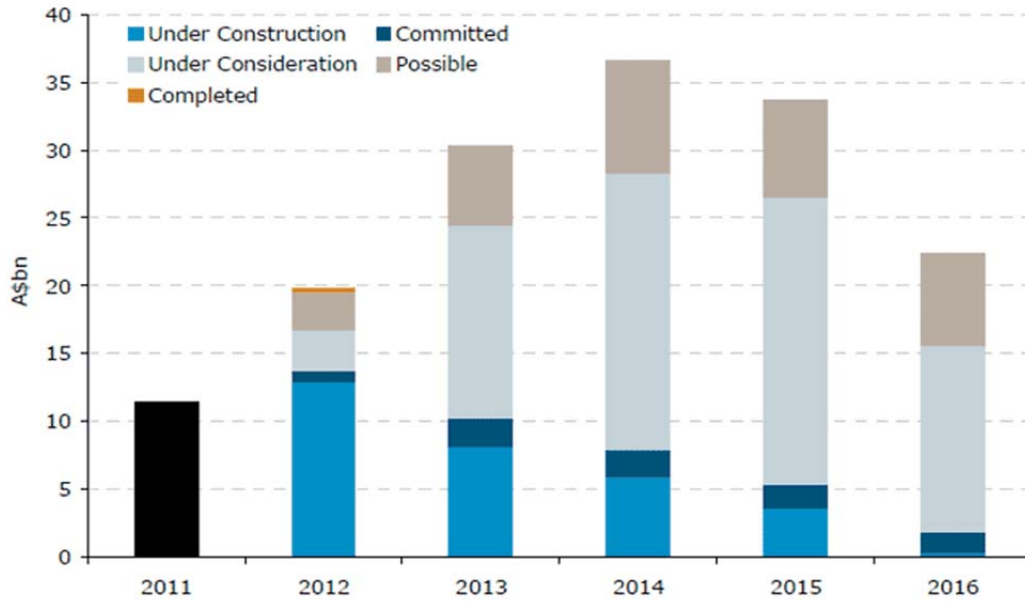
Figure 3: 2012 Rio Tinto operations across six continents (Rio Tinto, 2012)



Secondly, within an increasingly competitive global minerals market, Australia is now facing a projected ‘peak’ in business investment (Figure 4), alongside downward trends in bulk commodity prices (Figure 5) and rising operating costs that are increasingly constraining profitability (Figure 6). A recent report by ANZ (2012) on the status and outlook for major Australian business investments has concluded that the combination of these factors is contributing towards uncertainty about Australia’s future economic prospects:

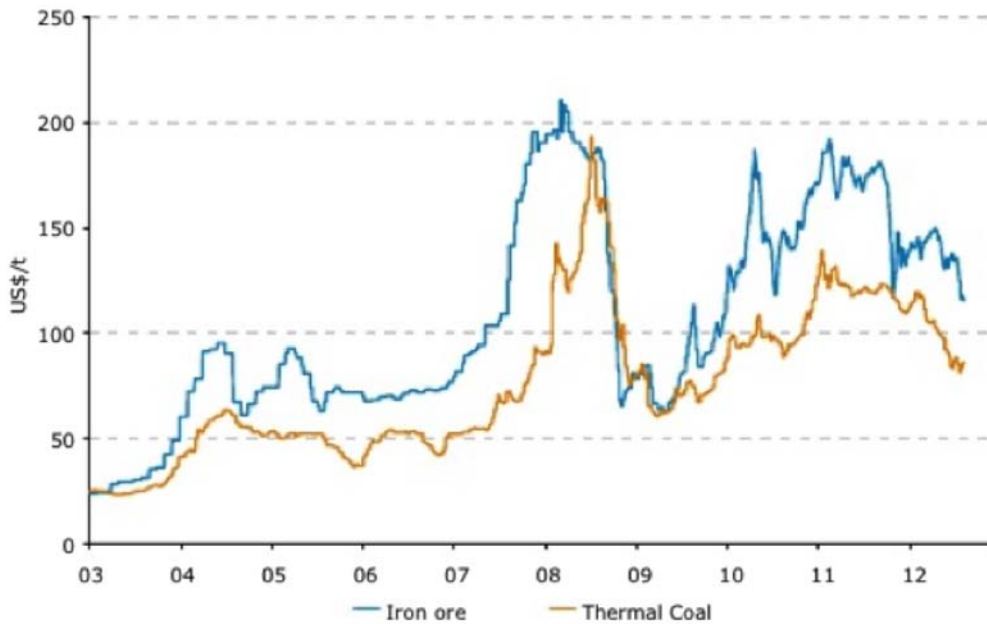
“Much of the planned investment up until mid-2014 appears locked in (under construction, committed or highly likely) and we remain confident that this investment (primarily in resources and related infrastructure) will be a key driver of domestic growth over the next couple of years. Beyond this horizon, however, weaker global economic conditions, easing commodity prices, the higher Australian dollar and rising costs have seen mining and resources companies (under some pressure from investors) becoming more conservative in relation to future capital expenditure. [...] Elevated commodity prices and more buoyant economic conditions may have allowed mining and resource companies to absorb rising project costs to date; but a still elevated AUD, more recent rising costs, and falling commodity prices have reduced profit margins, which could make an increasing number of more economically marginal future projects no longer viable”(p2, p5).

Figure 4: Mining Sector Investment



*Source: ANZ (2012), from original sources - Access Economics, BREE, state government budget papers, Construction Forecasting Council

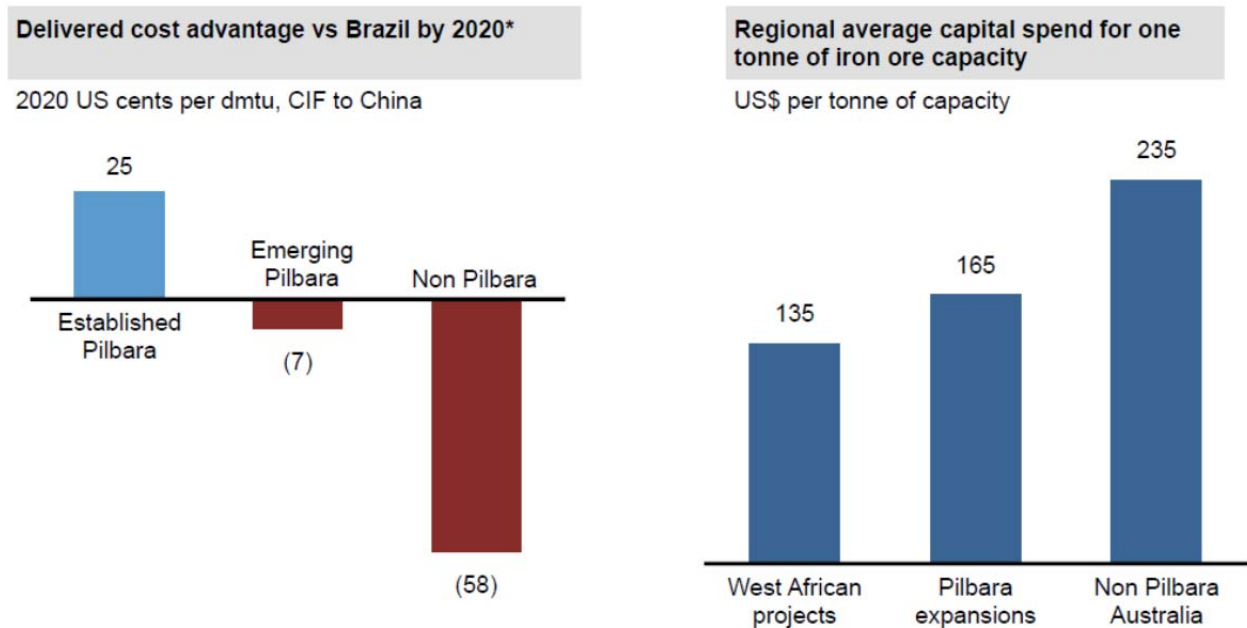
Figure 5: Bulk Commodity Prices



*Source: ANZ (2012), from original sources ABS, ANZ

As many of the emerging mineral domains have significantly lower labour costs, and higher ore grades in the initial stages of production, it is likely that Australia will struggle to command the market in the way it has in recent years. For this reason, it is important to make use of this unique window of opportunity to begin assessing how the present interest in Australia’s minerals can be used to the best long-term advantage.

Figure 6: Competitive position of Australian Iron Ore Projects (Port Jackson Partners, 2012)



* Growth volume only. For expansions at existing operations, growth volume is assumed to have the same cost structure as existing volume
 Source: CRU; JP Morgan; Company announcements

Finally, questions are also being raised as to whether longer-term planning for Australia’s future can rely on ‘business as usual’ demand forecasting in relation to Australia’s ongoing terms of trade with China. As evidence from some sources raising the possibility that the current Australian resource boom may come to an end earlier than previously expected. For example, as the most recent IMF Regional Economic Outlook for the Asia Pacific explains:

“What does the recent sharp decline in China’s external trade surplus reflect? In the main, it is a product of a secular worsening of China’s terms of trade as well as robust import growth fuelled by investment demand. Moreover, prospects for China to sustain the high export growth of the past decade remain uncertain. Taken together, while China’s external imbalances retreat, there is a concern that new domestic imbalances may be emerging. As a result, Asian trading partners that have benefitted from investment-led growth in China may face growing headwinds to their exports (IMF, 2012, pp41-42)”.

While again the ANZ (2012) report suggests that:

“Despite the relatively positive resources investment outlook, vulnerabilities remain, especially for projects beyond 2013. [...] China has slowed more sharply than anticipated, due to the deterioration in the external economic environment and previous policy tightening by the Chinese authorities. [...] The slowing growth momentum, particularly in China, has resulted in an easing in bulk commodity prices, with iron ore, thermal and coking coal all recording price declines over the past year, and are well off their earlier peaks. As a result, our commodities team has revised their forecasts for commodities (especially for bulks) downward” (pp4-5).

In addition, per capita steel consumption in urban China is reaching levels above those in the USA (Mctaggart, 2011) and similar to those in Japan, moderating estimates of future growth potential.

Concerns relating to the economic uncertainties surrounding Australia's capacity to derive benefits from mineral resources long-term, under changing market circumstances, have led to questions about a lack of '*genuine savings*' to offset this vulnerability. The International Monetary Fund (2011) and OECD (2010) for example have suggested that Australia should implement measures to shield the economy and budget from revenue volatility, and create a savings pool through the mechanism of a sovereign wealth fund.

Taken together, the historical evidence; contested views; unintended negative consequences; and future uncertainties, call into question the sustainability of Australia's current development trajectory and the extent to which the present economic benefits being derived from mineral stocks could be more strategically managed to support future generations of Australians, and assist in transitioning Australia's next sustainable development trajectory.

SUMMARY OF CHAPTER TWO

While Australia has been active in mining from early post-colonial times, mineral resource development has happened in phases and each significant boom period was enabled and constrained by different factors. Importantly, history suggests that peaks in Australian mineral production are more likely to arise from shifts in social, economic and environmental variables, rather than physical resource depletion alone. Each subsequent boom period has also restructured the economy, and accordingly, the extent to which new forms of economic development can be fostered in the wake of the current boom will depend on how well the proceeds of this economic development are used and invested.

However the extent to which Australia will benefit from developing its mineral endowment longer-term is now contested at several levels. Evidence that the minerals industry is increasingly the most dominant sector of the economy in terms of export value is clear, yet despite claims that Australia will not be subject to serious macroeconomic impacts, it is increasingly meeting classic definitions for a resource dependant economy and looking vulnerable to changing terms of trade with China. Alongside this, there are calls for the mining industry to be more accountable for the wider trade-offs previously perceived as '*externalities*'.

A strategy for moving beyond a '*two speed economy*' that is looking increasingly exposed to economic uncertainty will require a more strategic approach (rather than a business as usual approach), to understand, measure and evaluate long-term national cost/benefit trade-offs, across spatial and temporal scales, incorporating multiple stakeholder perspectives.

3 CHANGING GLOBAL CONTEXT: IMPLICATIONS FOR AUSTRALIA

CHAPTER THREE OUTLINE:

The context for production is changing in Australia. High commodity prices have accelerated production over recent years, despite declining resource quality. However, increasing global competition and near-term supply in key minerals, is expected to result in decreases in commodity prices, reducing the interest that international miners might have in more expensive Australian ore production. Such changes add to the impetus for strategically taking stock of remaining mineral resource assets and carefully assessing the benefit that they can be expected to generate in the future.

Changes are also occurring to the impacts from mining. Despite higher standards of environmental and social performance than some countries, increasing conflict over competing land-uses (such as coal mining and agriculture), rising cumulative environmental impacts, and declining social benefit for local communities are being recognised as powerful factors in determining the future 'social licence' of the mineral industry in Australia.

Importantly, changes are occurring to the context for global trade. World Economic Forum Scenarios developed with the assistance of international mineral production companies, mining investors and financiers, non-government organisations (NGOs), and researchers challenge existing assumptions about the future place of Australian minerals in a global market.

Emerging challenges for the resources sector in Australia include: slowing demand for mining resources from key export customers (China) and associated reductions to the current historically high commodity prices; peaking of mine infrastructure investment; and depletion of high quality, easily accessible resource stocks, meaning new resource extraction is technically more difficult. These challenges are also influenced by other wider socio-economic trends including a growing awareness and opposition to mining activities over other land uses; the impacts of global efforts to decarbonise energy systems and economies; and increased awareness of total life cycle costs of consumer goods.

Research for this project has provided insight to these questions and challenges, and explored the interplay between changes to the physical, economic, technological, environmental and social determinants of mineral production in Australia, including likely changes to the global trade context between 2012 and 2040.

3.1 Australian mineral development in the context of Asian industrialisation

The rapid urbanisation and industrialisation of emerging economies within Asia in the decade of 2000 (particularly China) led to increased demand for mineral resources. The speed of industrialisation of emerging Asian economies was largely underestimated in the period from 1999 to 2007 (Connelly and Orsmond 2011) resulting in significant undersupply. A number of factors limited the ability of the global market to respond rapidly to this increased demand. Firstly, commodity prices had suffered under 'stagflation' economic conditions of the 1970s and 1980s; this led to depressed global commodity prices. Low commodity prices led, in turn, to less investment in mineral exploration and production, as mining companies became unwilling to invest in expanding capacity in such conditions (Connelly and Orsmond 2011).

Urbanisation and industrialisation in Asia brought investment in infrastructure and buildings on a massive scale. China, a major producer of the crude steel that played a major role in this process, increased its output from 151, 000 Mt in 2001 to 626, 600 Mt in 2010 (World Steel Association 2011), driving the expansion of global steel production from 2000 onwards. Driven more by rising incomes than population growth, the Asia-Pacific region is now the largest consumer of resources globally (Schandl and West, 2010), however, growth in per capita consumption growth (e.g. of steel) is slowing.

The inability of global supply to respond quickly to this increased demand from Asia led to historically high commodity prices. For example, thermal coal and iron ore contract prices rose 70%, while coking coal prices rose 120%, in 2005. Further price rises of between 125% and 200% for coal and iron ore occurred in 2007, although the increases of recent years have now begun to decline. High commodity prices in the late 2000s led to rapid increases in mining investments around the globe. Australia was the largest supplier of iron ore in 2009-2010, supplying 25% of the world supply (ABARES 2010). It has a key export advantage in lower shipping costs and faster delivery times, than rival market leaders in Brazil,

Over the same period, the structure of Australia's mining industry changed significantly. The number of innovative mid-sized Australian-owned companies (such as MIM, WMC) declined dramatically in the early 2000s, due to a combination of factors including the weak commodity markets, downward trend in the investment and exploration cycles, and the Asian financial crisis, leading to high-profile failures of several mining companies (e.g. Pasminco) and a series of mergers and acquisitions including the merger of BHP and Billiton and subsequent takeover of WMC as well as the takeover of MIM Holdings by Xstrata (Connelly and Orsmond 2011). By the late 2000s, the dominant mining companies were large multi-national organisations (except for companies like FMG and Hancock Prospecting) with significant capital availabilities and preference for large operations to maximise economies of scale and minimise administrative overheads. The implications of this change, for Australia, is that it is now only one of many potential sites for development, and that world class deposits (with a life-span of 40 or more years) are required to maintain the interest of multi-national mining companies like BHPBilliton and RioTinto (this preference is noted in their 2011 annual reports).

3.2 Changing terms of production for Australian minerals

Although Australian mineral resources are currently being extracted at increasing rates to take advantage of rising demand and unprecedented prices, this is likely to change substantially in the decades leading up to 2040. Changes to ore quality and complexity, and the increasing costs and impacts that accompany these changes, all raise questions about the ongoing attractiveness of Australian minerals in a changing global market. Of particular concern, in these circumstances, is the decline in productivity (multi-factoral), and the absence of significant new discoveries of new world-class deposits.

Declining quality of natural resources deposits are identified in Loughton's (2011, cited in BREE 2011) analysis of the productivity of the mining industry from 1985-86 to 2009-10 as one of the causes of declining multi-factor productivity of the mining industry during this time. Similar issues were raised in the Productivity Commission report released in 2008 (Topp et al. 2008). Other causes nominated in the Productivity Commission report include the time lag between mining investment and

increased output, and the slow rate of new technology uptake in existing mining operations. This view also appears in a more recent report by the Bureau of Resources and Energy Economics (BREE 2011, Topp et al 2008).

Some of these issues are also identified in a decade-old report on Australia's Mineral Exploration presented to the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) Secretariat, which found a lack of new discoveries² and challenges associated with accessing deeper mineral deposits as some of the "main issues facing the Australian minerals industry". This report also nominated "...maintaining the intellectual edge and managing changes in social values and expectations..." (PMSEIC 2001). Before this 2001 work, the most significant reviews of mining and minerals in Australia was the Industry Commission (forerunner to Productivity Commission) report on mining and minerals processing from 1991 (Industry Commission, 1991) and in 1974 the Fitzgerald Report on "The contribution of the mineral industry to Australian welfare". This 1974 report showed the Commonwealth was making a *net loss* on mining despite a boom in the late 60s-70s due to generous tax concessions.

Recommendations regarding how these challenges might be addressed have gone some way towards the objectives, however, changes to the 'social values and expectations' have potentially exceeded the expectations of the report's authors in terms of the influence that they are now having through impacts on 'social licence to operate'. For example, better 3D mine models (CSIRO 2006) allow deeper deposits to be more efficiently extracted, but this only partly offsets the increase in energy and processing costs associated with deeper mining. At a time when increasing energy use is also increasing carbon dioxide emissions, the bar for improvements to technology is becoming much higher.

Maintaining the "intellectual edge" has also been pursued, in some quarters, with a great deal of success. Technological development, particularly the development and export of software and mineral services (see for example www.austmine.com.au) have placed Australia at the forefront of innovation. However, in other areas, such as technology that focuses on automation and remote tele-operation, potential gains in productivity are confronted by potential losses in social and economic benefit for local communities (McNab and Garcia-Vasquez, 2011).

Research undertaken by the CSIRO and AusIMM (Moffat et al 2009) also indicates that mineral industry professionals view the economics of mining, and social expectations around how the industry operates, as two key future industry drivers for the mineral industry. In addition to changing trends in global consumption patterns, changes to end uses for minerals, and carbon emissions trading (Moffat et al 2009) will significantly challenge the industry in its ability to continue 'business as normal'.

Increasing global competition

The high commodity prices witnessed in the last 5-7 years have triggered investments in exploration and expanded mineral production in a number of countries and regions around the globe. This

² Including information about the nature of deposits being evaluated by private explorations companies.

expansion builds upon the development that has been taking place more gradually over several decades. In 1973 OECD countries accounted for over half of the global production of coal, now they account for 23% (IEA 2011). Expenditure is occurring at several levels, including investments in exploration, new and increased production capacity, and in the development of infrastructure to facilitate the processing and transport of a range of materials.

Significant expenditure in exploration has been made in Canada, the US and Mexico. Exploration expenditure globally increased by 44% in 2010 and a further 50% in 2011 to a high point of \$18.2 billion in 2011 (MEG 2012). Australia was ranked fifth in terms of exploration expenditure in 2011, behind Latin America, Canada, Russia and Africa. Given the time lag between exploration and production and future capacity coming onto the market, this could be expected to reduce the price, and therefore the margin for profit.

In a future characterised by adequate or oversupply, attractiveness of Australian minerals will need to have a significant edge to account for the lower labour and energy input costs available to producers like Brazil and West Africa (Hurst 2012, MCA 2012). *Balancing Act* (Foran et al 2005), a 'generalised input-output analysis' aimed at developing a "...triple bottom line account of the Australian economy for three financial, three social and four environmental indicators", concluded that given the circumstances at that time, Australia would need to look towards providing a premium mineral product with high environmental and social performance, rather than attempting to compete on price with those nations whose mineral development is emerging in a different stage of the economic development cycle. This could be a bridge between short-mid term over-supply and longer term resource constraints globally, especially for selected minerals including rare earths. There is also increasing global interest in recycling and urban mining as part of resource efficient economies.

3.3 Changing future global context for trade in minerals, metals and finished goods

As one of several inputs to the development of the Vision 2040 report (detailed in Chapter 6), CSIRO, the Institute for Sustainable Futures (UTS) and the Minerals Council of Australia (MCA), in collaboration with the World Economic Forum, undertook consultations with key industry and other stakeholders. Using global scenarios for mining and metals, developed by the World Economic Forum in 2009, the consultations aimed to draw out stakeholder views of how the minerals industry in Australia might respond to plausible changes to the system of global trade (Davis, 2010). Each of three scenarios explored possibilities offered by existing trends, and participating stakeholders were asked to provide their views of useful strategies for tackling the challenges presented.

Table 3 outlines the key characteristics, and assumptions, that underpinned the scenarios.

Table 3: WEF scenario assumptions and Australian contextualisations

Scenario (Growth assumptions)	Assumed objective of trading nations under scenario
'Resource Security' (Global GDP + 1.5%)	To ensure that resources remain available for domestic use.
<p>Global Scenario Description: <i>In 2030, the era of globalisation is a distant memory as nations prioritise narrow self-interest. They hoard domestic resources, enter cartels based on regional and ideological alliances and resource blocks, and engage in neo-colonialism and import substitution strategies (WEF 2010).</i></p> <p><i>Australian contextualisation:</i> <i>Inputs and outputs of domestic mineral production and mineral-based goods production will need to be closely monitored. Where Australia is currently sourcing important goods from trade, it will be important to assess options for maintaining access. Domestic supplies of iron ore will also be more difficult to bring to markets, and may also become the target of other nations or regional alliances resource security strategies. Australian manufacturing is poorly placed to replace the materials currently being sourced from overseas producers, and this will impact on the industries that rely on these imports -construction to name the most direct, but with flow-on impacts for the housing and finance sectors (ISF 2010) .</i></p>	
'Rebased Globalism' (Global GDP +4%)	To ensure that resources remain available for domestic use and suitable for trade with dominant markets.
<p>Global Scenario Description: <i>In 2030, the world is committed to realising the benefits of global interconnection but has become far more complex and multipolar. Power comes from control of resources as well as possession of capital, with resource-rich countries playing by their own rules. Civil society has gained power, resulting in various local laws that affect global corporations (WEF 2010).</i></p> <p><i>Australian contextualisation:</i> <i>In this case Australia's market share would be reduced as other countries with comparable mineral domains begin to produce in greater volume. Remaining competitive with new producers is most likely to create further pressure for reducing costs for labour and other increasingly high-cost inputs such as transport fuels and electricity for day to day operations (ISF 2010) .</i></p>	
'Green Trade Alliance' (Global GDP +2%)	To ensure that existing domestic resources remain available and suitable for trade with Green Trade Alliance member countries.
<p>Global Scenario Description: <i>In 2030, the world is divided and countries are defined economically by whether or not they belong to the Green Trade Alliance (GTA), formed in 2016 to promote "environmental sustainability without compromising competitiveness." GTA countries, including some industrialised, resource-rich and developing countries, have experienced a period of accelerating innovation and lifestyle changes. While there is strong alignment among GTA countries, non-GTA countries operate independently (WEF 2010).</i></p> <p><i>Australian contextualisation:</i> <i>In this case, it is likely that this will be measured in a triple-bottom-line approach that facilitates a more comprehensive assessment of environmental and social impacts of production by trading partners. Extraction and processing practices will need to be compliant with relevant procurement, chain of custody, and disclosure requirements of downstream producers of finished and semi-finished goods (ISF 2010) . .</i></p>	

The aim of the scenarios is to help stakeholders explore the implications of the plausible and distinct futures, rather than to suggest that one or another is more likely to eventuate. In reality, aspects of all scenarios have been observed since the workshop in 2010, for example: restrictions on rare earth exports by China [resource security]; the manifestation of new social structures through the

emergence of new players in the global economy [rebased globalism] and the discount on trade in environmental goods agreed to at APEC in 2012 [green trade].

Key concerns for participants included the need for improved community engagement and development in the Australian context, particularly the need for Australian firms to be more:

- Creative in formulating strategies for employment growth in the community;
- Transparent and sophisticated in their communications about performance and decision-making; and
- Aware, and supportive of the visions, values and expectations of communities in which they operate.

Issues of sustainability, and what this might mean for ‘day-to-day’ mining and mineral processing operations’ were also prominent concerns for these stakeholders. Emerging from this, a real need was seen for stakeholders in Australia (including governments, communities and the mining industry as a whole) to have a common understanding of “a sustainable Australia” and the role of the mining industry in this. It was suggested that the group explore the development of a framework for a national mining strategy in a multi-stakeholder context and a five star sustainability rating tool for operating mines.

Feedback from this, and earlier stakeholder consultations, along with forecasting research and reviews of existing issues surrounding mineral commodities, has been used to support the development of the final Vision 2040 report (detailed in section 5).

Changing global context is a key consideration for Australia’s mineral industry, and should be considered in parallel with the changes to terms of production both within Australia, and in relation to nations with comparable mineral endowments. Also important are shifts in historical benefits from mining, which create social and environmental constraints that may come to be as important as physical and economic limits to mining and mineral processing. While thought has been directed to some of these issues by government agencies, such as the Australian Productivity Commission (see Topp et al 2008), researchers (Gregory 1976; Hancock 2001; Willett 2002;), and industry (MCA 2005, AMIRA 2004, MMSD 2002), the failure to meaningfully implement the existing National Strategy for Ecologically Sustainable Development (NSES) policy, and the absence of national or state policy for a transition to sustainable economic development, indicates that other mechanisms and approaches may be required.

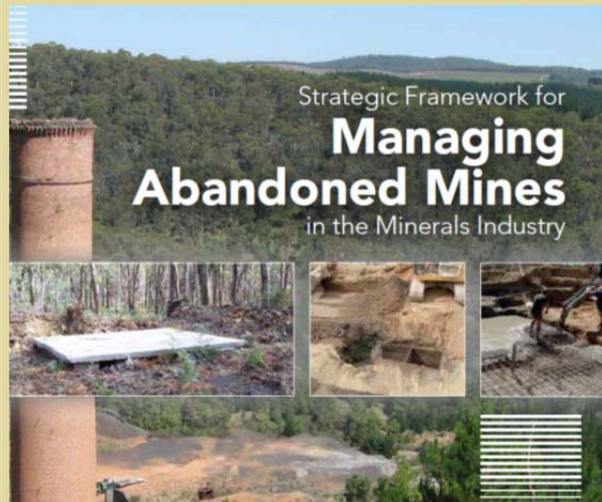
Box 2. Strategic Framework for Managing Abandoned Mines in the Minerals Industry

In 2010, the strategic framework for Managing Abandoned Mines in the Minerals Industry was produced jointly by the Minerals Council of Australia and the Ministerial Council on Mineral and Petroleum Resources.

It focuses on the themes of

1. Valuing abandoned mines
2. Data collection and management
3. Risk assessment and management
4. Resourcing and partnership opportunities
5. Information sharing and leading practice

Whilst it provides high level guidance, a stronger implementation plan is needed and was the focus of a 2012 Managing Mine Legacies Forum.



For more information on the Managing Mining Legacies Forum see

See <http://www.cmlr.uq.edu.au/Portals/0/MMLF/MMLF%20Program.pdf>

And to download the strategic Framework visit

<http://www.ret.gov.au/resources/Documents/mcmpr/MCMPR%20Strategic%20Framework%20for%20Managing%20Abandoned%20Mines%20vWeb%20Jan25.pdf>

The next section outlines a range of existing and new challenges to mining in Australia using selected case study commodities as examples and mineral futures assessments which may help in addressing these challenges effectively.

SUMMARY OF CHAPTER THREE:

Along with shifts in historical benefits from mining, a clear understanding of changes to the context of mining and mineral production in Australia, and changes to the current terms of production, will be important to understanding the range of possible futures for the mineral industry in Australia.

Changes to the terms of production, including increasing production costs, declining ore grades, a lack of major new discoveries, and reduced social benefits for local and national communities, raise significant challenges to the future of mining in Australia.

Taken together, existing changes and challenges to routine operational drivers are likely to have a significant impact on the viability of future mineral commodity production, and suggests the need for a more strategic approach, underpinned by nationally consistent and reliable data on exploration, production, impacts from mining activities.

4 AUSTRALIAN MINERAL FUTURES: COMMODITY VULNERABILITIES

CHAPTER FOUR OUTLINE:

Economic, social, environmental and technological constraints on production are becoming more challenging. Although physical depletion may not present a problem in the short-term, continued increases in production combined with falling resource quality brings greater technological, environmental and social expense. Despite the substantial dependence of Australian governments on revenues from mineral development, and the present importance of Australian minerals in supplying the global market, the majority of the issues presently facing mineral development in Australia, have received limited attention since the early 1990s.

Data on social and environmental impacts of production are scarce. Whilst data on resources and production are collected, little data is available on the social and environmental impacts of production at site, regional and national scales. This limits the ability to assess benefit from mining and minerals processing over time.

Technological breakthroughs are not sufficient to maintain comparative advantage in Australia. These factors make it more likely that some resources will face economic depletion long before they 'run out'. As such, 'peak minerals' offers a useful model for assessing and representing the transition between 'easier and cheaper' and 'more complex and expensive' production.

Data-rich case studies analysing specific resources were undertaken as part of the Commodity Futures research project within the Mineral Futures Collaboration Cluster. Case studies were conducted for: Iron (Yellishetty et al., 2012); Copper (Mearny et al., 2012b), Gold (Mudd et al., 2012), Lithium (Mohr et al. 2011) and Coal (Mohr et al., 2012)³. This chapter builds on the synthesis in Giurco et al. (2011), which identified similarities and differences across commodities to outline contemporary challenges for commodity futures. This analysis confirms that the future for Australia's mineral sector is changing and increasing in complexity.

4.1 Taking stock of mineral futures: Assessing future prospects for Australia

A common theme across Australian mineral commodities is extraction and production becoming more challenging; as ores become more complex in terms of refractory and grade declines, and mines become deeper and more remote. Whilst physical depletion may not present as a problem in the short-term, increased extraction complexities now coincide with rising production volumes, as commodity prices gradually decline. The idea of a Hubbert-style '*peak*' in resource production has been used in a conceptual sense, to represent and model the changing impacts associated with a transition between early '*easy and cheap*' production, and later production modes which are characteristically '*more complex and expensive*' (Giurco et al. 2010; Giurco et al. 2012). Changing factors within Australia's resource extraction industries are now contributing to the likelihood that some commodities will face economic constraints and become *economically inaccessible*, long before they '*run out*' (Prior et al. 2012a; Mudd and Ward 2008).

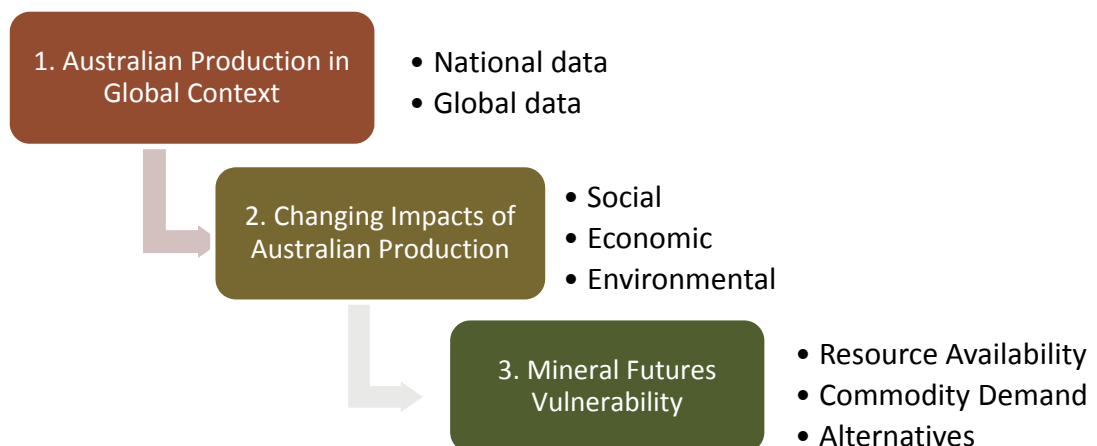
³ The selection of case study materials was illustrative of different dynamics (rather than comprehensive), coal and iron have significant economic value, copper builds on detailed techno-economic assessments and similarly gold but for a high value small volume, well recycled commodity and finally lithium is a rapidly growing market with a more vertically integrated supply chain.

Maintaining Australia’s competitive advantage for mining, now requires addressing the task of continuing production while ore grades decline and become more complex to develop and costly (e.g. labour, transport, energy, capital/equipment); **representing both a challenge and an opportunity for innovative technological change**. However, there are also social and environmental challenges that have emerged within this changed context that are less susceptible to resolution by technological means, and therefore more likely to be resolved through **innovative approaches to policies, practices and business models**.

An assessment of Australian production in a global context is informed by parallel assessments. The first is based on a high level snapshot of resource and production data in Australia, relative to global competitors. The second explores examples of the changing impacts of Australian production, demonstrating how changing social and environmental impacts are affecting the future production of specific commodities in different regions. Finally, a third national perspective is adopted to assess how competitiveness is changing for Australian commodities, based on available resources, global demand and potential for substitution of demand by alternatives (after Mason et al. 2011b).

Figure 4 provides an outline of the information used to assess the future prospects for mineral development in Australia and each component is discussed in turn in the following sub-sections.

Figure 4: Understanding changes to Australia’s mineral futures



4.2 Australian production in global context – contemporary data

The following sub-sections provide an overview of Australian resource and production data in a global context.

4.2.1 Iron

Iron and coal are the leading value commodity exports from Australia. As shown in Table 4, Australia was the third largest producer of iron ore in 2009 after China and Brazil.

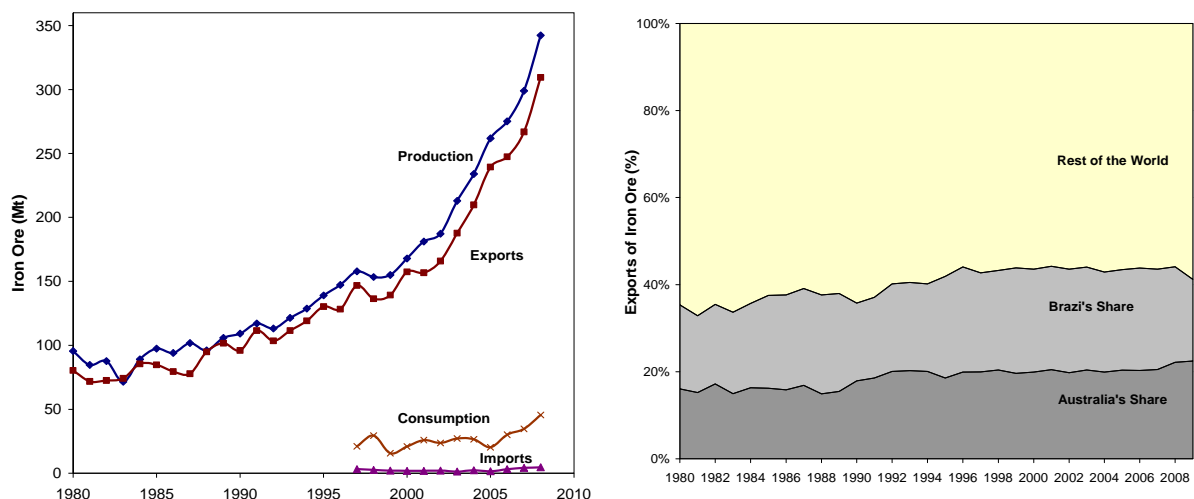
Table 4: Iron ore reserves in selected countries in the world (2009 data) (USGS, 2010)

Country	Iron Ore Reserves (Gt)	Iron Content (Gt)	Production in 2009 (Mt)		Production Rank in 2009	
			Iron Ore	Crude Steel	Iron Ore	Crude Steel
Australia	20	13	370	5.25	3	23
Brazil	16	8.9	380	26.51	2	9
China*	22*	7.2*	900	567.84	1	1
India	7	4.5	260	56.6	4	5
Russia	25	14	85	59.94	5	3
Ukraine	30	9	56	29.75	6	8
USA	6.9	2.1	26	58.14	10	4
World	160	77	2,300	1,220	-	-

*China is based on crude ore, not saleable ore (China has large but low grade, poor quality reserves)

Australia's production and consumption of iron ore, together with imports and exports and share of world exports, are shown in Figure 5.

Figure 5: Australian iron ore production, consumption, imports and exports (left); Australia's share of world iron ore exports (right) (Yellishetty et al., 2012)



As outlined in Yellishetty et al (2012), a difficulty assessing Australian iron ore grades is that grades are estimated based on saleable production and not raw ore, despite the majority of iron ore requiring beneficiation before use (Mudd 2010). Despite this, the long-term trend is a gradual ore grade decline for saleable iron ore, both for Australia and globally. A challenge for Australian ores, is that as grades decline, impurities (e.g. phosphorous) rise which require further processing to produce a saleable product. In addition, ore type (e.g. magnetite, hematite, goethite) affects ore grades, impurities and processing requirements.

A graph of the price of iron ore over time is shown in Figure 6, demonstrating that the high prices enjoyed in 2010 are fading as demand slows and more global capacity comes online. Whilst well established operations in the Pilbara are still profitable at these prices, it makes new expectations either less economic or uneconomic.

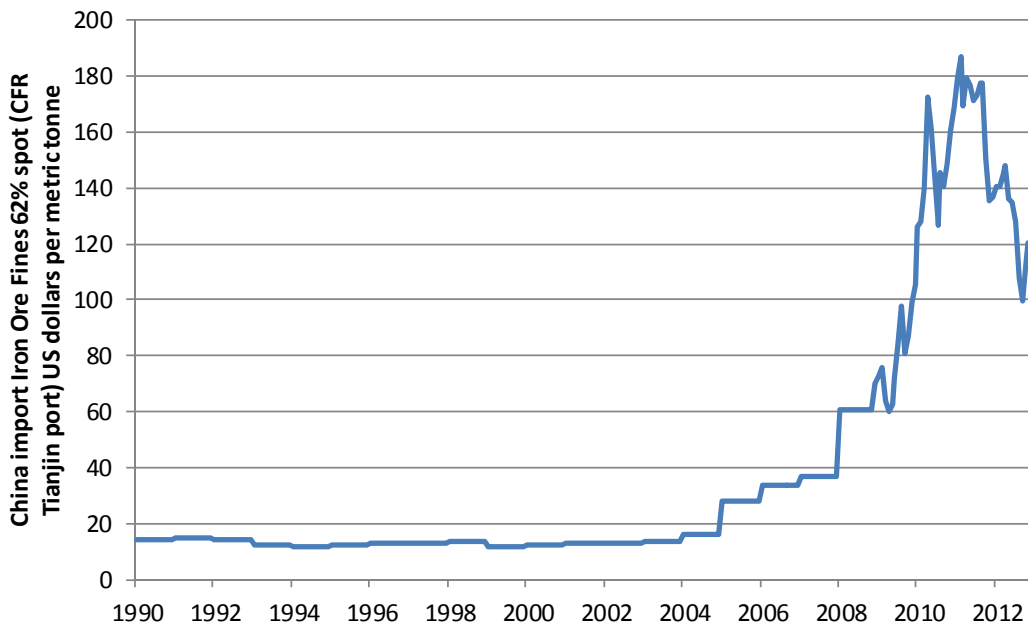


Figure 6: Price of iron ore over time (International Monetary Fund, 2012)

4.2.2 Coal

Australia produced 406 Mt (327 Mt saleable) black coal in 2010-11 (BREE, 2011). Coal is a significant energy export for Australia (143 Mt black; 140 Mt metallurgical), heading mainly to Japan, China and Korea. At a national scale, however, strong prices of well over \$100 per tonne are waning (Figure 7).

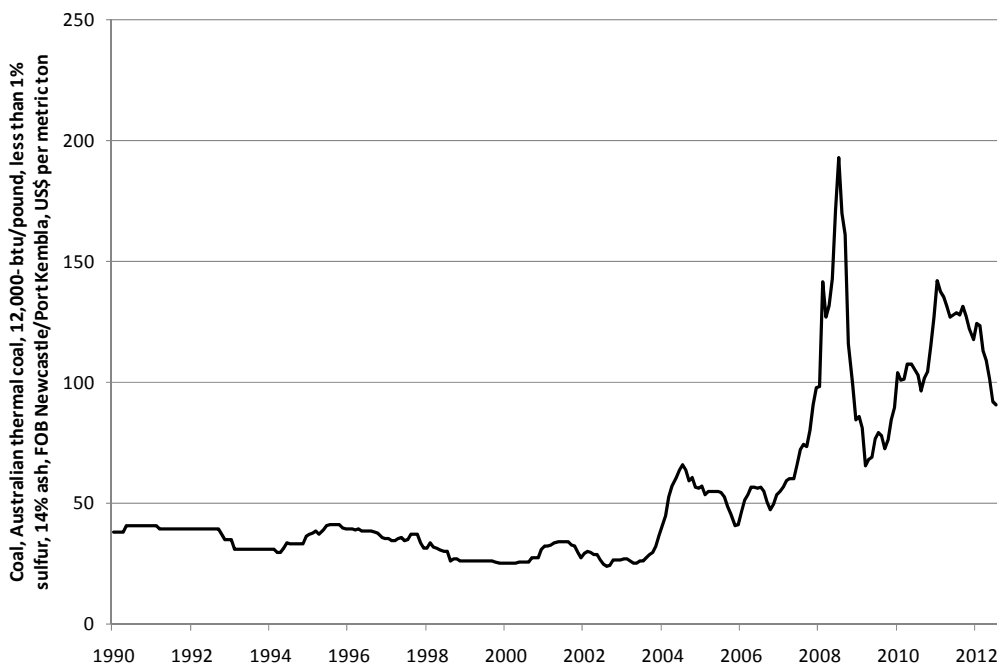


Figure 7: Price of black coal over time (International Monetary Fund, 2012)

Whilst Australian black coal exports generated significant revenue in 2010-11, namely \$30 billion (metallurgical) and \$14 billion (thermal) (BREE, 2011), as a nation we are increasingly required to import more liquid fuel (where Australia is no longer self sufficient) and this cost \$33.5 billion in 2010-11 (BREE, 2011). The revenue generated through coal exports also has impacts on the environment and health of local communities. Changes in the Economic Demonstrated Resources for Coal from 1976-2008 are shown in Figure 8.

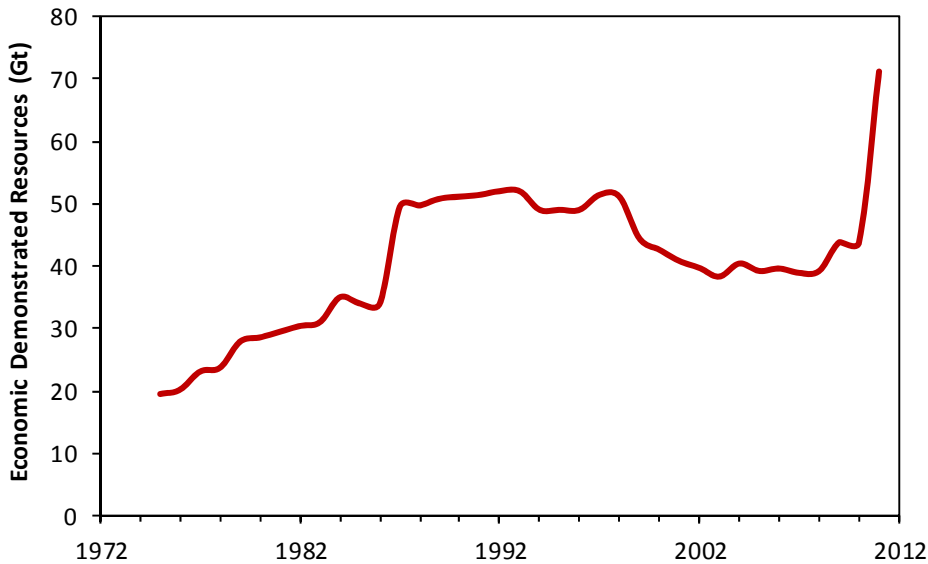


Figure 8: Economic Demonstrated Resources for Coal (updated from Geoscience Australia and ABARE, 2010)

As annual production rises, associated projected resource life for coal declines from 1990-2010 as shown in Figure 9. The recent rise in resource life is associated with an increase in Economic Demonstrated Resources.

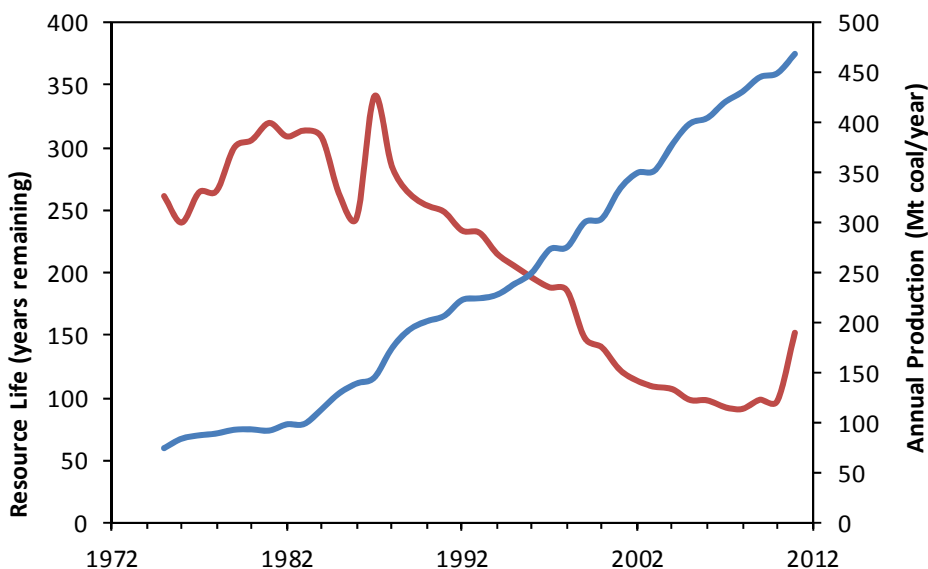


Figure 9: Historical production for coal and associated remaining resource life based on economically demonstrated resources at current annual production (updated from Geoscience Australia and ABARE, 2010)

A more comprehensive mine-by-mine model that was developed to project future black coal production (i.e. excluding lignite) in Australia and globally is shown in Figure 10 (Mohr et al 2012).

This shows Asian production (particularly China which has gone from significant coal exporter to importer in the last decade) is expected to peak before Australian production.

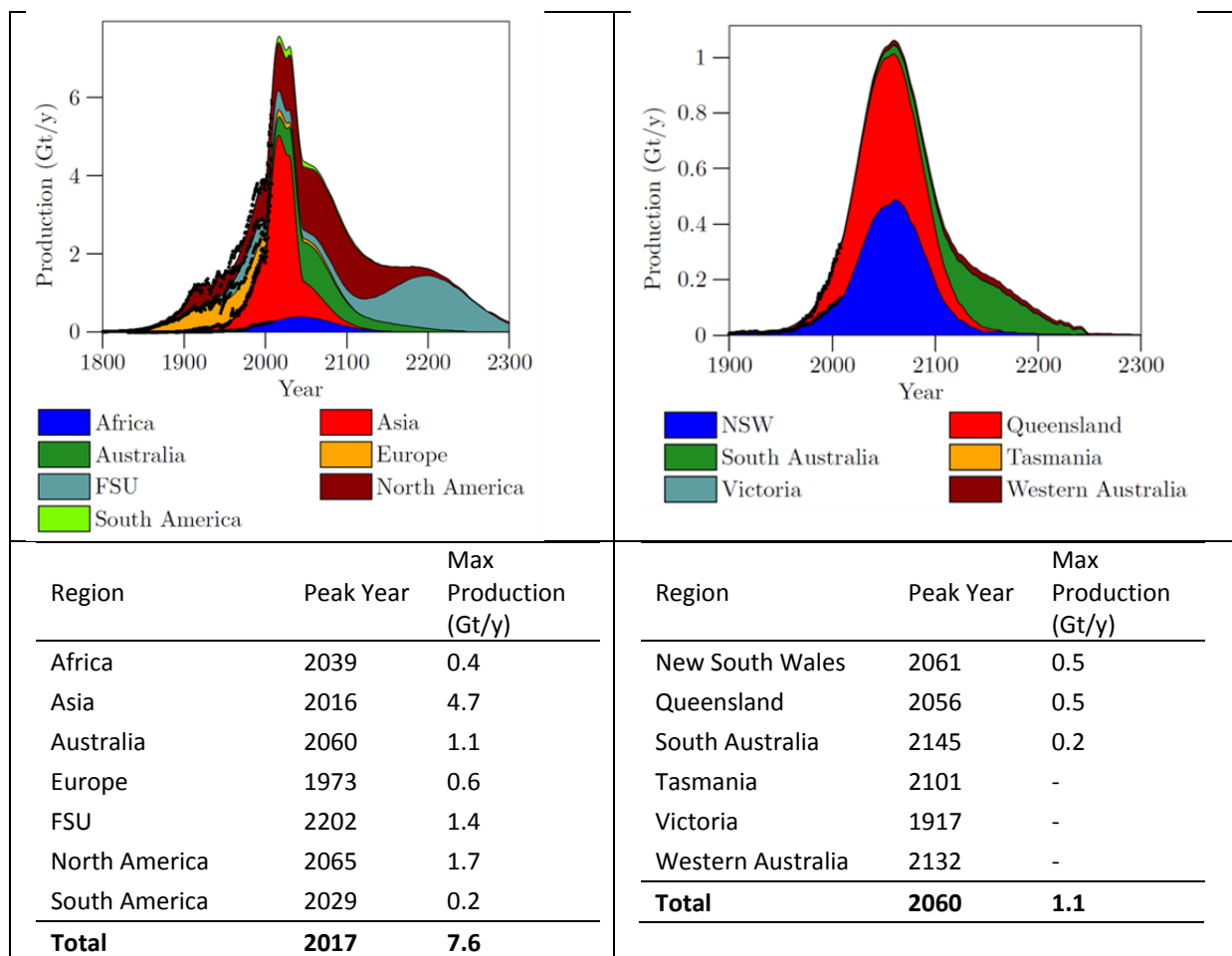


Figure 10: Modelled world black coal production (left) and Australian production (right) (Mohr et al. 2012)

Whilst there is limited comprehensive data available on environmental and social impacts across Australian coal mining regions, Table 5 (overleaf) highlights the importance of monitoring and responding to impacts at the regional scale, given they can be cumulative across space and time. Furthermore, many companies do not publically report data down to a site-specific level, making it difficult to moderate discussions about regional impacts.

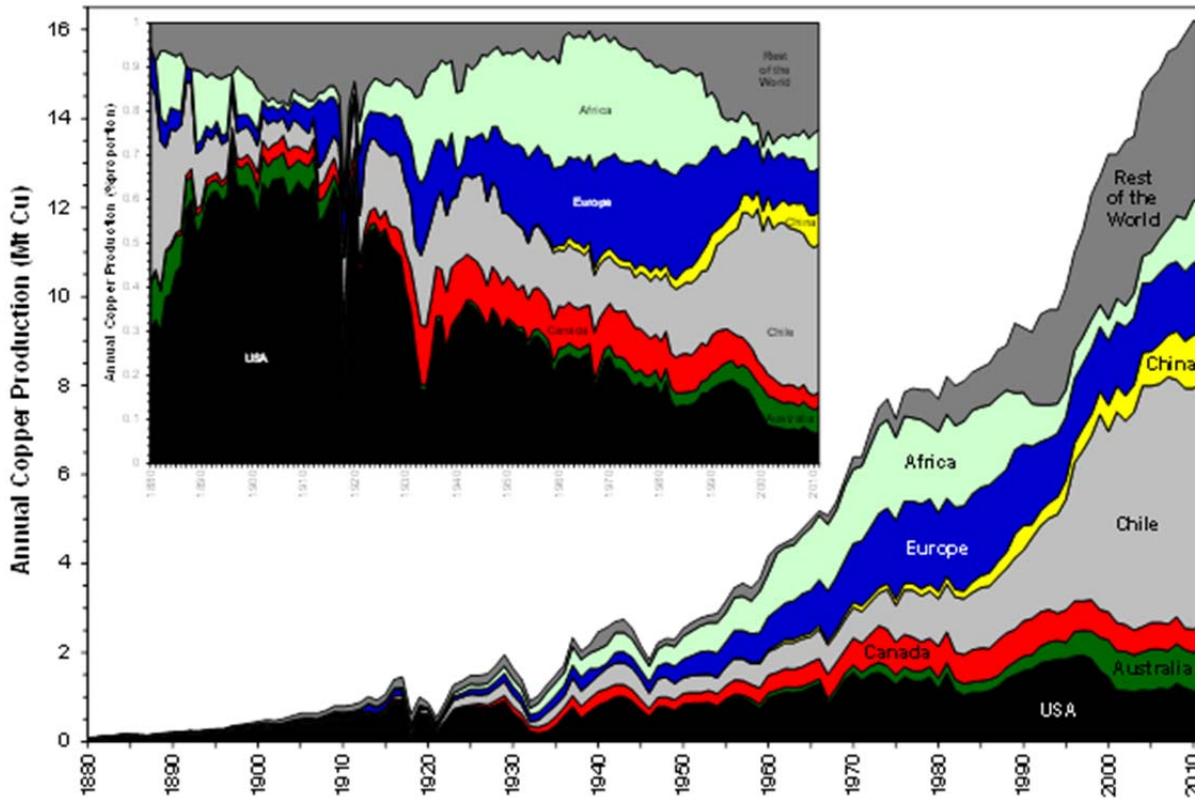
Table 5: Examples of coal mining impacts with the potential to be cumulative (Franks et al., 2010)

EXAMPLES OF NEGATIVE IMPACTS	EXAMPLES OF POSITIVE IMPACTS
<ul style="list-style-type: none"> ▶ Price inflation (e.g. housing and rents) and the disproportionate impacts on residents not employed in the mining industry. ▶ Overloading of existing social services (e.g. childcare, healthcare and education). ▶ Reduced visual amenity (especially in high density mining regions). ▶ Perceived and real loss of community identity due to demographic change. ▶ Increased noise and vibration from blasting and hauling. ▶ Reduced water quality (e.g. saline discharge into rivers). ▶ Increased dust and associated air quality issues. ▶ Reduced water quantity (groundwater draw and water table impacts from multiple mines and industries). ▶ Greenhouse gas emissions, including fugitive emissions. ▶ Traffic congestion and road degradation. ▶ Vegetation clearing and loss of biodiversity. 	<ul style="list-style-type: none"> ▶ Increased employment and economic investment. ▶ Regional and community development benefits from mine community investments. ▶ Local business development from mine procurement. ▶ Greater royalties and taxes. ▶ Road and infrastructure upgrades. ▶ Investment in biodiversity offsets and rehabilitation (on and off lease). ▶ Increased awareness of health and safety. ▶ Population increases that create a critical mass for better services and infrastructure (e.g. schools, and sporting teams). ▶ Development of human capital (skills, employment and training).

4.2.3 Copper

The third case study explored within the Commodity Futures research theme was copper (Memary et al., 2012b). In particular, the focus was on understanding how the environmental impact of copper production in Australia has changed over time, including the contribution of new technologies. It found that whilst new technologies lowered impact in the short term, this was eroded by declines in ore grade over the longer term. World copper production is dominated by Chile as shown in Figure 11.

Figure 11: World copper production (ex-mine) by selected countries and region, 1880 to 2011, with inset of fractional production (Mudd et al., 2012)



Notwithstanding, Australia is the fifth largest copper producer as shown in Table 6 and has the third largest copper reserves in the world.

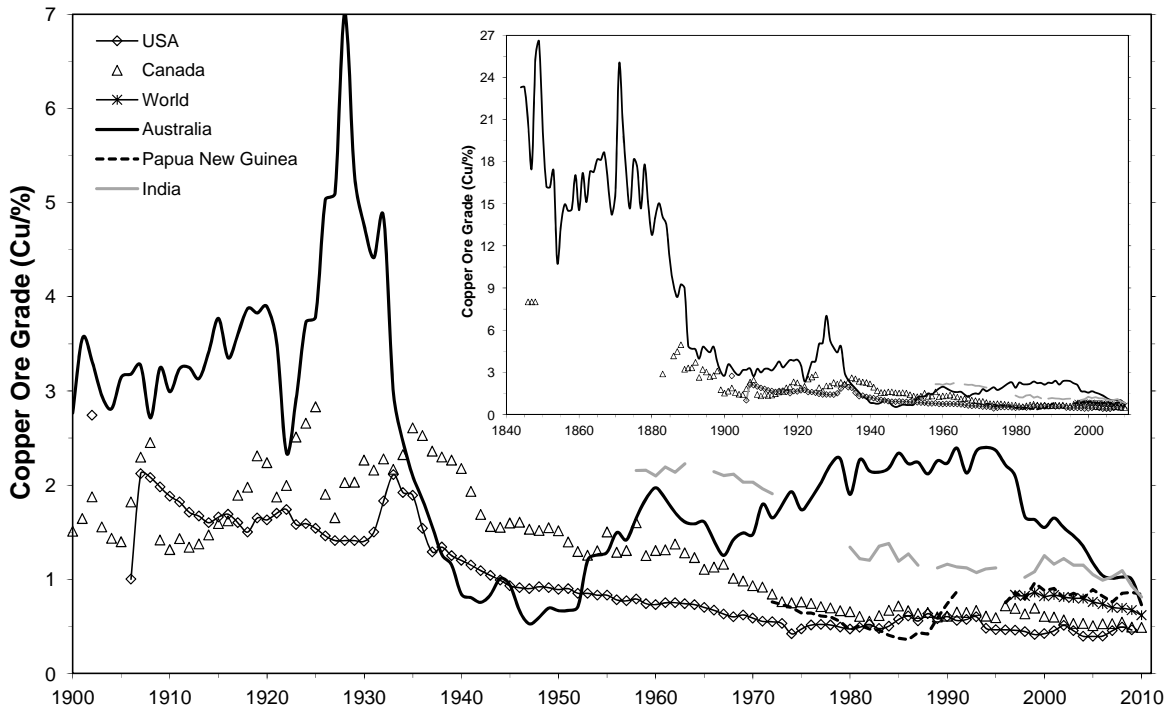
Table 6: World copper production (USGS MCS 2012) and reserves (USGS 2011)

Country	2010 Production (kt)	Country	Reserves (kt)
Chile	5,520	Chile	150,000
Peru	1,285	Peru	90,000
China	1,150	Australia	80,000
US	1,120	Mexico	38,000
Australia	900	US	35,000
Indonesia	840	China	30,000
Zambia	770	Indonesia	30,000
Russia	750	Russia	30,000
Canada	480	Poland	26,000
Poland	430	Zambia	20,000
Kazakhstan	400	Kazakhstan	18,000
Mexico	230	Canada	8,000
Other	2,300	Other	80,000
World	16,200	World	630,000

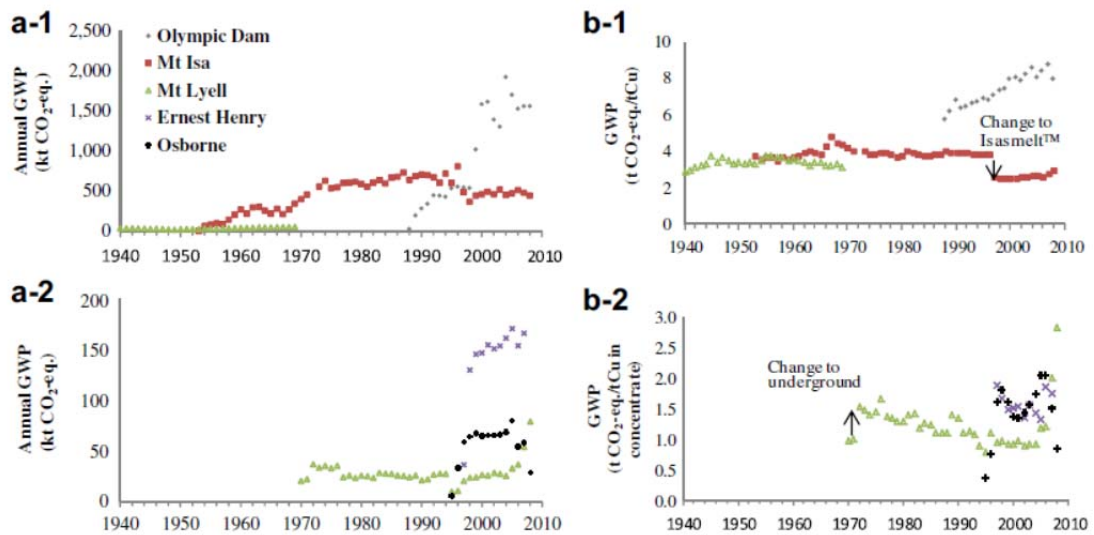
As with the rest of the world, copper ore grades have been in decline across the twentieth century, both as richer deposits have become exhausted and as technology has developed to allow the

profitable exploitation of lower grade ores. Ore grades in Australia now average around 0.7% as per Figure 12.

Figure 12: Copper ore grade over time in select countries (Mudd & Weng, 2012)



As grades have declined, as has occurred at Olympic Dam, environmental impacts have risen, as shown in Figure 13b-1.



Key: a-1: Annual GWP for mines with smelters. a-2: Annual GWP for mines. b-1: GWP per tonne of copper for mines and smelters. b-2: GWP per tonne of copper in concentrate for mines. (Olympic Dam – Mine/Smelter; Mt Isa – Mine/Smelter; Mt Lyell – mine only; Ernest Henry – mine only; Osborne – mine only).

Figure 13: Changes in global warming potential for selected Australian mines (Memary et al., 2012a)

Whilst copper has global recycling rates of >50% (UNEP 2011), there is little current data available in Australia – a study using 2006 data suggests rates of 70% recycling in Australia for copper (van Beers et al, 2007).

Further to the research presented above, additional work was undertaken for copper on modelling the future greenhouse gas emissions of copper mining in Australia (not including smelting) under a range of energy scenarios. The results are presented in Figure 14 showing a significant rise under business as usual conditions (red line) and reductions relative to current emissions – even with increased production – should solar thermal for comminution and plant electricity (blue line) be provided. The final case with lowest emissions (green line) uses solar thermal for plant electricity with biodiesel substituting diesel for vehicles. Another approach (not modelled) would be to electrify mining vehicle fleets and provide the electricity via solar thermal plants. Given the increased energy efficiency of such an approach (i.e. high conversion of the embodied electricity into application), this could present even further opportunities for reducing energy inputs and reducing the environmental footprint of copper production.

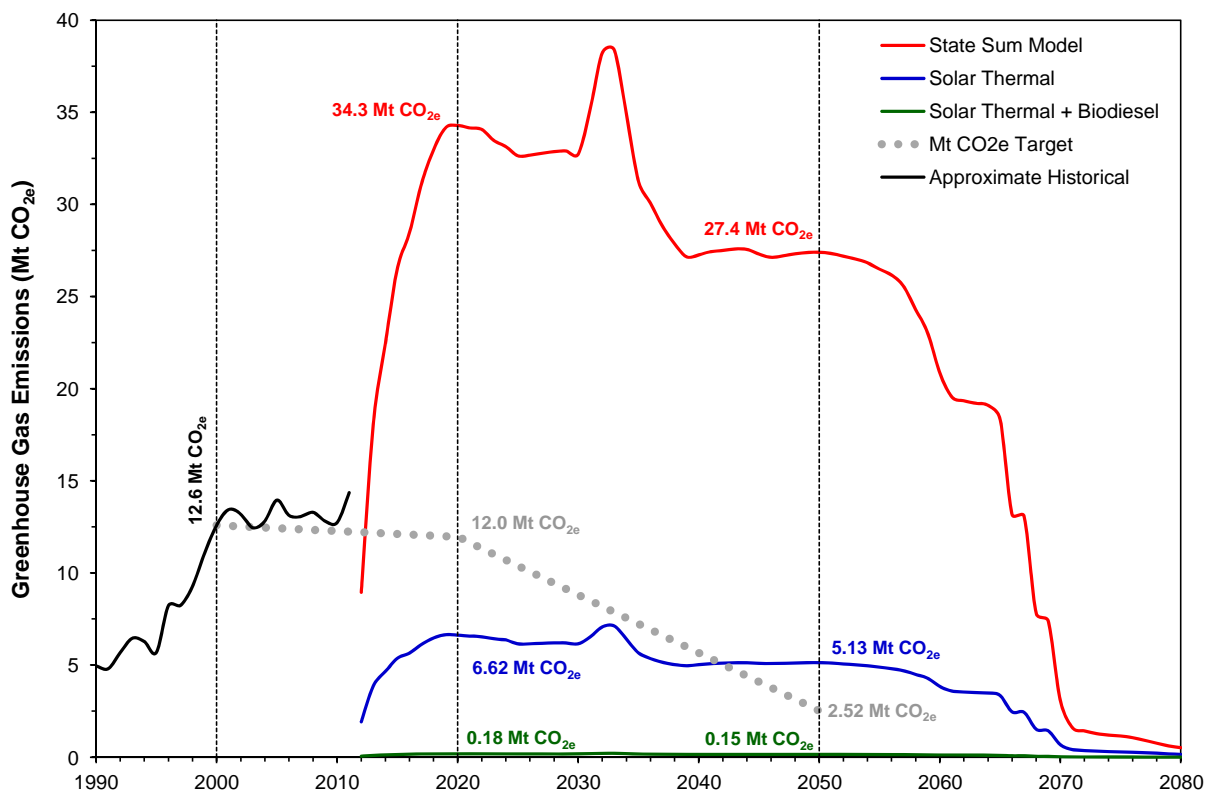
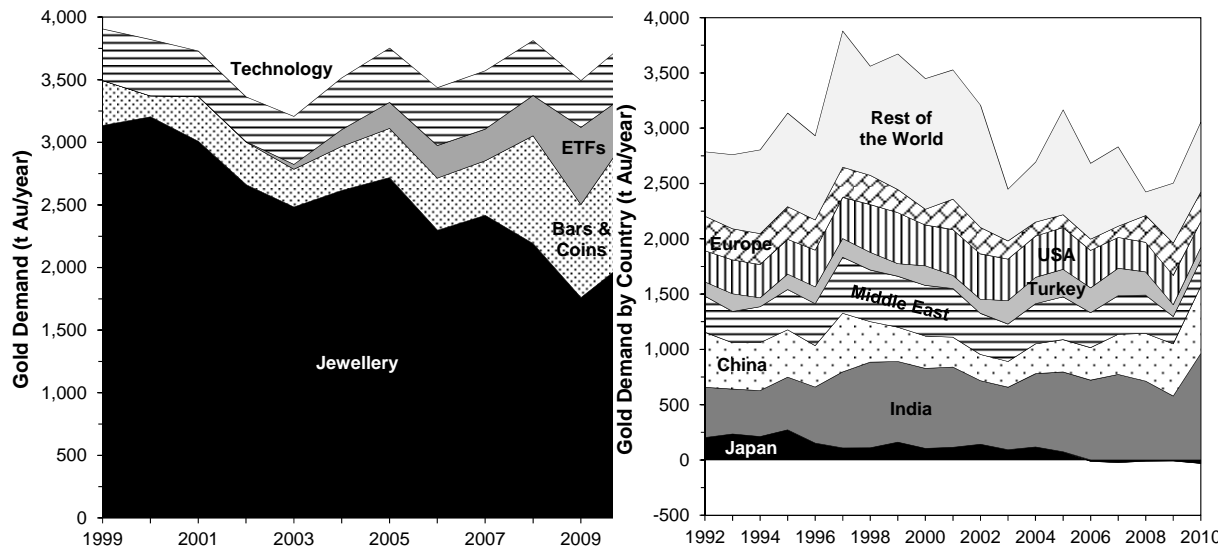


Figure 14: Comparison of estimates of annual greenhouse gas emissions over time for different energy scenarios and potential target levels for the Australian copper sector (N.B. State Sum Model ~ business as usual)

4.2.4 Gold

Historical gold demand is shown in Figure 15 by type and country, showing the dominance of jewellery and the large and rising consumption by India. Consequently, a key opportunity for reducing the environmental impacts associated with gold mining is to reduce the demand for gold itself, or at least for ‘extracted gold’ with the potential for forex reserves security to be provided by in-situ gold.

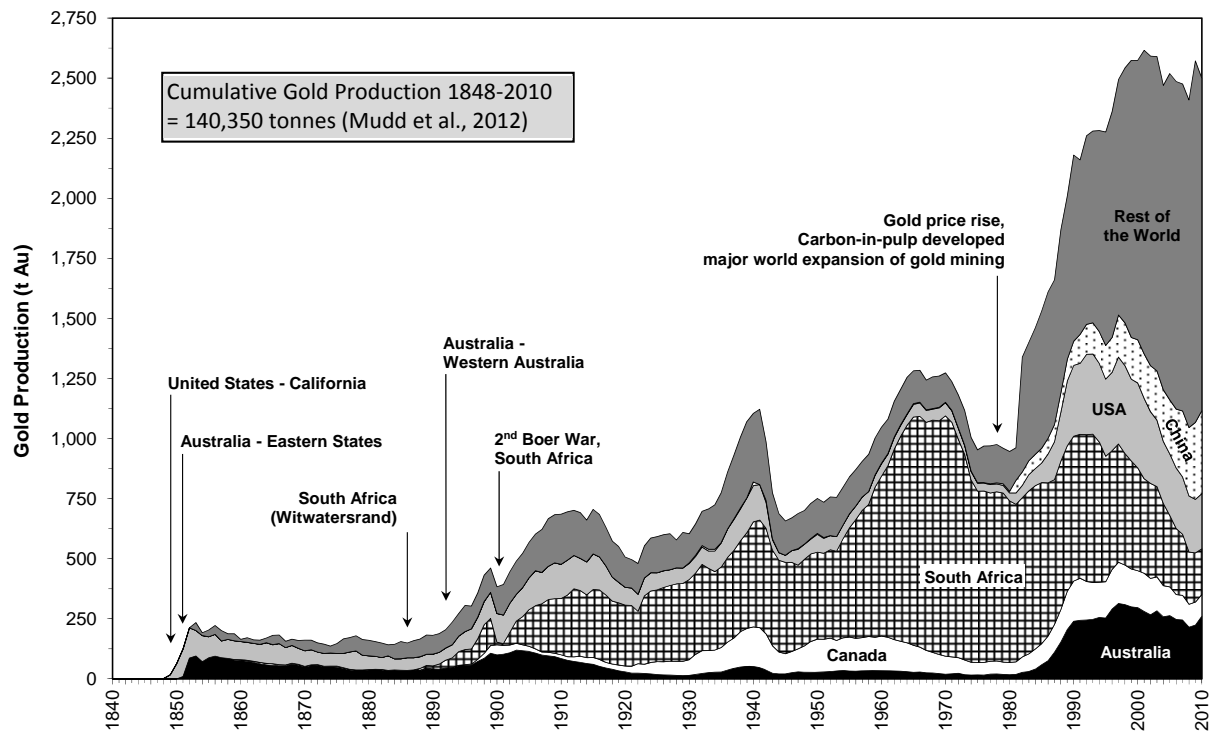
Figure 15: Gold demand by type (left) and country (right) (data from (WGC, var.)



Note: differences are due to World Gold Council data (Mudd et al. 2012).

Historical gold production is shown in Figure 16, showing the declining dominance of South Africa and the rise of Australia and China as producers.

Figure 16: Historical gold production by country (data updated from (Mudd, 2007)



Interestingly, cumulative gold production (i.e. above ground gold stocks of 140,350 t)⁴ are far greater than current estimates of reserve estimates of both the US Geological Survey at 51,000 tonnes (in 2010) and of a bottom up company by company analysis (where companies were reporting more than 300 tonnes) by Mudd et al. (2012) using 2010 data of 85,700 tonnes. The USGS reserve estimates are shown in Table 7.

⁴ One could imagine this as a giant cube of gold with sides approximately 20 m long (based on a density of 19.3 t / m³)

Table 7: USGS 2010 gold reserves by country (t Au) (USGS, var.-a)

Country	Reserves	Country	Reserves
Australia	7,300	China	1,900
South Africa	6,000	Uzbekistan	1,700
Russia	5,000	Mexico	1,400
Chile	3,400	Ghana	1,400
Indonesia	3,000	Papua New Guinea	1,200
USA	3,000	Canada	990
Brazil	2,400	Rest of the World	10,000
Peru	2,000	World	51,000

An important point to note is that the location of below ground stocks is the detail of data which are available, compared with publically available government collected data on above ground stocks. Increasingly, control of above ground stocks will be as valuable as control of below ground stocks (Morrison and Giurco, 2011).

The importance of recycling is highlighted when contrasting the resource quality found in above and below ground stocks (see Figure 33 later in the report) with above ground stocks (e.g. from discarded mobile telephones). Electronic scrap can have concentrations of metals approximately one hundred to one thousand times higher than in ores. For example, considering the case of gold, mobile phone scrap can contain approximately 200g/t compared with 0.2–2g/t for ores. Whilst recycling offers a high resource quality stream, it is still important to ensure the material is recycled safely and efficiently as the informal recycling sector poses significant health and environmental problems in countries such as China and India (Sepúlveda et al., 2010)

4.2.5 Lithium

The final case study focuses on Lithium, a mineral whose demand is growing rapidly from a low base as demand in Li-ion batteries in electronics and battery-electric vehicles grows. Whilst recycling is currently insignificant it is projected to grow, as shown in Figure 17. Furthermore, lithium is an interesting case as there are examples of more vertically integrated supply chains with joint ventures between miners (such as Galaxy) and battery manufacturers (in China). This opens the potential for ‘green / responsible supply chains’ with traceability from mine through battery manufacture to use in electric vehicle or other application and eventually recycling. Furthermore, it opens up the concept of leasing metal (rather than selling) as outlined by Morrison and Giurco (2011) and Kromer and colleagues (2009) for platinum fuel cell vehicles.

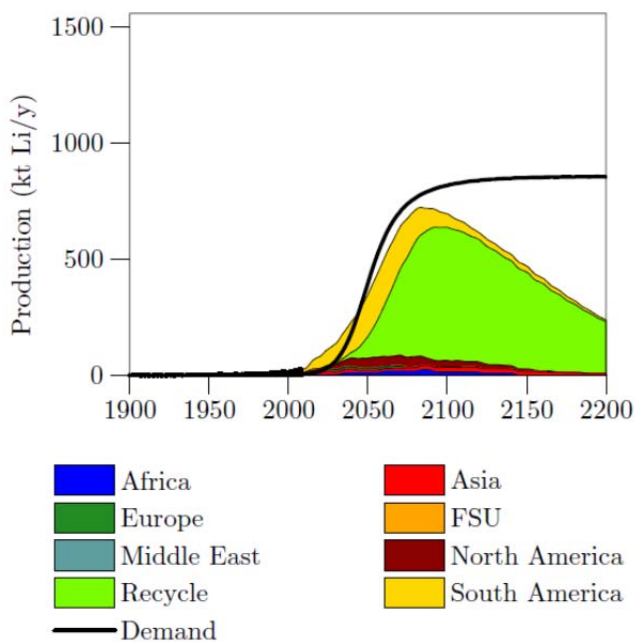


Figure 17: Possible future supply demand projection [Case 2; Mohr et al., 2012]

Australia is currently the second largest lithium producer after Chile, as shown in Figure 18.

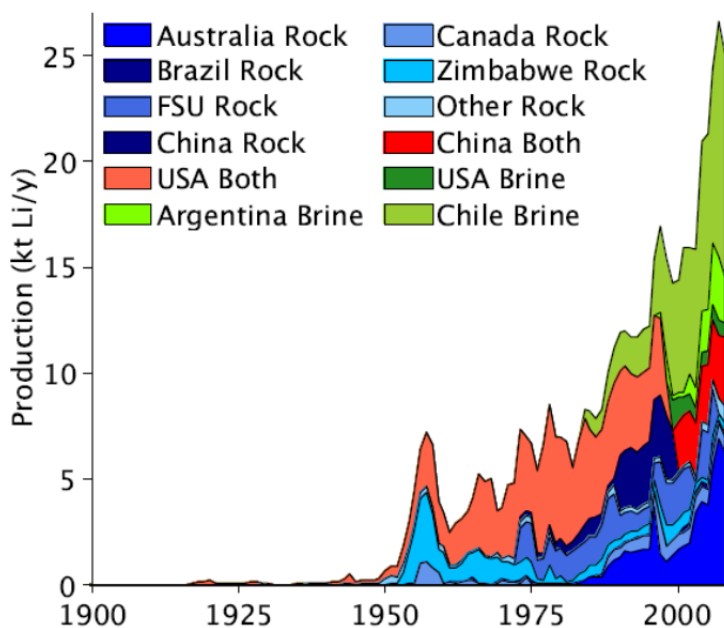


Figure 18: Global lithium production (Mohr et al. 2012 compiled from several other authors)

4.3 Changing impacts of Australian Production

Having reviewed Australian production in the global context, this section explores the changing impacts of Australian production – with respect to social and environmental factors, as well as economic factors.

On the basis of production data, reviewed in Section 5.2, Australia is well placed to take advantage of its remaining resources. However, the rate of discovery of ‘world-class’ deposits, which more readily attract foreign investment, is slowing. Furthermore, when looked at from the perspective of

increasing economic, social and environmental impacts a more complex picture develops, requiring a much more strategic and targeted response.

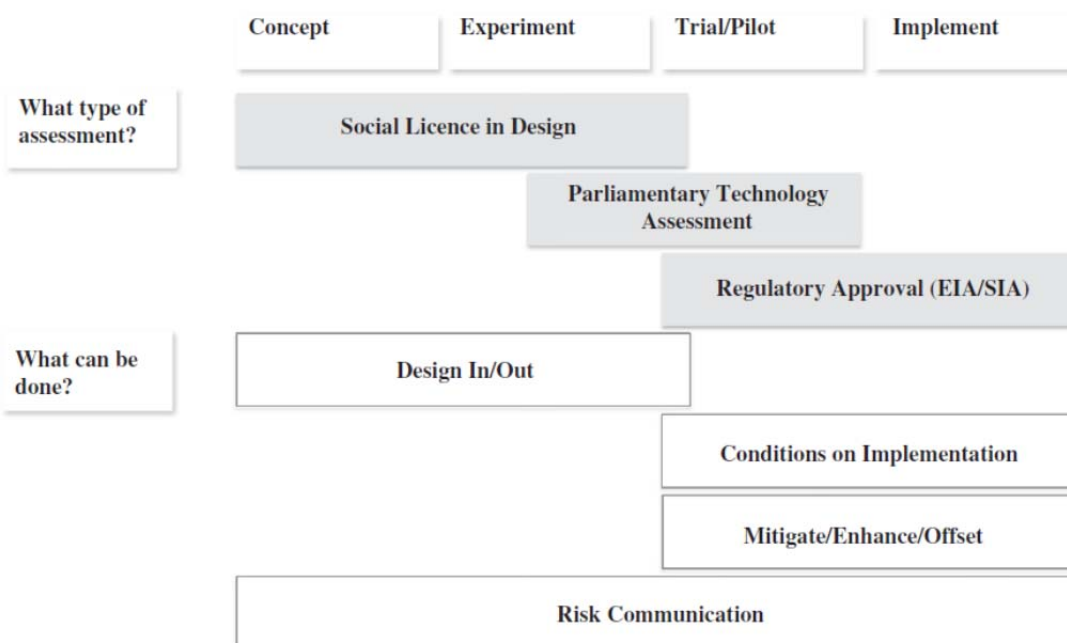
4.3.1 Social impacts and social licence to operate

While energy and water use present economic challenges to mining operators, the fact that these inputs are generally shared with communities mean that social licence to operate is also increasingly affected by energy and water use in mining.

The expansions of operations in areas that have supported other industries or other forms of land use development are the subject of land-use conflicts. For example in Australia’s Hunter Valley, horse breeders, wine growers and coal mining companies have clashed over a range of issues, including a substantial element of concern about the effects of mining on local water sources (Australian Senate 2009). There has also been conflict over coal seam gas exploration and extraction in areas of NSW and QLD, which has resulted in lock-outs by landholders (Townsend 2011), bans on projects that “...would permanently damage cropping land ...” (Roocke & Douglas 2011), moratoriums on fracturing processes (AAP 2011) and recommendations for similar measures from the Australian Senate (2011).

Whilst the Environmental Impact Assessment process aims to ensure ecological sustainable development’ (which encompasses the social domain), the focus of impact assessments are on flora, fauna and the natural environment. People are not given the same focus, as highlighted by Cleary (2012). One step to address this has been the introduction of Social Impact Management Plans in Queensland. However more is needed, including at earlier stages of development involving new technologies. As part of the Technology Futures research theme within the Mineral Futures Collaboration Cluster, a process of ‘social licence in design’ has been developed to integrate social licence considerations into early stages of design as shown in Figure 19.

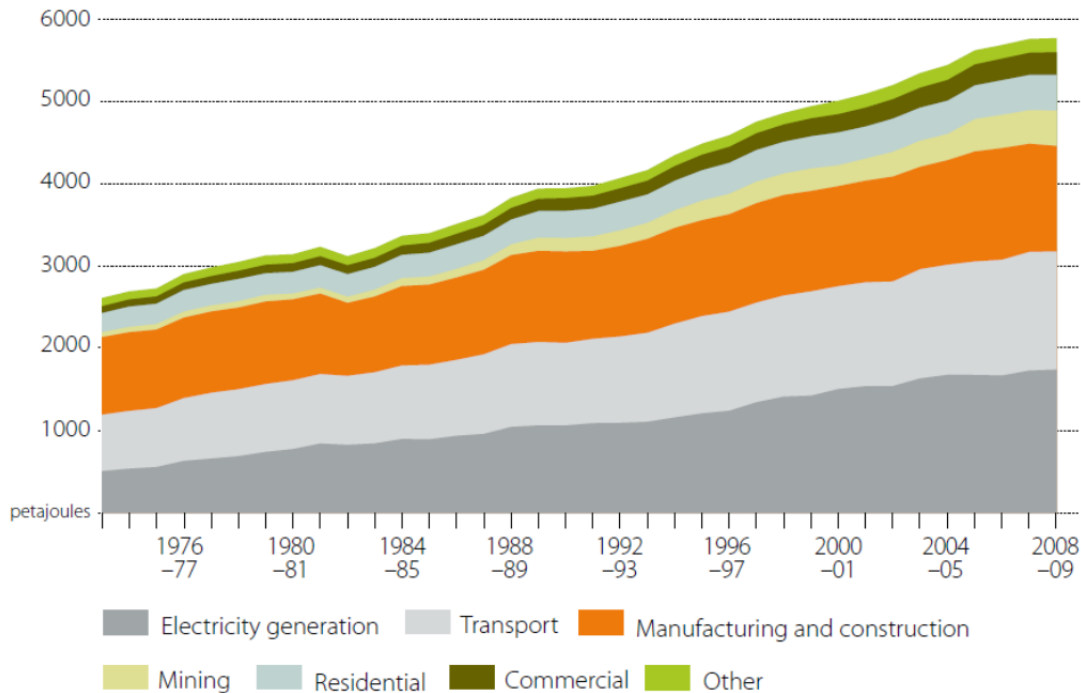
Figure 19: Contrasting Social Licence in Design, Technology Assessment and Regulatory Approval (Franks & Cohen 2012)



4.3.2 Key environmental issues: energy and water

The energy intensity per unit of output has risen by 50% from 1990-2006 (Sandu and Syed, 2008). The energy consumption of mining, compared with other sectors over time, is shown in Table 8. We see that mining is the fastest growing sector, with an average growth of over six per cent over the last five years. .

Table 8: Australian energy consumption by sector (Schultz and Petchy, 2010)



The influence of cheap, available energy, including liquid fuels for transport, must be factored into assessing the future of mineral development in Australia. Lost competitiveness from rising energy costs is also likely to present as reduced availability of low-cost oil to power operations (Foran et al. 2005) and transport mineral products to markets (Moriarty & Honner 2008). In the absence of substantial efforts to address these challenges, competition from other mineral producing countries such as Brazil (which has access to significant hydro power and abundant biofuels - see Bauen 2006), new mineral frontiers which are close to market (e.g. Mongolia, Afghanistan) or still have high grade deposits (e.g. Africa). In addition, there is potential for increasing competition from markets where metals are sourced from lower-energy recycled sources (such as Taiwan) which will, over time, present a challenge to Australian primary production (Giurco et al. 2010).

As outlined by Mason et al. (2011c), off-grid remote mines are particularly vulnerable to oil prices. In these cases diesel is trucked to the mine to run electricity generators. The costs of trucking diesel to be used for electricity production can cost a mine in the order of \$200/MWh, hence there is a strong business case for having some wind generation capacity at remote mines dealing with high electricity costs (Sarder, 2010).

Increasing water use has also been a factor in recent negotiations for new or expanded gold-mining operations. For example at Cadia East the community has expressed concerns over water usage and ongoing water availability for farmers (Markham, 2009). However, conditions for approval of the mine do not pertain explicitly to water management (EPBC 2006/3196).

In NSW, for example, there is an increasing recognition of the need to account for water issues in longer term regional planning such as the Namoi region (Price & Bellis, 2012). A water accounting framework for the minerals industry has also recently been developed (SMI & MCA, 2012).

4.3.3 Economic factors

The changes for Australia, in an evolving global operating environment, were outlined in Chapter 3. Table 9 provides a summary of evaluations of the changing context across key minerals. With respect to the influence of economic conditions, the recent drop in commodity prices has already tested the financial viability of mining projects in South Australia and Western Australia. This has led to the delay of a number of expansions, most notably, that of Olympic Dam.

Table 9: Present estimates, advantage and issues for key Australian minerals

Global position	Nature of Australian 'advantage' (and caveats)	Changes to the terms of production / Economic Impacts	Social Impacts	Environmental Impacts
<p>Iron Ore</p> <p>In 2009, Australia had about 12.5% of the world's reserves of iron ore, and was ranked third after Ukraine (19%) and Russia (16%).</p>	<p>Established operations in Pilbara have lower \$/tonne operating costs than newer operations. Despite extensive resources, rising production rates are consuming higher quality ore. Remaining ores have greater impurities, and newer mines are more remote, leading to a need for new infrastructure (e.g. Oakajee, WA).</p>	<p>Less direct shipping ore, increasing need for comminution and more tailings and waste rock. Increasing water consumption and impacts on catchments; land use conflicts, rising energy intensity (diesel for trucks and electricity for process plants), changes to local workforce through automation and remote tele-operation.</p>	<p>Increased land disturbance and conflicts in areas of high conservation, cultural, or agricultural significance. Fly-in-Fly-Out impacts on host and home communities. Income inequity in communities.</p>	<p>Increased land disturbance, energy use and GHG emissions and water use. Mine remediation issues.</p>
<p>Coal (black)</p> <p>Australia is ranked fifth in terms of black coal reserves behind USA, China, Russia and India. Coal and iron ore exports dominate the mineral resource exports from Australia. The Bowen Basin (Qld) produces over half of the world's coking coal exports.</p>	<p>Australia has extensive coal resources, and is a particularly important global supplier of coking coal. Future use will be affected by pressures to reduce the carbon-intensity of the global economy, carbon taxes, CCS viability, and land use conflict, particularly with farming.</p>	<p>Increasing move from underground to open-cut long wall mining. Vast increase in average size of coal mines from ~1Mt in 1990s to ~3 Mt now. Increasing overburden ration, water consumption and impacts on catchments, land use conflicts, and cumulative impacts from multiple mines on community health.</p>	<p>Conflicts over land use and water (particularly with agriculture) are increasing, e.g. Liverpool plains</p>	<p>Cumulative impacts from dust are affecting communities as well as subsidence, water and greenhouse gas impacts.</p>
<p>Gold</p> <p>Australia remains a major global gold producer, with production of ~261 tonnes in 2010 (ABARE), and ranked second behind China with ~345 tonnes (USGS).</p>	<p>Extensive resources and highly prospective regions for new discoveries and additions to existing deposits or mines.</p>	<p>Increasing tailings and waste rock, increasing water consumption and impacts on catchments, land use conflicts, and highly energy intensive (diesel for trucks and electricity for process plant).</p>	<p>Higher land disturbance and land-use conflicts in areas of high conservation, and cultural and agricultural significance. Conflicts regarding water use and quality have also arisen.</p>	<p>Increased land disturbance, energy use (GHG) and volumes of pollutants, including cyanide and mercury. Legacy mine remediation issues.</p>
<p>Copper</p> <p>Reserves: Australia is third largest (80 Mt) after Chile (150 Mt) and Peru (90 Mt). 2010 Production: Chile dominates (5.5 Mt); Australia (0.9 Mt). Olympic Dam expansion on hold. Globally Mongolia on the rise.</p>	<p>Despite historically high prices for copper, Australia makes more money from export of mining software, than exports of refined copper.</p>	<p>Olympic Dam expansion was to move to a massive open cut operation, with increases in diesel required to move huge quantities of overburden. Grades continue to decline and waste rock rises. Water requirements for copper mining are high.</p>	<p>Concerns over closure of Mt Isa smelting and associated refining. Concern over Olympic Dam expansion – now on hold.</p>	<p>Water use is a significant issue, plus land disturbance, energy use and mine remediation issues.</p>
<p>Lithium</p> <p>Australia has extensive hardrock resources and is second largest producer after Chile. A brief note on scale: global production of lithium is around 27 kt/yr or seventy thousand times less than global iron ore production at nearly two billion tonnes per year.</p>	<p>Comparatively low volumes of hardrock lithium are presently required (mostly as additive in glass and ceramics). Significant shifts to lithium based batteries or other uses, and the development of cost-effective technology for converting lithium from hard rock to carbonate needed for batteries (which is more readily derived from brines), will underpin competitiveness.</p>	<p>Businesses in the lithium supply chain are becoming more vertically integrated across mines – processing – battery production, partly in order to secure supply.</p>	<p>Internationally, social considerations around Li mining are more problematic in Bolivia, where they would be extracted from brines than they are in Australia. Local communities in Australia are still affected.</p>	<p>Demonstrating 'provenance' of source materials will become important within 'ethical' supply chains, as will 'green' consumer items, including electric vehicles.</p>

Source: Commodity case studies for Iron (Yellishetty et al. 2012); Gold (Mudd et al. 2012); Lithium (Mohr et al. 2011); Coal (Mohr et al. 2012); Copper (Memory et al. 2012b).

4.3.4 Summary discussion

An assessment of Australia's mineral resource potential indicates that there are substantial volumes of minerals remaining to be developed. However, the concerns of investors and the increasing unwillingness of companies to develop isolated small deposits cast doubts on the prospect of an expanding boom. Furthermore, existing deposits present their own challenges in terms of changing ore quality and distribution, leading to increasing costs and increasing environmental impact. Rising costs are also creating additional social and economic impacts, which influence the social licence to operate mining operations. The presence of minerals is a necessary but not exclusively sufficient determinant of future mineral development capacity. An assessment of the constraints arising from changing terms of production, are a more telling indicator for future prospects. A more detailed analysis of such indicators is a key element of designing initiatives that ensure that negative impacts do not erode benefits.

Integrating physical data used to assess the availability of mineral resources with information on the economic, social and environmental constraints goes some way to providing the inputs for a more accurate assessment of Australia's mineral future. This also provides a useful set of objectives for targeting innovative technology development and governance. Nonetheless, without additional integration with the wider economy, as a whole, it is possible for Australia to become a victim to negative macroeconomic impacts from heavy reliance on the mining sector for export revenues.

4.4 Australian mineral futures

4.4.1 Peak minerals as a conceptual framing

Building on the earlier sections in this chapter, which explored (i) production and reserves and (ii) changes to economic, social and environmental impacts, this section provides an overall discussion of Australia's mineral futures for the selected commodities. It is based not only on the availability and accessibility of our economically demonstrated resources, but also global demand and a dual consideration of alternatives. Firstly, alternatives for consuming countries to meet demand in new ways that do not purchase Australia commodities, and secondly, opportunities for Australia to leverage value from its resource base in new ways beyond digging and selling low unit-value commodities.

The analysis is framed around the peak minerals metaphor (see also Giurco et al. 2010; 2012). Whilst contemporary discussions relating to peak oil and minerals have proceeded in several directions (see for example Bridge, 2010; Hemmingsen, 2010), they often focus on replicating Hubbert's prediction of a geological "peak" in production. These studies have largely focused on comparing the historical production of various minerals to the 'bell-shape' of Hubbert's ultimate cumulative production curve for oil in the US (Hubbert, 1956). The majority of these studies ignore Hubbert's stated purpose for undertaking this task, namely to provide a plausible basis for exploring the broader economic and social impacts from a permanent decline in domestic fossil fuel production, both in terms of availability of materials and in the case of Australia's economic dependence on the resources sector for export income.

The concept of peak minerals outlined herein takes an explicitly *national perspective* to planning for sustainable resource management. The use of a national perspective is necessary due to the fact

that, unlike China whose nationally-owned mining companies operate internationally, Australia's capacity to benefit from the sale of minerals is limited to its continental territory. In another sense, the concept of peak minerals outlined here and elsewhere (Giurco et al., 2010; Mason et al., 2011b, Giurco et al., 2012, Prior et al, 2012, May et al., 2012; Mudd and Ward 2008), is distinct from Hubbert's work, in that it is concerned with both **geological** and **non-geological** production constraints, such as increasing social, environmental, and economic costs associated with lower-grade primary mineral production.

Figure 20 illustrates the basic principles of the peak minerals metaphor, developed as part of cluster research to illustrate a transition from cheaper and easier to more complex and expensive processing over the life of a resource.

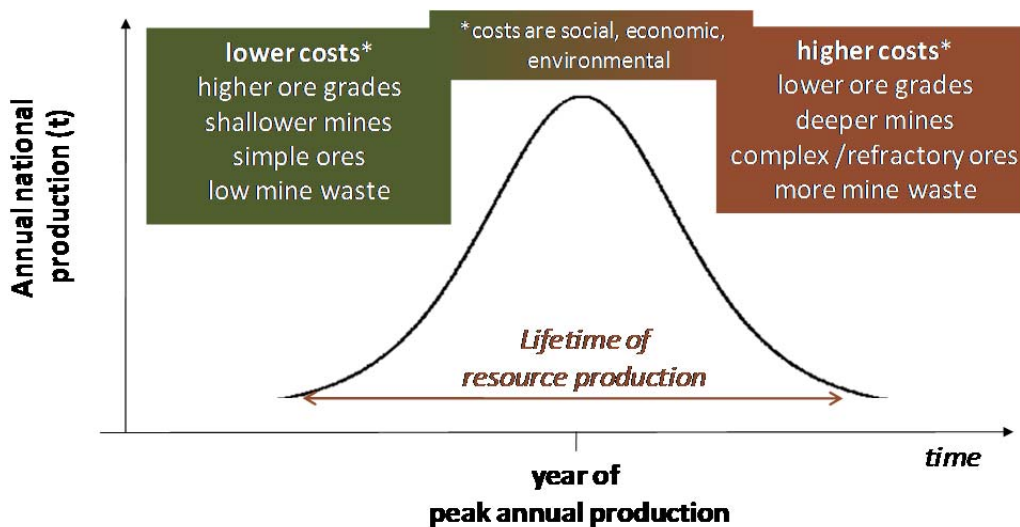


Figure 20: Peak in annual production contrasting 'cheap and easy' vs. 'complex and expensive' (after Giurco et al, 2010)

In an alternative representation Figure 21 illustrates the impacts of social and environmental constraints on resource availability. This more explicitly shows that whilst new technology or more favourable economic conditions (e.g. cheaper operating costs or higher commodity prices) can increase the total volume of economic resource which could be extracted, higher social, environmental and techno-economic pressures can also constrain total available resources (and production).

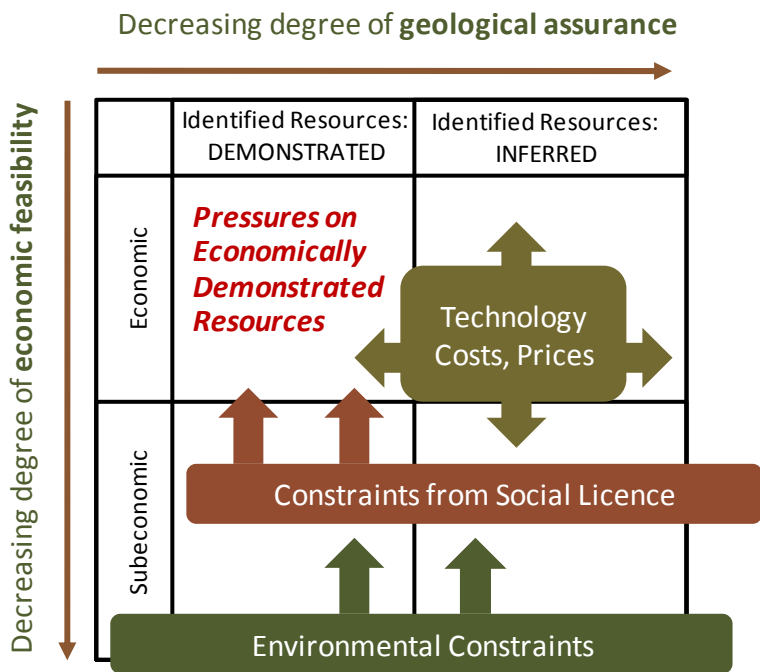


Figure 21: Possible cumulative production over the life of a resource (overlaid on JORC)

Making an accurate assessment of where Australia’s advantage lies in the global mineral market will require producing good data on the status of its identified resources, as well as routine analysis of significant changes. This includes information that is comparatively easy to quantify, such as the quality of ores, the rate at which minerals are being produced, and the financial and economic costs of producing them.

An example of the need for greater clarity and transparency in assessing vulnerability can be seen in the case of Iron ore, which has just overtaken coal as Australia’s largest export earner. In 1993-94, the average price for iron ore and pellets was approximately \$24 per tonne, while a decade later it had reached \$27 per tonne. However, in 2011 the price for this mineral had increased to more than \$180 per tonne. Even at the more moderate prices available in 2004-05, the export value of iron ore and pellets was reported as \$8.12 billion (ABARE 2009, Table 39), while WA government figures for revenues from iron ore indicate that the WA government received just \$380 million (around \$200 per WA resident) during this period. This comes out to around 4.6% of the value of the iron ore minerals taken from WA.

This kind of outcome has raised questions about present economic benefit, the distribution of this benefit, and inspired new approaches to royalties, such as WA’s royalties for regions initiative, and to taxation (i.e., the RSPT and the MRRT). Suggestions, noted in earlier sections, that the revenues from mineral development be hypothecated as a sovereign wealth fund, appear to support concerns that efforts to secure benefits for future generations are also underdeveloped at the present time.

Regular monitoring and analysis of other indicator sets is also needed to support the responsible management of Australia’s remaining mineral endowment. In particular, greater accounting and accountability is being called for in terms of land disturbance, water quality impacts, water use levels, generation of air pollutants, and fossil fuel use. While this is to some extent recognised by government, as illustrated by internationally recognised Guide To Leading Practice Sustainable Development in Mining and associated handbooks produced by the Department of Resources,

Energy and Tourism (DRET 2011), few companies operating in Australia are comprehensively or consistently reporting on indicators related to maintaining it, nor is there any requirement for them to do so.

Not only are these items important for managing mining companies' social licence to operate, they are critical to sustainability within the mining sector. Without this information, Australian decision-makers are significantly less informed than the companies that they negotiate with, putting them at a distinct disadvantage. This reality makes it difficult for decision-makers to identify when the mineral industry is generating more costs than benefits at a particular time, or to compare the performance of the mineral industry with other, perhaps more renewable or longer-term, prospects for economic development.

4.4.2 Assessing vulnerability: availability, dependence and alternatives

Extending the concept of peak minerals, the assessment elaborated below is based on three specific characteristics of production that can be applied at local, regional, national or global scales. The first is the 'availability'⁵ of a resource (geological characteristics, geographical distribution, other constraints on production). The second is society's present dependence⁶ on the resource (its centrality and criticality to economic, social and environmental systems), and the third is the possibility of finding alternatives (whether the resource can be substituted by another metal or non-metal or recovered) and recycled products can be used to meet demand.

Table 10 illustrates connections between availability of selected commodities, Australia's national economic dependence on these commodities, and the possibility that substitutes might be found that replace the services (for both material products and financial dependence on export) and the commodities that are currently provided to society (Mason et al, 2011b). As explained in Giurco et al (2011), "It connects these characteristics of commodities with future opportunities for new technology, policy and market innovations that link the mining and minerals sector in Australia to more sustainable patterns of production, consumption and prosperity". Certainly as part of the Asian Century initiative, there will be an emphasis on selling more services into Asia and mineral services can also be part of this.

⁵ With respect to availability, there are two important clarifications to highlight. First, in mineral economics the availability is construed as the 'availability of mineral supply, which is a function of price, input costs, technology, disruptive events, government and market structures (Maxwell, 2006). This ignores the geology and location of the resource and assumes sufficient reserves are available to be exploited. In this paper, we define availability as available Economic Demonstrated Reserves in a given geographical territory (Lambert et al., 2009), noting that social criteria can also prevent access to developing otherwise available resources, because they can make demonstrated reserves uneconomic.

⁶ Referred to as addiction in Mason et al. 2011b

Table 10: Assessing mineral futures for selected commodities in Australia (summary amended from Giurco et al, 2011)

	Availability	Dependence	Alternatives	Issue for Australia	Potential Innovation
Iron/Steel	<ul style="list-style-type: none"> Australia and Brazil are dominant iron exporters Australia production increasing, decades of availability, but impurities are increasing Australia peak estimate = 2040 	<ul style="list-style-type: none"> Transport distances to market are an increasing factor in costs of supplying market Uses are rising and long lasting in structures 	<ul style="list-style-type: none"> Recycling is active but can be increased (for example, in China) What role may timber play in future structures? 	<ul style="list-style-type: none"> How can we ensure metals and monies from iron ore exports underpin long-term benefit in iron-mining regions of Australia (Pilbara) and nationally? 	<ul style="list-style-type: none"> Use Sovereign Wealth Fund to drive innovation within and beyond mining Steel Stewardship Forum
Coal	<ul style="list-style-type: none"> Worldwide, coal will peak before gas Australia: availability will be constrained not only from physical scarcity, but also farm land conflict; peak estimate = 2060 	<ul style="list-style-type: none"> Uses link heavily with other sectors: electricity, steel, cement Future use will be affected by carbon taxes and CCS viability 	<ul style="list-style-type: none"> For electricity: energy efficiency and cleaner energy are alternatives As a reductant (e.g. steel making), biomass has potential 	<ul style="list-style-type: none"> Australia derives over 50% of export revenues from mining; Coal and Iron ore exports dominate Coal also dominates Australia's electricity mix 	<ul style="list-style-type: none"> Alternative scenarios for coal regions (Giurco et al, 2011) Clean energy future Mineral carbonation as sequestration option
Gold	<ul style="list-style-type: none"> Volatile: Historical peaks in Australia affected by (i) ore discoveries; (ii) technology (CIP); and (iii) policy / gold standard World stocks above ground (122,000 t) greater than below ground (100,000 t) 	<ul style="list-style-type: none"> Uses are predominantly jewellery then bullion Getting 2g of gold for a wedding ring requires 10t of ore (at 0.2g/t) versus 10kg of mobile phone scrap at 200g/t Au 	<ul style="list-style-type: none"> Are there other ways to provide the societal value or services derived from gold jewellery and bullion? 	<ul style="list-style-type: none"> Australia is number 2 global producer of gold, what underpins future competitiveness? – "Brand Australia Gold", i.e. being a supplier of gold with good environmental / social credentials (cf. Responsible Jewellery Council) 	<ul style="list-style-type: none"> Extend gold options for 'yet to be mined gold' Link production to renewable energy to export 'green gold'
Copper	<ul style="list-style-type: none"> Cu Sulfides dominate; Cu oxides unprofitable Expansion of Olympic Dam mine dominates Peak estimate = 2030 	<ul style="list-style-type: none"> Use intensity correlates with GCP Uses are diverse (wires, pipes, electronics) 	<ul style="list-style-type: none"> Electricity: Aluminium can substituted Pipes: Plastic substitutes Recycling an important alternative to mining 	<ul style="list-style-type: none"> Australia makes more money from export of mining software than export of refined copper 	<ul style="list-style-type: none"> Copper Sovereign Wealth Fund In-situ mining Leasing of metal
Lithium	<ul style="list-style-type: none"> Australia largest hard rock supplier of Li Near term availability not constrained by geological factors 	<ul style="list-style-type: none"> Small but growing market in batteries – demand depends on uptake of electric vehicles and alternative battery technologies not using lithium 	<ul style="list-style-type: none"> Alternatives to dig and sell business model...Is there a useful role for a product-service system leasing lithium across mines; battery suppliers and electric vehicles? 	<ul style="list-style-type: none"> Developing cost-effective technology for converting lithium from hard rock to carbonate (more readily derived from brines) for use in batteries will underpin competitiveness 	<ul style="list-style-type: none"> Leasing / Product Service Systems Brand Australia Lithium and joint ventures with Battery Manufacturers

As can be seen in this cross comparison, there are a number of common threads in the economic impacts that are likely to be felt from a peak in production in key mineral commodities. For commodities such as coal and iron ore, the implications that arise from the assessment of dependence raise questions about capacity to address the potential loss of export income, loss of capacity to purchase goods from a global market (with inflationary impacts), and indirect impacts for other sectors whose materials and levels of service presently rely on such imports (i.e. the housing and construction sectors).

The mineral commodities examined here illustrate the range of different circumstances that are presently associated with developing them. Each also occupies different positions within the global and national economy, making changes to the terms of production or trading context an important part of any assessment of their capacity to provide benefit. While production and exploration data suggest that resources in Australia could meet some part of existing projections for growth, the mere presence of minerals does not guarantee that they will be developed. For this reason, a detailed assessment of the future of Australian mineral commodities will require data on a wider range of indicators, including negative economic, social and environmental impacts, and technological constraints. This will be required to further support the delivery of added value products from Australian minerals identified in the innovation column of Table 10. Ongoing comparison of Australian data with information about the terms of production in other countries is also required to ensure that shifts in comparative advantage are able to inform long-term strategies for economic development.

The next section explores the possibilities for addressing these challenges through technological and process innovation that improves social and environmental performance within the mineral development industry, and takes advantage of Australia's greatest resource – the ingenuity of its people.

SUMMARY OF CHAPTER FOUR

Different minerals, at different times, have different capacities to support economic development in Australia. Careful management of the resources, and close attention to the impacts of developing them, are required if Australians are to benefit from this activity in the present and in the future.

Economic, social, environmental and technological constraints on production are becoming more challenging. On top of this continued increases in production, combined with falling resource quality, is creating greater technological, environmental and social impact.

Successfully resolving the challenges outlined here will be more or less difficult depending on the extent to which the combination of economic, social and environmental factors are understood and incorporated into the framing of problems and solutions.

Assessing the present benefit and longer-term vulnerability of mineral development in Australia is also important for taking a pro-active approach to long-term planning for a transition to other sources of economic development. With improved data collection across a range of different indicators, it will be possible to begin understanding what our options might be, and to plan for a transition to a more diverse and sustainable economic base.

5 VISION 2040: INNOVATION IN MINING AND MINERALS TO ADVANTAGE AUSTRALIA

CHAPTER FIVE OUTLINE

Thriving in a changing global market facing costlier local production requires a long term vision and innovation. Vision 2040 acknowledges the significance of changes to the terms of production in Australia and to the global trading environment. It embraces the opportunity presented by these circumstances i.e., to invest effort and support in other areas where Australians can achieve, or are already achieving, world-leading status.

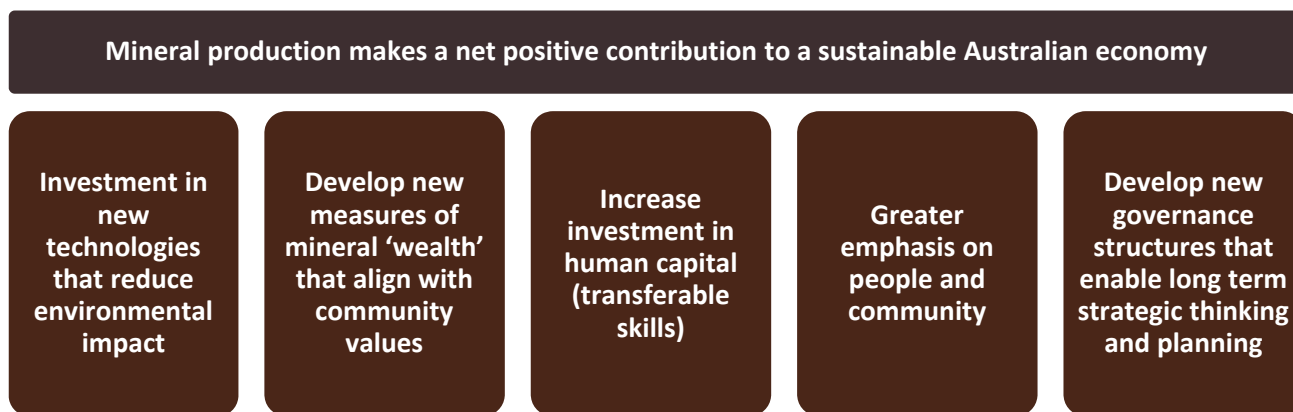
Rising to the challenge will depend on greater strategic commitment to innovation. Overcoming contested views regarding the benefits and impacts of developing Australia's mineral endowment, have informed proposals for innovation that create 'step changes' in environmental and social performance of mining and mineral development.

Vision 2040 provides a strong platform for a national conversation about minerals and their role in ensuring long term benefit for present and future generations. Greater consensus about the long-term objectives and benefits of mineral development will assist in creating a system of responsible mineral resource governance. A shared vision for a sustainable mineral development strategy will increase trust between a wide range of stakeholders and assist decision-makers to make strategic decisions toward long-term benefit. This will provide greater certainty for industry stakeholders.

Meeting the challenges of a changing international context, and changing terms of mining and mineral production, will require Australian citizens, governments and industry to acknowledge the breadth of the 'resources' that can make contributions towards securing benefit for Australia's longer-term future. Foremost amongst these resources is the ingenuity of its people, who have provided the world with some of the most revolutionary techniques and technologies. *Vision 2040: Innovation in Mining and Minerals* (Mason et al, 2011a) outlines a vision for Australia's mineral future to advantage Australia in the Asian century. It resulted from a research process incorporating three stakeholder workshops, an online survey, and targeted interviews to facilitate a national discussion focused on three critical questions: (a) What models of sustainable resource management are relevant for Australia and how can this be implemented?; (b) Will Australia's platform for prosperity be tied to the minerals sector, and what role will mining and minerals processing play?; and (c) What can be done to ensure current and future mining activity leads to long-term national benefit?

Participants in the third Vision 2040 workshop were also asked: How can we deliver benefit now, tomorrow and in thirty years' time? Answers to these questions were resolved into an initial vision statement, with five associated areas for strategic development, and a range of initiatives to achieve these objectives. Figure 22 (overleaf) outlines the initial vision statement and the strategies that were identified as important areas for further development.

Figure 22: Initial vision statement and strategies for development developed at Vision 2040 Workshop

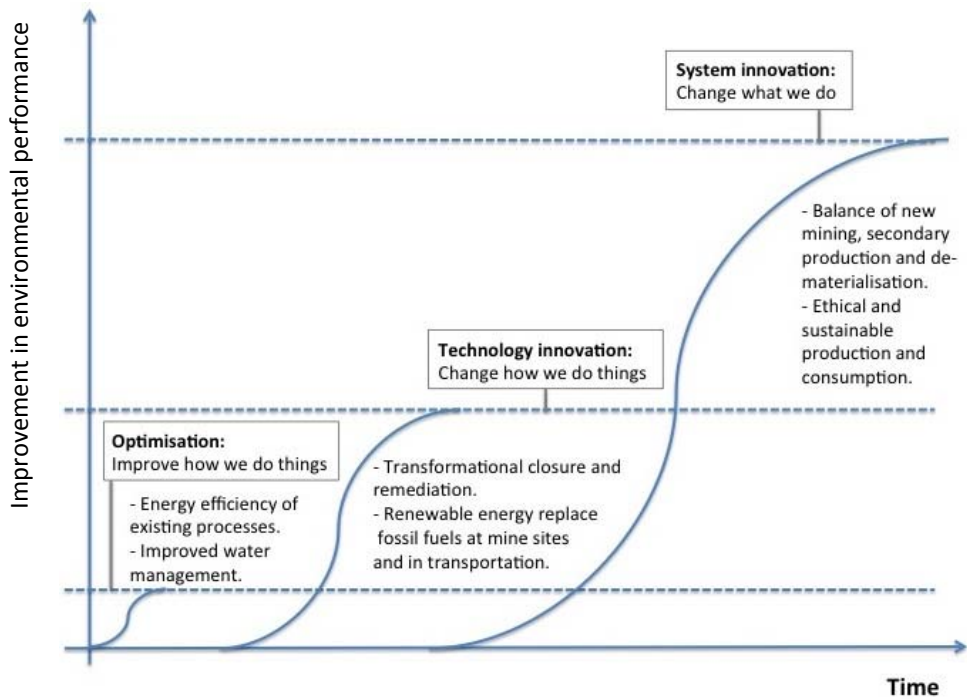


Using these initiatives as the focus for future innovation in technology, business models and governance, a consultation paper *Vision 2040: Mining, minerals and innovation – starting a national conversation about sustainable mineral production* (Mason et al. 2011d) was developed. Following stakeholder feedback, the final document was prepared *Vision 2040: Mining, minerals and innovation – a vision for Australia’s mineral future* (Mason et al. 2011a). It proposed three key areas where there are opportunities to ensure that Australia can meet the challenge of changes to global markets and local terms of production. Firstly, a more comprehensive approach to innovation that meets the goals of different stakeholders through ‘step changes’ in environmental and social performance of mining and mineral development using transformational technologies. Secondly, Vision 2040 also looks beyond conventional views of mineral development (mining), existing business models with a focus on increasingly responsible supply chains. Thirdly, a National Minerals Strategy to support governance to assist in positioning Australia to achieve the goal of a net positive benefit from developing Australia’s mineral endowment (more detail is provided in Section 6). Sovereign wealth funds were also proposed to support innovation beyond mining.

5.1 Delivering benefit today: harnessing more of Australia’s resources

Figure 23 and Figure 24 illustrate how specifying innovation at different levels – improving how we do things, changing how we do things, and changing what we do – can deliver significantly different outcomes. Figure 23 shows an approach to innovation in the environmental performance of mining and mineral production. This approach makes a virtue of the fact that Australian metals are increasingly being produced at higher costs, but under leading practice standards that avoid the inequalities and questionable practices that may underpin the competitive position of mining operations elsewhere.

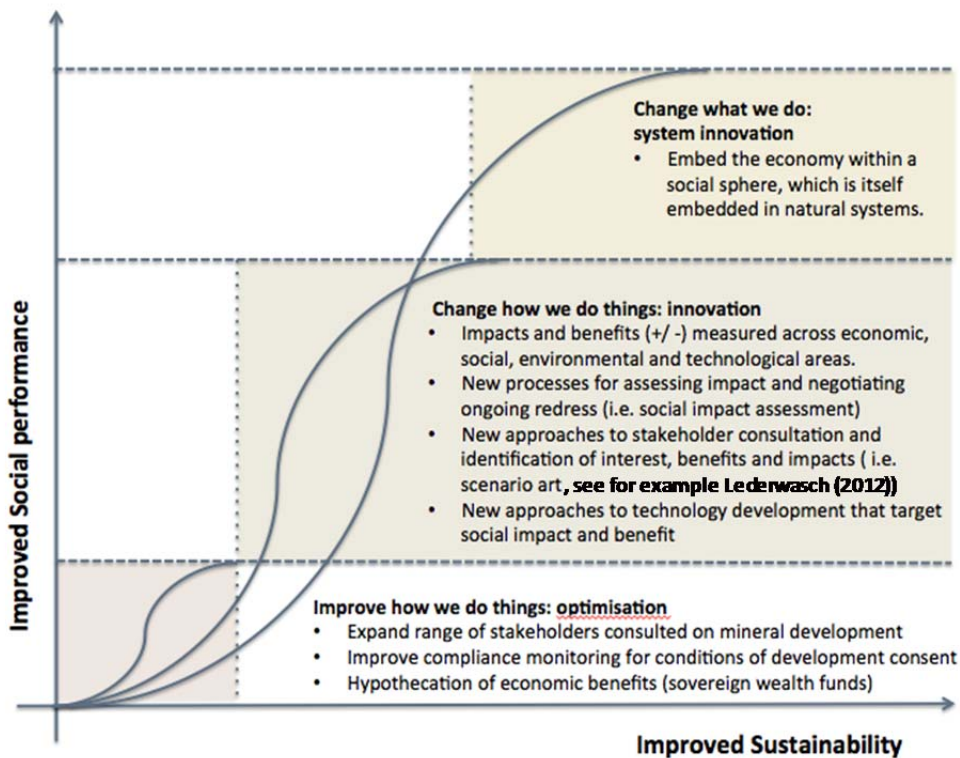
Figure 23: Three levels of innovation to improve environmental performance (after Brezet, 1997)



Source: Vision 2040, Figure 3: potential for different levels of innovation in the mining industry, and the impacts this may have on environmental performance.

Figure 24 builds upon this idea, but applies it within the context of improving the **social performance** of mineral development in Australia in order to achieve progress against social aspects of sustainability.

Figure 24: Three levels of innovation to improve social performance (after Brezet 1997)



As shown in Figure 23 and Figure 24, more extensive approaches to innovation can present opportunities for creating change that address sources of conflict over the impacts of conventional

mining and mineral development. Examples of the opportunities that might come from taking this approach have been outlined below in terms of their key focus, and the timeframes in which they might be expected to deliver benefit.

5.2 Delivering benefit tomorrow: greater emphasis on environmental and social sustainability

Opportunities identified in Vision 2040 for delivering more benefit in the near future have focused upon developing ‘high profile *Brand Australia*’ metals for an increasingly environmentally and socially focused consumer market. If we think differently about ‘value’ and how it might be added, there are several opportunities available.

5.2.1 Delivering low carbon metals by linking to renewable energy

Some stakeholders suggested that a good way forward would be to support policy that fast tracks research, development and use of clean production technology. Manufacturers are now also thinking more about how they can create high products whilst minimising water and energy use, social disruption and environmental degradation. In practice, this could mean increasing the development of renewable energy use connected to mining operations, but it could also mean mining Australian rare earths and supporting local manufacturing of magnets for wind turbines to provide clean energy. Deploying clean energy in Australia would also allow Australia to produce ‘green minerals’ for use in high-value products and goods certified as environmentally and socially responsible, strengthening the long-term attractiveness of Australia for mining, while exporting ‘green’ magnets would provide export dollars.

Figure 25: Potential pathways for Australian sunshine to add value to Australian minerals

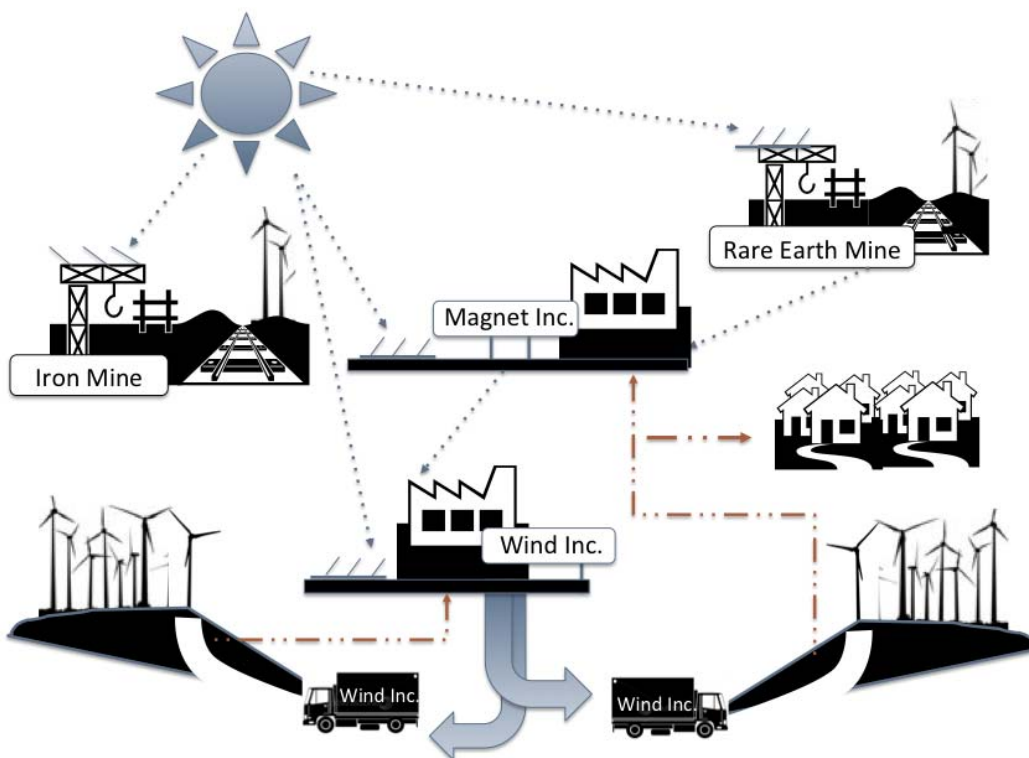


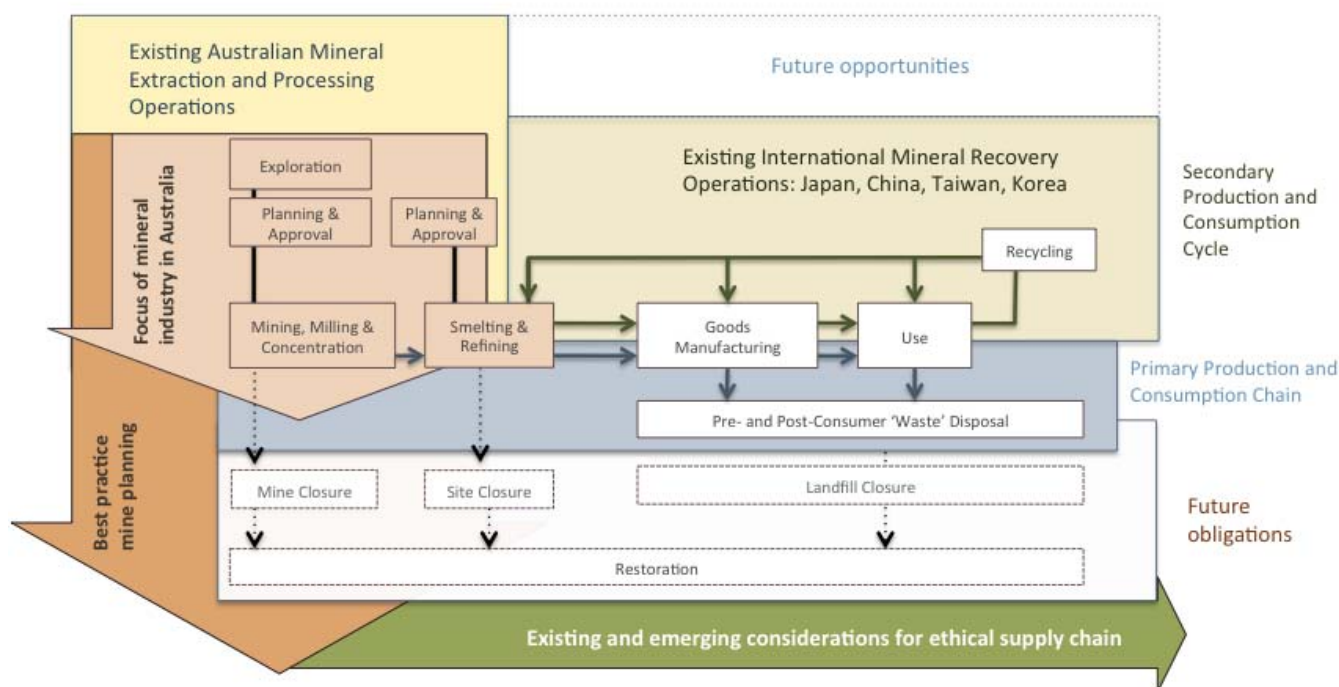
Figure 24 (above) illustrates a mineral development cycle that makes use of solar power to reduce the contribution of fossil fuels and green house gases to mineral production, creating an increasingly ethical base for renewable energy infrastructure.

5.2.2 Developing environmentally ethical metals turns future obligations into business opportunities

Key stakeholders have suggested that Australia’s current position, as a ‘big voice in mining’ internationally, is an opportunity to set the standards and the pace for developing transformational technology. Vision 2040 also outlines a future in which obligations become opportunities, by developing expertise and best practice in transformational mine remediation. To date, the primary focus in Australia has been on mining and the stages preceding mining (exploration and planning), with less attention historically going to planning for closure and remediation. Encouragingly this is changing and the Australasian Institute of Mining and Metallurgy which represents over 11,000 professionals working in the industry held its first Life-of-Mine conference this year with a focus on maximising rehabilitation outcomes (see also Box 2).

Some measure of the conflict raised by mining in Australia may be resolved through a greater commitment to whole-of-life-cycle planning, and collaborative development of transformational practices and technologies for mine closure and restoration (the full extent of the tan arrow in Figure 25). Figure 26 shows opportunities for best practice responsible mine management in the arrow going down the page on the left in orange - extending from exploration, through construction, mining, mine closure, and restoration.

Figure 26: Outline of future opportunities and obligations in the context of existing mineral development and trade considerations.



However, Figure 26 also illustrates another potential area for development, by joining a growing industry trend in secondary production. An example of technologies that could very quickly impact upon Australia’s exports of some bulk commodities are those that facilitate greater reuse of locally-sourced, post-consumer, mineral resources. The example that Japan is providing by designing their products for disassembly and reuse in successive production cycles pave the way for more efficient reuse as well as establishing national indicators for a Sound Material-Cycle Society (Hashimoto et al.

2008). Although minerals can be used and reused (given sufficient energy to collect and re-process), current rates are far from theoretical maxima. However, an increasing number of countries are investing in processes and technologies that will make this a reality for a range of metals.

A key theme of a shared vision may be how Australia will source materials or goods, and derive income, as more countries take advantage of technologies that create goods without significant cost to the environment or society. Vision 2040 has identified both a challenge and a range of opportunities that are evolving from reusing mineral resources in more than one production cycle. For Australia to be in a position to leverage value from scrap metal and cities as mines of the future (as Europe and Asia are doing), some funding from the current boom should be directed toward investing in future technology and infrastructure needed to realise profits from above ground stocks.

Another example of how technologies for disassembly and recycling could change future trade in primary metals comes from advanced manufacturing techniques that use 3D printers to create objects from a range of different materials.

Box 3. Additive manufacturing—shaping the future

(Reproduced from CSIRO Fact Sheet)

A rapid low-cost, low-waste manufacturing technology

Additive manufacturing is a revolutionary low-waste manufacturing technology which uses a source of energy such as a laser or electron beam to build up products layer by layer from powder, ribbon or wire.

CSIRO is supporting growth of the fledgling Australian industry in additive manufacturing using technologies such as electron beam melting and selective laser melting. In comparison with traditional “subtractive” manufacturing methods in which a block of finished material is machined down to make a product, additive manufacturing methods are fast, use less energy, and generate less waste material.

The Flagship seeks to build on CSIRO’s world class polymer science, as well as “getting more from Australian ore” via a manufacturing industry for high value-added titanium products, capable of increasing Australian export earnings by a factor of 100 in comparison with unprocessed ore.

Additive manufacturing offers a number of benefits to Australian industry:

1. Maximising the potential from Australian natural resources, increasing Australian exports of high value-added items – Ore to More
2. Resource efficiency – making more from less, lowering the environmental footprint
3. Embracing new enabling technologies and innovation to keep Australian industry competitive
4. Global competitiveness – mass customisation, countering low cost imports, growing exports
5. Growing productivity and efficiencies – wealth creation, energy efficiency, less waste, less material input
6. Building the Australian requirement for high-skilled “green collar” manufacturing jobs in design and production.

For more information see

<http://www.csiro.au/en/Organisation-Structure/Flagships/Future-Manufacturing-Flagship/Ti-Technologies/Arcam.aspx#1>



While additive manufacturing technologies have primarily been used for quick, high quality but low-volume, production of prototypes, three-dimensional printers are becoming cheaper and finding their way into homes. For example, a model designed for domestic use went on exhibition this year at the world's largest technology expo, the Consumer Electronics Show in Las Vegas, can be purchased for less than \$2000 and used to replicate a range of game pieces, toy parts and other small ABS plastic or biopolymer objects using templates downloaded from the internet (Borrowman, 2012).

Figure 27: MakerBot Industries Replicator



Figures 26 (left) and 27 (below) demonstrates what is possible with commercially available 3D printers, opening up the future possibility of new business models for selling cartridges of 'brand Australia: responsible minerals' which are used and then recycled. This functionality may be the foundation of a truly information-based economy in which companies sell template files that can be used to create their products anywhere that the materials and equipment are available.

Figure 28: Silver rings made in Sydney, Australia, using a 3D printer (Museum of Small Things, 2011)



Proposals for more complex 'printers' that will use cartridges filled with a range of different materials, that can be laid down in very thin layers to create new composite products, are likely to support smaller scale manufacturing systems, and may also create favourable conditions for locally-based material recovery and reuse.

5.3 Delivering benefit in 2040: responsible mineral resource management and transition planning

The issues paper developed to engage stakeholders and assist with making submissions to the Australia in the Asian Century white paper identifies the need to expand areas of comparative advantage, 'adapt and innovate', and also notes that this will "...require a change in mindset as well as building new skills and capabilities "(Commonwealth of Australia 2011). Submissions to this ongoing process have pointed to the need for looking ahead to the post-boom economy and the industry sectors that will be called upon to fill the hole in the balance of trade. Submissions from Tourism, Education and Training, and financial services sector have argued that this task cannot be successfully undertaken without strategic management of the existing impacts from mining (investment pit, labour market distortion, high value currency) and the development needs of sectors that will be important to the post-boom transition.

Box 4. Steel Stewardship Forum: responsible steel (Reproduced from Steel Stewardship Website)

The Steel Stewardship Forum (SSF) is a body formed to develop steel stewardship in Australia across the entire steel supply chain and for this to be a template to be presented by Australia at the APEC Mining Ministers Forum as a 'best practice' model for the region.



The concept of the Forum is to bring together all major sectors of the steel product life cycle – from mining through to steel manufacturing, processing, product fabrication, use and re-use, and recycling – in the shared responsibility of working together to optimise the steel product life cycle using sustainability principles including minimising the impact on society and the environment. The SSF believe that collectively we can continue to add value to and improve the performance of the steel industry across the whole product life cycle – thereby reducing negative commercial, social and environmental impacts.

The Steel Stewardship Forum is seeking to develop a credible and independently verifiable steel certification scheme, to be known as Responsible Steel, that seeks to minimise impact and improve performance throughout the steel value chain, recognised by the industry and external stakeholders.

For more information see <http://steelstewardship.com>

The challenges that have been identified in this report, present a good case for developing specific strategies to maintain the value and/or extend the lifespan of existing mineral resources, so that they can deliver benefit to both present and future generations. The opportunities identified in Vision 2040 will require us to expand our existing view of our resources, and examine the support and guidance available to Australian innovators, both in the mineral development sector, and in the sectors that will be important post-boom.

Although Australians are extremely inventive, companies in other countries have brought many of the technologies developed to the world market. Several stakeholders have indicated that existing structures and programs of funding for developing useful technologies remain insufficient (Peak

Minerals National Forum July 2010; WEF Future Scenarios Workshop September 2010; Vision 2040 Workshop November 2010; Australian Academy of Science 2009⁷; Australia-China Business Council 2012). This section has outlined several areas where Australian ingenuity could be applied to the task of leading the world in environmentally and socially sustainable mineral production. Could Australia also benefit from the proactive approaches towards sustainable technological and economic development taken by other resource rich countries? These, and other issues relating to innovation, long-term benefit, and responsible mineral resource governance, will be explored in greater depth in the following section of this paper.

SUMMARY OF CHAPTER FIVE

While mineral resources are presently an important input to the national economy, there is little agreement about the benefit that this is creating for the Australian community as a whole. Stakeholders have suggested that a shared vision for a sustainable mineral development strategy would be useful for providing guidance about where innovation in mineral development should be focused, building trust between the national community and decision-makers, as well as providing more clarity and certainty for industry and investors.

Vision 2040 outlines a range of opportunities to create a future in which mineral production makes a net positive contribution to a sustainable Australian economy/society. It is intended to support a broad-reaching national conversation about how Australia can use its mineral endowment strategically, and ensure that short-term economic benefits for some do not outweigh the negative impacts for others in the present or in future generations.

A shared vision, such as that outlined in Vision 2040, is seen as a necessary foundation for a national strategy, to deliver measurable and meaningful long-term benefit. A national strategy would assist in monitoring and evaluating benefits and impacts at regional and national scales, and also play a significant role in helping Australia to avoid the negative economic, environmental and social impacts that are associated with a dependence on minerals for economic development.

⁷ Submitted to public consultation process on the 'Australia in the Asian Century' issues paper.

6 RESOURCE GOVERNANCE FOR LONG TERM BENEFIT

CHAPTER SIX OUTLINE

Australia does not have an explicit policy or strategy for maximising benefit from minerals. Despite the substantial dependence of Australian governments on revenues from mineral development, and the current importance of Australian minerals in supplying the global market, key challenges identified by government, industry and research organisations have not received coordinated attention since the early 1990s, despite the narrowly focussed RSPT and MMRT tax discussions. Accordingly, government bodies and agencies are currently poorly placed to monitor progress in addressing these challenges, or scrutinise the long-term sustainability of the mineral industry in Australia.

Some resource rich countries are making successful transitions to renewable economic development. This has been achieved through a range of different mechanisms, but in each case, there has been commitment to transition planning and innovation at several levels – technological, organisational and institutional. Australia is well placed to observe and learn from a range of international examples of responsible resource management approaches that have been successfully implemented elsewhere.

Vision 2040 provides a basis for the development of a long-term national strategy based on a broadly shared vision and objectives, and reliable data. Conflicting views about the benefits and impacts of mining and mineral processing, and resulting loss of social licence to operate, cannot be resolved while consistent data on the economic, social and environmental impacts of mining remain lacking – **a National Mineral Account would address this gap.**

A National Mineral Strategy, and the consultation processes that support the development of a national approach, fits well with a wide range of existing international, national and state-based governance objectives. A National Mineral Account, as support for this process, would be a useful starting point for a national conversation around objectives, key indicators for benefit and negative impacts, and innovation that creates a positive legacy and long-term benefit from developing Australia’s mineral endowment.

6.1 Governance transitions to underpin enduring benefit

Previous sections have provided arguments for changing the current approach to planning the sustainable development of Australia’s mineral resources. At present, Australia does not have an explicit policy or national strategy for maximising benefit from a large range of minerals over the long-term.

In 1974, T.M. Fitzgerald wrote report to the Minister for Minerals and Energy (R.F.X. Connor MP) entitled “The Contribution of The Mineral Industry to Australian Welfare”. Following the boom of the late 1960s and early 1970s it showed that whilst State governments received royalties, the Australian government’s net take from the minerals industry from 1967/8 to 1972/3 was negative. It had spent more on assistance and services than it received in tax revenues. Nearly forty years ago, it wrote

“Australia’s natural endowments in minerals are the envy of most countries in the world. The apparently overwhelming justification for that envy is all around us, not only in great new physical operations but in the very large values quoted for mineral production and export

which go on rising from year to year.....developments are taken as tangible evidence of national success, with more success to come.

A definition of national success, however, is not often attempted...the question is seldom asked....it should not be taken as a matter of course that the opinions of these groups [associated with mining activities] encompass the national interest or are invariably consistent with that interest in matters concerning the exploitation of natural resources. In this context, the national interest is to be equated with the welfare of the people..." [p.2-3].

As then, in this report we argue for more focus on defining national success – in the Asian Century and the strategic role which minerals can play in achieving it.

In subsequent years the following reports have been prepared which encompass a national perspective yet the most comprehensive from 1991 is now more than twenty years old and a changing global context as well as increasing recognition of cumulative environmental and social impacts merits further attention:

- 1991 Mining and Minerals Processing in Australia (Industry Commission)
- 1999 Black Coal Industry Inquiry (Industry Commission)
- 2008 Productivity in the Mining Industry: Measurement and Interpretation (by Topp et al).

At an economy-wide level, a National Strategy for Ecologically Sustainable Development was developed in 1992 (COAG – covering mining and other sectors), but momentum for implementation has waned. Then in 2000-1 a useful parliamentary research paper was prepared on *Sustainable Development and the Australian Minerals Sector* (Hancock, 2001) which explored comparative advantage for a sustainable minerals sector in Australia and the need for consistent indicators and monitoring.

"Australia's realisation of its great comparative advantage for minerals production has led to a high level of dependency on exporting minerals and basic mineral products and is arguably suffering from the as yet mild symptoms of Dutch Disease or the Resource Curse... Unlike resource poor countries, necessity has not been there to be the mother of invention to drive the development of added value industries in 'the lucky country'. Added value manufacturing and services for export have not been significantly developed. Even in the minerals sector there is very little high-value production of inputs and downstream products compared with other economically developed countries with significant minerals sectors, as is the case in Canada, Sweden and Finland. The economy and society is at risk when nominal or real commodity prices fall, as they have done progressively for most minerals, and other export industries are still unable to compensate. This is not a reason to allow the sector to decline, but a reason to foster it as a part of sustainable development by using it as a foundation for developing mineral sector related added value manufacturing and services, such as has occurred in Finland."

While some economic and environmental challenges raised in this report are acknowledged in more recent documents, such as the *Leading Practice Sustainable Development Handbooks* (RET, 2011a) and Chapters 3,6,7,8 of the *Energy White Paper* (RET, 2011b), the absence of a specific national policy for non-energy minerals is problematic, given the substantial contribution of commodities such as iron ore and gold to export income. The initiation of a *National Exploration Strategy* (SCER,

2012) in 2012 by the Standing Council on Energy and Resources is a welcome beginning, but with a sole focus on exploration, remains too narrow in scope.

Governance concerns have also been raised by international economic organisations such as the *Organisation for Economic Co-operation and Development (OECD)* and the *International Monetary Fund (IMF)*, in relation to the implications of Australia's existing approach to managing the proceeds of its mineral endowment. Both organisations have commented on the role of the mining sector within Australia's economic development trajectory; expressing that some form of savings initiative should be undertaken to reduce the impacts of "revenue volatility" (OECD, 2010 p9) and "long-term fiscal vulnerabilities", to "ensure a more equal distribution of its benefits across generations" (IMF, 2011, p22).

These concerns, added to the public conflicts about the costs, benefits and impacts of mining and mineral development (across social, economic and environmental indicators), support calls for a more strategic national conversation about how minerals are developed in Australia. Stakeholder consultations undertaken as part of the *Vision 2040* process have suggested that a coherent national strategy is required to generate shared objectives across stakeholder groups, and to give a greater organisational focus to collecting and analysing data on production levels and impacts (WEF 2010). A shared strategy would also enable coordinated, and thus more efficient, strategy implementation (and consequently vision realisation).

6.2 Principles for responsible mineral resource management

Consultations with stakeholders indicated that while there may currently be little agreement about the nature and extent of benefits (particularly where there are also substantial negative impacts), there does appear to be considerable agreement about what Australia should be trying to *avoid* in the future.

For example, objectives identified in the research include ensuring that Australia avoids 'Dutch Disease' progressing to the 'Resource Curse', and does not become an example of unsustainable development.

Expressed positively, these objectives suggest that responsible mineral resource management be viewed within the wider economy, rather than as a competitor to other industry sectors, with specific focus on ensuring that:

- Other areas of economic development are not unduly limited by activity in mining and mineral development, and that all sectors of Australian industry continue to explore and innovate; and
- Mining development provides transparent, measurable support for present and future generations - *mining development does not limit the opportunities* available to present and future generations through a failure to ensure that:
 - existing wealth (natural and other capitals) is equitably distributed, and
 - the value derived from development is not lost to short term decision-making.

Although a number of stakeholders indicated that there was confusion about how ‘sustainability’ may be practically applied in mining, there are substantial efforts associated with increasing levels of transparency in corporate reporting against social, environmental and economic indicators, including the Global Reporting Initiative (GRI), which has mining specific components. The United Nations Global Compact (UNGC) and the OECD Sustainable Materials Management framework also provide guidance in this area. These objectives fit broadly within the principles outlined by Bleischwitz et al. (2012) and their correlation is shown in Table 11, with examples of exemplar countries implementing innovative strategies and comments on the current position of Australia.

Table 11: Convergence of OECD objectives for resource efficiency and principles for responsible mineral resource management

OECD objective and strategies of Sustainable Mineral Management (SMM) (2011)	Principles for Responsible Mineral Resource Management*
<p>Principle 1 - Preserve natural capital</p> <p>SMM can contribute to the preservation of natural capital, on which humans depend, and which is needed to foster long-term sustainability. Strategies for SMM Policy Principle 1 include:</p> <ul style="list-style-type: none"> • Improving information about materials, their flows and environmental impacts; • Increasing resource productivity and resource efficiency; • Reducing material throughput, particularly of high impact materials; • Increasing reuse/recycling of materials to preserve natural capital; and • Advancing technologies for obtaining materials from natural resources that eliminate waste and toxics and support long-term ecosystem health (Eco- innovation). 	<ol style="list-style-type: none"> 1. Secure, adequate supply and efficient use of materials, energy, and land resources as a reliable biophysical basis for creation of wealth and well-being in societies and for future generations. 2. Maintain life-supporting functions and services of ecosystems. 7. Radical scaling-up of resource productivity (total material productivity), at least at a rate higher than GDP growth, and go beyond GDP.
<p>Country examples: Japan, Korea, Taiwan (see section 6.3). Australia: beginning to give some attention to reducing material throughput via the National Waste Policy.</p> <p>Principle 2 - Design and manage materials, products and processes for safety and sustainability from a life cycle perspective</p> <p>“... maximising positive (and minimising negative) impacts to the environment and human health and well-being through design. ... increased cooperation between actors across the life-cycle, so that all actors are aware of the impacts of their actions and decisions on other phases of the life-cycle, and can act accordingly. Three overarching material, product and process design strategies support SMM. Specifically: detoxification, dematerialisation, and design for value recovery.</p>	<ol style="list-style-type: none"> 6. Minimize problem-shifting between environmental media, types of resources, economic sectors, regions and generations.
<p>Country examples: Japan, Korea (see section 6.3). Australia: Does not specify environmental performance for domestic or imported goods.</p> <p>Principle 3 - Use the full suite of policy instruments to stimulate and reinforce sustainable economic, environmental and social outcomes</p> <p>To shift societies toward more sustainable materials management, governments can leverage a variety of policies and policy instruments including: regulations; economic incentives and disincentives; trade and innovation policies; information sharing; and, partnerships.</p>	<ol style="list-style-type: none"> 3. Provide for the basic institutions of societies and their co-existence with nature while maintaining the resilience of local communities and economic sustainability of resource extraction in producer countries. 4. Minimize risks for security and economic turmoil due to dependence on resources. Respect for Human Rights of peoples living in mining areas. Benefits from extraction should accrue fairly to both current and future generations.
<p>Country examples: Japan, Korea, Taiwan, China, Chile, Norway, Finland (see section 6.3). Australia: Can draw upon the National Strategy for Ecologically Sustainable Development but does not currently have an active policy process that directly addresses resource dependence or its economic, social and environmental impacts.</p>	
<p>Principle 4 - Engage all parts of society to take active, responsibility for achieving sustainable outcomes</p> <p>SMM outcomes can be improved by systematic cultivation of:</p> <ul style="list-style-type: none"> • Multilateral stakeholder engagement, responsibility and collaboration; • Open information flows; and • An ethical perspective. <p>Country examples: Japan, Taiwan (see more detail below). Australia: Is beginning to explore extender producer responsibility in key areas, and the focus given to waste as a resource by the National Waste Policy is positive.</p>	<ol style="list-style-type: none"> 5. Contribute to a globally fair distribution of resource use and adequate burden-sharing at the international, national, and local levels. 7. Radical scaling-up of resource productivity (total material productivity), at least at a rate higher than GDP growth, and go beyond GDP.

*Adapted from Bleischwitz et al. 2012 and aligned relative to OECD objectives with original numbering maintained

As can be seen in Table 11, the collection and analysis of comprehensive data is critical to developing coherent approaches to managing the economic, social and environmental benefits and impacts from resource development and use.

As reported by several countries in the SMM survey (e.g. Finland, Japan, Netherlands, Sweden), an effective way to achieve SMM is to audit or monitor progress with regard to resource productivity and sustainable use of resources/materials on the basis of indicators and quantitative objectives or targets. Japan also has national resource efficiency indicators. At present, the larger mining companies operating in Australia are reporting regularly under the GRI, although this is generally reported at the corporate rather than site level, making regional impacts harder to identify – although the National Pollutant Inventory helps with respect to emissions.

Table 12 shows the companies that are registering public accounts of their performance under the GRI indicator set with the Global Reporting Initiatives Sustainability Disclosure database.

Table 12: Comparison of sustainability reporting by companies mining in Australia (2002-2011)

Company	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002
Bendigo Mining (now Unity mining)		x								
BHPBilliton	x	x	x	x	x	x	x	x	x	x
Emeco Holdings Ltd	x									
Fortescue Metals Group Pty Ltd		x								
Illawarra Coal (part of BHP Billiton)			x	x						
Kingsgate				x	x	x	x	x		
Lihir Gold Limited (now Newcrest)				x	x					
Newcrest Mining	x	x	x							x
OZ Minerals	x	x	x	x	x	x				
Panoramic Resources			x							
Rio Tinto Iron Ore				x						
Xstrata Copper North Queensland	x	x	x							
Xstrata Australia			x	x	x	x	x			
Xstrata Coal	x	x	x	x						
Xstrata Mt Isa Mines		x	x							
Xstrata Zinc Australia	x	x	x							
Anglo Coal					x					

Source: GRI Sustainability Disclosure Database

Table 13, is taken from the recent case study of potential for a peak in production of iron ore in Australia (Yellishetty et al 2012), and shows the extent to which iron ore producers are already reporting on key aspects of sustainable mining⁸.

⁸ Defined in the most recent update of the Department of Resources, Energy And Tourism's Leading Practice Handbook

Table 13: Example of how key sustainability indicators are being reported upon by iron ore miners.

Company	Ore			Waste	Energy		CO ₂ Emissions		Water		SO ₂	NO _x
	Raw	Saleable	Grade	Rock	Direct	Indirect	Direct	Indirect	Amount	Source		
BHP Billiton	-	✓	-	-	-	-	-	-	-	-	-	-
Rio Tinto (Hamersley)	-	✓	-	-	✓	✓	✓	-	✓	✓	-	-
Fortescue Metals	✓	✓	-	✓	✓	-	✓	-	-	-	-	-
Cliffs	-	-	-	-	-	-	-	-	-	-	-	-
Mt Gibson	✓	✓	-	✓	-	-	-	-	-	-	-	-
OneSteel (now Arrium)	-	✓	-	-	✓	✓	✓	-	✓	✓	-	-
Grange Resources	✓	✓	✓	-	-	-	-	-	-	-	-	-

Note: tick (✓) means data is reported. Source (updated from Yellishetty et al 2012)

This table provides a useful view of the information that mining companies could be providing to assist in understanding the current performance, and potential for future improvement, of the mining sector. From this example, it would be possible to inform a discussion of the status of Australian iron ore production (raw ore), sales (saleable ore) and potential for future sales (where 'grade' can be used to compare the economic value of the ore to that produced in other countries). However, the information available regarding the amount of waste rock being removed to provide access to saleable ores is not widely reported. This absence of data makes it difficult to assess the impact of higher or simply more volatile, fuel prices on the viability of the iron ore trade. Similarly, the absence of data on Sulphur Dioxide emissions in company sustainability reports is an impediment to a discussion of how these operations contribute to air quality issues. The information is generally available through the National Pollutant Inventory (www.npi.gov.au) however summaries of this data could be better utilised to inform policy making as part of a National Mineral Account.

An example of a 'site' based assessment is provided by OZ Minerals Prominent Hill operation. This operation utilizes the GRI indicator set to report on the environmental performance of the company. Table 14 compares the performance over three years, with 2010 being the first year of full production.

Table 14: Comparison of Prominent Hill copper-gold-silver mine environmental performance data (2009-2011)

Indicator	2009 *	2010*	2011*
Significant (level 4) environmental incidents ¹	1	0	0
Significant (level 3) environmental incidents ¹	2	1 [#]	0
Regulatory reportable environmental incident	1	1 [#]	0 +
Spills or discharge	40	1 [#] +	
Energy use (petajoules)	2.06	2.54	3.05
Total greenhouse gas emissions (t CO ₂ –e)	236,000	297,995	331,983
Water input (megalitres)	5253	4954.2	6,020
Water recycled (megalitres)	^	^	416
Waste rock mined (tonnes)	35,000,000	53,353,057	59,947,816
Tailings produced (tonnes)	6,500,000	9316,872	9,687,594
Hazardous waste generated (tonnes)	234	403	620
Land disturbance (hectares)	1908	3607	50 +
Land rehabilitation (hectares)	1	4	10

¹ Characterised as Level 3 and 4 significant incidents are internally classified as those that cause or have the potential to cause moderate to major environmental impact within OZ Minerals' operational control. ^ Not currently measurable *Energy use, greenhouse gases data includes head offices in Australia and Asia. # Same incident + Changed reporting criteria apply to this indicator in previous years report. Data sources: OZ Minerals 2011, 2010 and 2009

The data shown in Box 4 (above), provides an illustration of the trajectory outlined in the 'peak minerals' model outlined in section 4, and this interpretation of the data is also supported by comment in the 2011 sustainability report, that "...increased productivity and ore hardness" generated "expected increases" in "energy and water use, as well as increased emissions and waste"(OZ Minerals, 2012).

6.3 Developing a National Mineral Account

A National Mineral Account is needed to provide a comprehensive representation of activities and impacts across economic, social and environmental indicators. It is important that the data be available at a regional level which can then be brought together to form a national view. Two things are required (i) a systematic aggregation of data which is currently collected (ii) the regular collection of data where it does not currently exist, in particular with respect to social and environmental parameters.

An illustration of the fragmented state of the currently available data is shown in Figure 29, for example, social impact management plans and environmental impact assessments are administered by different departments. Indeed social impact management plans (or similar) are not required universally across states so national data is not even available. With respect to abandoned mines, data on rehabilitated sites is given in NSW (by number of sites) and in Tasmania (by percentage), but this too is not comprehensive nationally, nor is there consistency on what counts as 'rehabilitated'. Mining companies are required to report on the emission of many pollutants through the National Pollutant Inventory, however much of this data no longer appears in annual sustainability reports of companies as it once did for some sites.

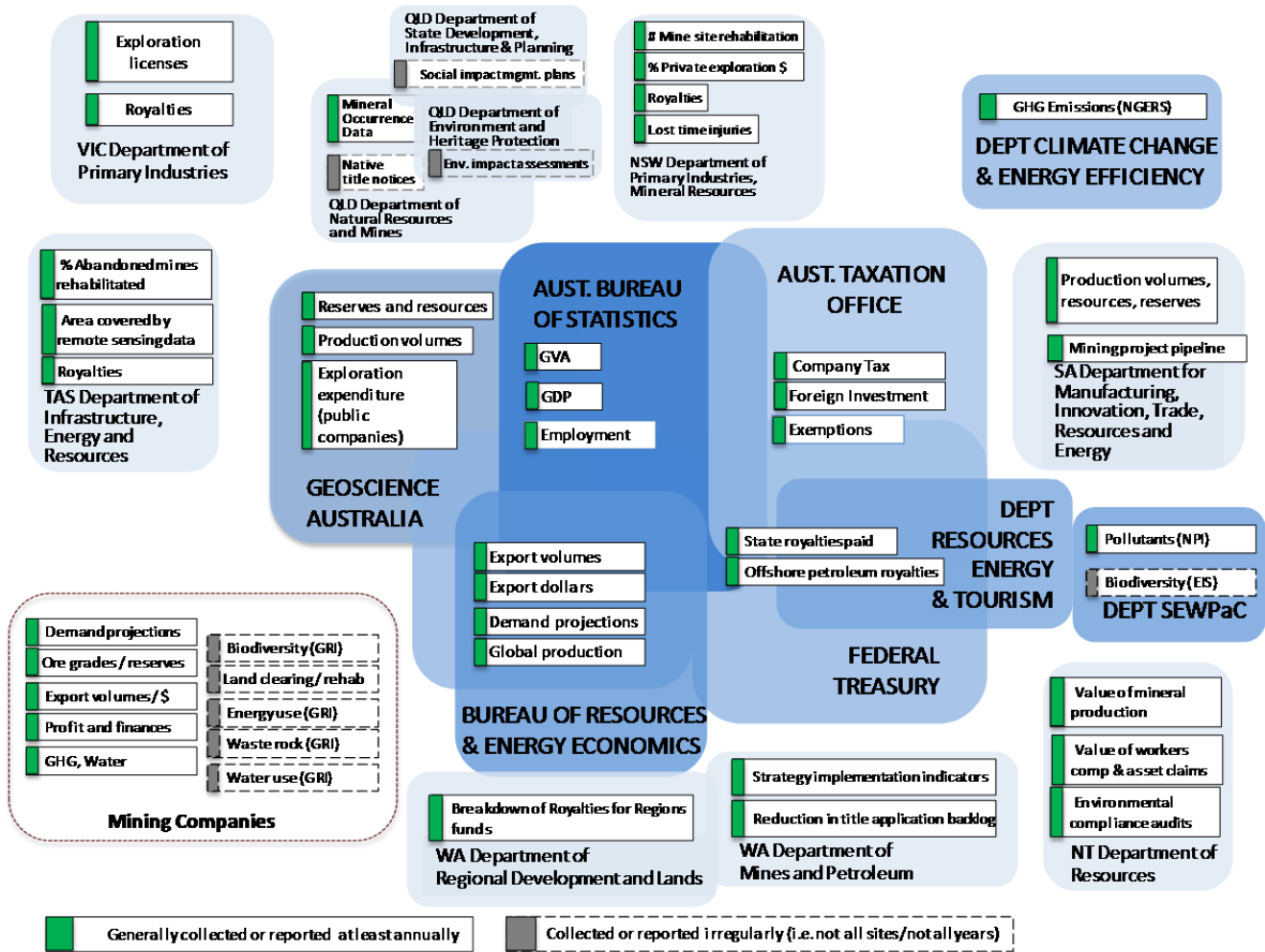


Figure 29: Illustrative selection of data currently collected for mining and minerals activities in Australia

In addition, reporting periods for indicators are often unaligned, making effective comparison difficult. Whilst the research herein recommends that further analysis and consultation be undertaken to establish the indicator set for a National Mineral Account. An initial version of an account 4608.0 was developed in 1996 by the ABS (1996) which focussed on environmental (but not social) dimensions.

“The Mineral Account for Australia is one of a series of ABS publications reporting on estimates of Australia's naturally occurring resources, in quantity terms. It presents a set of accounts for Australia's mineral and petroleum resources. These accounts form a major component of a broader project being undertaken by the ABS, that of environmental accounts.

Environmental accounts are important for a number of reasons. They can track the use of materials through the economy (as presented in the Mineral Account). They can also describe the release of wastes or pollutants resulting from the economic activity using the resources. Work is in progress to track this flow in the form of a waste and residuals account and will be published when available. The resulting information system of environmental accounts linked to economic accounts can be used to derive indicators, which are used to address a wide range of policy questions relating to sustainable development.” [page v.]

A much richer and more strategic discussion, of how and where benefits and impacts were being felt by a range of stakeholders, could be supported by this type of data, particularly if it were provided by all mining and mineral processing operations within Australia. Some additional data will also be

collected and reported as part of the Extractive Industries Transparency Initiative being piloted in Australia. Examples of a full reports (e.g. by Timor Leste, Norway are available here <http://eiti.org/document/eitireports>)

Figure 30 shows a selected illustration of potential indicators for use in a National Mineral Account. Further possible indicators are given in Hancock (2001). Those with a red sidebar are not currently collected regularly. The aim of the structure is to ensure that stocks and flows of the minerals as well as economic, environmental and social impacts are captured.

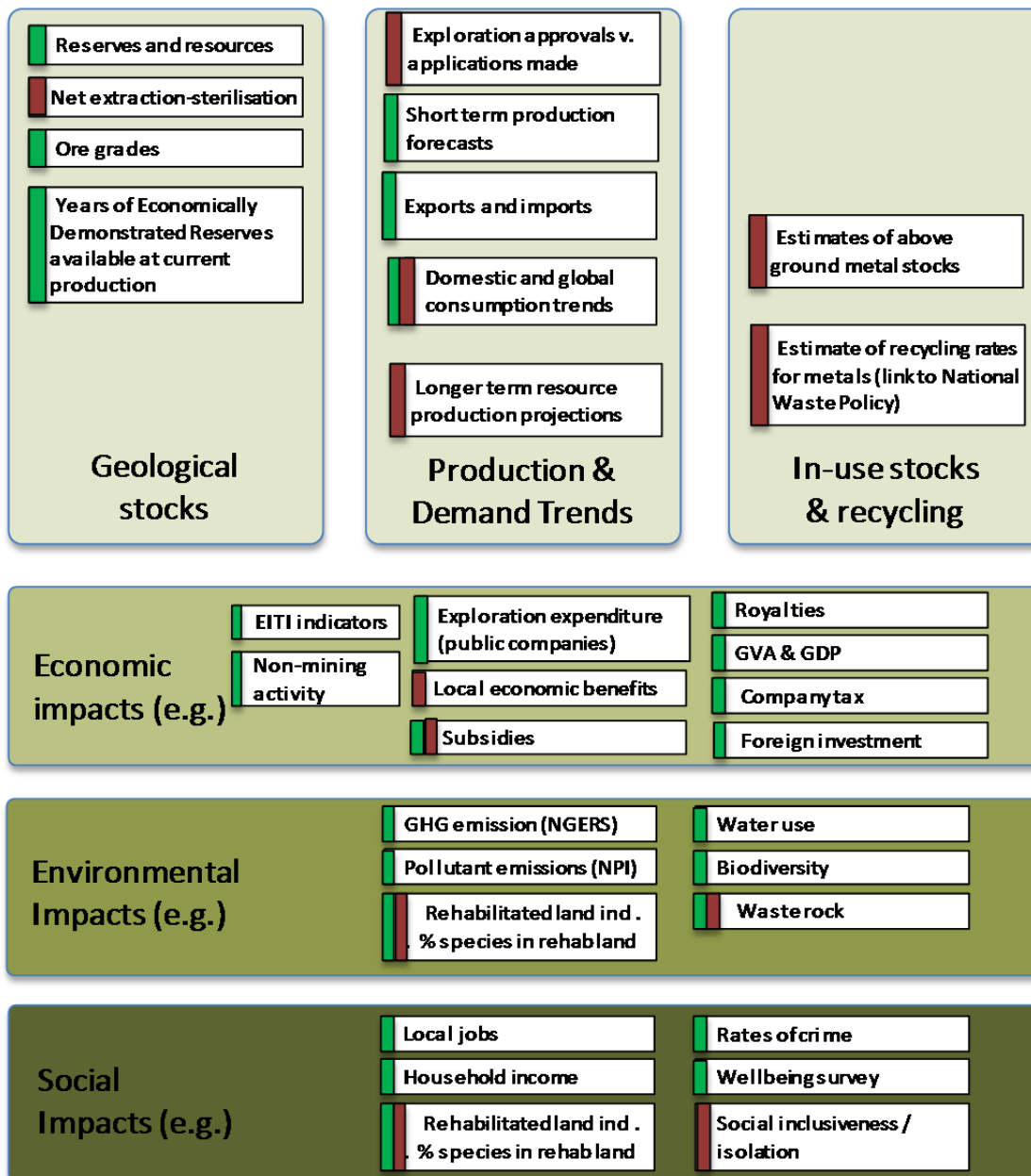


Figure 30: Illustrative selection of potential indicators for National Mineral Account indicating stocks, flows and economic, environmental and social impacts

In order to use the information effectively as an evidence base to underpin both a National Minerals Strategy and regional policy and decision making by governments, industry and the community – a regional level of data would be necessary. The aggregation of regional data to form a national picture is shown in Figure 31.

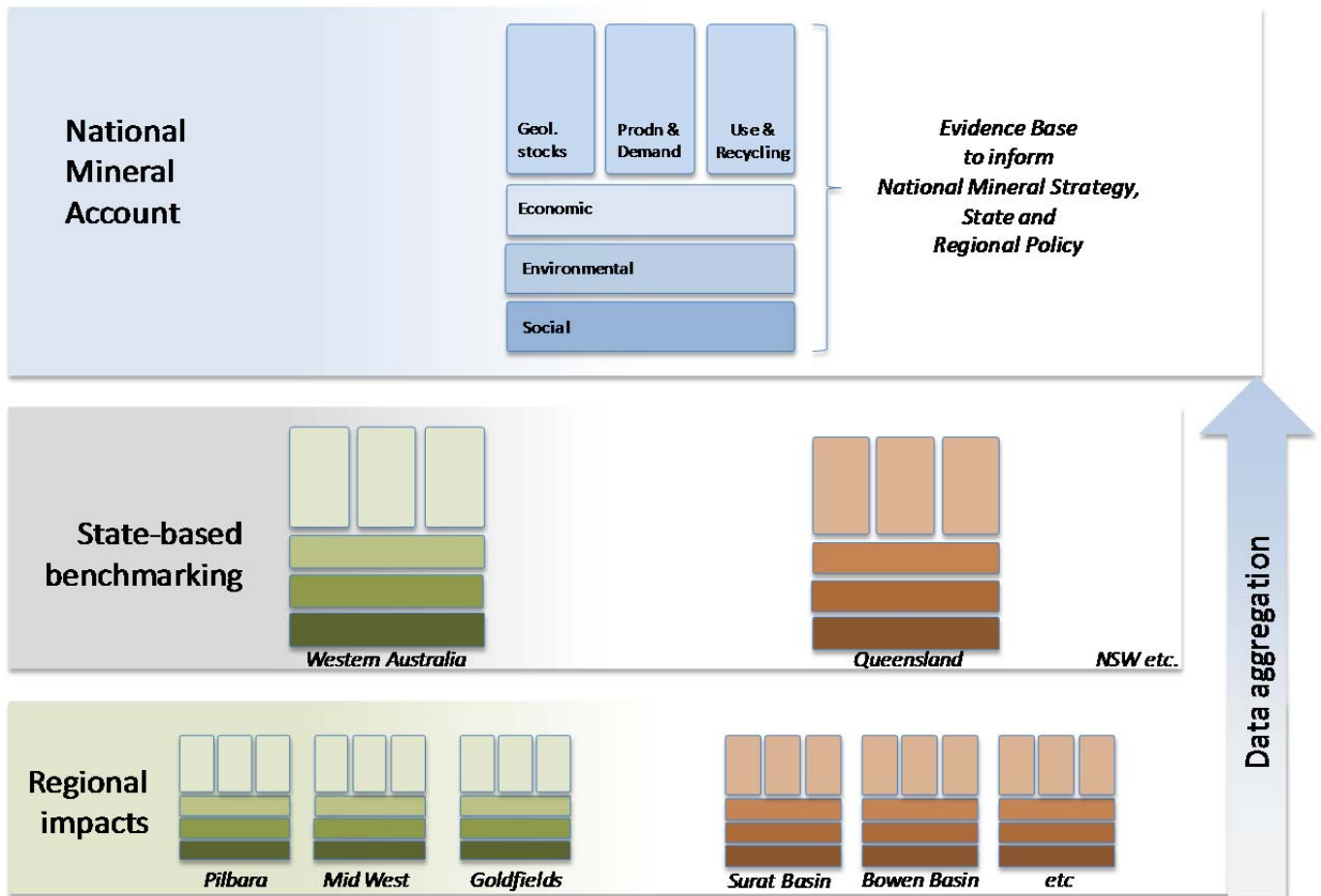


Figure 31: Structure for the National Minerals Account

Importantly it allows for comparisons across regions and states on a consistent basis and provides the evidence basis for developing a National Minerals Strategy and as a basis for follow up monitoring and evaluation of performance.

6.4 Advantage Australia: building on international innovations

The data underpinning a National Mineral Account could better illustrate the role which mining and minerals processing currently plays in Australia and could play in future. Many countries are making changes to business models and governance to provide support for a more efficient and sustainable future economy. This section explores examples of innovations from other countries relevant for Australia.

6.4.1 Saudi Arabia: Innovative governance maintaining and extending the resource base

Stakeholders have suggested that Australia, without a national approach to minerals, is like Saudi Arabia without an oil policy. Like Korea and Finland, Saudi Arabia has recognised that specific measures are required to ensure future economic development, and have begun investing heavily in research that will help them to both capture the most value from their remaining resources, and to create more diverse sources of economic development. Specific initiatives of the Strategic Priorities for Oil and Gas Technology Program (King Abdulaziz City for Science and Technology, 2007) include addressing issues such as higher sulphur content in petroleum, high water-to-oil ratio, slow information gathering, including survey and seismic acquisition in land, through:

- Development of an advanced and integrated database with high end visualisation and communication tools for Oil and Gas information
- Completion of the petroleum geological information
- Enhanced oil recovery and oil reserves
- Improved reservoir monitoring and management
- Improved Oil and Gas exploration and success rates
- Enhanced Natural Gas Production
- Enhanced Gas Production
- Improved drilling quality and efficiency
- Protecting the environment

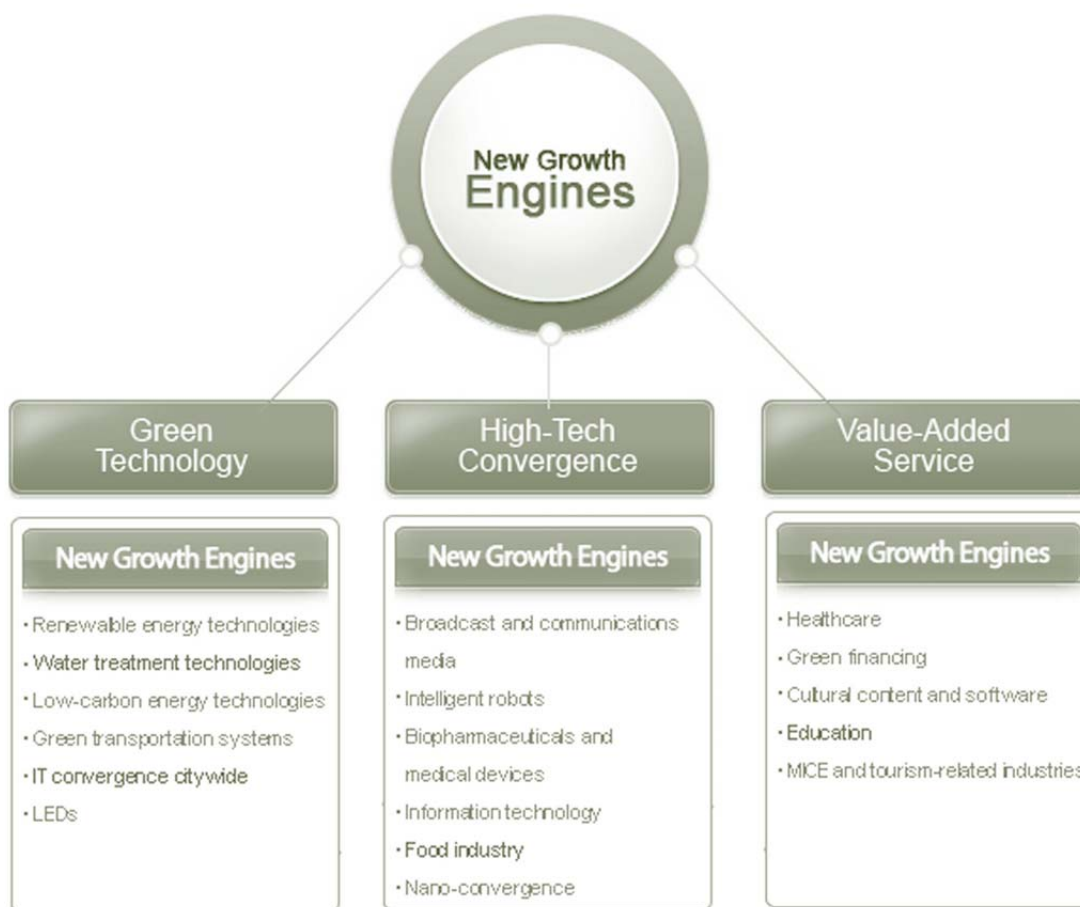
While Saudi Arabia is considered by many to be heavily dependent and invested in the development of oil and gas reserves, the goal of a series of five-year development plans implemented since the early 1970s has been to develop a modern economic base in industrial production. A description of the “*dramatic industrial and economic transformation*” of the Saudi Arabian economy indicates that the non-oil sector's share of GDP increased from 46 per cent in 1970 to just over 70 per cent in 1995, when total GDP was 125.1 billion U.S. dollars (Royal Embassy of Saudi Arabia, 2012).

6.4.2 South Korea and Finland: Innovative governance supporting high performing technologies

South Korea recognises that knowledge itself is a renewable resource upon which long-term development can be planned. Under the ‘*growth engine*’ of Green Technology, the South Korean Ministry of Knowledge has goals of establishing an innovative research and development system, and expanding financial support for developing and commercialising technologies (MKE, 2011). South Korea has identified key growth areas of a future global economy and is now investing in its capacity to take advantage of this. Figure 32 outlines three major emergent areas in the South Korean economy that encompass 17 ‘*growth engines*’ to be ‘*actively fostered and promoted*’.

Figure 32: Key emergent areas of the South Korean economy*

17 New Growth Engines in 3 Sectors



***Original source adapted from (MKE, 2011)**

A mining specific example of intensive support for transformative technology development can be found in Finland, which has set its sights on developing a mineral industry that is “*intelligent*”, “*invisible*” and “*highly productive*”. The stated goal of the Finnish Funding Agency for Technology and Innovation Green Mining program is to “*minimise environmental impact throughout the process chain*” and to promote “*both material and energy efficiency in extraction processes*”. Finland has committed approximately 30 million euros to the program over 5 years, with the aim of being a “*global pioneer*” by 2020. This initiative is reflective of Finland’s interest in innovation more generally, and provides insight to its ranking second behind Singapore, and two places ahead of the United States in the most recent report on innovation and competitiveness (Atkinson & Andes, 2011).

The initiatives developed by Saudi Arabia, Korea, and Finland demonstrate high levels of commitment to a future that is both sustainable over the long-term and extremely innovative. Although Australians are extremely inventive, companies in other countries have brought many of the technologies developed to the world market. Several stakeholders have indicated that existing structures and programs of funding for developing useful technologies within Australia remain insufficient.

These views are consistent with the views advanced by the Australian Academy of Science (2009) and the recent submission of the Australia China Business Council (2012). Indeed, the

recommendations of the ACBC include a doubling of the Export Market Development Grant (EMDG) for high tech and low-carbon industries and additional funding for Australian Research Centre linkage grants to facilitate partnerships between researchers and manufacturers (ACBC 2012)

6.4.3 Innovative governance supporting transitions for Australia in the Asian Century

In an address to the AsiaLink and Asia Society Lunch in Melbourne during September 2011, Australia's Prime Minister acknowledged that a 'business as usual' approach to the Asian Century would not be enough to manage the policy and planning challenges that will come with changes within the global market for minerals and other goods:

"What we know clearly is there isn't a single aspect of government policies and national planning that won't be touched by the great changes to come. Food security and foreign investment, immigration and education, stock market structures and financial regulation, energy policy and environmental standards. This is a vast landscape of change. Some parts of this landscape we can see already, and the challenge there is to set our course, while some parts are uncharted still." (Gillard 2011)

The white paper on Australia in the Asian Century was developed with input from a broad range of stakeholders. It recognises the role of resources in the economy and the need to move beyond resource based industries for prosperity in the decades ahead, but undersells the role that know-how from the resources sector can play as a bridge to future prosperity. Approaches taken by other countries also provide examples of innovative governance that are facilitating transitions from one form of economic development to other forms. Examples provided in the following sub-sections demonstrate three different approaches being taken by countries with some degree of direct and indirect interest in high volumes of minerals.

6.4.4 Norway and Chile: saving for the present and the future

As Australia wrestles with the questions of what it should be getting in return for allowing companies to develop mineral resources, it may also look to how Norway is managing its resource endowment. Norway is one of the world's richest countries (per capita) and has mineral resources including iron ore, titanium, coal, nickel, as well as large offshore reserves of petroleum and natural gas (Newman, 2012). However, in the absence of significant new discoveries, petroleum production is deemed to have '*peaked*' (the point at which the resource is being used much faster than it is being '*replaced*') in the early 2000s. The State Petroleum Fund (SPF) (now known as the Government Pension Fund Global) was set up in 1990, but not used until 1995 when successive budget surpluses had confirmed the usefulness of such an initiative. The relevance of this example for Australia can be seen in the description of why the fund was set up:

"A key reason for establishing the SPF was the desire to make more transparent the intertemporal policy choices available to the country, related to the expected secular decline in oil and gas output and increase in pension outlays. In this context, the SPF has helped to provide a long-term framework for the annual process of setting the non-oil budget deficit. There is currently a wide-ranging debate in Norway on the proper use of the rapidly growing assets in the SPF,

which focuses on both long-term and cyclical considerations” (Davis et al., 2001, p23).

In terms of how the “*fund*” interacts with the mineral sector and the wider economy, it presents a sharp contrast with the discussion that is presently taking place in Australia. Norway’s system imposes a total tax rate on petroleum resource rents of 78 per cent (a 50 per cent rent-based tax rate and a company income tax of 28 per cent) with no deduction at the company tax level for the rent-based tax paid (US State Department, 2012). As Davis *et al.*, have noted, the fund is “*effectively a government account rather than a fund*” that is integrated with a “*unitary fiscal system*”. In 2001, the fund had close to 20 percent of GDP at end-1999. In 2010 this had grown to 130 per cent (Gruen and Garton, 2012).

Chile has also established a fund that saves and invests the earnings from its own state-owned copper mineral company. This stabilisation fund was established in 1985, following a “*sustained increase in the international copper price*” (Davis *et al.*, 2003). The fund uses a reference price for copper that is determined annually, and has been set at, or below a ten year moving average.

“When the price of copper exceeds the reference price by between \$0.04 and \$0.06 a pound, 50 per cent of the resulting state copper company’s revenues is deposited in the CSF; above \$0.06 per pound, 100 per cent” (Davis et al., 2003, p306).

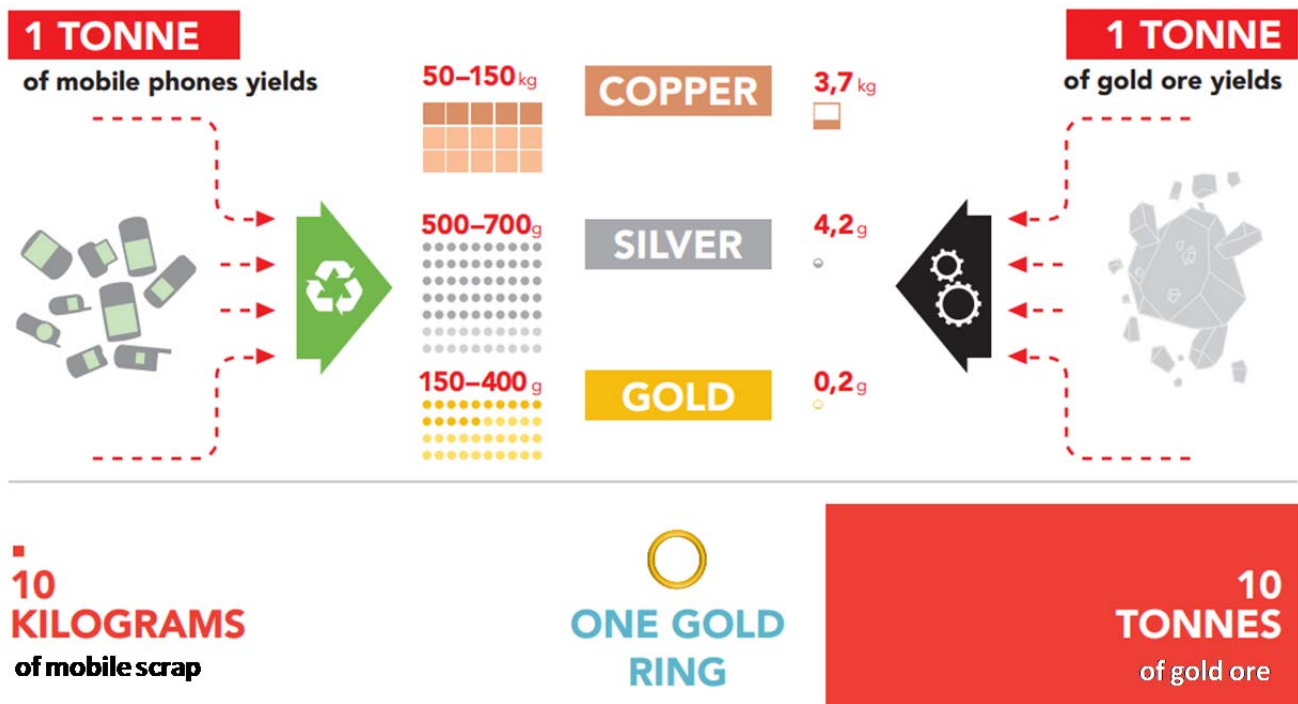
Davis *et al.* have noted that this practice, and the operations of the CSF, “*may have helped the government to resist expenditure pressures during the upswings in the copper prices in the late 1980s and mid-1990s, a fact consistent with the negative correlation between copper price increases and government spending...*” (Davis *et al.*, 2003, p306). During the recent GFC, \$US4 billion from the fund were used to limit the impact of the recession (SWF Institute, 2009).

Such funds do not automatically create good economic outcomes, such as in the case of Nauru where such a fund – the Nauru Phosphate Royalties Trust with \$1billion under management at its peak – was subsequently mismanaged exhausting the fund (Gowdy and McDaniel 1999, Cox 2009). However, there is confidence that they can achieve their objectives if the rules and operations are transparent, and stringent mechanisms to ensure accountability and prevent the misuse of resources are in place. As Davis *et al.*, have noted, this requires regular and frequent disclosure of the ‘*inflows and outflows*’, allocation and return on assets, and clear communication about the ‘*principles governing the fund*’. It is also recommended that the fund be audited by an independent agency, and investment performance be ‘*periodically*’ evaluated. More recent analysis also confirms their view that sovereign wealth funds must be integrated into highly disciplined fiscal policy (Davis *et al.*, 2003, Gruen and Garton, 2012).

6.4.5 Japan and Taiwan: Taking advantage of new high quality resources above ground

Mudd *et al.* (2012) when compiling detailed estimates of gold reserves, found that world production to date has been 140,350 t whereas USGS reserves are estimated at 51,000 tonnes (USGS MCS, 2012), highlighting the importance of managing above ground stocks. This has profound implications for responsible resource management, for example it takes 2 grams of gold to make a wedding ring, which can be produced from 10,000 kg of gold ore or 10 kg of mobile phones (see Figure 33).

Figure 33: Contained metals in mobile phone scrap versus copper-gold ore (after Boliden, 2008, representation by Dawson 2010).



In relation to managing above ground resource stocks, Japan’s industry department has been very proactive, in particular when it comes to tackling its problems with a lack of landfill space and huge volumes of household electrical and electronic waste. Companies producing goods like refrigerators, washing machines, televisions and computers in Japan are required to take these items back and manage them using funds from a levy paid by the purchaser at the time of purchase (DTI, 2005). As a result, manufacturers have become more interested in designing their products for easy disassembly and reuse in future product lines to keep costs for disposal down and maintain a useful supply of inputs. Products not made by Japanese companies have been assigned to local manufacturers and carry a higher levy to help these groups recover the cost of disposal. As a result, Japanese manufacturers have developed innovative processes for sorting, disassembly, and recycling (DTI, 2005). These companies also purchase less materials, including many high value minerals such as gold and indium, as these are being reclaimed from their own and non-local products.

Taiwan has also been utilising technology developed by Japanese companies pursuing improved waste management, and has recently changed its laws regarding potentially hazardous mixed metal waste, to take advantage of an international trade in scrap metal. The reasons given by Taiwan’s environmental protection agency at the time the changes were drafted were:

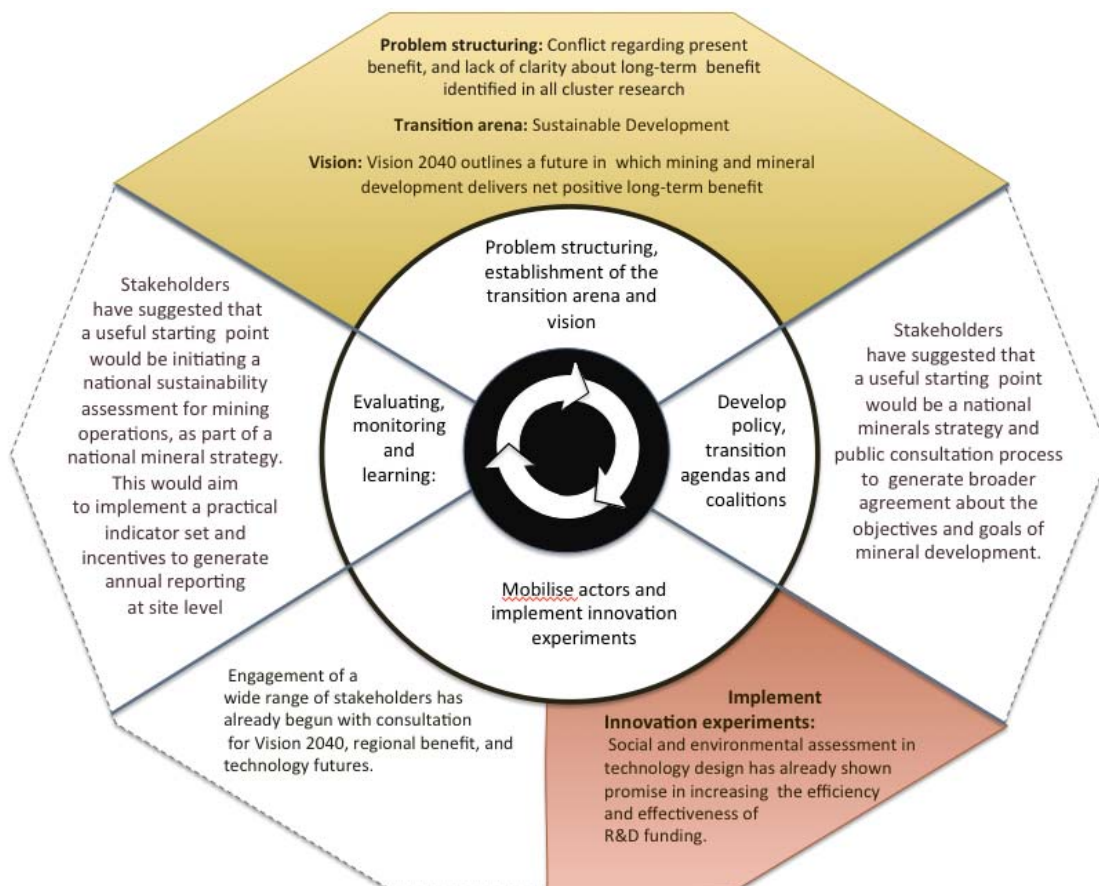
“...the international drive toward more recycling and reuse, the growing shortage of natural resources worldwide, and supply problems in the domestic market” (TEPA, 2009).

The inevitable shift from high-quality/more-accessible ore bodies, to lower quality/less-accessible ore bodies, alongside increasingly high public expectations of economic, environmental and social performance by the mineral development industry, raises important questions about the future viability mineral development in Australia. The examples provided here illustrate what can be achieved with good long-term policy to support industry. The diversity of approaches being taken to more efficient and sustainable future economies provides several models for taking a proactive approach to economic development through innovative technology and innovative governance. At a time when Australia’s increasing dependence on the mining sector is also making it increasingly vulnerable to negative macroeconomic consequences, a national conversation about the long-term objectives of mineral development, assessment of key indicators for benefits and impacts, and transitions to other sources of economic development would be very useful. Recognising that circumstances will change through the decisions that are made, and through external events, an adaptive approach can be taken using a cyclical process of monitoring and evaluation.

6.5 Managing long-term benefit – increased transparency and adaptive planning

Changes to governance that will support responsible mineral resource management can be planned, monitored and evaluated using a shared vision and an adaptive management cycle. Figure 34 (below) outlines this generic adaptive planning model (inner circle), using cluster research outcomes to demonstrate how it could work in practice (see text in outer polyhedron)

Figure 34: Adaptive management cycle underpinned by research outcomes from Mineral Futures project



*Adapted from Loorbach (2007)

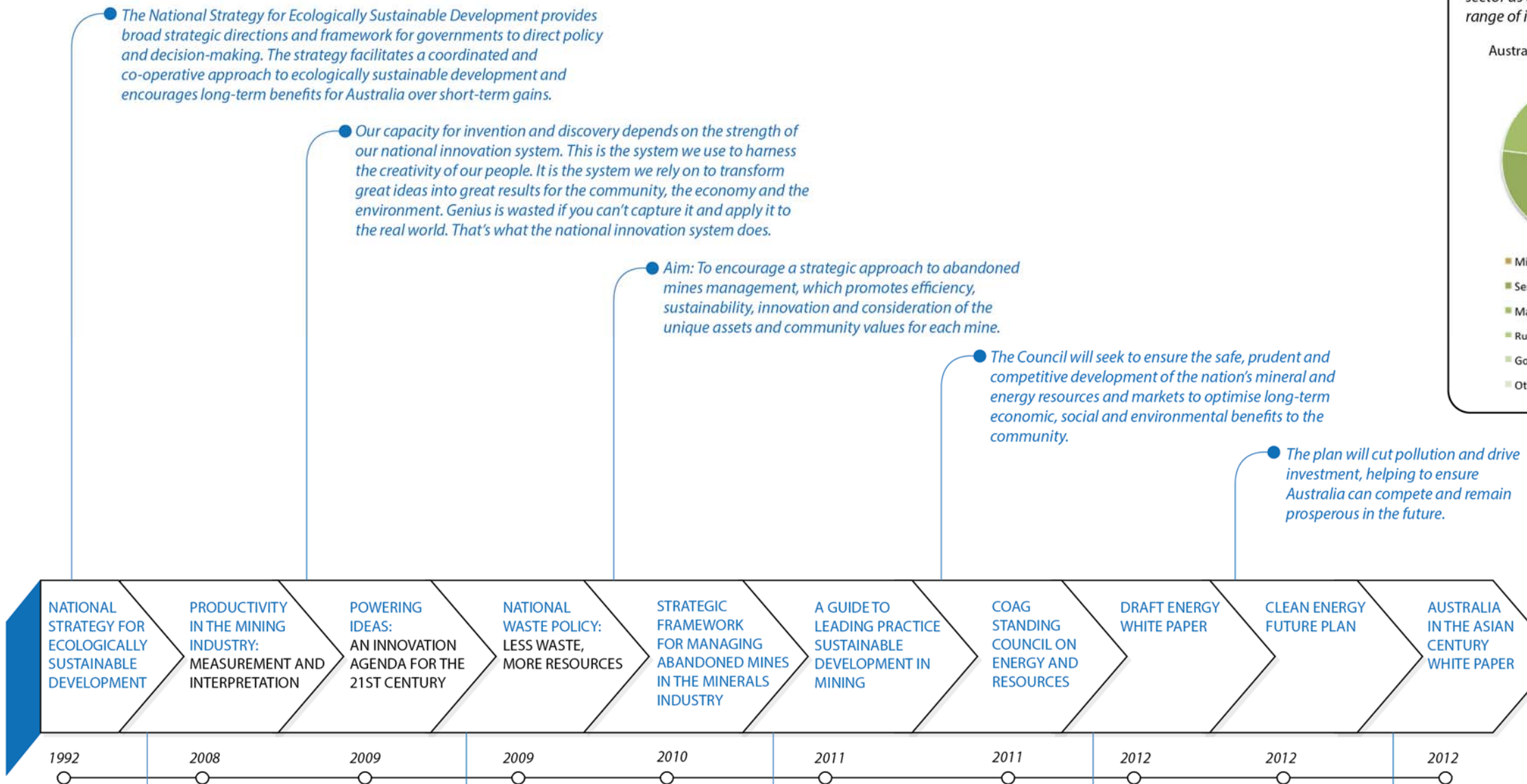
As discussed in the previous section, and shown in Figure 34, Vision 2040 has analysed a key challenge to ongoing mineral development in the conflicts about the nature and extent of benefit that is being generated. The vision statement and initiatives proposed by participants indicate the need for significantly higher performance in economic, social and environmental domains, and this points to a 'transition arena' of increased sustainability.

As part of the aim of supporting a national discussion, Vision 2040 provided a series of potential areas for further development, representing initiatives that are likely to meet the criteria for delivering a positive net benefit from mineral development in the future. It is likely that a greater range of initiatives will be generated from a broader consultation, however, once established, a shared vision can be used to develop a 'transition path' that explicitly identifies the nature of the problem/s, the vision, the stakeholders (and their specific objectives or goals), policy and programs aimed at facilitating progress.

The absence of data across economic, social and environmental indicators for impact (positive and negative) makes an objective discussion of 'benefit' from mining difficult to support at present. It has been suggested that the establishment a National Minerals Account would improve the evidence base for discussions of benefit and impact, provide a home for tracking quantitative information on key indicators, and thus increase transparency and capacity for well-informed decision-making. In addition to being consistent with existing national and international programs for making data available, the collection of data on land disturbance, water and energy use, air, land and water pollution would also assist in developing and implementing innovations and interventions that can encourage significant improvements to performance in these areas.

Existing international agreements, national policy initiatives, and research undertaken for a range of government and industry bodies, provide support for a more strategic plan of management for Australia's mineral endowment, and transition planning that broadens our view of mineral development. Figure 34 provides a high level survey of this support and indicates where the initiatives suggested in this report fit amongst existing economic, social and environmental governance.

National Policy Timeline: This timeline shows existing national policy documents that support the development of a National Minerals Strategy.



The National Strategy for Ecologically Sustainable Development provides broad strategic directions and framework for governments to direct policy and decision-making. The strategy facilitates a coordinated and co-operative approach to ecologically sustainable development and encourages long-term benefits for Australia over short-term gains.

Our capacity for invention and discovery depends on the strength of our national innovation system. This is the system we use to harness the creativity of our people. It is the system we rely on to transform great ideas into great results for the community, the economy and the environment. Genius is wasted if you can't capture it and apply it to the real world. That's what the national innovation system does.

Aim: To encourage a strategic approach to abandoned mines management, which promotes efficiency, sustainability, innovation and consideration of the unique assets and community values for each mine.

The Council will seek to ensure the safe, prudent and competitive development of the nation's mineral and energy resources and markets to optimise long-term economic, social and environmental benefits to the community.

The plan will cut pollution and drive investment, helping to ensure Australia can compete and remain prosperous in the future.

Changing Policy Context: Australia has become increasingly reliant on the minerals sector as a source of export income. However, changing circumstances in recent years across a range of indicators calls for a more strategic approach towards Australia's mineral development.

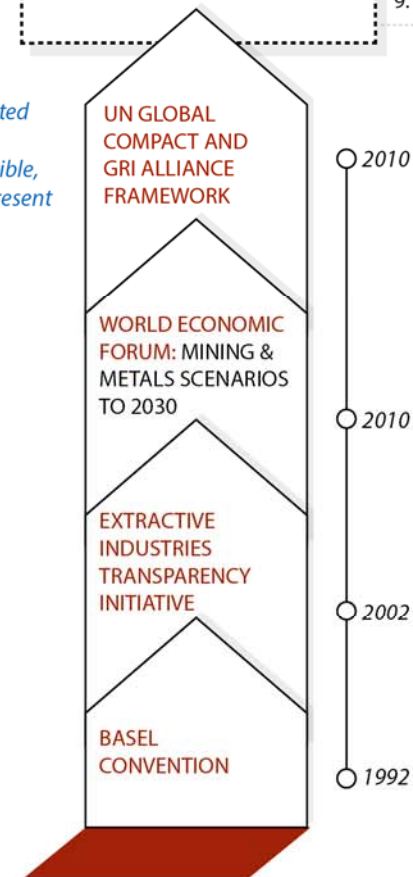
Sector	Percentage
Minerals & fuels	47.4%
Services	18.4%
Manufactures	14.2%
Rural	9.7%
Gold	5.3%
Other goods	5.0%

- Costs of Production (Upward arrow)
- Overseas Competition (Upward arrow)
- Ore Grades (Downward arrow)
- Australian Investment (Upward arrow)
- Commodity Prices (Upward arrow)
- Multi-factor Productivity (Upward arrow)
- Environmental Externalities (Globe icon)
- Impacts on other sectors (GVA icon)
- Demand Uncertainties (Flag icon)

NATIONAL MINERALS STRATEGY WHITE PAPER

Strategic Policy Opportunity

1. Position for long-term sustainable development
2. Achieve global leadership
3. Inform industry, government and community
4. Respond to key challenges
5. Support labour and skills development
6. Excellence in delivery of product and service
7. Strengthen our competitiveness
8. Facilitate investment and regulatory reform
9. Measure our performance on key indicators



International Policy Timeline: This timeline shows existing international policy documents that support the development of a National Minerals Strategy.

The measurement and interpretation of productivity frequently presents significant challenges, especially when conducted at the industry level. In this regard the mining industry is no exception. This report identifies measurement and interpretation issues of relevance to productivity estimates for the mining industry in Australia.

The National Waste Policy provides the basis for collaboration among jurisdictions towards producing less waste for disposal and managing waste as a resource to deliver economic, environmental and social benefits.

This reference book is designed to assist the mining industry to maximise opportunities for economic and social development by implementing leading practice sustainable development principles to deliver practical mining solutions in Australia and overseas.

As our energy resources are developed we must seek to ensure the ongoing support of the broader community, and development must occur in a manner that meets best practice with respect to environmental standards and land owner engagement.

A cautionary remark about both our natural and created endowments, and the capabilities that have been constructed upon them. None of this should be taken for granted. Our abundant natural resource endowments are not inexhaustible, even though earlier generations of Australians – and the present one, largely – have acted as if they were.

The overview provided in Figure 34 is a survey of the instruments that can be drawn into a discussion of a strategic long-term approach to responsible mineral resource management; it is sufficient to illustrate the value that it would bring to existing discussions of present benefit and future sources of more sustainable economic development.

Further research, based on a more comprehensive survey of available policy and regulatory frameworks across the entire economy, is likely to reveal many more opportunities for increasing the transparency and coherence of resource management within the wider national and global contexts.

SUMMARY OF CHAPTER SIX

A national mineral strategy, supported by an expanded base of data on the economic, social and environmental benefits and impacts of existing mining operations, would be a useful addition to existing policy initiatives such as the National Waste Policy, National Strategy for Ecologically Sustainable Development, and white papers being developed for Energy and Australia in the Asian Century.

The development of the strategy and the processes involved in creating a 'national mineral account' would also assist in establishing a clear consensus about the objectives of ongoing development of Australia's mineral endowment, and in negotiating the terms of future development.

Research conducted by the Mineral Futures Research Collaboration Cluster concludes that it will be difficult to achieve, or demonstrate measurable and meaningful long-term benefit at regional and national scales, in the absence of an explicit strategy, and a high level of transparency regarding the nature and distribution of benefit.

7 RECOMMENDATIONS FOR A NATIONAL MINERALS STRATEGY

OUTLINE OF CHAPTER SEVEN

As a mineral dependent economy, Australia faces challenges from declines in key minerals. It must also find ways of adapting to carbon constraints and a new tax structure. If Australia is to be the country that proves that sustainable development can come from high levels of natural resource exploitation, making a comprehensive assessment of the industry's current and future role in the Australian economy is an important goal. This is particularly the case if new areas of economic development must be fostered while global demand for Australian minerals and metals continues to rise. The development of a national minerals strategy is an opportunity to integrate mining sustainability into economic planning. Such a strategy should include policy measures and programs that improve the coordination of mineral development across states and territories, identify challenges, such as declining productivity and high currency values, and develop innovative responses.

While Australia has often been seen as likely to avoid the macroeconomic, social and environmental complications experienced by other mineral dependent nations, this outcome will ultimately depend on creating long-term value for successive generations. To achieve this objective, Vision 2040 has proposed that consideration be given to a nationally consistent, multi-criteria, approach to developing these resources in the context of a future sustainable economy.

7.1 Outline of National Minerals Strategy

A National Minerals Strategy offers a framework in which to negotiate the present and future challenges and opportunities through:

1. Positioning for long-term development

A strategy for mineral development as a bridge to a sustainable economy - Research conducted as part of the Mineral Futures Collaboration Cluster indicates that the current approach to managing mineral resources is not sufficiently responsive to changing dynamics in the global economy, or productivity and ore grade declines in the Australian mineral industry. A key finding of the research across the cluster is the need for a more strategic, long-term approach to promoting innovation that meets community expectations for a sustainable economy in the Asian century.

1.1 National Minerals Strategy

A national minerals strategy would round out existing long-term strategic documents for important economic sectors such as tourism and energy, and meet the need to harmonise regulatory complexity and the distribution of benefits across state jurisdictions for long-term prosperity.

Models for national strategy development already exist, and can draw on the success of processes that have been utilised in other critical areas of economic development and international relations. Approaches that might be considered are a white paper, such as those created for energy and "Australia in the Asian Century", or the extensive consultation and ongoing cross-jurisdictional cooperation that has characterised the development of the National Waste Policy. The process of developing a national minerals strategy could also aid in:

- Clarifying important links between industry policy, industrial relations, and macroeconomic aspects of mineral resource development; and
- Creating governance structures that can coordinate across states and territories and drive progress in increasingly sustainable management of resources.

2. Global leadership

Supporting environmentally ethical and socially responsible supply chains - Australian policy makers and companies can cement a competitive advantage by leading the development of standards and practice.

2.1 Product and material stewardship

In Australia, there are developments in two important areas for improving the relationship between production and consumption of metals. The first is in the area of waste policy, where extended producer responsibility and product stewardship legislation has been introduced for a limited range of specified consumer goods (DSEWPaC 2011). The second is the Steel Stewardship Forum, developed to overcome the significant difficulties of fostering stewardship along the production chain (SSF 2012). Presently these initiatives are developing independently. However, a national minerals strategy could provide a useful connection between these separate initiatives and provide a mechanism for reducing waste, and meeting resource efficiency and recycling goals listed in objective 5.3 of the NSESD.

2.2 Developing Brand Australia

Corporate reputations increasingly depend on being linked within environmentally ethical and socially responsible supply chains. The importance of this issue involves global companies seeking certification for avoiding issues such as conflict minerals, but also improving social and environmental outcomes. How can Australia position itself for advantage in this future market? Australian policy makers and companies can cement a competitive advantage by leading the development of standards and practice. The value chain focus also recognises that in cities of the future, controlling the recycling of above ground stocks of metals in used equipment, buildings and infrastructure will be as valuable in meeting supply as below ground stocks are today.

Exporting fresh air and sunshine

Renewable energy in mineral production - Using Australia's vast resource of sunshine to mine, and process, minerals would put Australia at the forefront of coupling clean energy and heavy industry. By leading the way, we can both "export fresh air and sunshine" in a wide array of mineral and other products, and then sell our knowledge, expertise, and services in this area to the rest of the world.

3. Informing industry, government and community

Data to inform long-term decision making - A National Mineral Account that brings together site-based data on key indicators on an annual basis, will underpin analyses of local, regional and national benefit. Data collection should aim to monitor and evaluate five key areas, including resource characteristics, economic, social and environmental impacts (positive and negative), as well as technology development (see Appendix for an initial set of indicators). With better data, it will be possible to better understand economic, social and environmental impacts at local, regional and national scales through monitoring terms of production including declining ore grades, increasing

energy and water intensity, adaptation to carbon constraints, and significant successes in exploration.

4. Responding to challenges

Transformational innovation - Seeking out and supporting the development and commercialisation of technologies that make a 'step change' in the environmental and social performance of mining and mineral production.

4.1 Technological advances

To date, the principal focus in Australia has been on mining and preceding stages, whilst under-delivering on rehabilitation and restoration. A strategy that focuses on developing governance processes, as well as practical knowledge in transformational mine remediation, would enable industry to be a 'welcome guest' in communities, rather than a 'bad tenant'. Progress in the achievement of a mineral industry that makes a net positive contribution to the Australian community would be seen in the development of processes, technologies and practices that leave mining sites in a better condition than when mining began – increased ecological services, increased biodiversity, improved water quality and land management, and more fertile soils.

4.2 New business models

Stakeholders have noted growth in the number and influence of conflicts with local communities, and the power of informal regulation through the concept of 'social licence to operate'. Stakeholders identified the need for a new approach with the suggestion of Australia taking a new role as a 'mineral services hub' rather than a 'quarry'. New approaches to developing higher value products are required as the present 'dig more, sell more' model of resource development does not maximise long-term benefit. Exploring new business models to generate value along the supply chain such as

5. Labour and skills

High value skills for a high value industry - Addressing shortages in high value and transferable skills, addressing negative impacts of different workforce configurations (including Fly-In-Fly-Out and Drive-In-Drive-Out), and increasing Australian expertise in developing and managing responsible supply chains.

6. Excellence in delivery of product and services

Focusing on our strengths and extending our skills - Supporting Australian ingenuity: growing exports of mining software and sustainable mining services including development, and deployment, of regenerative mine remediation techniques and technologies.

7. Strengthening our competitiveness

Positioning research and development for future success - Evaluating "social licence in design" as a pre-development assessment of public new technology funding is one way to ensure that new technologies fail less often. In addition, if the performance criteria for new technology were to move from the present standard of doing "less harm" to doing "more good", it may be possible to begin delivering positive net benefit from mineral resource development.

8. Facilitating investment and regulatory reform

One-stop-shop for coordinated development - Creating governance structures that can coordinate across states and territories and drive progress in increasingly sustainable management of resources. One part of this program would be to begin the task of harmonising systems for licensing projects and regulations across jurisdictions. The other would be to begin integrating mining sustainability and economic planning for future transitions to an economy based on renewable resources.

9. Measuring our performance

Tracking progress towards 2040 - Improving our understanding and management of regional scales of inflation, benefit sharing, and cumulative impacts through:

- Ensuring the broad take up of consistent methods for collecting data on site-level social, environmental and economic performance.
- Creating greater transparency through increased public reporting on performance in economic, social and environmental sustainability.
- Hypothecation of mineral revenues

7.2 Implications for implementation

The development and ongoing evaluation of a national mineral strategy requires significant government, private sector and community resources. Existing bodies such as the Standing Council on Energy and Resources may provide initial leadership and coherent guidance for the development of a national minerals strategy by building on the *National Exploration Strategy* begun in 2012. Ongoing monitoring and evaluation of geophysical, economic, environmental and social indicators of benefit from mineral resources might usefully bring together the existing activities and expertise of Geoscience Australia, Bureau of Resource and Energy Economic, and the Australian Bureau of Statistics. Critically, significant time and effort will be required to engage a wide range of citizens, organisations and industry, departments and agencies in order to understand and map the interactions as part of developing a viable strategy.

A National Mineral Account would underpin the strategy. Integrated datasets provide public benefits in terms of improved research, supporting good government policy-making, program management and service delivery. Integrated datasets also create an important opportunity to expand the range of official statistics to better inform Australian society.

Fortunately, there is an existing framework for increasing the integration of important data that can also be drawn upon as support for improved data collection and integration for the purpose of analysis. For example, the goal of the *High Level Principles for Data Integration Involving Commonwealth Data for Statistical and Research Purposes (2010)* - “Australian Government Portfolio Secretaries have established a Cross Portfolio Statistical Integration Committee (CPSIC), jointly chaired by DoHA and ABS, to create an Australian government approach to facilitate linkage of social, economic and environmental data for statistical and research purposes.

In conclusion, Australia’s people, Australia’s environment and Australia’s resources are powerful, unique and precious – may we act to ensure each be stewarded wisely; to advantage Australia in the Asian Century.

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About the Australian Mineral Futures Scenarios Artworks used to develop Vision 2040

Scenario Art involves the use of visual representations of future scenarios, alongside a process of asking a series of strategic questions.

Three artworks have developed from plausible global scenarios by the World Economic Forum (Green Trade Alliance, Rebased Globalism, Resource Security) together with a fourth scenario from Raskin's "Great Transition". These scenarios have been contextualised for Australia by researchers at the Institute for Sustainable Futures (ISF), and the artworks composed to facilitate discussion with participants in the Vision 2040 workshop.

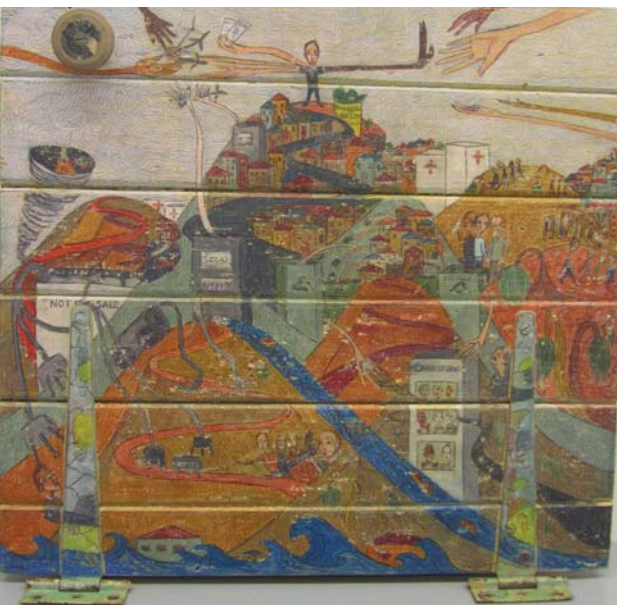
The works are painted on recycled wooden gates, and draw out the key defining elements of the four scenarios, using symbolism to generate discussion. Of particular value was its influence on participant's willingness to share and consider alternative perspectives and interests.

Participants were given one of the four artworks to discuss, and then asked to answer two questions that aimed to gain insight into their ideas about the changing values, opportunities and the risks that Australia's mining industry will face over the next 30 years.

Green Trade Alliance (top left), **Great Transition** (top right), **Resource Security** (middle left), and **Rebased Globalism** (bottom left).

About the Artist

Aleta Lederwasch (BLaw, BBus) is an artist and researcher at the Institute for Sustainable Futures (ISF), University of Technology, Sydney. Aleta uses artistic interpretations of sustainability data, trends and scenarios to facilitate in-depth explorations of issues that involve sustainability challenges.





This report was produced by the Institute for Sustainable Futures, at the University of Technology, Sydney. Images used on the front and back of this report are sections of larger works, developed as part of the process for creating a shared vision for the mineral industry in 2040 (see inside cover for more detail).