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Research Paper
No. 24 2000–01

Sustainable Development and the Australian Minerals Sector

ISSN 1328-7478

Published by the Department of the Parliamentary Library, 2001

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6 March 2001

Acknowledgments

The assistance of Mike Roarty of the Parliamentary Library, John Hogan of Australian Bureau of Agricultural and Resource Economics (ABARE) and Sharyn Sturgeon of Australian Bureau of Statistics (ABS) is kindly acknowledged for help in providing latest mineral sector performance statistics and of Ian Lambert, Group Manager National Project and Advice of the Australian Geological Survey Organisation (AGSO) for a review of the Major Issues section and update of information on the Commonwealth Government Policy Statement on Minerals and Energy. Comment from Parliamentary Library Research Officers, Greg Baker, Scott Bennett, Sean Brennan, Bill McCormick, Rod Panter, Mike Roarty and Richard Webb on the author's draft report and seminar is also gratefully acknowledged.

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Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AMEC	Association of Mining and Exploration Companies
AMIRA	Australian Minerals Industries Research Association
AusIMM	Australasian Institute of Mining and Metallurgy
EDR	Economic Demonstrated Resources
ESD	Ecologically Sustainable Development
EU	European Union
GDP	Gross Domestic Product
GMI	Global Mining Initiative
MCA	Minerals Council of Australia
MMSD	Mining and Exploration Research Network
MMSD	Mining Minerals and Sustainable Development
NRCan	Natural Resources Canada
OECD	Organisation of Economic Cooperation and Development
PEP	Population-Environment-Process
PCSD	Presidents Council for Sustainable Development
PSR	Pressure State Response
SP&C	Sustainable Production and Consumption
TNS	The Natural Step
USGS	United States Geological Survey
WBCSD	World Business Council for Sustainable Development
WECB	World Commission on Environment and Development

Glossary

Added value:	The value added to production of basic resource by further processing or manufacture to higher value product, or the value added to minerals sector returns by providing plant, supplies and technology
Downstream outputs:	Products and services that follow on after production of basic resource product ie in the latter half of the mineral sector lifecycle
Economic demonstrated mineral resources:	Mineral resources that have been proved-up as economic to extract at present day costs and prices and for which consent to extract has been or is likely to be granted
Overburden:	Soil and rock overlying an ore body that is removed and relocated during open pit mining
Sovereign risk:	The risk for mineral companies from governments making adverse changes to operating conditions from those pertaining when a decision is made to invest in exploration or mine development; commonly relates to adverse changes in legislation, terms of consent to mine, taxation, repatriation of profits or funds and is assessed from a country's track record for making such changes
Tailings:	Material left after ore has been processed to recover a mineral concentrate
Upstream inputs:	Products and services that are provided for exploration and mining, i.e. in the first half of the minerals sector lifecycle

Major Issues

The minerals sector, of which the mineral companies are an essential part (see Section: Defining the Minerals Sector) has substantially sustained the economic well-being of Australia since the development of the first goldfields. It now provides 62 per cent of the country's commodity export income, 45 per cent of merchandise exports and 35 per cent of all exports.[1] While the benefits of this enormous contribution are welcomed, Australia, unlike many less well-endowed countries, has become resource dependent and has not been driven by 'necessity, the mother of invention' to develop its own added value upstream inputs and downstream outputs to its production of basic mineral products. Australia has become and still is significantly dependent on the export of resources—mainly mineral resources. This major source of export income is both a blessing and a curse. It still provides handsomely for the well-being of Australians, but at the same time it has denied Australia of any pressing need to develop other major industries, which creates economic difficulties when mineral commodity prices fall. Too great a dependency on such export income and failure to utilise the wealth from it to break that dependency by developing other exports, such as added value manufactures and services, is known as Dutch Disease or the Resource Curse Thesis[2] (see Section: Conclusions, third paragraph, p. 27).

The mining industry is essential because it produces for human needs everything that cannot be grown. It is perceived by some as unsustainable in that it extracts a resource that is simplistically considered to be non-renewable. While this is true in the strict sense for an individual mineral deposit, mineral resources, other than oil, are abundant, but they are all too valuable to be squandered. Sustainable development for the minerals sector is far broader than the sustainability of the nation's 'bank balance' of defined mineral resources. It encompasses, for both public and private property, the sustaining of natural resources, ecosystems, communities and economies as they relate to the processes and products of the sector. For the minerals sector it involves minimising rather than optimising the negative effects of production and maximising the potential benefits of the sector's substantial current capacity to become a major producer of downstream high added value products and high value mining and processing equipment, such as has been achieved by some other mineral producers, as so well exemplified in the case of Finland.

Economically, socially and environmentally, sustainable development of the minerals sector has to be seen in terms of its performance and potential for Australia. It is therefore important to recognise that the debate must move on from arguments over what sustainable development means for the minerals sector (see section: The Concept of

Sustainable Development and the Minerals Sector, p. 1) to one of how to measure its performance in areas that are important for sustainable development. Australia, like Canada, has enormous and similar comparative advantages over other countries for sustainable development of its mineral sector, but, unlike Canada, is not harnessing these advantages and addressing the sustainability issues with any national policy.

As the contribution of the sector to the economy dramatically increased from the 1960s, negative community perceptions have emerged that threaten the sustainability of the industry. The industry is often perceived as 'dumb, dirty and dangerous', regardless of its application of high technology and environmental best practice. The negative perceptions have been derived not only from a legacy of now unacceptable historic practices and minesites, notably Mt Morgan in Queensland and Mt Lyell in Tasmania, but also from the inability of the industry (with increasing number of recent exceptions) to open up two-way communication on its social, economic and environmental effects. Negative perception has been heightened by the few notable failures overseas, particularly tailings containing cyanide flooding into river systems, such as recently by an Australian company in Romania, and use of riverine disposal for waste rock and tailings at Ok Tedi in Papua New Guinea. The nadir for the minerals sector may well be the Romanian spillage.

The challenge for the Australian mineral sector, and the global minerals industry, is to move away from just addressing environmental and community issues after they have emerged and become contentious, to addressing the big picture of the sustainability of its processes and products (from exploration through to smelting and refining) socially, economically and environmentally for all the communities and countries in which it operates. Even with the maximum conceivable level of recycling, mining is essential for everything that cannot be grown to sustain present needs and development for the increasing global population. However, this is not sufficient reason for the mineral sector to continue business as usual. The challenge for the industry is to become, and be seen to become, an increasingly significant contributor to sustainable development **for** society and the environment.

Sustainability requires collaboration and communication with the local and the wider community. It requires a holistic view of sustainable development, in which the industry opens itself to the community and contributes innovatively to education, tourism, wildlife and heritage protection with its expertise and its present and past operational sites. Strategic partnerships with communities should be fostered to optimise social and economic benefits from its activities. It is important to avoid even attempting to develop mines in societies and terrains where they are likely to create major social, economic or environmental problems. Government as well as industry should look at the big picture of the mineral resource-mining-manufacturing-consumption lifecycle to foster strategic stewardship alliances for eco-efficiency to maximise value and minimise waste and negative effects. These needs are often acknowledged but many have yet to be met.

The overriding issue for the Federal Government is whether it should develop and pursue a policy to foster sustainable development of this most important sector of the Australian

economy, which has unrealised potential for added economic and social value to Australia. Mineral companies increasingly take a global view of where to invest and develop. The sustainability of mining and downstream production in the various social, economic and physical environments of countries is of paramount importance in their investment decisions. Should Australia, led by Federal Government, face the realities of a globalising minerals industry by competing with Canada and other developed countries to develop and drive a policy to make the Australian minerals sector the most economically, socially and environmentally sustainable for the benefit of Australia? At present Australia has no other major industry to replace the income it creates. For reasons of geology, climate and historical settlement, Australia is remarkably like Canada as a developed country with a high level of comparative advantage for mineral production compared to most other countries (see Section: Australia's Comparative Advantage, p. 7). Australia could develop a progressively more sustainable minerals sector, as Canada is doing—a minerals sector that would do ever more good and less harm for Australia and the world than a minerals sector could do in most other countries.

At present Australia has only a Minerals and Petroleum Resources Policy Statement and no policy that is driving sustainable development for its minerals sector. This puts the future of the minerals sector, and thus Australia, at a comparative disadvantage to countries such as Canada, where government has collaborated with industry and community to develop such a policy—and drive it in order to make the Canadian sector the most sustainable and competitive nationally and internationally. The Australian minerals sector faces many sustainability issues which reduce its potential to contribute to the well-being of Australia. A policy of relying on a competitive Australian economic environment, but taking a laissez-faire approach to the sustainability of the sector, may well see its contribution unnecessarily decline in the face of international competition and globalisation of the industry. The wisdom of sustainable development is that issues should be addressed within the big picture of a policy **for** sustainable development for optimal outcomes for the industry, society, economy and the environment, rather than by responding to individual issues with ad hoc policy decisions, often for short-term solutions.

The minerals sector has a plethora of issues, which if addressed positively would make the sector more sustainable. Some are of much less significance for mineral companies, who will invest and develop outside Australia whenever and wherever it is advantageous to do so.

Sustainability issues of great significance for both Australia and mineral companies are:

- greenhouse gas emissions related to production activities and use of fossil fuel products
- eliminating or minimising all other deleterious discharges from operational sites
- toxicity issues and perceptions

- socioeconomic effects of mine development on local communities
- planning for end of life mine closure, minesite rehabilitation and minimising social and economic negative effects
- fluctuating and falling commodity prices
- declining relative attraction of mineral sector employment due to insecurity of employment, downsizing, outsourcing and changed working conditions such as fly-in/fly-out arrangements
- occupational health and safety.

Sustainability issues of great significance for Australia rather than the mineral companies are:

- Australia's high level of economic dependency on mineral resource exports
- need to produce high value equipment inputs and added value outputs rather than mainly basic mineral products with diminishing unit prices
- reduced access to land for exploration and mining due to native title and wilderness issues
- need for multiple and sequential land use
- maintaining a healthy level of economic demonstrated mineral resources.

Australia's economic demonstrated mineral resources have increased over the last decade mainly as a result of exploration around existing mines. There is nevertheless a real concern that in spite of an excellent and extensive geological endowment there has been no major economic mineral resource proved-up for mining in Australia in the last two decades. A new paradigm for the Australian minerals sector is required in which geoscience based on advances in technology can discover large high grade mineral deposits, such as Olympic Dam, concealed beneath overlying sediments[3]. This requires continued government support for exploration with pre-discovery geoscience to narrow down target areas and attract companies to invest risk capital for exploration to identify such mineral deposits.

Introduction

The aim of this paper is to outline the major current issues pertaining to sustainable development of the Australian minerals sector, provide a broad overview of the ideas, philosophies and events that are driving changes for its sustainable development and provide insights into its potential for sustainable development. The paper endeavours to address sustainable development with respect to the minerals sector in terms of Australia's national interest rather than that of the narrower perspective of the minerals industry. The author has spent 30 years in the minerals sector in government, industry and education, followed by 10 years researching minerals and energy sustainability and policy issues. His interest is in minimising negative effects and maximising the benefits of the sector for the general community. This paper aims to do this through informed discussion of sustainability issues to help resolve real and apparent conflicts between social and environmental interests on the one hand and the wealth creation and usefulness of minerals and mineral sector production on the other.

The Concept of Sustainable Development and the Minerals Sector

Sustainable development is now a widely accepted concept for the way we live and decide on developments that will affect present and future generations and their environment. The accepted definition from the World Commission on Environment and Development (WCED) is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'[4]

Inherent in this definition are the following principles:

- intergenerational equity—not stealing from one's grandchildren
- intra-generational equity—care and equity for today's disadvantaged
- maintaining ecological integrity—protection of environment and biodiversity
- multi-stakeholder consultation and partnerships for sustainable development with the stakeholders and the wider community.

Sustainable development incorporates the social, economic and environmental dimension locally, regionally, nationally and globally. It is about sustainable communities and their environment.

Companies operating in the Australian minerals sector have responded to the environmental movement with greatly improved minesite rehabilitation and containment against undesirable discharges. However, excellence in such environmental performance is but a part of sustainable development. The question of what sustainable development variously means for governments and their minerals agencies, the companies that explore and produce mineral products, the many who work in or for the sector and the wider community cannot be answered in narrow terms such as the sustainability of just mineral resources, companies or land-use. Sustainable development for the minerals sector is far broader. It encompasses, for both public and private property, the sustaining of natural resources ecosystems, communities and economies as they relate to the processes and products of the sector.

Sustainable development for the minerals sector is:

finding, extracting, producing, adding value to, transporting, using, reusing, recycling, and **disposing** of mineral and metal products under its stewardship in the most efficient, competitive, and environmentally responsible manner possible, using best practices and in collaboration with users and others in the lifecycle from production to disposal

- **respecting the needs and values** of all resource users, and considering those needs and values in corporate and government decision-making

- **maintaining or enhancing the quality of life** and the environment for present and future generations

- **securing the involvement and participation of stakeholders**, individuals, and communities in decision-making.

In defining sustainable development thus, it is also recognised that not all the social and economic benefits derived from mineral development are consumed by the present generation. Current investments in both human and physical capital benefit future as well as present generations.

Sustainable development requires wise and efficient use of mineral resources in mining individual deposits and in maintaining the level of economic demonstrated resources. It currently involves mineral producers in internalising some external (environmental) costs by footing the bill to minimise or terminate deleterious discharges and other effects in response to regulations and awareness of sustainable development.

Background

In 1990, an initiative by the conservation movement and the Australian Federal Government addressed the conflict between economic development and environmental concern by establishing an Ecologically Sustainable Development (ESD) Working Group of leaders from industry and the environment movement for each of the minerals, energy and other industry sectors.[5] Some common ground was identified between those primarily concerned with protecting the environment and those engaged in exploration and production of minerals and energy. Although the Federal government did not continue with the initiative, other than producing the National ESD Strategy that has not really been pursued, a much less confrontational and more productive debate emerged between environmentalists and the minerals sector. Common ground was identified and mutual recognition developed for the positions held by industry and environmental interest groups. At the same time, some of the leading corporations of the world, including mineral companies, joined together as the World Business Council for Sustainable Development to embrace the principles of sustainable development. The drive for sustainable development for the corporate world was articulated and widely publicised in the landmark book, *Changing Course*.[6] It firmly placed the question of sustainable development on the agenda of the major mineral companies.

Governments of most developed countries are addressing sustainable development with policies and initiatives for their minerals sectors and some of these are outlined in this paper. The world's largest mineral companies have recently got together to launch a Global Mining Initiative (GMI). GMI acknowledges that 'business as usual' will not do and companies have to learn how to face the complex changes required for sustainable development. GMI aims to engage with critics and through an independent arms length analysis, Mining, Minerals and Sustainable Development (MMSD), identify and learn about the issues that will determine the future of the industry.[7]

Defining the Minerals Sector

It is important to be aware of the scope and components of the sector when addressing sustainable development. The sector encompasses the mineral resources that are owned by all Australians, as well as the companies and institutions providing pre-exploration geoscience through to mining, smelting, refining and production of basic mineral products, plus recycling, regulation and the provision of specialised goods and services such as education and research, equipment, contracting, legal and finance. The sector produces coal, oil and gas, metals, non-metals and construction materials.

The essential components or major internal stakeholders are listed below:

- Companies that produce minerals and basic mineral products, fossil fuels and dedicated supplies of goods and services to these producers are what is commonly referred to as 'the industry'. They are the capital and entrepreneurship of the minerals sector. Their raison

d'etre and survival depends on providing value to shareholders or principals by return on invested capital and capital growth. The mineral companies are represented by the Minerals Council of Australia (MCA), State Chambers of Mines/Minerals Councils and by the Association of Mining and Exploration Companies (AMEC) which serves the smaller companies.

- Governments and government mineral and energy agencies representing the interests of the local/state/national community, and responsible for the management and wise use of mineral resources with innovative approaches for future development and orderly regulation of the minerals and energy industry.

- Educational and research institutions that specifically train technicians and graduates who obtain employment in the minerals sector and/or carry out research relevant to the minerals sector.

- Mineral sector workers including professionals who are responsible for regulatory compliance, best practice, self-education, research, policy advice, health and safety, community collaboration and environmental performance—and particularly for the ethical and realistic reporting to government, community and stock exchanges on resources and performance. Mineral sector professionals (other than those in the oil and gas area) are represented by the Australasian Institute of Mining and Metallurgy (AusIMM) which has a code of ethics and codes for reporting on mineral resources with which members must comply.

The Australian minerals sector includes the activities of companies in Australia, regardless of their origin and country of registration, but not the activities of Australian companies outside Australia, although the latter can have a major impact on the sustainability of the Australian industry. The industry is undergoing consolidation through corporate takeovers, globalisation, reduced exploration and the demise of many of the junior companies because they are unable to raise capital for exploration and mine development. The number of medium to large companies is diminishing with takeovers. Rio Tinto (UK), BHP (Australia), Anglo American (South Africa) and Billiton (South Africa/UK) are global companies that increasingly dominate both globally and in Australia. Globalised companies are also becoming dominant in contracting and consulting. At the same time Australian companies are increasingly investing in other countries where it is now more attractive to do so as a consequence of improved access and regulatory regimes, while access to minerals has become more restricted and difficult in Australia due to unresolved native title issues and increased area under or adjacent to national parks.

Contribution to the Australian Economy

In Australia and other developed countries a progressively higher value is being placed on the natural environment. Although the values of the environment cannot simply be weighed against those of the industry, it does help the community to know the value of the

industry and who benefits from the wealth it creates. Informed public opinion can then be brought to bear on the political decision-making process.

Unfortunately, the industry's total value is not easily determined, as the Australian Bureau of Statistics (ABS) and the Australian Bureau of Agricultural & Resource Economics (ABARE) publish statistics which treat the extent of the industry differently. The industry's most visible value is its contribution of 45 per cent of the nation's merchandise export income.[8] Key performance statistics are given in Table 1.

Table 1: Mineral sector key statistics

Year	1990-91	1995-96	2000-00
Mineral sector export income ($ M)	27 649	35 585	43 802
Per cent of merchandise exports	53	45	45
Per cent contribution to GDP	9	9	9
Exploration minerals ($M)	793	1149	*838
Exploration petroleum ($M)	507	853	*867
Exploration total ($M)	1299	2002	*1705
Capital investment ($M)	8136	12 193	9057
Employment no.** (000)	95	86	78

* 1998–99 as 1999–2000 as yet unavailable
** excludes smelting, refining and basic metal production

Source: ABARE and ABS

In 1990–91 minerals industry gross export income amounted to $27.6 billion, or 53 per cent of all merchandise exports and this has risen to $43.8 billion in 1999–2000, being 45 per cent of merchandise exports. The percentage contribution of the rural sector, which produced most of Australia's export income until the late 1960s, declined to only 27 per cent of merchandise exports in 1990–91 and is still at this level in 1999–2000. Other merchandise yielded $10 billion or 20 per cent of merchandise exports in 1990–91 and $23 billion or 24 per cent in 1999–2000. The value of production for the domestic market cannot be readily determined but it must substantially increase the total value of production of the sector. Total turnover of the sector including electricity generation (mainly from mineral fuels) is now in excess of $100 billion per year (1999–2000). The total value of production and the value of production for the domestic market cannot be readily determined or reconciled with the value of exports due to the use of differing statistical classes and definitions of the extent of the sector, together with the duplication of production value inherent in the statistics for total turnover.

Linkages

The contribution of the minerals sector to the Gross Domestic Product (GDP) is recorded as 2 per cent in 1960, rising to 9 per cent in 1990–1991 and remaining at that level to date, which is considerably higher than in any other OECD country. This suggests one reason why the manufacturing sector's share of GDP is among the lowest of all developed countries and why the service sector has become the major employer and largest contributor to GDP. The minerals sector is capital intensive with only some 78 000 in direct employment (120 000 with smelting and refining of metals and petroleum), but much greater in indirect employment. A threefold increase of the minerals sector's share of GDP between 1970 and 1984 produced a less than twofold increase in employment within the industry, but provided much greater indirect employment in the service industries and support for the small manufacturing industry.[9]

A detailed study of minerals sector statistics for 1990–91[10] showed that Australia's mineral export income works its way through the domestic economy, with an estimated 80 per cent being paid to Australian entities. This is because Australia's developed economy provides the capital inputs and other supplies rather than having to import most of them, as is the case for the minerals sector in developing countries with immature economies. The sector's payments into the Australian economy include payments to governments of fees and taxes, wages and salaries, interest, dividends and most significantly goods and services. In the early 1990s industry leaders and analysts argued that it would not be feasible to maintain this income flow in the face of increased competition from other mineral producer countries and reduced access for exploration in Australia. However, the statistics show that the contribution has been maintained to date by increased production. Nevertheless, the reduced level of exploration and the absence of mega-discoveries in the last two decades indicates that the present level of contribution and the scale of the industry (with the probable exception of the offshore gas sub-sector) cannot be maintained in the near future—unless there is innovative policy for sustainable development, including a new paradigm for exploration and production.

Foreign ownership in the Australian minerals sector is no longer regarded with great concern with respect to the destination of distributed profits (dividends) because these are only a small part (generally less than 5 per cent) of the gross revenue of the industry.[11] Foreign investment in mining and mineral processing provides for expansion of private investment, development of internationally competitive export-oriented industry and the creation of employment opportunities. However, one aspect of foreign investment relates to the relatively low level of added value processing of minerals in Australia. Foreign companies that own or control Australian mineral developments are arguably less interested than Australian owners in investing in downstream high added value production within Australia, because it is distant from both their home countries and their markets for the end products. Furthermore, Australian mineral resources may not be so well considered for development by a foreign owner that has a global portfolio of undeveloped resources.

Other contributions to the Australian economy are in infrastructure. Between the mid-1960s and 1990 the industry constructed or instigated 25 new towns, 12 ports, 20 airfields, 1900km of railway line and many roads outside the major conurbations.[12] Mines and their associated facilities underpin economic development in remote and many regional areas. In many cases a viable community has remained after the completion of mining, where tourist and service centres have become established.

The growth and wealth of many of Australia's cities is based substantially on the minerals industry. Much of the revenue of the industry is channeled into the major cities, where the industry's payments for goods and services and much of its distributed profits are put into circulation and invested. The spectacular growth of Melbourne in the mid-19th century was due to gold mining, and the rapid growth of Perth and to a lesser extent Brisbane since the 1960s has been largely the result of the expansion of the diversified mineral industries of Western Australia and Queensland.[13.]

The industry's broader contributions include many innovations in mineral and metal processing, many of which have been exported, such as carbon-in-pulp systems used in gold recovery processes. The industry has also developed expertise and economic value in environmental care and land rehabilitation that is now applied to the restoration of degraded agricultural and industrial land in Australia and overseas. The first tertiary educational institutions in many of the States were the schools of mines, some of which have now become universities. Present day mineral companies support minerals sector education at several universities.

Australia's Comparative Advantage for a Sustainable Minerals Sector

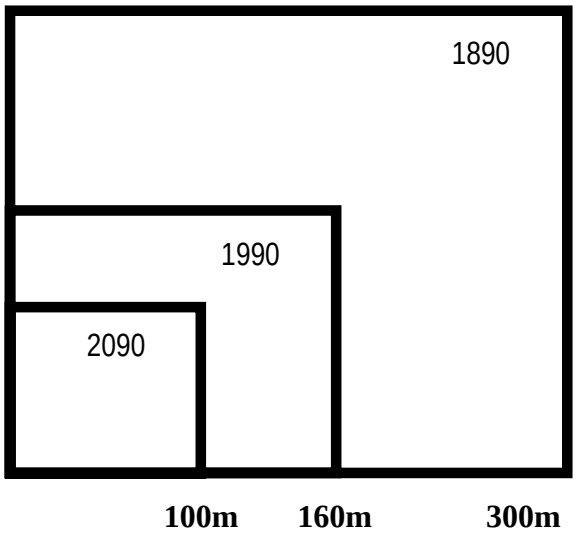
In addition to its advantages of a favourable geological endowment throughout most of its large landmass and a healthy balance of economic demonstrated resources (EDR), Australia has the critical mass of minerals industry capital and expertise necessary to foster future developments. A further major advantage is its low population density that leaves the mineral resources and prospective geological endowment relatively free from competing land uses. Compared to most other developed countries, these circumstances favour the long-term sustainability of the Australian minerals industry. Nevertheless, unsettled native title issues, together with single land use for conservation that denies exploration and mining, has created uncertainty and reduced access—and thus exploration.

Comparative advantage for mineral production can be explained in terms of support squares shown in Figure 1. Whereas in 1890 the global population then had a 300m x 300m support square of land per person, in 1990 the support square was only 160m x 160m per person. With projected population growth this will be only 100m x 100m per person in 2090.[14] This average support area must provide the natural resources, living space, conservation and recreation area as well as accommodating the storage of wastes and scrap for recycling or emplacement. Australia, like Canada, enjoys a

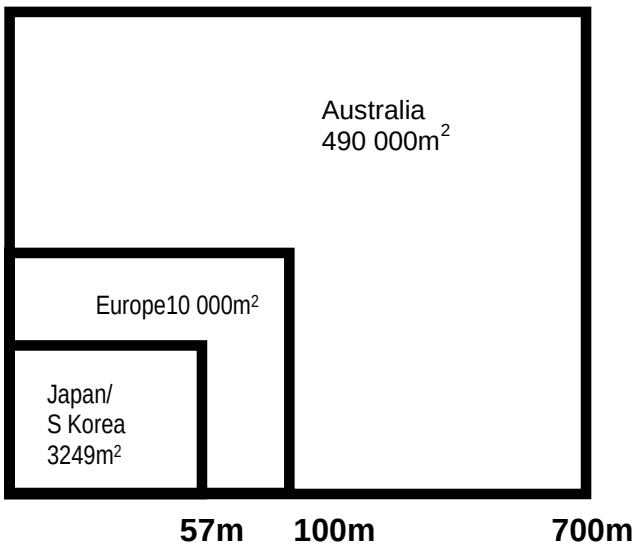
support area of about 700m x 700m per person, which is 50 times larger than that of Europe and 150 times larger than that of Japan and Korea.

Figure 1: Australia's Comparative Advantage—a large support square

(a) Decrease in size of global support square per person, 1890 to 2090 (projected)



(b) Comparison of size of support squares in year 2000



Note: m=metres
Source: (Hancock 1995 after Skinner 1988)

Both Australia and Canada, for reasons of climate and history, are further especially advantaged by having most of their population concentrated in urban areas on their southwestern, southern and eastern margins leaving over 90 per cent of the land very sparsely populated. Potential and known mineral resources are therefore much more accessible, that is less subject to competing land-use, than in the more densely and more evenly populated developed and developing countries. Australia, like Canada has a developed economy and a robust democracy. It provides many of the inputs for its mining and mineral processing, and accommodates the resource rents and other wealth that flows from the industry without significant negative effects. As a developed country with an informed and increasingly environmentally conscious democratic society, Australia has high standards and regulations that successfully constrain significant environmental damage from present day mine development. Australia is therefore in a much more favourable position geologically, socially, environmentally and economically than most countries to accommodate and benefit from its minerals sector as a part of sustainable development. It does more good and less harm in Australia than in most countries, particularly densely populated countries or developing countries where the economy benefits little and resource rents discourage the development of other industries.

Worldwide competition to attract capital for new mine, smelter and refinery development has increased with the end of the Cold War. Countries as diverse as Guyana, Greenland, Namibia, Kirghizstan and Vietnam are successfully wooing foreign companies to invest in their mineral industries. This has been by wholesale revision of mining and mineral legislation to facilitate access to resources and long-term contractual arrangements to reduce sovereign risk. The many countries that are rapidly developing their mineral sectors provide new competition for Australian exports and for attracting exploration and development capital.

The compelling question for Australia is not one of scarcity of minerals in the ground, but how it compares with other countries in overall potential for investment in exploration, development and production. In addition to improving the investment and operating climate while maintaining quality of environment and public approval, Australia must maintain a high level of EDR and develop downstream added value products to sustain future export income. The quality and quantity of Australia's EDR should be relatively easy to maintain, given the highly prospective geology and resident exploration expertise - **provided** a better level of access for exploration can be re-established, and the level of sovereign risk reduced to that in most other major mineral-producing nations. To achieve this it is essential that there be changes in the public's perception of minerals, mining and the industry, as well as the industry and government responses to sustainable development and indigenous and non-Indigenous community concern and aspirations.

Maintaining a healthy EDR bank balance will require a long-term investment in mapping and evaluating the crustal zone to depths of 15 to 20 km, because future mineral explorers will favour those countries where baseline exploration information is available to facilitate finding large-scale, high-grade resources. In Australia this means applying innovative technology for exploration beneath the mantle of the usually unmineralised mantle that covers the prospective older rocks over most of the continent.

The potential for Australia to integrate its minerals sector into the wider sustainable development of Australia is significant. This potential is being realised with some mining developments as at Orange, Central West NSW, where the world class copper-gold Cadia-Ridgeway mine development demonstrates such integration socially, economically and environmentally at the local and regional level. Achieving harmonious and sustainable development nationally will require a broader view and a further cultural shift by the major companies, a more informed community perception and a federal government that will pursue a policy of sustainable development for the minerals sector.

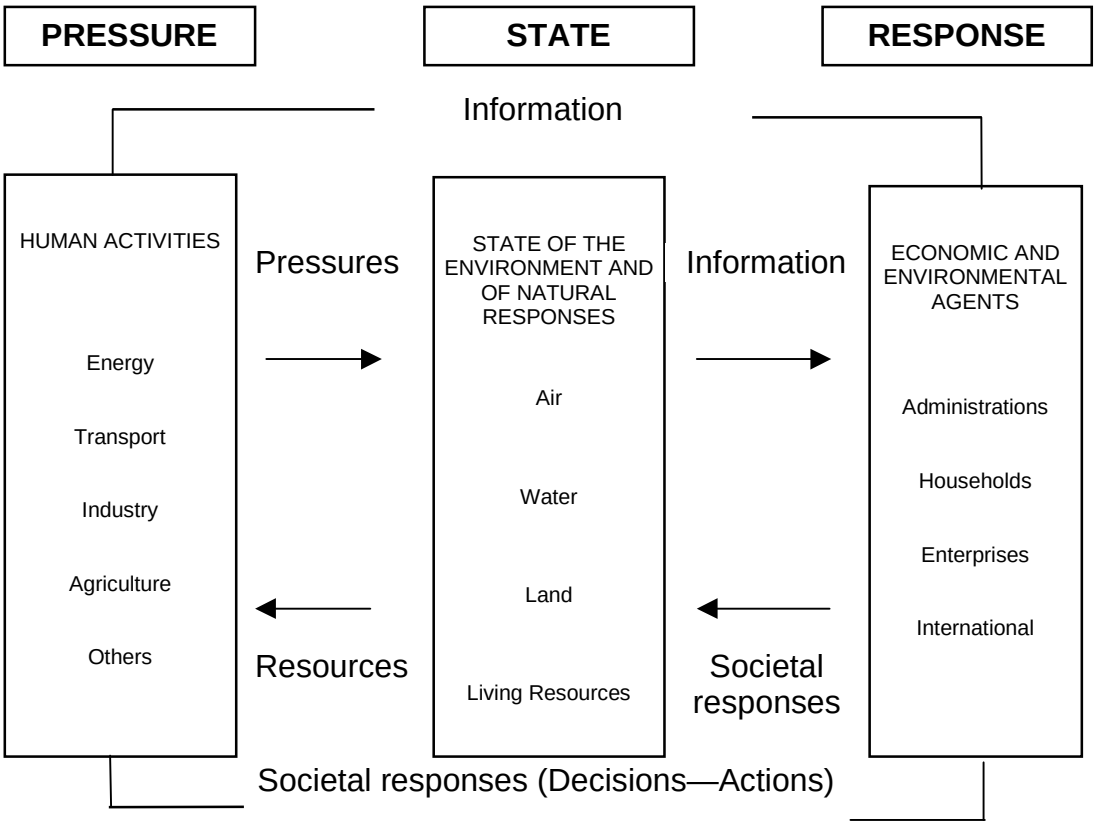
Philosophies and Initiatives Driving Minerals Sector Sustainable Development and Sustainability Indicators

The minerals sector globally, and particularly in developed countries, is being driven towards a more sustainable development by the following emerging philosophies, community interest and government initiatives, as well as its own interest in sustaining profitable production and being seen to contribute to sustainable development.

The Pressure-State-Response System

The Pressure-State-Response (PSR) System shown in Figure 2 has been adopted by OECD countries for State of the Environment (SOE) reporting. It is pivotal to sustainable development policies and agendas. Human activities such as mineral production are seen only as *Pressures* on the environment.

Figure 2: Pressure-State-Response Framework (after Adriaanse 1996)



This OECD-wide system emanates from the EU countries. It leads the debate and influences the agenda for establishing indicators for the minerals sector by identifying the sector as a pressure on the environment. Australian Federal, state and local governments have adopted the system. It excludes the sector's beneficial effects and its progress towards sustainable development.

The widespread application of the PSR system, without parallel reporting of the performance and effects of the minerals sector, presents the sector only as an environmental problem. The sector's stewardship performance and its products, infrastructure and wealth creation that benefit the community are excluded. It does not allow for comparison of the sector's sustainability performance with its past performance or with that of other sectors, most of which have already established indicators or indicator development programs.

Indicators and reporting for sustainability of the minerals sector in Australia are not being developed at the state or federal level—even though there is some commitment for Australia to do so as a member of the OECD. It appears that government mineral agencies will not be given a mandate to commence this work unless the industry makes it clear that

it is wanted. Much of the data needed for state and nationwide reporting is already being recorded by state agencies.

Population-Environment-Process System

The Population-Environment-Process (PEP) System of sustainability monitoring and reporting was developed by the Australian Bureau of Statistics (ABS) in response to the weaknesses of the Pressure-State-Response system.[15] It shows the interaction of the economy and the population with the stock of natural assets and natural processes. All sectors of the economy and 'state of the environments' are drawn together, so that improvements and relative performances of sectors can be demonstrated with appropriate indicators.

A large number of indicators were proposed for the system to demonstrate:

- the environment and its effects on people and the economy
- the people and their effects on the environment
- the economy and its impact on the environment.

The ABS found its application impracticable but considers the principles of the system to be excellent. The ABS now propose to redevelop the system for the minerals sector as an input-output system which will cover both economic and environmental flows and stocks.

Community Environmental Monitoring

Monitoring activities by 200 000 volunteers operating within more than 200 network groups, such as Landcare, Streamwatch, Frogwatch, Soilcheck and Threatened Bird Network, are driving community and mineral industry awareness of environmental and sustainability issues, together with the evolution of sustainability indicators. There is collaboration between these groups and state and local governments. Many are supported by government and some by companies. CEM has become part of an information network with local government, catchment management and central agency databases. **Mineral company collaboration with these groups can be a partnership in sustainable development.** At the local and company wide level there can be useful partnerships in monitoring areas around mineral company operational sites**.**

Technology advances in other industries to address sustainability issues

Chemical, energy and engineering companies with major research capacity are focusing on advancing their technology to profit from opportunities presented by sustainability

challenges. For example, Monsanto, a member of the USA President's Council for Sustainable Development (PCSD) identifies pollution, climate change, biodiversity, soil loss, water availability, population growth, economic development and consumption of non-renewable resources (including minerals) as their leading sustainability challenges. Monsanto welcomes these issues as economic opportunities for innovative chemistry and biotechnology.[16] Opportunities already realised include:

- new environmentally benign herbicides, pesticides and fungicides
- contaminated site clean-up technology with electrolytic clean-up of soils in situ
- genetic engineering of pest and disease-resistant crops requiring minimal use of pesticides or herbicides.

Similar opportunities exist for the minerals sector in clean-up operations of contaminated sites of other industries, sale of clean-up technology, containment of other industries' emissions, further recycling of metals and developing valuable products from otherwise hazardous wastes such as magnesium metal from asbestos tailing by Canadian mineral company, Noranda.

The Natural Step

The Natural Step (TNS) is a powerful new movement that has captured the interest of the US Presidents Council for Sustainable Development (PCSD) and the allegiance of some very large, multi-national companies. It has engaged environmentally concerned youth in Europe and North America. TNS has four principles built on the concept that 'sustainable society must have stable physical relations with the ecosphere' (living environment plus soil). This implies some sustainable level of material exchange between society and ecosphere and limitations of society's manipulation of nature.[17]

TNS principles are:

1. *Substances extracted from the lithosphere must not be systematically accumulated in the ecosphere (therefore, extraction plus liberation by weathering and other natural processes, must not exceed the natural return to lithosphere—mining must be scaled down to achieve this as a stable relationship).*
2. *Society-produced substances must not systematically accumulate in the ecosphere.*
3. *The physical conditions for production and diversity within the ecosphere must not be systematically deteriorated.*
4. *The use of resources must be effective and fair with respect to meeting human needs (inter-and intra-generational equity).*

The four principles are stated to have been worked out in close contact with wide pedagogical practice. Many businesses and local governments, particularly in Europe and to some extent in the USA, apply them as the basis of their strategies for sustainable development. TNS has expanded from its Swedish origins into most developed countries where it promotes the four principles in business and politics through training programs, consultancy and TNS Youth Parliaments.

TNS considers mining inherently bad for the environment and society because:

- it damages ecosystems
- it brings substances from the lithosphere into the ecosphere which are inherently deleterious to the ecosphere
- mineral resources are simply non-renewable.

For the minerals sector, common ground with the Natural Step is about restraining the entry of metals and other substances into the ecosphere—that is, into the soil and living environment in those situations where they **do** have the potential for a significant deleterious toxicity effect.

Environmental Assessment of Mineral Deposits

In the USA the PCSD has set up a panel of representatives from industry and academia to review mineral deposit types using environmental criteria. The United States Geological Survey (USGS) is using 'geo-environmental' models to evaluate potential environmental problems from historic mining. 'Several hundreds of thousands' of historic mine sites are being prioritised on geo-environmental criteria to determine their need for remediation. The geochemistry, mineralogy and structure of 32 types of mineral deposit have been classified on environmental criteria. Environmental signatures are provided for drainage, metal mobility from mine wastes and workings, soil and sediment, smelter effects, climate effects and potential environmental concerns. Climate, hydrology and physiography, together with mining and mineral processing methods, are then characterised for individual sites to determine post-mining signatures and mitigation of environmental effects.

The USGS notes that the models are not yet sufficiently detailed to be used to set mining-environmental regulatory policy and approvals for proposed mines, but they can be used by industry and state regulators to set conditions to address potential environmental concerns that might result from development of the specific mineral deposit types.[18] The USGS has recently expanded its work to assess the environmental impacts of mines in developing countries, which is significant in view of the US Government's underwriting sovereign (political/regulatory change) risk on behalf of American companies in such

countries. The addition of socioeconomic criteria enables an overall assessment for sustainability of such proposed mineral resource developments.

The US Congress's recent legislation to underwrite sovereign risk for American companies exploring and developing mineral resources in some specified developing countries of Southeast Asia and Africa must lead to reduced interest in mine development in the USA, Canada and Australia. The legislation suggests that mining in the USA is now a less sustainable industry politically. It disregards the studies of resource analysts that show mining does relatively more good and less harm, that is, it is more sustainable environmentally, economically and socially in the developed countries of USA, Canada and Australia than in developing regions such as PNG, Iryan Jaya, Zambia and Bolivia.[19,20]

EU Initiatives on Environmental Costs and Mining Prohibitions

The German Government is concerned that the expected increase in primary production of mineral resources and increasing exploitation of lower grade ore deposits will inevitably lead to increasing impacts on the environment.[21] Consequently, Germany is looking at measures to counteract this development by requiring its importers to apply environmental costs of mineral production in determining which mine's product can be imported into Germany. If overburden is to be included as a waste, this will discriminate against present and future low-cost large-scale open pit copper mines of the world and favour underground mines with their occupational health and safety issues.

A German Scientific Board of government, industry and academic interests is guiding a study 'to inventory the worldwide material flows and environmental effects of the most important mineral commodities—from mines to smelting plants to the production of marketable basic products'. Recommendations will be made on how production techniques, the behaviour of individuals and corporations, and export-import relationships can be changed in order to conserve limited environmental resources. Recommendations will also be made on how sustainable development of commodity exporting countries can be enhanced.

The German approach reflects that of most EU countries. Selection of suppliers already takes place where buyers hold or seek International Standards Association (ISO) certification and will themselves therefore buy from such certified companies. Examples are British Steel's selection of the ISO certified Iron Ore Company of Canada and Swedish uranium buyers' performance checks of the Ranger Uranium Mine in Australia.

An EU Directive on mine 'wastes' classifies tailings as such and will ban the production of tailings in member countries. This is of great concern to the metal mining member countries, particularly Ireland, Sweden, Finland and Spain, who oppose the Directive.

Sustainable Production and Consumption

Sustainable Production and Consumption (SP&C) is a key concept arising from the 1992 Rio Earth Summit. It is the production and use of goods and services that respond to basic human needs and bring a better quality of life, while **minimising the use of natural resources**, toxic materials and emissions of waste and pollutants over the lifecycle, so as not to jeopardise the needs of future generations.

Agenda 21, from the Rio Earth Summit, calls on governments, business and others to implement measures to promote efficiencies in production and sustainable patterns of consumption. United Nations Council for Sustainable Development (UNCSD) and OECD member governments have agreed on the following as recommended actions:

- pricing reforms to internalise environmental costs
- green public procurement policies
- extending producer responsibility for lifecycle environmental impacts
- eco-labelling
- environmental criteria and processes
- more efficient design of products and processes
- increase life spans of durable goods
- reuse and recycle
- more sustainable consumption through advertising, and product efficiency.

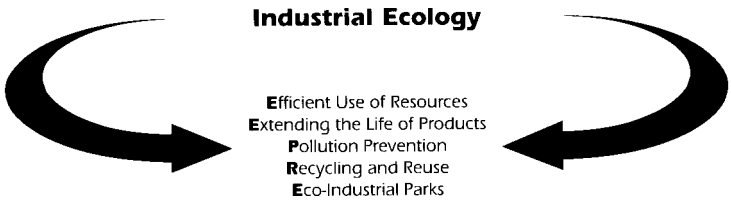
These recommendations are part of an emerging responsibility for eco-efficiency and lifecycle partnerships between industry sectors.

Eco-efficiency has been defined as the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the lifecycle, to a level at least in line with the earth's estimated carrying capacity.[22] Eco-efficiency focuses not merely on reducing waste and material use, but on resource productivity, i.e. maximising added value per unit of resource production—in other words, doing more with less by:

- taking account of entire lifecycle of goods and services from design to purchasing, materials management, production, distribution, usage and waste management
- applying eco-efficiency to increased value for customers

- making scientifically sound information available to the public.

A sense of industrial ecology is currently emerging, that is, a system which consumes limited resources and produces limited amounts of waste by having materials and energy sources continually cycled within the economy rather than being consumed and disposed of to the environment as wastes. In a sustainable industrial ecosystem, materials extracted from the earth, and wastes that leave the industrial system, do not exceed the assimilation capacity of natural systems. The principles of TNS are evident in industrial ecology, including the general assumption that all materials extracted from the lithosphere are potentially toxic and will be assimilated by natural systems, thereby putting those systems at risk. Collaboration between industry sectors and companies, distributors, retailers, consumers and producers brings improvements in eco-efficiency. This is affected through lifecycle management of production and products, with materials and energy recycled so that the waste of one industry is the input for another industry or sector. Industrial ecology is portrayed in the diagram below and as outlined by The World Business Council for Sustainable Development (WBCSD):[23]



Sustainable industrial ecology is seen where there is symbiosis between sectors, as at eco-industrial parks. In Denmark, Kalundborg Eco-industrial Park interlinks a fish farm, a gyproc plant, a pharmaceutical plant, a coal-fired power plant, an oil refinery and 5000 homes so that the stream of waste emissions of each are the inputs of the others.[24]

Initiatives of other industry sectors and the Canadian minerals sector

Initiatives of other sectors and the Canadian minerals sector are leading the agenda for sustainable development and sustainability indicators for the Australian minerals sector.

The **chemical industry**'s Responsible Care program applies globally and includes the major Australian companies. It demonstrates how an industry can raise its community approval rating (license to operate) through a commitment to improved performance, open communication and collaboration with the community.

The **forestry sector** in Australia and nine other countries with temperate or boreal forests has established seven principles (criteria) for sustainable development in accord with the Montreal Process[25] and developed a set of indicators for each. Some of these have relevance for developing minerals sector indicators.

Australia's agriculture sector has established an indicator system with four primary determinants (goals) serving an overriding goal of economic viability. The indicators and linkages in the system are rational and elegant, but in the process of their establishment by bureaucrats, the most involved stakeholders—the farmers and rural communities—were excluded. It provides a lesson for the minerals sector on how **not to** establish an indicator system. However, the water-use efficiency indicator should be recommended to those in the minerals sector concerned with minesite rehabilitation and health of establishing ecosystems. It measures the weight of the product grown/ha/mm rainfall and relates to erosion and siltation viz-a-viz percolation to root systems.

The land and water sector in Australia has established sustainability indicators and follows the concept of **Total Catchment Management,** which brings together sustainability issues of all land-based sectors including mining. Indicators are being developed for a holistic system of sustainability indicators for water resources and use.

The **transport sector** has established sustainability indicators in several developed countries. The indicators for economic use of energy and emissions have some relevance for the minerals sector, as have the social indicators for well-being of local communities.

Canadian initiatives for sustainable development of minerals and metals have been spurred on by the intense Canadian debate on forestry. Both the Canadian collaborative policy formulation process (which involved industry, NGOs, academics and all levels of government) and the policy itself are highly relevant to the issues faced by the Australian minerals sector. The policy (see Appendix 1) is focused on placing the Canadian minerals industry to the fore in both Canada and internationally with a sustainability indicator system as an essential part of that policy. A large multi-stakeholder working group is now identifying values and objectives that will form the basis for indicator development. Canada and Australia have much to gain by collaboration, which was initiated by the author's recent sustainability indicators research project for Australian and Canadian mineral companies[26] and Canadian discussion tour for Natural Resources Canada.

Sustainable development for the minerals and metals sector is vigorously pursued by Canadian Ministers for Natural Resources, commencing with a Green Plan and then fostered by the Whitehorse Mining Initiative, in which mining and metals industry, labour, aboriginal peoples, environmentalists, academics and governments collaborated. They all signed a shared vision of a socially, economically and environmentally prosperous industry, underpinned by community and political consensus. The collaboration is ongoing and all Canadians can participate directly through a website or via an interest group. The shared vision recognises that less mineral resource development in Canada will not moderate global increase in mineral consumption—and neither will it have significant impact on consumption of minerals in Canada. The goal for a sustainable minerals sector is to find, extract, produce, add value to, use, reuse and recycle mineral and metal products in the most efficient manner possible, while respecting the needs and values of other resource users and maintaining and/or enhancing environmental quality for present and

future generations. This requires consideration of intra- and inter-generational equity, mineral consumption and depletion.

Lifecycle management is for both processes and products of the sector with risk management and risk assessment as a fundamental component of the Canadian policy and indicator development.

The participants in the Canadians' collaborative process concluded that the generational debate on sustainability and the industry has drawn attention away from several important considerations, namely:

- the durability of many metals—they can be consumed by people today but recycled by future generations
- environmental, social and economic investments made from today's mineral resource developments are not all consumed today, but will also be enjoyed by future generations as human and physical capital.
- there are no guarantees that the minerals we use today will have the same economic value for future generations
- the idea of mineral reserves is an economic concept limited to mineral deposits that are known and currently economic
- the need to ensure that the activities of the industry do not place long-term stress on the environment and that they support social objectives

The Canadian Government policy for sustainable development of minerals and metals would be of great value to Australia and its mineral sector if adopted in Australia. It is summarised in Appendix 1.

Responses of the Australian Minerals Sector

Essentially all the major mineral companies and many of the smaller ones have responded to negative community perceptions and environmentalist calls for change by pursuing best practice in environmental management in exploration, production and minesite rehabilitation. To date, 46 companies representing some 85 per cent of Australia's mineral production have signed-up to the Mineral Council of Australia's Code of Environmental Management to progressively improve their performance and to report to the community. Some are developing reporting in terms of sustainable development as 'triple bottom line'—social, economic and environmental performance. Some are engaging with national non-government environmental organisations on the big issues of sustainability and in assessing company performance.

International minerals industry agencies, such as the International Council of Metals and the Environment, focus on sustainable development issues pertinent to their industry. Most of the major mineral companies have joined together in the Global Mining Initiative (GMI) and state that they have become aware that sustainable development brings threats and opportunities and that they must aim to contribute to the sustainable development of the changing world. They have launched a Mining Minerals and Sustainable Development Project (MMSD) in 2000 to analyse the issues, listen and engage constructively with others so that the industry can learn how it may face the issues of sustainable development in developed and developing countries.

In 1997, 16 Australian companies financed a preliminary research project (AMIRA P496) by the author and others at the Australian National University to assess the application of sustainability indicators for the Australian minerals sector.[27] In the UK, another response, the Mining and Exploration Research Network (MERN), has signed up multi-national mineral companies to develop sustainability indicators.

Sustainability indicators have been or are being developed by government in Australia for all the resource sectors other than the minerals and energy sector. There has been no significant response by Federal Government to calls to foster mineral sector sustainable development since the Ecologically Sustainable Development (ESD) process in 1991 and the ensuing 1992 ESD National Strategy, which has not really been pursued.

Performance Indicators for Sustainable Development

Formulating a sustainability policy and selecting and establishing indicators to measure performance in sustainable development are interdependent functions. A government may formulate a minerals sector sustainable development policy and then devise indicators to assess, communicate and drive performance. Canada is ten years into this process and is now devising the indicators in collaboration with the industry and other stakeholders.

In the corporate world in Australia, sustainability indicators are evolving ad hoc through companies reporting their environmental and sustainability performance without necessarily being driven by a sustainable development policy vision. Ad hoc development of indicators will result in disparate indicators and units of measurement across the sector, preventing meaningful and valid comparisons between operational sites, companies, regions and internationally. A vision of sustainability needs to be articulated to develop a holistic and generic indicator system.

A sense of ownership of indicators and their message and positive stakeholder relationships are engendered by companies and the industry articulating their own sustainability vision and developing their own indicators in collaboration with the stakeholders. Mineral companies in collaboration with government and other stakeholders need to work through the indicator selection process themselves. Time and energy invested in collaboration provide a vested interest and pride of ownership in the indicators

by all the stakeholders. However, it is vital that government plays a leadership role in ensuring that meaningful indicators are developed that will show sustainable development performance at the national level to enable comparisons over time, between sectors and internationally. Such indicators are essential tools for good management. They are not going to emerge in Australia without government leadership with a sustainable development policy and vision **for** Australia.

Criteria for developing indicators

A comprehensive set of indicators should include core (global), regional and local indicators. It is important to choose some **core indicators** which spread across all spatial jurisdictions (local municipalities, state, national and global) because they reflect a global concern and conditions. Greenhouse gas emissions and sinks are well established examples of core indicators.

It has been found that indicators determined for one country, region, or industrial site have often been unsatisfactory for others, due to operational, geographic or cultural diversity. Thus, **local and regional indicators** are also required to reflect local or regional concerns and conditions, as well as those peculiar to sectors of the industry and their operational sites e.g. radio-activity in relation to uranium mines.

Processes and criteria for selecting indicators are well established from many indicator development programs by industry sectors, local government and at country-wide levels in USA, Canada and Europe.[28] In evolving indicators fundamental questions need to be thought through:

- *Who are the indicators for?* e.g. management, employees, local community, urban and general community, regulators, investors, insurers, etc.

- *Are they to form an holistic set across socioeconomic and environmental issues*?—or are they to only address the biophysical environmental issues?

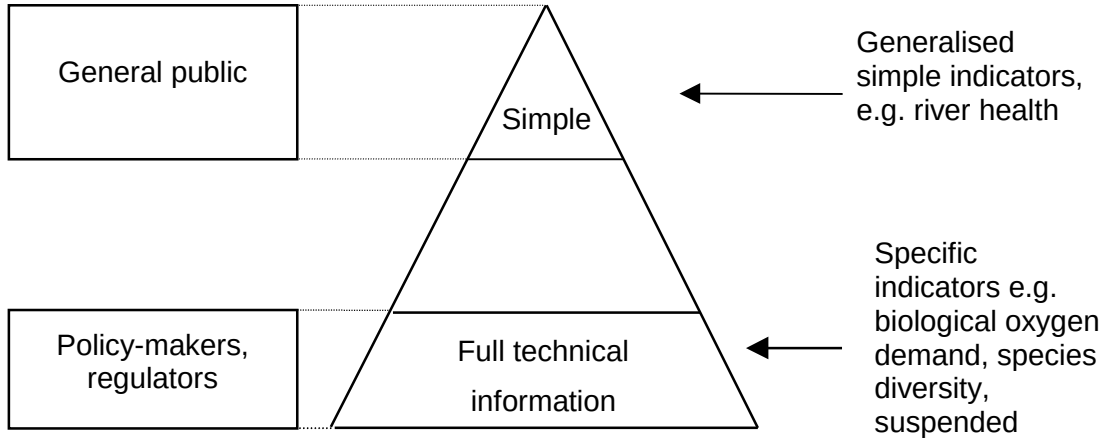
- *What interpretation of sustainable development is to be used ?*

  – sustainable growth?
  – sustainable societies?
  – what time-frame on sustainability?
  – with or without social equity considerations?

Policy-makers and scientists are likely to prefer specific indicators that convey significant amounts of technical information in precise ways, for example, indicators that relate various pollutants to a river's carrying capacity as well as indicators of biological status. The public, however, requires simpler indicators in the form of composite, key and resonant indicators, for example, assessing the river quality as high, low or medium downstream of a tailings dam or mine as demonstrated in Figure 3.

Key resonant indicators are highly effective in inspiring public concern and rapid action by both the public and governments. But unless used with caution they can be misleading and result in inappropriate action and unnecessary expenditure. For example, in 'Sustainable Seattle' one of the key resonant indicators is the number of wild salmon returning to spawn each year. It integrates many specific indicators and issues and causes—river pollution, river bottom disturbance and aquatic plant health. Major expenditures might be outlaid on these specific issues without any increase in spawning salmon because of overfishing in the North Pacific.

Figure 3: Levels of Information Conveyed by Indicators



Key resonant indicators can also fail to reflect progress made or can give a false impression of progress, for example, the presence of koalas in the establishment of Australian woodland ecosystems in minesite rehabilitation. While this would have public relations value it would say little about the health of the ecosystem.

Lifecycle assessment for minerals sector sustainable development

A lifecycle-based vision of stewardship of mineral resources, minerals sector processes and mineral products is considered the most appropriate for constructing an indicator system for the Australian sector. A study of methodical and collaborative approach of the Canadian Government, the work of European environmental agencies and institutions, the WBCSD identification of the industrial ecosystem concluded that a lifecycle assessment approach is the most appropriate for understanding, measuring, communicating and driving sustainability.[29]

Lifecycle assessment identifies where the greatest environmental and socioeconomic burdens and benefits occur for each product and allows comparisons between processes, products and industries. A lifecycle-stewardship vision for the minerals sector is modelled

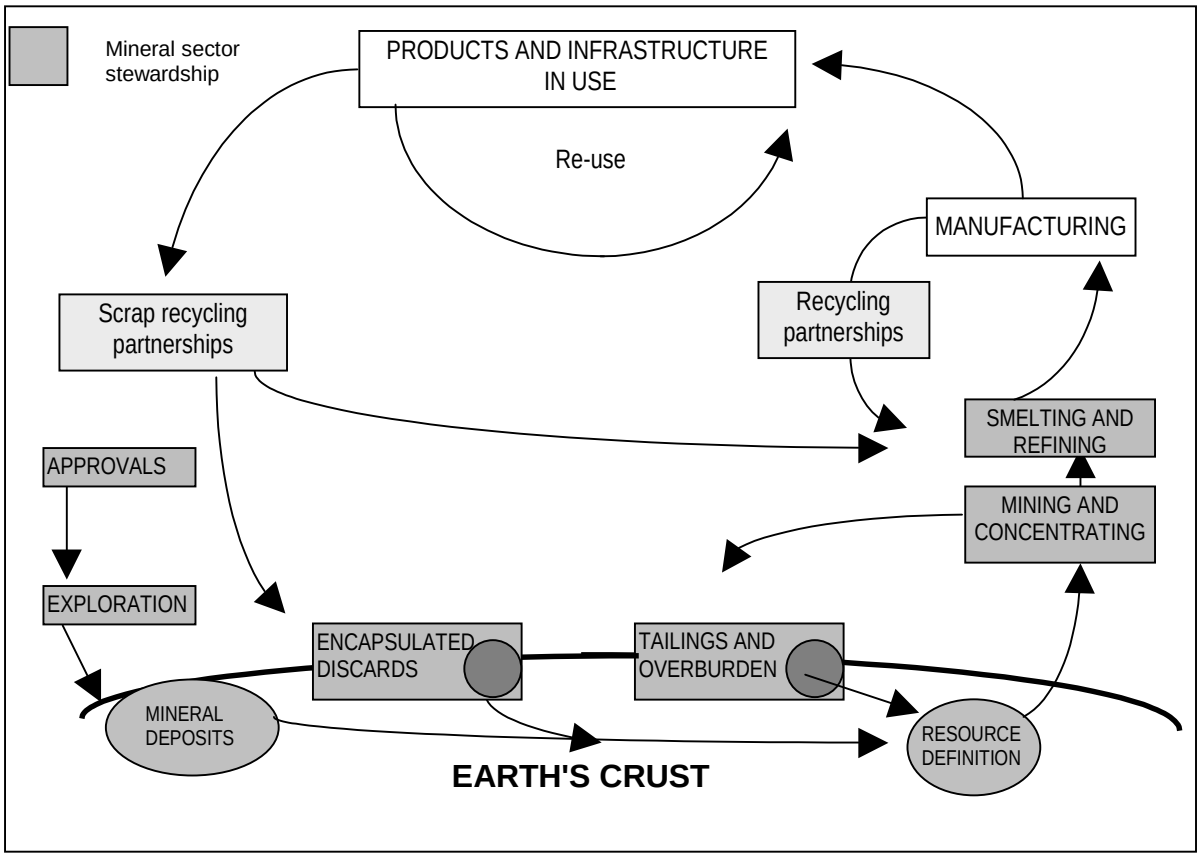
in Figure 4, which encompasses good housekeeping and stewardship of the environment and its resources. It identifies for us that part of the lifecycle from exploration through to production of basic metal and mineral products for society, from the Earth's crust where the sector has its primary responsibility for stewardship and sustainable development. Inputs and outputs, performance and stewardship responsibilities occur at each stage. Lifecycle linkages and sustainability partnerships can be identified and assessed with manufacturers and consumers, from production through to recycling/reuse and disposal (materials at rest). This involves the flows of physical materials, energy and wealth as well as biodiversity and well-being of the environment, economy and community.

Mineral sector stewardship includes the management of waste rock and tailings, with careful emplacement to ensure containment against deleterious discharges and for possible reuse as future resources. Waste management of discarded products—with sorting and encapsulation of hazardous waste (e.g. radioactive waste from energy sector customers, and old asbestos mine tailings) emplaced 'at rest' in the crust of the earth are a part of a sustainable future for the minerals sector. Such cradle-to-grave lifecycle stewardship is a logical extension of current mineral sector stewardship in water, land and ecosystem management and community collaboration. At every stage, the technology, skills and capital and physical presence already established by the industry can be put to good use.

Eco-efficient mineral production with lifecycle containment of materials and processes provides a focus for evermore sustainable development of mineral resources. This is a vision that should gain acceptance in the community. It is based on avoiding or minimising stress to ecosystems and society from emissions, solid waste, environmental degradation and loss of biodiversity. **If the minerals sector articulates a vision of broad sector stewardship with a sustainability indicator system, it will be a visible part of working for sustainable development for the environment, society and economy.**

Effective indicator systems for sustainable development must be holistic and not based solely on a minerals industry-centred vision, which would look at issues from the perspective of the industry or companies rather than well-being of Australia's community, environment and economy. It would lose sight of the wider minerals sector, which includes governments' management of mineral resources for the benefit of the whole community and the larger socioeconomic and environmental systems within which the industry operates. Indicators based on 'minero-centric' visions cannot win currency with the bureaucracy or the wider community.

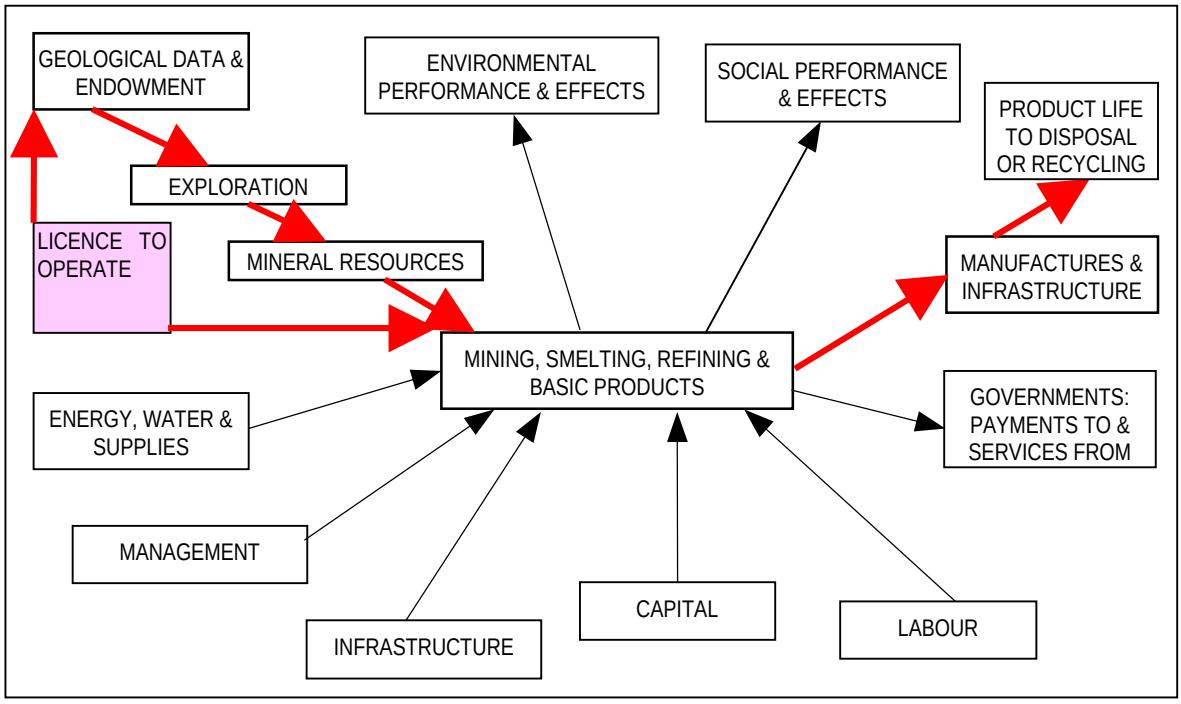
Figure 4: Lifecycle stewardship model for mineral sector sustainable development



A lifecycle-stewardship indicator system for the mineral sector

The indicator system shown in Figure 5 is based on the lifecycle-stewardship model shown in Figure 4 and developed in the AMIRA P496 Project.[30] The system follows the minerals sector lifecycle with flow-through from the community perception and approval (license to operate) to the production of mineral products and the wealth distributed as payments to the factors of production and directly to government for the community. The flow can be interrupted or even prevented at various stages from exploration to development. All the major inputs and outputs of mining, smelting and refining are incorporated as are sustainability partnerships with the community (approvals), manufacturers (mineral products and recycling) and end-users (recycling). Indicators can be selected according to national policy goals and stakeholder interest in the issues.

Figure 5: Lifecycle stewardship indicator system for sustainable development



Licence to operate, that is community perception and approval, is placed in a fundamental position (Figure 5) because it controls both mining approvals and access for exploration through government policy and decision-making. Inputs of mineral resources, energy, supplies and water can be assessed with indicators of eco-efficiency as can emissions that affect environment and society. Inputs of capital, management and labour can be assessed with sustainability indicators based on their rewards as factors of production, level of efficiency (return on capital, wages and productivity) and risks (insurance/investment risk rating and injury levels).

Some important areas of social performance and effects are assessed with indicators that require social surveys, while the more direct social effects of employment and wealth creation for a community, can be assessed with indicators using readily available data.

Sustainability indicators for products and production include revenue, export income and contribution to GDP as well as the effects of the products themselves as they pass through manufacture into goods and infrastructure.

This system brings together the minerals sector lifecycle with the inputs and outputs of sector processes as a part of the larger production lifecycle (Figure 4). Relationships with, and effects on, society and the natural environment can then be seen as a part of overall human activity.

Core Indicators

Core indicators are essential for the major issues of national and international concern. Some possible core indicators are suggested below:

- mineral resources: balance, consumption, additions, $ value (ABS)
- greenhouse gasses: CO_2 equivalents, total and per unit $ value of production
- land under mining lease: total and per cent area, average net earnings and value of production as $/ha
- land disturbed vs. land rehabilitated: total areas, land disturbed per $ value of production
- energy and water consumption: total and per $ value of production
- recycling: per cent mineral products, water and energy (cogeneration)
- community approval rating for both general and environmental performance
- total wealth to Australian community, to governments, suppliers, labour, shareholders, etc. (from ABS, ABARE and MCA data, collated as per Hancock 1993), also net export income
- financial integrity: as after tax return on capital, debt to equity ratio.

Indicators for a lifecycle model to serve the range of sustainability goals

The indicators need to demonstrate performance in four primary goals for the minerals sector, namely:

- Community Approval and awareness—the 'licence to operate'
- Lifecycle containment and stewardship
- Financial viability
- Community well-being.

Examples of such indicators for the main inputs, outputs and stewardship of the minerals sector, a company or an operational site would are given in Appendix 2 and would include core indicators.

Conclusions

Mineral resource development can have a more sustainable future in Australia than in most other countries because of Australia's comparative physical and socioeconomic advantage. However, this advantage has been eroded to some extent and the sustainability of the sector's contribution to Australia is under threat from reduced access, competition for exploration and development from developed and developing countries, uncertainty over native title and the absence of any government policy that drives sustainable development of the sector.

Federal Government leadership is required to develop and pursue a sustainable development policy for the minerals sector. The policy should address the major issues, which include added value inputs and downstream production and a new exploration paradigm to maintain Australia's economic demonstrated resources.

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 Thesis.[31] 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.

Complete agreement amongst stakeholders on what sustainability means for an industry sector is unlikely to exist beyond the broad principles set out by the WCED. However, the debate has moved on to one of how to measure it. Sustainability indicators are needed to assess, communicate and drive the mineral sector's contribution to sustainable development and its own sustainability.

Indicators should not be developed ad hoc by companies as this does not address Australia's national interests. In many indicator development programs globally, differing views on what indicators should be used, and who should select them and monitor performance, have been resolved with a collaborative process led by governments acting as an initiator and facilitator in pursuit of their sustainable development policies. The Canadian experience (see section: Initiatives of other sectors and the Canadian minerals sector, p. 17) and the preliminary research in Australia[32] found that meaningful indicators need to be developed in collaboration with stakeholders within a system that takes a holistic view of the sector within the big picture of the Australian economy, environment

and community. Systems based on a lifecycle-stewardship vision such as outlined in this paper are appropriate for the sector and have been found the most suitable in sustainability indicator development in North America and Europe.

Appendix 1: Summary of Canadian Policy and Principles on Sustainable Development of Minerals and Metals

Canadian Policy on Sustainable Development of Minerals and Metals

The Canadian policy for sustainable development of minerals and metals is sub-titled *'partnerships* ***for sustainable development***'[33] (NRCan 1996*)* reflecting the collaborative approach taken to encompass the socioeconomic and environmental interest of other sectors and the community.

The policy vision is for Canada is 'to be a global leader in sustainable development (SD) in the use of energy, forest and mineral resources—through expertise in natural resource science, technology and economics, and to become recognised nationally and internationally for its contribution to:

- improving resource competitiveness and environmental performance
- formulating principles, practices and a knowledge base for sustainable development of natural resources
- enhancing health and safety of all Canadians.

Policy objectives are:

- integrating SD concept in all federal decision-making on minerals and metals
- ensuring international competitiveness through openness and liberalisation of global trade and investment
- advancing the SD of minerals and metals through partnerships in Canada and with multinational institutions and other countries
- establishing Canada as a global leader in safe use of minerals and metals
- promoting aboriginal involvement in minerals and metals activity
- providing a framework for applying science and technology to enhance industry's environmental stewardship and competitiveness.

Significant areas of policy application will be:

- streamlining environmental regulations for efficiency and performance
- ensuring non-regulatory approaches are considered prior to deciding on new regulations

- encouraging the minerals and metals industry to assume greater responsibility for environmental performance through stewardship of minerals and metals in lifecycle management of processes and products from exploration to recycling and disposal with value-adding

- formulation of criteria and indicators to measure progress towards sustainable development is a priority and to be a collaborative undertaking with all stakeholders—provinces, territories, industry environmental, aboriginal and other community groups

Analysis of Canadian policy and indicator process

The Canadian position is for a closed and insulated flow for all potentially toxic levels of minerals/metals. The Canadian sector sees this as a scientific and economically realistic position. It differs from The Natural Step and European-driven Industrial Ecology which assumes that minerals, and particularly metals, are all toxic at levels above their naturally occurring levels and must not be allowed to accumulate in natural systems.

Statements of Canadian policy principles for sustainable development of mineral resources (NRCan 1996).

Safe Use Principle

The safe use principle is an extension of lifecycle management incorporating risk assessment and risk management principles. It builds on recognition of the two points pertinent to minerals and metals in the Toxic Substances Management Policy:

- naturally occurring substances, such as minerals and metals, cannot be virtually eliminated from the environment

- there are instances where certain products containing minerals and metals, or their uses, because of the associated risks, may be candidates for bans, phase-outs, or virtual elimination of releases from specific anthropogenic sources

The safe use principle recognises:

- minerals, metals, and their products can be produced, used, reused, recycled, and returned to the environment in a manner consistent with sustainable development

- society enjoys important benefits from the use of these natural resources in conjunction with their sound management

- certain mineral-and metal-containing products may pose risks to human health or the environment and, as a consequence, need to be managed throughout their entire lifecycle

- naturally occurring inorganic substances, such as minerals and metals, behave differently from synthetic organic chemicals and, as a consequence, require different risk management approaches

- minerals and metals, in and of themselves, are not candidates for bans, phase-outs, or virtual elimination.

Recycling Principle

Metals recycling, practised since ancient times, embodies the spirit of sustainable development. While virgin materials will remain the primary source of minerals and metals for the growing world demand, recycled materials are an increasingly vital component in the materials supply chain. Recycling extends the efficient use of minerals and metals, reduces pressures on landfills and incinerators, and results in major energy savings relative to the level of energy inputs required to produce metals from primary sources. Recycled materials account for between 30 and 60 per cent of the total world consumption of metals and are a major component in the availability of minerals and metals for future generations as minerals and metals are not 'consumed' in the way other non-renewable resources are. Although it may be years before they are recycled, most minerals and metals remain available for new uses.

International Context

International efforts toward the sound management of minerals and metals are evolving. Traditionally, these substances have been covered under the rubric of chemicals. Canada's perspective is that the international community needs to recognise that minerals and metals possess roles and behaviours in the environment that are often considerably different from that of organic chemicals. Canada will seek to ensure implementation of international regulatory and related approaches for managing products and materials that exhibit risk factors of concern while allowing for the safe production, transportation, use, reuse, recycling, or disposal of mineral and metal products and raw materials.

Appendix 2: Range of indicators to be considered for indicator system

Community approval of industry/company/operational site

- environmental and general approval rating, traditional ranking method, percentage basis
- number of operational collaborative bodies
- level of contact with media and opinion leaders
- level of protest and complaint.

Exploration

- percentage of area of land under different land classifications with levels of exclusion and/or difficulty of access for exploration
- exploration approvals vs. applications made
- resource discoveries per exploration dollars per year
- exploration expenditure in Australia vs. exploration expenditure overseas by Australian companies.

Mineral resources

- balance of demonstrated economic resources including reserves, resources extracted vs. resources added per year
- resources sterilised (otherwise economic) by conservation land-use, past mining practices and infrastructure.

Mining

- number of approvals to proceed and time span for approval process
- operating and capital costs per unit of production.

Non-mineral resource inputs

- water, energy and supplies in total and per unit of production/production value
- percentage of water recycled and energy from cogeneration.

Management

- EMS, EMAS, ISO certification and other audit outcomes

- environmental and OH&S incident level
- fines and exceedences
- research and technology transfer as added value and objectives achieved
- corporate/employee environmental awareness and community sensitivity level
- pro-active environmental and community awareness training, employees per year.

Infrastructure

- present and post-mining (non-mining use) value of infrastructure provided

Capital and financial integrity

- after-tax rate of return on capital.
- capital cost per unit of production
- capital risk rating of a mining project and of mining countries
- debt to equity ratio

Labour

- percentage employment in the sector
- average and total wages
- risks to employees as number of lost time injury per million hours worked, fatality levels
- labour unrest as days lost by stoppages per 1 000 employees
- gender and ethnic equity in employment as a proportion of the population of the country.

Payments to government

- payments as percentage of industry/company revenue; royalties, all taxes and fees.

Products and production

- revenue level, export income and per cent contribution to GNP
- product/commodity life while in use, per cent recycled
- toxicity levels and effects of products

- level of product advice to manufacturers and users.

Environmental performance and effects

- emissions to air, and particularly GHG emissions, total and per unit/$ value production
- emissions to water, total and per unit/$ value production
- solid waste transported off-site, total and per unit/$ value production
- land rehabilitated vs. land disturbed, land under mining, area and per cent
- water efficiency coefficient to assess rehabilitation, ecosystem establishment
- proportion of original species in rehabilitated area
- introduction/eradication of noxious species
- change in wilderness value in vicinity of mine sites and access corridors
- effect on water tables, fall in bore levels/water table
- radioactive discharges.

Social performance and effects

Large projects do have socioeconomic effects on local and regional communities. The sustainability of the community may, as a consequence, be increased or decreased, and in turn affect the sustainability of the project. Effective indicators demonstrate risks to establishment and sustainability of proposed projects and can provide early warning signals for existing operations.

Indicators for direct social effects and issues are readily constructed and applied e.g:

- change in level of wealth into community
- changes in average household income
- 'jobs', employment provided
- non-mining economic activity that will continue after mine closure
- changes in community facilities, health and education level
- population increase (due to workforce, economic multiplier and attraction effect).

Indicators for indirect social effects and issues are more difficult to construct. Because the effects are less visible, they are more likely to cause unforeseen failure for mining projects and communities. Indicators for these are therefore more important. Indirect indicators fall into two categories:

1. **Indicators of social organisation** that give structure to community life and show how the community will respond to changes:

- diversity and complexity
- distribution (equity) of resources and power
- personal interaction
- outside linkages
- coordination and collaboration with the mineral project and the local organisations.

2. Indicators of social well-being:

- rates of behaviour: crime, divorce, violence (aggregate and per capita)
- access to resources: green space, clean air and water, transport, community facilities (aggregate and per capita)
- perceptions of community and individual well-being: by survey e.g. same, better, worse

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