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Part III: Challenges

Chapter 11 A Life-Cycle Approach to Using Minerals

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Chapter 11: A Life-Cycle Approach to Using Minerals

For the minerals sector to contribute fully to sustainable development, the use of materials and the downstream supply chain must be considered along with mining and mineral processing activities.[1] *Agenda 21*, the blueprint for action agreed to at the Earth Summit in 1992, acknowledged the importance of taking the whole product life cycle into account. It drew attention to the need to focus public policy on 'the demand for natural resources…and…the efficient use of those resources consistent with the goal of minimizing depletion and reducing pollution'.[2] In the mining and minerals sector, taking such a 'cradle to grave' approach is particularly challenging because there is little connection between the production and use of minerals. Even if mineral users realize that the material in their hands originated in a mine, they are generally unaware of its geographical origin or how it became incorporated into a product. The diversity of the sector – as well as the vast and ever-increasing range of applications for mineral commodities – adds to this challenge. (See Chapter 2.)

Like other stages along the life cycle, the use of mineral products has implications for the economic, social, and environmental dimensions of sustainable development. Minerals play an important role in meeting basic human needs and in enabling modern society to function effectively (see Chapter 4), but as noted throughout this report, there are environmental costs or health risks associated with their use.

Until now, much of the concern, policy, and regulation regarding the use of mineral commodities has focused on environmental issues, on health risks associated with use, and on physical measures of the long-run availability of mineral resources. A number of conceptual tools aimed at increasing the efficiency of minerals use and calculating optimal levels of use have been developed to this end. But the social and economic dimensions of current use and of potential future changes are generally not given equal consideration. A life-cycle approach to using minerals includes all dimensions of sustainable development. This is a particular challenge for the whole minerals sector, including mining companies. A PricewaterhouseCoopers survey of 32 mining companies undertaken for MMSD found that only 68% of respondents suggested that life-cycle issues were part of their company's understanding of sustainable development. (In contrast, 97% of them considered the impact of mining on people and local communities to be part of sustainable development.)[3]

To ensure that the level and patterns of use of mineral products are better aligned with sustainable development, stronger linkages need to be made between production and use. Life-cycle approaches – including market-based instruments, appropriate regulation, and more effective supply chain management – are key to this. Responsibilities for reducing the negative impacts as well as associated costs need to be shared among actors and along the supply chain. This applies to costs incurred not just in use but throughout the whole supply chain.

To address concerns about equity of access to mineral resources, 'wasteful' consumption, and environmental impacts, the use of primary sources of minerals must be managed more effectively through, for example, recycling, better product design, and re-manufacture. Yet decisions to reduce dependence on primary minerals (those produced from the natural resource stock) need to consider the impacts on, for instance, people whose livelihoods depend on extracting such resources.

The environmental and health impacts of the use of different mineral products need to be understood. Responsibilities for this can again be better apportioned in the context of a life-cycle approach. Where mineral products have potential risks associated with their use, the precautionary principle should apply.

Connecting Production with Use

Despite the strength of opinion concerning the performance of the mining and mineral processing industry, most people have little or no idea about the origin of minerals or how they are produced. Environmentally motivated consumers who buy a new vehicle or electrical appliance are more likely to be interested in energy efficiency and pollution potential than in any effects of resource extraction. This bias is reflected in eco-labelling schemes for products containing metals, such as refrigerators and washing machines, as the labels (perhaps sensibly) tend to concentrate on energy efficiency.

Traditionally, mining companies have been separated from direct contact with intermediate and final consumers by the way in which minerals are traded. (See Chapter 2.) From the perspective of the user, most mineral commodities are at least as anonymous as other materials, including glass and plastics. The contrast between the mineral and oil industries is striking. Unlike the former, the fuel products of the latter are usually associated with a logo that is identifiable all the way back to exploration. The metals in many products are likely to originate from numerous parts of the world, often remote from where they are used. And one product or batch of products could include metals from many different mining operations as well as from recycled sources. For most products, minerals from different sources can be used interchangeably. Furthermore, minerals often form a small, albeit important, component of the finished product. The product itself has impacts (such as through energy use) that may be greater and easier to quantify than those at the point of mineral production.

Although the supply chain for locally traded mineral products may not be as complex as globally traded ones, even at this scale there are often multiple suppliers and a mixing of materials from different sources. The main exception to this is where quarrying is undertaken to develop a particular item of infrastructure, such as a road or railway.

Supply Chain Management

The link between the production and use of minerals can be improved through more effective supply chain management. Strengthening the relationships among companies within the chain can help one company exert pressure on others or improve business practices between them and thus reduce negative effects.

The need to address the connections among firms is increased by the current trend to outsource jobs as a means of reducing costs, which gives rise to increasingly complex interdependencies between firms. Globalization is also leading to new relationships among companies in the supply chain.[4] In the last decade, there have been numerous cases of companies exerting pressure on upstream suppliers of materials to improve performance.

Examples include the environmental and social standards set by large buyers of forest products and textiles.[5]

The introduction of such supply chain measures flows in part from the growing need for companies close to the consumer to take responsibility for both upstream and downstream impacts. In many industrial countries, this is partly driven by 'take-back' and other environmental legislation.

In the minerals sector, most firms remain more concerned about the environmental performance of their immediate suppliers than the source of the minerals used in their products. Yet a few recent cases illustrate how concern about the conditions of extraction of a certain mineral in a specific location can lead manufacturers and users to exert pressure on producers to certify their means of production.

In 2001, concern over the impacts of coltan production in the Democratic Republic of Congo led to pressure from the World Conservation Union and other groups for buyers to avoid this source.[6] Coltan is a mineral used as a metal-hardening agent in electronics applications such as capacitors. It is incorporated into numerous electronic products, including mobile telephones. Concerns about its use are related to the health effects associated with extraction, the harm being inflicted on protected areas and on certain species of animal, and the financing of armed conflict in the region. (See Chapter 10.) Similarly, concern over the use of diamonds to finance the activities of various rebel movements in countries such as Sierra Leone and Angola has led other diamond producers and manufacturers, with assistance from third parties, to certify the origin of their diamonds. (See Box 11–1.)

These cases also demonstrate how the reputation of one part of the supply chain can become tarnished by the action of another. What remains to be established is the extent to which this type of pressure could work for minerals more broadly. For example, the Kimberley Process for diamond certification relates to armed conflict in a specific region and not the whole process of diamond production. In addition, the non-industrial uses of diamonds are associated with strong emotions that are not found concerning many other minerals. Currently, there is no commonly accepted system for manufacturers and other users of minerals to assess the overall performance of the mining and processing stages. This is partly because impacts of different mineral reserves or means of production are hard to describe, much less measure. Although it is difficult to trace a mineral from a particular mine through to the shop shelf, interest is gathering in the potential for a more broad-reaching system of verification for the minerals sector, similar to schemes in other sectors. In the forestry sector, for example, the certification schemes administered by the Forest Stewardship Council (FSC) and others have been adopted by a number of buyers as a requirement for doing business.[7]

Box 11-1. Evolution of a Diamond Certification System

Certification schemes are increasingly being developed and used to secure 'a chain of custody' between producer and final end use markets. In the diamond industry, certification has been introduced to deal with the problem of conflict diamonds to ensure a system is in place that can audit and verify by country of origin the passage of diamonds from mine extraction through to their entry into the legitimate diamond economy.

Growing concern over the links between armed conflict and the diamond trade has led to an emerging consensus between governments, NGOs, the UN and the industry for the need to introduce a coordinated system of regulation and self-regulation to address this problem. The Kimberley process embodies this approach by seeking to establish a minimum level of acceptable international standards for national certification schemes for the import and export of rough diamonds. It also aims to systematise the exchange of information on transactions between importers and exporters.

Specifically, the proposed scheme involves:

1) A certificate of origin for each shipment of rough diamonds, with agreed minimum standards of information present
2) An accredited office to handle the import and export of rough diamonds
3) Internal regulatory controls designed to eliminate the presence of conflict diamonds
4) The establishment of an international statistical database recording and analysing the production, export and import data for rough diamonds
5) The establishment of a Kimberley Process Secretariat
6) The establishment of an effective monitoring mechanism
7) The issuing of warranties by the diamond trade which are independently verified by auditors with government oversight

While measures like these to distinguish legitimate stones and prevent the illegal diamond trade are widely endorsed, including a recent Conflict Diamond Bill passed through the U.S. House in December 2001, questions remain over the efficacy of such measures to combat illicit diamond smuggling and the strength of compliance, verification and monitoring systems. There are also concerns over the ability to implement a workable system that takes into account the different control and export regimes of producer countries. To date the Kimberley process is seen to have failed to resolve these issues, though it is hoped these will be addressed at the next meeting in March 2002 in Ottawa. Following further endorsement by the UN General Assembly it is proposed that the Agreement be strengthened through the passing of a UN Security Council resolution in 2003.

Source: Personal communication, Alex Yearsley, Global Witness, February 2002; Global Witness (2000); MMSD (2001).

A number of models for modelling the supply chain are being developed for the minerals sector at the regional or company level. In Australia, the World Wide Fund for Nature is building on its experience with the FSC and investigating the feasibility of a system of independent certification on the environmental and social management performance of mine sites in the South Pacific.[8] Certification can help reassure downstream users that a certain standard is being met, or can distinguish between different levels of performance. Still, there remain considerable challenges in applying this to the complex and diverse supply chains for minerals. On the other hand, it should be noted that some companies are already attempting to distinguish their mineral products on environmental criteria: in

Brazil, the Plantar company is promoting 'green' pig iron smelted with charcoal originating from forests certified by the FSC.[9]

The complexity of the minerals supply chain may mean that in many cases pressure for performance verification from institutions financing mining operations will prove more effective than downstream supply pressures. (See Chapter 6.)

There are additional challenges associated with using supply chain pressures to drive environmental or social improvements in the sector:

- Standards set by large multinational companies and their customers may not be sensitive to the interests of smaller producers or their ability to conform. The setting of standards may therefore have a negative impact on small producers by excluding them from certain markets.[10]
- Dialogue will need to be developed among groups that may traditionally have regarded themselves as remote from one another along the supply chain.
- There is also a need to share the costs and benefits of improved performance. In the timber sector, for example, it has often been those at the beginning of the supply chain that bear the cost of improvements, while buyers reap the financial benefits.[11]

Product Stewardship

The term 'product stewardship' describes the shared responsibility that those with control over the life cycle of a product – including producers, manufacturers, retailers, users, recyclers, and waste managers – have for any costs associated with negative impacts and for reducing these impacts. Product stewardship is borne of the belief that without serious commitment from parts of the supply chain, significant progress cannot be made towards managing products in accordance with sustainable development.[12] This overlaps with the notion of 'extended producer responsibility', which so far has been largely focused on the responsibilities of individual manufacturers for products at the end of their life.[13] This provides a useful way for government and other actors to devise tools and incentives and to assign responsibilities for waste prevention and appropriate product design, and to further encourage recycling, re-manufacture, or re-use.[14]

To date, product stewardship initiatives undertaken by companies producing or using mineral commodities have focused mainly on the end of a product's life. (See Box 11–2.)

Box 11–2. Examples of Product Stewardship Activities

Collect NiCad is a non-profit association that represents European producers and importers of nickel-cadmium batteries as well as manufacturers that use batteries in their products. Collect NiCad runs a scheme to support and promote the development of collection and recycling programmes for spent batteries as an alternative to disposal in landfills. This involves collection of data on battery recycling and research on economic instruments to achieve better recovery rates. The work of Collect NiCad contributed to the recovery of 521 tonnes of the 1994 tonnes of cadmium used in Western Europe in 2000 (representing over 340 million batteries).

Box 11–2. Examples of Product Stewardship Activities (continued)

Collect NiCad hopes that its success will stop a proposal to ban NiCad batteries within the European Union (EU) by 2008. The scheme also hopes to benefit from the proposed Waste Electronic and Electrical Equipment Directive in Europe, which will make it easier to collect batteries from electronic products.

In resource efficiency terms, the main benefit of the scheme is the increased responsibility of industry for take-back, which should encourage innovation in battery design, collection, and recycling. On the other hand, it is important that the capacity to recycle is not used as the sole basis for decisions that simply increase the number of batteries in use without taking into account other environmental effects and alternative materials.

A similar initiative is managed by industry through the Rechargeable Battery Recycling Corporation in the United States and the Battery Association of Japan.

In 1984, Canadian-based metal producer Noranda acquired Micro Metallics Corporation (MMC), a supplier of recyclable materials based in San Jose, California. MMC offers secure processing of high-grade electronic scrap, including scrap from production of integrated circuits, circuit boards, and components salvaged from end-of-life electronic equipment. Noranda subsequently built a similar facility in East Providence, Rhode Island.

Noranda started a strategic alliance with global IT company Hewlett-Packard (HP). HP was a pioneer in asset recovery from obsolete electronic products but was unable to achieve an ambitious goal of eliminating waste. HP and MMC have worked since 1997 to increase materials recovery, expand the volume of material processed, and reduce costs at an HP facility in Roseville, California, that is now operated by MMC. HP sources material resulting from its own production processes and markets recovered components, while MMC sources external feeds and markets recovered materials. The Roseville facility extends Noranda's recycling activities to include a wide range of end-of-life electronic products. The cost of processing the low-grade mixture of metallic and non-metallic materials still exceeds the value of the recovered materials. Noranda smelts the copper and precious metals fraction in Canada. All other materials recovered are sold in the US.

In 2001, HP expanded its Planet Partners programme, offering a recycling service to all US consumers of HP or other electronic products. HP and Noranda built a facility for this in LaVergne, Tennessee.

Source: http://www.collectnicad.org/index_flash.html; Personal communication, L. Surges, Noranda.

Through engagement with stakeholders from outside industry, the Non-Ferrous Metals Consultative Forum on Sustainable Development is working towards more effective stewardship of this group of metals and their uses. (See Box 11–3.) Although the product stewardship activities of the forum are currently general in scope, the effective implementation of these suggestions presents a considerable challenge for all involved in the life cycle of non-ferrous metal products. The forum is seeking to identify real product stewardship issues to be resolved and to work towards addressing these on a pilot basis. Similar processes are needed to encourage and understand the implications of product stewardship for other mineral commodities.

To arrive at a balanced system, industry must also extend product stewardship principles to include choices between materials, including from where and how they are obtained. Information needs to be freely available to interested parties in a way that allows dialogue and feedback. (The need for reporting is discussed in Chapter 12.)

Box 11–3. Non-Ferrous Metals Consultative Forum on Sustainable Development

In September 2000, the member countries of three International Non-Ferrous Metals Study Groups organized the first Non-Ferrous Metals Consultative Forum on Sustainable Development. The forum was convened to build on the outcomes of a Workshop on Sustainable Development held in London in November 1999. The workshop had identified the need for activities that promote the production, use, re-use, and recycling of efficient, effective, durable, and environmentally sound materials. The forum then identified action items that could be achieved with support from governments, multilateral institutions, industry, and NGOs. Participants were given the task of developing the components of an action plan and its implementation, for consideration by member countries of the Study Groups and others. The plan included product stewardship programmes for non-ferrous metals, the promotion of recycling by better design of products and collection schemes, product design to ensure correct use and lowest risk of harm to human health or the environment, and open and transparent mechanisms to improve communication among stakeholders.

To address these and other issues, three multistakeholder Working Groups were established:

- Production of Non-Ferrous Metals (addressing sustainable development drivers and community engagement);
- Product Stewardship (addressing a product stewardship scheme for the non-ferrous metals industry and recycling technology transfer); and
- Science, Research, and Development (addressing sustainable development initiatives, risk assessment, Life Cycle Assessment and science networking).

Each Working Group is cochaired by representatives from government, industry, and civil society. Secretariat support is provided by the Study Groups. Currently, 13 countries (including the EU), 15 industry associations, 25 companies, 15 NGOs and academics, and 3 international organizations are actively participating in the groups.

Source: www.nfmsd.org.

Life-Cycle Assessment

Life-cycle assessment (LCA) involves measurement and appraisal of the environmental impacts of products from the beginning to the end of their life. It is a tool for supporting decisions concerning the reduction of these impacts. LCA has been developed and promoted by the UN Environment Programme/Society for Environmental Toxicology and Chemistry (UNEP/SETAC) Life Cycle Initiative, and the methods involved have been standardized under the ISO 14000 series.[15]

LCA use has been driven by three main pressures thus far. One has been public policy, requiring firms to assess their products or to justify the materials and production processes that they use. The second pressure has come from market competition in cases where substitution between materials has been possible. Third has been companies seeking to improve the efficiency and reduce the environmental impacts of their production processes. All these drivers are likely to increase in the future and to lead to the integration of decisions about the use and means of production of mineral products. LCA also has a wide set of broader potential applications, including helping governments to develop product-related policy and assisting NGOs concerned with the social and economic impacts of products and the materials and methods by which they are made.

At an MMSD workshop on LCA held in New York in August 2001, a number of possible uses of LCA for the minerals sector were considered: [16]

- to look at the environmental impacts in both minerals-producing and minerals-consuming economies, including the differences in the environmental burdens carried by industrial and developing countries;
- to help metal fabricators and manufacturers using mineral commodities understand the life cycle of mined products;
- to enhance the quality of supply chain management;
- to aid policy development, such as the Integrated Product Policy proposed by the European Union;[17]
- to support recycling initiatives, including the siting of facilities such as secondary smelters; and
- to determine which ore body to exploit using which technology.

The MMSD workshop identified several challenges that must be overcome, however, in applying LCA to minerals if it is to be an effective tool. First, although LCA is based on scientific understanding, it incorporates a number of value judgements. For example, the selection of environmental impact parameters to be considered will affect the assessment of the product or process. For minerals, there is uncertainty over the specification and integration of impact categories, the relative importance of different environmental impacts, and the boundaries of impacts over both time and space. Metals do not degrade, for example, so it is not appropriate to express the eco-toxicity of metals in terms of persistence, which is how a standard LCA works. The International Council on Mining & Metals (ICMM) is starting work with UNEP/SETAC and other organizations on improving the LCA methodologies related to metals.

A second set of difficulties relates to the lack of information and data available to undertake a mineral-specific LCA. This is compounded by the complexity of the value chain associated with mineral commodities. Finally, LCA only delivers an understanding of the potential environmental impacts. So for decision-making both within and outside the minerals industry, LCA should be only one component in a 'toolbox' required to make decisions in line with sustainable development objectives. It may be appropriate to assess social and economic impacts alongside an LCA, or after it has been completed.

Much more consideration should be given to the meaningful participation in LCA of all groups with an interest in decision-making about a product, process, or service. This includes those in developing and minerals-producing countries. It should go far beyond being a product defence tool for existing applications of metals, in which internal and non-attributable data are used. LCA calculations must be transparent and incorporate the viewpoints of all stakeholders. When applied to production processes, this tool must not be used to unduly favour the modern manufacturing plants in some countries, without taking into account other economic and social considerations.

LCA can inform policy development and become integral to the regulatory process itself. The notion of integrated product policy involves a shift in emphasis in environmental policy from solely evaluating wastes and emissions during manufacturing to consideration of the total environmental impacts caused by a product. The proposed EU Integrated Product Policy suggests that LCA is one part of the generation and collation of information on the environmental impacts of products.

It has also allowed consideration of the service life of products as well as the extent to which their component materials can be recycled. LCA initiated by industry has improved the quality of information available and thus facilitated a more holistic, realistic view of environmental objectives for sustainable development and the policies to achieve them.

Yet there are reservations about LCA's role in the policy development arena: there is a lack of consistent methodologies and data sets, a great complexity in defining indicators for sustainable development (and therefore in defining a 'sustainable product'), and difficulties in integrating social and economic indicators with environmental ones.

Pricing to Reflect True Costs

In a well-functioning market economy, the price paid for a mineral – as for any other good or service – should reflect the full marginal costs of both production and consumption. For the minerals sector, as for many others, this is currently not the case. In particular, the prices paid by users of minerals do not reflect the environmental and social costs incurred at all stages of the mineral life cycle, including environmental damage and social disruption in mining as well as pollution from processing and waste following use. There are many reasons why markets largely fail to reflect such costs, and many potential responses.[18] Ultimately what is required is a framework of regulations, property rights, liability regimes and market incentives that will lead producers, traders and consumers of minerals to "internalize" these environmental and social damages in their economic decisions. An important first step is to improve information on the extent and nature of these non-market costs, so that private and public decision-makers can craft appropriate responses.

Sufficiency, Efficiency, Equity, and Use

Concerns over Material Throughputs

In recent years, there have been growing calls by environmentalists for a reduction in the material throughputs that are demanded by many national economies, particularly in industrial countries.[19] (See Chapter 2 for data on production and consumption.) Numerous concepts have been developed in order to highlight current levels of dependence on natural resource throughputs, their link to economic output, and geographical imbalances in resource use. (See Table 11–1.) They apply to products, people, or countries. The statistics that arise from some are striking. For instance, the

Wuppertal Institute has estimated that 1kg of copper carries an 'ecological rucksack' of 500kg of natural resources (including water and air) that are used and transformed during its life cycle.[20] Similarly, in order to meet the global environmental and equity targets derived from the concept of environmental space, Friends of the Earth Europe proposes that the consumption of metals such as aluminium per European resident will need to be cut by nearly 90% over the next half-century.[21] Calls such as this challenge all associated with the supply chain of minerals: mining and minerals processing companies, governments (in both producing and consuming regions), manufacturers, those involved in the recycling industry, and others.

Table 11–1. Measures, Principles, and Targets for Resource Efficiency That Could be Applied to Mineral Commodities

Name	Origin(s)	Measure
Environmental Space[a]	Friends of the Earth Europe; Wuppertal Institute (Germany)	The amount of natural resources that can be used per capita without exceeding the carrying capacity of the planet or impinging on the rights of all members of present or future generations to have a equitable access to these resources.
Ecological Rucksack	F. Schmidt-Bleek, Wuppertal Institute	Total weight of natural material that is disturbed in its natural setting or is 'carried' in order to generate a product, minus the weight of the product itself.
Material Intensity Per Unit Service	F. Schmidt-Bleek, Wuppertal Institute	Material input (including that associated with energy transformation) per total unit of services delivered by a product over its useful life span.
Ecological Footprint	W. Rees, University of British Columbia (Canada)	The area of land and water required to produce the resources used, and to assimilate the wastes produced, by an individual or population at a specified material standard of living.
Total Material Requirement[b]	World Resources Institute (WRI)	The sum of total material input, including hidden or indirect flows caused by economic activity within a country.
		Principle
The Natural Step		Stability with regard to human influence on the 'ecosphere', fair use of resources with respect to meeting human needs.
		Targets
Environmental Space	Friends of the Earth Europe; Wuppertal Institute (Germany)	A series of targets for the reduction in resource throughputs (per capita) in Europe, based on the Environmental Space measure to be achieved by 2010 and 2030.
Factor Four	E.U. von Weizsäcker (Wuppertal Institute) and A. Lovins	Industrial countries should use energy, water, materials, and mobility four times as efficiently so as to increase wealth in developing countries by a factor of four without additional resource use, and stabilize wealth in industrial countries while reducing resource use by a factor of four.
Factor Ten	F. Schmidt-Bleek, Wuppertal Institute	Industrial countries will have to invent ways to generate wealth with some 10% of their present consumption in order to let the 'poorer' nations claim their fair share of resources and still halve the world-wide total flow of natural resources.

[a]Preceded by the 'eco-scope' concept, promoted by the Dutch government and developed by other Dutch organizations. [b]One of a group of measures for materials cycles developed by World Resources Institute.
Source: http://www.foeeurope.org/sustainability/foeapproach/espace/t-frame-espace.htm; http://www.factor10-institute.org/MIPS.pdf; Wackernagel and Rees (1996); Matthews (2000); von Weizsäcker et al. (1997).

The concepts, principles, and targets in Table 11–1 are mostly based on the view that current levels of dependence on natural resources are exceeding Earth's carrying capacity in the biophysical sense. For at least some aspects of mining and minerals processing, such as the contribution of activities to climate change, the concern is sufficient to be a matter of government policy. (See Chapter 10.) But other concerns are far more controversial. For example, many argue that the mass of wastes associated with minerals production is not an accurate guide to the resultant environmental effects, as these depend on their characteristics and how they are managed.

Obviously the intensity of use of mineral commodities can change as a result of factors unrelated to resource efficiency.[22] Patterns of minerals use depend on the stage of development – particularly in respect of infrastructure requirements. The World Resources Institute has examined materials flows in a group of industrial countries (Netherlands, Japan, Austria, Germany, and the US) over the last 25 years.[23] The results show that overall resource use and outputs of waste to the environment in these countries are increasing in absolute terms. The rate of increase has, however, been less than that of economic growth, due in part to changes in the intensity of use of materials. But WRI's findings do indicate that if impacts are to be reduced, greater efforts towards resource efficiency in the industrial countries are required.

Resource efficiency can be increased in numerous ways, some of which may be ranked according to their relative environmental impact.[24] (Table 11–2.) Others, such as substitution between materials, do not fit easily into this order. The substitution of one mineral for another is, however, often controversial and must be based on rigorous life-cycle assessment, as well as tools to evaluate social and economic implications of this.

Table 11–2. A Materials Efficiency Hierarchy Applied to Mineral Commodities

Class	Practice	Benefits	Status with regard to mineral commodities
Recovery	Recycling	Avoids primary resource extraction and associated environmental impacts	Subject of a long-established industry. Dispersion and complexity of old scrap a key limitation. Also price largely determined by that of the equivalent primary material.
Extended Product Life	Product and component re-manufacture Repair and re-use	Avoids manufacturing new products and resource use for recycling More service from each product, reducing resource use per unit of service	Undertaken for some product groups (such as vehicle parts), but re-manufacture for other groups (such as electronics) a key challenge, given the rate of technological change.
Increased Intensity of Product Use	More intensive product use Product sharing/ lending/ leasing	Reduces resource use per unit of service Reduces number of items produced and may assist those who could not otherwise afford use of the product	Materials science being used to make products more durable (metals, construction minerals).

Table 11–2. A Materials Efficiency Hierarchy Applied to Mineral Commodities (cont.)			
Avoidance of Use	Product redefinition, service rather than product Voluntary simplicity/self-sufficiency Redesign of systems (buildings, urban planning, transport)	Cuts resource use per unit of service Avoids product purchase Could eliminate groups of products and wastes	Policies to prevent use for resource efficiency motives largely un-adopted. Some metals banned due to certain views on their inherent toxicity, or the risk of harm associated with their use in products or upon disposal.

Source: Adapted from Young (2000).

In pure resource efficiency terms, the benefits of recycling, are clear, as noted by the US Geological Survey: 'One metric tonne of electronic scrap contains more gold than that recovered from 17 tonnes of gold ore.'[25] But across all the minerals, recycling may not be the answer. It is important to consider associated costs, such as the environmental costs of transporting recycled products or even some would argue the loss of employment in production from avoidance of use. (See below.)

In effect there are complex trade offs that have to be weighed together. In the end they can only be resolved by public policy decisions and even then they will be complex because they have implications for the trade rules and international relations. MMSD has not attempted to go into these complex issues in any depth. But some key points have emerged in the MMSD discussions around the issue:

- Mining and minerals processing and recycling provide an important source of livelihoods that support whole communities and national economies. They have to be considered in the policy mix.
- Concerns about long-run availability must be dealt with alongside questions of present human need and questions of equity in availability matter.
- Mandated change – if it is to be enforced (and be enforceable under the current trade rules) – must be implemented over a time frame sufficient to enable producer countries to adapt.
- The use of metals may have implications for the efficiency of other materials and energy use (and vice versa). For instance, reducing the amount of copper used in an electric motor may make it less energy-efficient. (See Box 11–4.) Optimized resource efficiency requires careful analysis.

Box 11–4. Energy Efficiency Linked to Greater Copper Use
Although electricity suppliers may purchase less copper for generators, this should be more than offset by electricity-saving devices that use more copper. The main opportunities to market more copper to help save electricity include: • *motors* – the most efficient models use at least 20% more copper per kW than old ones; • *interior distribution wiring* – increasing wire diameter cuts resistive losses, so in a new installation the extra copper typically pays for itself in less than a year and it can even make sense to retrofit; • *pipes* – since friction falls in a pipe as diameter increases, there is a strong economic incentive to specify larger pipes; • *heat exchangers* – increasing the surface area of heat-exchangers also increases capacity; and • *lighting* – retrofitting old fluorescent lighting systems with more energy-efficient systems typically involves replaces aluminium with copper wiring. Source: Lovins et al. (2002).

Given these considerations, it is important to determine how businesses and governments can respond most appropriately to resource efficiency considerations and the associated targets.

Business Responses

The overall framework for business responses to concerns about resource efficiency is 'eco-efficiency' – improving business competitiveness while simultaneously reducing pollution and resource use. The World Business Council for Sustainable Development (WBCSD), which coined this term, has suggested a series of principles for businesses aiming to increase their eco-efficiency. (See Table 11–3.)

Table 11–3. WBCSD Eco-efficiency Principles, with Key Considerations Regarding Mineral Commodities

WBCSD eco-efficiency principle	Key consideration for mineral commodities
Reduce the material intensity of goods and services	The amount of waste material associated with mining and minerals processing is as important a consideration as the amount of material actually used in a product.
Reduce the energy intensity of goods and services	Primary and recycled sources of some mineral commodities require very different amounts of energy; the quantity of energy used should inform decisions on primary versus recycled material. The use of some metals may increase the efficiency of a product by making the product lighter (aluminium versus steel in cars) or more energy-efficient (such as use of more copper in wiring or motors).
Reduce the dispersion of any toxic materials	This should include not only toxic releases associated with product manufacture, use, and disposal but also toxic materials associated with mining and minerals processing operations. The balance between risk precaution should take into account the views of all stakeholders.
Enhance the 'recyclability' of materials	All metals are 100% recyclable in theory: the key is in the economics of recycling and a thorough assessment of the environmental and social benefits and drawbacks.

Table 11–3. WBCSD Eco-efficiency Principles, with Key Considerations Regarding Mineral Commodities (continued)	
Maximize the sustainable use of renewable resources	Although mineral resources are not renewable, minerals in products are not always easily substitutable with other materials.
Extend the durability of products and increase the service intensity of goods and services	The durability of products can be enhanced by the use of minerals – for example, by means of specialized metal alloys or industrial minerals to coat paper. Durability is not always an appropriate criterion, such as where it decreases the potential for recycling. Instead, durability and service intensity should give priority to the design of products for re-manufacture and easy maintenance.
Source: World Business Council for Sustainable Development (1996).	

The business case for eco-efficiency has been outlined by numerous organizations, including WBCSD, the Rocky Mountain Institute (RMI), and The Natural Step.[26] These groups provide examples of how businesses have succeeded in achieving radically more efficient use of natural resources while maintaining a profit.[27]

RMI has promoted a strategic framework, under the title of 'natural capitalism', of far-reaching innovation.[28] The approach calls for major shifts in business practices so as to acknowledge the true economic value of services derived from the natural environment. The concept is rooted in the notion that the most efficient and therefore profitable industrial processes should be regarded as those that are integrated in a way that has inputs and outputs (including wastes) flowing continuously.

Over the last few decades, competition and other commercial pressures have lead to significant changes in the resource efficiency of products, including the processes by which they are made. In the US, for example, aluminium cans on average now weigh more than 40% less than in 1985.[29] And an office building that needed 100,000 tonnes of steel 30 years ago can now be built with no more than 35,000 tonnes because of improvements in steel technology and architectural design.[30] Efficiency gains have also been made by the development of new materials, including advanced metal alloys.

Government Responses

In 1997, the governments of the world called for consideration of increased resource efficiency by a factor of 4 to 10 over the next two to three decades.[31] Individual governments of some industrial countries have made commitments for resource efficiency in addition to waste recovery targets. In 2001, the UK government noted that 'greater resource productivity offers significant benefits not only to the environment but also to business. New methods which make use of fewer resources and minimize waste point the way to an economy that will in the future be radically different from the resource intensive, and often hugely wasteful, economies of the past.'[32] Local governments also play a key role in deciding on specific priorities and goals for resource efficiency.

Governments have a role in setting the policy framework within which businesses pursue resource efficiency for mineral commodities. The practice of eco-efficiency can be either facilitated or blocked by the environmental and product policies of national governments.

The Organisation for Economic Co-operation and Development (OECD) has assessed the implications of eco-efficiency for national policy among its members and found that policy instruments that increase incentives for firms to identify and act on environmental-commercial synergies are key.[33] Within governments, there is a need for better integration among departments so that appropriate resource efficiency policies can be complementary and effectively implemented.[34]

The introduction of market-based instruments can provide an effective and cost-efficient means of stimulating innovation in resource efficiency as well as in reducing other costs throughout the life cycle. In some cases, they may be preferable to conventional 'command-and-control' regulations that rely on uniform standards and provide no incentive to go beyond compliance. Governments are increasingly using such incentives to achieve environmental and social goals. An example of a simple market-based tool is the deposit refund on aluminium cans to encourage recycling in the US, Canada, and Australia. Although the prime motive for many of these schemes is waste management, they could feasibly be extended to consider the costs of production. Creating the incentives for innovation of recycling and re-manufacture is critical.

A wider role of government is that of education and public information sharing. Governments need to provide information to companies, the public, and others on resource use; options for reducing it in line with sustainable development objectives; and existing resource efficiency activities such as recycling. (See Chapter 12.)

Public authorities at all levels have a key role to play in practising resource efficiency for mineral commodities. In the most industrialized parts of the world, it is estimated that government activities alone are responsible for up to 15% of gross domestic product, thereby having a significant potential to stimulate market demand for products designed with resource efficiency in mind.[35] In mining related sectors this can be even higher. The parallel WBCSD study on cement estimates that some 40% of total demand is for public procurement.[36] Procurement policies based on environmental considerations are already a reality for governments in a number of countries in Europe and North America.

The ultimate challenge for all stakeholders is to develop an extended sense of responsibility for the way they use mineral resources – not just in terms of direct impacts, but also in relation to the aspirations and models they generate elsewhere.

Keys to Advances in Recycling

There have been economic incentives to recycle mineral commodities for many hundreds of years. The recycling industry is presently an important source of livelihoods world-wide, as well as an important component in the supply of many mineral commodities. This is especially the case for metals, which are often promoted as being infinitely recyclable. The extent and nature of recycling for mineral commodities is discussed further in Chapter 2.

From a sustainable development perspective, the recycling of any material is far from a panacea. It is associated with many of the same trade-offs between environmental and social factors that concern the extraction and processing of primary resources.

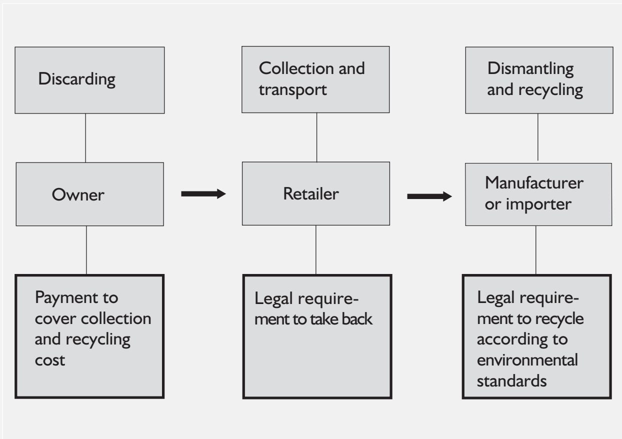
Consequently, there will be an optimum recycling rate for any mineral product that can feasibly be recycled.

Appropriate Public Policy

The role of public policy is key, not only in creating incentives for recycling but also in facilitating, improving, and encouraging the collection, transport, and trade of mineral products before and after recycling. This report does not go into this well worked area of public policy, particularly in the case of the OECD countries. Suffice it to say incentives for recycling need to be considered in product design, and means by which users can avoid disposal costs and the processors can show a positive return on capital employed. Increasingly regulations, such as take back laws, are being used to achieve higher recovery rates. The principal groups of products that are the focus of take-back laws are vehicles, packaging, and domestic electronic goods. (See Box 11–5.) In the EU, the proposed Waste Electrical and Electronic Equipment Directive is designed to make manufacturers responsible for taking back and recycling products.[37] A supplementary Electric and Electronic Equipment Directive is also being drafted that aims to integrate environmental considerations into products at the design stage.[38]

Box 11–5. Recycling Home Appliances in Japan

The Law for Recycling of Specified Home Appliances, enforced in 2001, introduces a series of responsibilities to be shared among the owner, the retailer, and the manufacturer. These responsibilities can be summarized as follows:



To ensure that appliances are returned to the retailer and not dumped, the law is supported by a waste disposal law with stringent penalties.

Appliances covered by the law include televisions, refrigerators, washing machines, and air conditioners. Approximately 20 million units are disposed of every year, totalling 600,000–700,000 tonnes. Metals are an important component of all these products. For instance, according to Toshiba, steel, aluminium, and copper constituted three-quarters of the mass of air conditioners it produced between 1990 and 1995. Prior to the new law, local governments had processed 40% of these appliances in the domestic waste stream, while private businesses dealt with the remainder. Although some metal recovery took place, many appliances ended up in landfills. The new scheme means that recycling is undertaken entirely by the private sector.

The law was driven by a scarcity of disposal sites in Japan and by government policy concerning resource efficiency. It illustrates how waste management and resource efficiency considerations can be brought together in a single policy instrument based on shared responsibilities for products. Moreover, pressure to reduce the cost for the owner to return an appliance for recycling creates some motive for design for recycling.

Sources: Development Bank of Japan (2001).

In some countries, tax incentives encourage the use of recycled rather than virgin material. An example of this is the UK tax on the production of aggregates, which exempts recycled material.[39] In the United States, there are numerous examples of how public policy at the national and local level has encouraged the development of an aggregates recycling industry.[40] These include grants, incentives for collection, and reduced fees for permits to set up recycling facilities.

Public policy in one region has to be balanced with the impacts in another. The Basel Convention demonstrates the problem, in this case of balancing the hazards of dumping toxic waste products outside the industrial world with the potential for recycling in developing economies. (See Box 11–6.)

Box 11–6. The Basel Convention: Implications for Metals Recycling in Developing Countries

The Basel Convention on the Transboundary Movement of Hazardous Wastes and Their Disposal entered into force in 1992. As of August 2001, there were 148 parties to the agreement. The treaty was motivated by cases in the 1970s and 1980s of illicit trade in toxic substances that receiving countries did not have the capacity to manage. The convention has three principal objectives:

- to reduce the generation of hazardous wastes globally,
- to minimize transboundary movements of hazardous wastes, and
- to ensure that there is prior informed consent from the recipient country before export takes place.

Hazardous wastes are defined according to lists of characteristics (such as toxicity), constituents (such as mercury), and origins (such as the pharmaceutical industry). Much metal-bearing waste may be included on the basis of contaminants and associated materials (such as toxic metals).

Since ratification, the requirements of the convention relating to the regulation and monitoring of trade have been extended to include bans on the export of certain materials. In 1992 the Conference of the Parties decided to prohibit the export of hazardous wastes for final disposal between Annex VII countries (OECD, the European Union, and Liechtenstein) and other countries. More recently, this has been extended to material intended for recycling, and in 1995 an amendment was passed to incorporate these bans into the text of the convention. The latest amendment has not yet come into force, and legal uncertainties lead some to question whether it ever will. On the other hand, some Parties to the Convention have created national export and import bans in response to the 1995 decision.

The overall impacts of these bans on the capacity of developing countries to source recycled metals are not clear. Some argue that they will have serious impacts on the economies and industrial growth of these countries. Others believe that the wastes most likely to be affected by the ban do not constitute an important part of the international trade in non-ferrous metal-bearing wastes and scrap, and that changes in the relative amounts of waste generated in developing and industrial countries could mean that the ban is likely to affect a declining proportion of potential trade.

There is, however, a need for the parties to the Basel Convention to consider the effects of such a ban on the livelihoods supported by metals recycling in developing countries as well as the contribution of recycling to these national economies.

Box 11–6. The Basel Convention: Implications for Metals Recycling in Developing Countries (continued)

Bans on the import of metal-bearing waste are likely to encourage and enhance the collection and recuperation of domestically generated scrap. From an environmental perspective, it is therefore important that the requirements for technical and financial cooperation in the environmentally sound management of wastes laid out in the original convention are fulfilled. The regional centres envisaged and set up to help implement the training and technology transfer aspects of the convention have a key role in this.

Source: Cosbey (2001); Johnstone (1998); Subramanian (1997); Hoffmann and Wilson (2000).

Finally, environmental standards for other concerns (such as air pollution) can limit the economic feasibility of recycling activities. For example, in the US the costly administrative requirements and pollution abatement technology required by environmental regulations have been cited as factors underlying a dramatic reduction in secondary copper smelting and ingot-making capacity.[41]

Overall the direction of the recycling economy is clear. It is growing. The drivers are clear too. The principal concern is energy efficiency, and within that climate change mitigation is all-important. But also resource availability in some instances and other environmental considerations are important too. Options for safe disposal, toxicity and even visual impact can be important. Not all agree where it will end. Industrial ecologist Robert Ayres, who developed a global model of copper supply and demand for the MMSD, concludes that it will be significant indeed. Based on scenarios for copper availability (defined in terms of depletion of the physical stock of copper ores), Ayres argues that recycling will become the dominant source of copper at some point in the twenty-first century.[42] He concludes: 'Best of all…would be an evolutionary transformation of the primary producers from an extract, refine and sell industry to a true service industry which treats each of the metals as a capital asset rather than as a commodity.'[43]

Information and Decision-Making Frameworks

To make policy decisions on recycling, decision-makers need to know how much is currently available for recycling and what proportion of this is actually being recycled. Both statistics are difficult to determine and are often not collected in any systematic way. This is further complicated by the lack of information about the service life of different mineral products before recycling.

Life-cycle analysis can be used to aid decision-making based on environmental factors for recycling. By undertaking an LCA, it is possible to:

- compare the environmental performance of different recycling scenarios, including energy provision and transport considerations;
- compare the relative environmental impacts of recycling versus primary extraction (although this depends crucially on how they are weighted);
- compare the environmental performance of different recycling technologies;
- develop products that can be recycled at lower cost;
- determine appropriate and effective collection mechanisms; and
- assist in developing better routes for access to financing.[44]

To determine the rates and forms of recycling versus primary production that can best contribute to sustainable development, however, a life-cycle approach that goes far beyond environmental considerations is required.[45]

Technology

Technological advances are key to increasing the rate of recycling for mineral commodities.[46] This is particularly so for the recycling of metals once they have been used in products. Whereas the waste arising from production of metal shapes such as wire and tube ('new scrap') is always likely to be recycled because of the ease of retrieval, collecting waste from used products ('old scrap') depends on technologies for efficient recovery. Although advanced technologies for separating many metals from products such as cars and electronics have been developed in some parts of the world, there is a need to ensure that they are more widely available. The sorting and identification of alloys and composite materials is critical. For instance, Huron Valley Steel in the US has developed a laser technology for separating aluminium alloys from scrap that cannot be recycled by a single process.[47] New chemical technologies will have a role in aiding better recovery of by-product metals, such as zinc from dust produced during steel manufacture.

Considering that the price of recycled metal is set according to the price of metals from primary sources, producers of minerals from each source are effectively in competition. The principal effect of downward trends in metal prices to date is on the potential for increased recycling of material from used products (old scrap).[48] New technologies for recycling play a crucial role in maintaining the competitiveness of all industries involved in the recycling process. And as indicated, governments have a role in creating the climate in which the necessary investment can occur.

Product designers and managers, together with regulators, have a role to play in developing systems for recycling (such as product take-back schemes) above and beyond new engineering solutions for processing wastes. The question of where to allocate and direct funding for research and development into recycling technologies needs to be addressed by companies in the minerals sector as well as by governments.

Re-manufacture and Re-use

Complementing recycling, re-manufacture and re-use can help slow the growth in demand for primary mineral commodities. Re-manufacture refers to the process of product disassembly, whereby parts are cleaned, repaired or replaced, and then re-assembled to sound working condition.[49] Re-use involves extending the life of a product through maintenance or re-conditioning. From an environmental perspective, re-use and re-manufacture may have advantages over recycling in that in many (but not all) cases, more of the energy and capital cost embodied in a mineral product can be conserved. By comparison, recycling requires a product to be broken down its constituent materials before they can be used again.

Many products containing metals are already re-manufactured after first use, including some types of computers, photocopiers, automotive components, tyres, refrigeration compressors, and printer toner cartridges. The US Environmental Protection Agency has estimated that approximately 480,000 people are employed in re-manufacture of all products in the United States.[50] For some products, the vast proportion can be re-manufactured because of the way they are designed. Xerox Corporation, for example, claims that 90% of its office equipment can be re-manufactured if the appropriate facilities for doing so are available.[51]

Caterpillar, the mining equipment manufacturer, states that they rebuild trucks and excavators once or twice to extend their life.[52] And it re-manufactures engines, transmissions, and hydraulic components as many as three or four times. Despite these encouraging signs from individual companies, few policies are targeted at using re-manufacture as a way of encouraging resource efficiency.

Consumer purchasing trends in many countries pose serious challenges to the design and demand for re-manufacture and re-use. For example, consumers are increasingly concerned with owning the 'latest' hi-tech equipment. The fast rate of technological advance in hi-tech equipment combined with a high turnover of what is deemed 'fashionable' has increased the rate of disposal of such goods and reduced the demand for re-use. This problem must, however, be balanced with the potential energy efficiency of advanced products on the market.

Regulation and End-use

Some people believe that from a sustainable development perspective, the costs associated with using certain minerals outweigh the benefits. This may be the case if, for example, they consider the health risks associated with use to be unacceptable or subject to uncertainty. (See discussion of metals in the environment in Chapter 10.)

It is primarily a government responsibility to balance the uncertainties regarding the potentially negative impacts resulting from the use of a mineral with the merits of allowing it onto the marketplace. Governments should, however, undertake this task in a transparent manner – with the full participation of all interests. Industry possesses (or at least has some capacity to generate) much of the scientific information required for the regulation of end-uses. The proposed revision of the EU Chemicals Policy has addressed this by placing new responsibilities on industry to provide information about the nature of substances being placed on the market. (See Box 11–7.)

Box 11–7. Regulating Chemicals in the European Union: New Responsibilities for Industry

In 1998 the European Commission reviewed its chemicals policy and concluded that there was a lack of knowledge about the properties and uses of chemical substances already on the market and that it had no mechanism to assess the risk posed by the introduction of new substances. The response to the review has been a proposed Chemicals Strategy. This aims to place all substances produced at over 1 tonne per year per manufacturer under one system for centralized registration. Metals and metallic compounds are included in this. Industry, including users of chemicals downstream in the supply chain, is responsible for supplying information about chemicals and their uses. Substances of high concern will require authorization for specific uses.

Box 11–7. Regulating Chemicals in the European Union: New Responsibilities for Industry (continued)

Eurométaux, the European non-ferrous metals industry association, has proposed that thorough risk assessment should be used to evaluate and manage substances placed on the market. In addition, the particular characteristics of metals should be considered, including their natural cycling and their combination in the form of alloys. Non-governmental groups representing environmental and consumer interests are calling to expand the number of chemicals requiring authorization (as opposed to registration). They also call for tighter deadlines for the provision of data by industry and ultimately a ban on various hazardous chemicals by 2020.

Agreement needs to be reached between industry and regulators on the extent of the risk assessments proposed and the balance of responsibility for the cost of carrying them out. Collaboration is required between industry and government to define both the need for assessments and their level of detail.

Source: Commission of the European Communities (2001); Eurométaux (2001).

National governments have an important role to play in ensuring the safety of material products placed on the market. In some cases this involves the ban of specific uses. The decision to ban the end-use of a certain mineral (or a substance based on it) must, however, be based on a thorough and transparent risk assessment. Furthermore, the relative merits of substitutes or alternatives must also be considered from the point of view of sustainable development. Rigorous life-cycle assessment is also key to this, despite the fact that it involves only environmental considerations. An example of the consequence of failing to take such an approach is demonstrated by the ban on metal cans for beverages in Denmark. (See Box 11–8.) In the EU, policy developments that restrict certain uses of metals remain controversial because of differing viewpoints on the implementation of the precautionary principle with regard to the risk they pose and the relative merits of alternatives.[53]

Box 11–8. Ban on Metal Use: The Danish 'Can Ban'

In 1989, the Danish government introduced a system obliging Danish producers of beer and carbonated soft drinks to use refillable or reusable bottles. This included a general ban on the use of metal cans. The Danish Environmental Protection Agency did an LCA as a basis for this policy. The LCA has been criticized for failing to meet internationally agreed standards for this procedure, such as those of the ISO 14040 series. The Danish Government was taken to the European Court of Justice (ECJ) by the European Commission for infringement of the EU Packaging Directive and for preventing the free movement of goods on the basis of what it regards as a flawed environmental justification, and the ban is therefore likely be rejected by the ECJ. Can manufacturers have opposed the Danish policy as it has considerable implications for markets access, which is a critical issue in the European Union.

Source: Legislation or rule n° 124, 27/02/1989, modified by rule n° 583, 24/06/1996, and rule n° 300, 30/04/1997; ENDS Magazine (2001).

The Way Forward

Connecting the production and use of minerals is critical to ensuring that the minerals sector contributes optimally to sustainable development. The necessary integration of the supply chain is a two-way process: users of mineral commodities have a key role in influencing the way in which commodities are produced, and producers have a responsibility to ensure that mineral commodities are used in a manner that is efficient.

Current resource efficiency concepts (as far as they go) argue for a reduced dependence on physical quantities of mineral resources (including the energy needed to extract and refine them) and greater emphasis on the services that they provide. A recent Worldwatch Institute publication summarizes this vision:

> Recognizing the problems caused by depending on materials is a first step in making the leap to a rational, sustainable materials economy.…Societies that learn to shed their attachment to things and to focus instead on delivering what people actually need might be remembered 100 years from now as creators of the most durable civilization in history.[54]

The industrial countries where the greatest proportion of minerals are currently used must take a lead in resource efficiency and ensure that developing countries are not disadvantaged or excluded from the associated benefits. The trade-offs of greater resource efficiency need to be recognized. Recycling, re-manufacture, and re-use – some of the means by which resource efficiency can be improved dramatically at a national and business level – are only just starting to become part of effective public policy. The next stage of improvement in resource efficiency will be product design that focuses on providing the same services but with greatly increased resource efficiency, including in their manufacture and in the potential for recycling, re-use, or re-manufacture. This presents a challenge not only for designers and technologists within companies, but also for governments to create incentives so that those who improve performance can be rewarded.

The minerals sector must address questions of efficiency in the use of minerals alongside those of sufficiency – in terms of both equitable access to these resources (both affordability and local availability) and the livelihoods currently gained from producing them. Public policy decisions that frame markets should give greater consideration to the interests of those who do not have access to the services provided by mineral commodities or who are dependent on the livelihoods associated with mining and minerals processing.

Supply Chain Collaboration and Information

Individual companies throughout the supply chain for each mineral need to improve their collaboration. This can take two forms. First, they can explore business opportunities inherent in forming partnerships throughout the supply chain. They can learn from those that are already doing so. New business relationships among mineral producers, manufacturers, retailers, recyclers, and customers are forming and will grow where there is a policy framework that rewards innovation. Companies can and should communicate their sustainable development policies to their suppliers, contractors, partners, and customers and encourage similar practice along the supply chain.

Second, companies throughout the supply chain for each mineral product need to work collectively to provide information on minerals use and its effects at each stage of the chain. This information should be collected, collated, and distributed, perhaps by an independent organization if the data was thought to be contested. But in the mean time industry associations representing individual mineral commodities and product groups have a particularly important role to play in compiling, standardizing, and disseminating information on supply chains for the benefit of their members, consumers, government policy-makers, and the public. If they are to be trusted by non-industry actors, there will need to be independence and peer review.

Life-Cycle Assessment

The mining and minerals industry should engage more directly in the development of LCA as one element of a holistic approach to decision-making for sustainable development. NGOs have a significant role to play in reviewing the different sources of information and the trust to be placed in it.

The International Council on Mining & Metals and the individual mineral commodity trade associations should continue to be actively involved in developing advisory or instructional literature on the meaning and interpretation of LCA. Efforts will need to be coordinated to ensure that there is no duplication, and to learn from experiences in other sectors. The mining industry should strive to build consensus within the industry on definitions of assessment boundaries, allocation procedures to be used, and approaches to aggregation over space and time. This should be facilitated by an industry association such as ICMM with input from, among others, industry personnel, up-stream users of LCA information, and academics.

A specific focus on LCA and metal recyclers is needed. The recycling industry associations should facilitate access to recyclers, bring them on board in the data-gathering process through outreach and education, and build consensus within the group.

The UNEP/SETAC Life Cycle Initiative should continue to address the methodological shortcomings of applying LCA to the minerals sector. Representatives from all parts of the minerals sector should provide their input. The Life Cycle Inventory element of this initiative should become a forum for the assimilation of data on mining and minerals processing, for use by downstream industries using mineral commodities.

Impact categories included in LCA need to be reviewed, as they are currently unable to reflect the performance of the minerals sector adequately. Salinity, land use, and water management need to be added to the existing categories. Information and data need to be collected on the effects of mining and minerals processing with respect to eco-toxicity, resource depletion, and other impact categories.

Further research needs to determine what tools other than LCA can be used to incorporate an understanding of the 'social performance' of the system, using the work of the Life Cycle Management element of the UNEP/SETAC Initiative.

Product Stewardship

It may be appropriate to begin a Product Stewardship Initiative that would enable all parts of the supply chain for minerals to exercise their joint responsibility to provide information on the safe use, transport, recycling, and disposal of their products. This responsibility includes providing information on the best way to use the product in a particular application to minimize risk, information on prolonging service life, and advice on recycling and final disposal. The initiative could build on the work already undertaken by the Non-Ferrous Metals Consultative Forum on Sustainable Development.

Companies throughout the life cycle need to set aside resources and train employees to implement product stewardship programmes. Mining and minerals processing companies should develop joint strategies and measurable targets for product stewardship. These should involve:

- ways to ensure non-industry participation in setting objectives and targets,
- definition of clearly measurable and transparent targets,
- mechanisms for non-compliance,
- accounting for regional and sectoral differences, and
- longer lead times for smaller companies with less capacity.

Industry needs to collaborate with regulatory authorities, downstream users, and other groups to develop sound, scientifically based means to ensure safe use, re-use, and eventual disposal of its products.

Recycling

The different mineral commodity–specific industry associations, recycling trade organizations (such as the World Federation of Recycling Industries and the Bureau of International Recycling), and multilateral organizations (including OECD, the UN Conference on Trade and Development, UNEP, the World Customs Organization, and the European Committee for Standardisation) should collaborate in order to develop permanent systems for the systematic monitoring of trade flows in scrap and secondary materials. This information should be made publicly available.

Governments should continue to identify clearly the incentives and disincentives for recycling and for innovative design in metals use. On this basis, they should develop stronger policy frameworks for recycling so that recycling levels can increase. Policies and legislation aimed at this need to include provisions for helping to manage any negative social or economic consequences of any associated transition from dependence on primary sources for mineral commodities.

Governments should continue to work with industry associations to develop national strategies for recycling mineral commodities and extending product life, with measurable targets. These may include collection networks, infrastructure, and investment in recycling technologies. Policy initiatives need to be coherent so that one policy does not contradict another in promoting recycling. Policies and legislation aimed at increasing levels of recycling need to include provisions for helping to managing any negative social or economic consequences. Governments should clearly identify incentives and disincentives for recycling and for innovative design in metals use.

Governments of industrial countries that are currently working to promote resource efficiency could assist developing countries through technology transfer and demonstration models for recycling.

The aluminium industry is generally more advanced in its recycling thinking and practice, and more needs to be done to examine what lessons and practices could transfer to other metals. As part of an overall product stewardship or integrated materials management initiative, ICMM should work with the recycling trade associations to compile a database of good-practice examples for recycling across regions (both nationally and internationally) and across mineral commodities.

The precise effect of the Basel Convention on trade in scrap metals needs to be clarified by the metals recycling industry. This relates particularly to the implications of the proposal to amend the treaty to prohibit the export of recyclable materials from industrial to developing countries. Parties to the convention and the various working groups must consider how limits on scrap metal exports will affect wider sustainable development criteria. In particular, there needs to be greater clarity regarding the definition of environmentally sound management of material controlled by the convention, and practical ways to enable developing countries to implement this in recycling need to be identified.

There should be greater communication between product designers and both primary and secondary producers of mineral commodities, including their trade associations. Product designers and governments should devote more attention to re-manufacture in order to ensure that products do not have to be broken down to their constituent raw materials before further use.

Risk Assessment and Policy

The mining and minerals processing industry needs to work with regulatory authorities to ensure that risk assessments for the use of metals can properly inform regulation and materials selection. The relevant industry associations should have input, together with other stakeholders, into the development of national- and regional-level government policy to ensure that assessments are adequate and fair. For this to happen, the information needs to be provided in a transparent and open way to inform policy-making.

Endnotes

[1] In this context, 'use' is meant to describe the service derived from primary mineral commodities (refined metals, raw processed industrial and construction minerals) in products handled by industry, government, and the public. For the purpose of this chapter, use includes re-use.
[2] United Nations (1992) Chapter 4.3.
[3] PricewaterhouseCoopers (2001).
[4] Gereffi et al. (2001).
[5] Roberts (2000).
[6] The World Conservation Union News Release 19 March 2001, http://www.iucn.org/info_and_news/press/coltan.html; MMSD telephone interviews with five electronics manufacturers, November 2001.
[7] Bass et al. (2001).
[8] Rae and Rouse (2001) p.33.
[9] http://www.plantar.com.br. Accessed December 2001.
[10] Roberts (2000).
[11] Bass et al. (2001).
[12] http://www.epa.gov/epr/about/index.html
[13] The concept of Extended Producer Responsibility was first coined in 1990 by Swedish environmental economist Thomas Lindhqvist.
[14] OECD (2001) p.161.
[15] http://www.unepie.org/pc/sustain/lca/lca.htm
[16] MMSD (2001b) p.55.
[17] Source: Commission of the European Communities (2001b).
[18] See, for example, Baumol and Oates (1988); Cornes and Sandler (1996); Portney and Stavins (2000).
[19] Young (2000) p.290; Jackson (1996) p.218.
[20] Schmidt-Bleek (1999).
[21] http://www.foeeurope.org/sustainability/foeapproach/espace/t-frame-espace.htm.
[22] Radetzki and Tilton (1990).
[23] Matthews (2000) p.138.
[24] Johnstone (2001).
[25] USGS (2001) p.4.
[26] See World Business Council for Sustainable Development, http://www.wbcsd.org/projects/pr_ecoefficiency.htm; Hawken et al. (1999); The Natural Step, http://www.naturalstep.org
[27] [[Examples of business eco-efficiency and profit]]
[28] Hawken et al. (1999) p.396.
[29] http://www.world-aluminium.org/applications/packaging/cans.html
[30] Womack and Jones (1996) p.316.
[31] Paragraph 28, United Nations Special Session of the General Assembly to Review and Appraise the Implementation of Agenda 21, New York, 23–27 June 1997. http://www.un.org/documents/ga/res/spec/aress19-2.htm
[32] Blair (2001).
[33] OECD (2001c) p.74.
[34] OECD (2001b) pp.265-272.
[35] http://www.unepie.org/pc/sustain/design/green-proc.htm
[36] WBCSD (2002 in print)
[37] Commission of the European Communities (2000).
[38] Commission of the European Communities (2001c).
[39] Part of the UK Government Finance Act 2001.
[40] Wilburn and Goonan (1998).
[41] Jolly (2000).
[42] Ayres et al. (2001).
[43] Ibid. p.87.
[44] MMSD (2001b).

[45] Quinkertz et al. (2001).
[46] Tilton (1999).
[47] See US Department of Energy, Office of Industrial Technologies (2001).
[48] Tilton (1999).
[49] Definition from The Remanufacturing Industries Council, US. http://www.reman.org/frfaqust.htm#1. Accessed November 2001.
[50] US EPA (1998).
[51] http://www.xerox.com.
[52] Correspondence from Caterpillar Global Mining, October 15, 2001.
[53] For example, the End of Life Vehicles Directive and the proposed Waste Electrical and Electronic Equipment Directives include bans on certain uses of metals.
[54] Gardner and Sampat (1998) p.24.