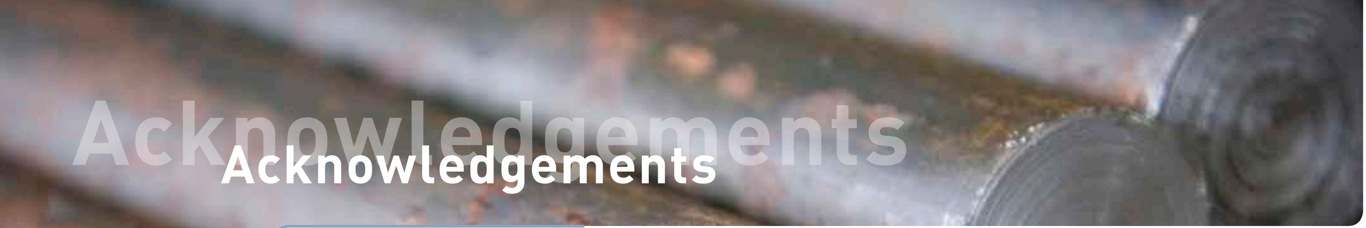
UNEP

International Resource Panel

Assessing Mineral Resources in Society:

ENVIRONMENTAL RISKS AND CHALLENGES

OF ANTHROPOGENIC METALS FLOWS AND CYCLES



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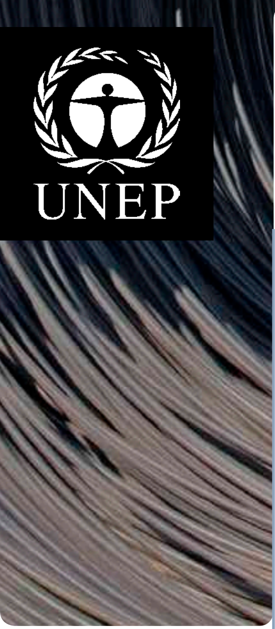


International Resource Panel

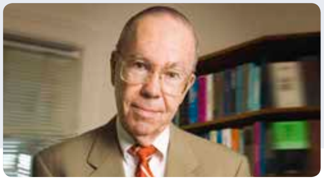
The following is an excerpt of the Report 3 of the Global Metals Flows Group

ENVIRONMENTAL RISKS AND CHALLENGES

OF ANTHROPOGENIC METALS FLOWS AND CYCLES

The full reports are available on CD-ROM (available inside the back page of this summary booklet).

Preface



The present report on environmental impacts of metals is part of a series of six reports produced by the International Resource Panel's Working Group on Global Metal Flows, which aim at identifying non-prescriptive policy options to improve recycling, sustainable mining, and metals utilization through authoritative scientific assessments of global metal flows.

Providing a scientific baseline knowledge of the impacts from metals use, and pointing out options for reducing those impacts, is urgent in view of the fact that environmental impacts of metals will be increasing in the future due to the rapidly rising demand for metals and that pressures on the environment and human health occur during the whole life cycle of metals. Mining and refining of metals for example, can cause local environmental and health problems due to the release of toxic substances into groundwater and surface water. Moreover these processes contribute to environmental problems on a global scale as they are very energy intensive, currently using about 8 % of the total global energy supply.
The increasing share of metal emissions to the environment coming from non-metal sources such as fossil fuels and phosphate fertilizer or from final metal waste streams entails another significant danger for the environment and human health. A sustainable metals management that uses metals to further sustainable development while minimizing environmental impacts is an exciting challenge for society.

Increased recycling of metals can be expected to alleviate some of the adverse environmental pressures from the use and production of metals. However, increased recycling rates alone will not be sufficient, but will need to be accompanied by a levelling off of the demand curve for metals. On a local level, substantial efforts in the prevention of adverse local impacts modelled on the example of the more progressive mining companies will remain of significant importance.

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Preface

Preface

Metals are an essential part of our economy as core raw materials for infrastructure and manufacturing of products. Demand is expected to remain strong in the future: in developing countries because of rapid industrialization, and in developed countries because modern technologies will require the use of metals. Meanwhile renewable energy technologies – as part of the transition to an inclusive green economy – are generally more metals intensive than fossil fuel ones.

This report from the UNEP-hosted International Resource Panel gives a clear picture of the potential environmental impacts of metals at different stages of the life cycle while linking with other areas of resource use such as water, food production and energy.

For example, mining can have significant impacts on local ecosystems and landscapes through mining wastes or the pollution of ground- and surface water.

Meanwhile, in a less visible manner, the high energy consumption of metals production adds significant pressure on the global environment through the emission of greenhouse gases.

In addition the complex environmental footprints of metals, and inadequate final waste treatment are cause for concern at the End-of-Life stage.

This report concludes that recycling is a positive example towards an integrated approach – for example, producing metals from ore consumes around two orders of magnitude more energy per kg produced metal when compared with recycled metals.

Many possibilities exist that can help to improve recycling rates of metals and increase secondary production – and thus resource efficiency. Handling metals in a sustainable way also means responding to the economic realities, challenges and needs, as well as the imperatives of the social agenda of equity, employment and human well-being.

Only a systemic approach can live up to the challenges of sustainable development and of sustainable metals management as we transition to an inclusive, low carbon, and resource efficient global Green Economy.

Achim Steiner

UN Under-Secretary General and
Executive Director UNEP

UNEP's IRP activities on metals

International Resource Panel (IRP)

The International Resource Panel was established in 2007 by UNEP to provide independent, coherent and authoritative scientific assessment on the sustainable use of natural resources and the environmental impacts of resource use over the full life cycle.

By providing up-to-date information and the best science available, the International Resource Panel contributes to a better understanding of how to decouple human development and economic growth from environmental degradation. The information contained in the International Resource Panel's reports is intended to be policy-relevant and support policy framing, policy and programme planning, and enable evaluation and monitoring of policy effectiveness.

Global Metal Flows Working Group

The International Resource Panel launched the Global Metal Flows Working Group in order to contribute to the promotion of the re-use and recycling of metals and the establishment of a sound international recycling society. Therefore it is publishing a series of scientific and authoritative assessment reports on the global flows of metals. The expected results of these include identification of potentials for increased resource efficiency at national and international levels. The present booklet summarizes the findings of Report 3: Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles by Ester van der Voet and co-authors.

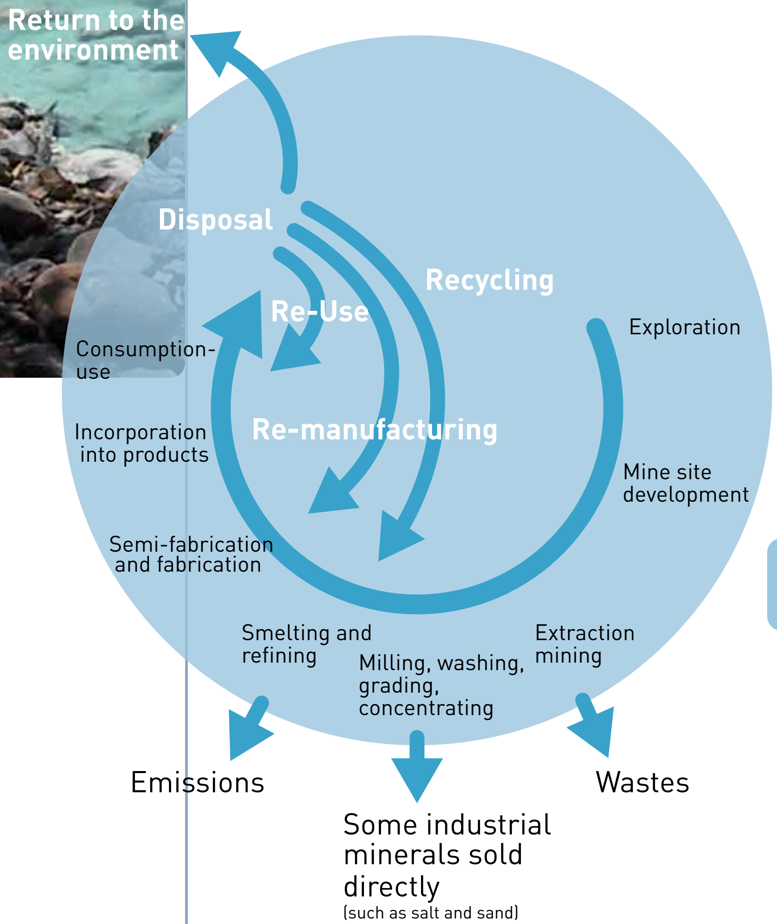
Relevance of metals for sustainable development

Economic development is deeply linked to the use of metals. Metals are essential for numerous important applications like buildings and infrastructure, vehicles, electronics, etc. Metals are high-value resources and can in principle be easily re-used and recycled. Especially for metals, closing material loops through re-use and recycling brings benefits: it reduces pressure on primary resources as well as reducing energy use and environmental impacts. Furthermore metals recycling contributes to securing metal availability, as well as reduced metal prices, and promotion of jobs in the related economic sectors.

Objectives of Report 3

Objectives of Report 3

The Minerals Cycle
(IIED & WBCSD, 2002).



Motivation and objectives

The unique properties of metals make them essential for many applications. Particularly, three important trends can be identified which are bound to increase the future global demand on metals. Firstly, the building up of infrastructure in rapidly developing (emerging) economies will cause a continuously rising demand for steel and other base metals.

Mine site closure and rehabilitation

Ore extracted
↓
Land reclamation initiated
↓
Mine closed
↓
Land available for other uses

Secondly, the electronics revolution expressed in products like smartphones, flat screen televisions, or USB sticks is leading to a growing demand for many specialty and precious metals. Thirdly, the shift towards renewable energy technologies like wind mills, photovoltaic and others will contribute to an increased global metals demand. Given this predicted growth in demand the environmental pressures caused by the global mining, refining, and manufacturing industries as well as the use and stock of metals may drastically increase in the next decades if strategies for a significant reduction of the related impacts are not realized.

Given this relevance Report 3 published by UNEP's International Resource Panel exclusively focuses on the environmental impacts of metals, their production, and their use and means of their reduction. Other relevant topics like economic and social aspects of metals as well as scarcity debates are covered by other reports. Impacts related to the production of metals occur along the whole minerals cycle: from mining to the renewed utilization of a metal contained in an EoLproduct or its final disposal. Thus, the identification of the environmental impacts and corresponding mitigation options requires the consideration of all relevant steps.

The significance of anthropogenic metal cycles

Since the mobilization of metals is greatly increased by mining, the natural biogeochemical cycles of metals show a large anthropogenic contribution. Report 3 reveals the scale of anthropogenic metal cycles and their environmental significance compared to the biogeochemical cycles. All important sources of metal emissions including non-metal sources like fossil fuels and phosphate fertilizers are covered.

Energy demand and environmental impacts of metals production

The life cycle energy use and environmental impacts of metals and their applications are key issues for sustainable development in view of increasing global metals demand. In order to identify mitigation measures Report 3 analyzes the impacts and works out the most important contributions along the metals´ life cycles on local and global scales.

Anthropogenic and natural metal cycles

Metals emissions into the environment

Typically, metals are bound underground in mineral deposits. From there, they enter the above-ground environment via natural geological processes (e. g. weathering, volcanism) as well as through human activities. In the environment metals tend to accumulate in soils and sediments, and potentially infiltrate surface and ground water. Metals often accumulate in the food chain. Concentrations of metals in the environment show large regional and local variations. These occur both as a result of natural processes and of anthropogenic sources.

The anthropogenic impact

Anthropogenic activities have increased the magnitude of above-ground metal cycles. Most of the metals mobilized by mining accumulate in the technosphere, in useful products and infrastructure. However, environmental metal concentrations generally are higher now than some centuries back, indicating the anthropogenic contribution. On the continental scale it has been impossible to differentiate between anthropogenic impact and natural background variation. However, at a local scale, increased environmental metal concentrations due to emissions of metals from anthropogenic point sources (e. g. mining sites, stacks) have been demonstrated.

Metals and human health

Metals enter the food web via plant uptake and through bio-accumulation, which may lead to a high intake in animals and humans at the top of the food chain. Many metals are essential for life, but there is definitely an optimum intake: below, deficiency symptoms occur, above, adverse impacts due to oversupply can be detected. Impacts on human health occur mostly on a local scale. Ecosystem impacts occur more widely. Although there are still many unknown variables, it is becoming likely that metals in the environment have an impact on biodiversity. A lot of knowledge has been generated in this field, but there are still gaps concerning the dispersion as well as toxicological impacts of metals. Among these gaps are the impacts of exposure to a metals mix, and the distribution and ultimate fate of metals in the global environment.

The lead (left) and copper (right) smelters at Mt Isa, Queensland, Australia, viewed from the downtown area.

Sand dump 20, West Rand gold field, Johannesburg – note the dust from the tailings and large flow of AMD-rich water in the front pipe.

Anthropogenic and natural metal cycles

Sources of anthropogenic metals emissions

Emissions of metals from society to the environment, including emissions to the atmosphere, emissions to water and diffusive emissions to soil, have been estimated to be roughly in the same order of magnitude as emissions from natural sources, like weathering and volcanic activity. The anthropogenic emissions are increasingly dominated by non-metal sources, especially fossil fuels combustion and the use of phosphate fertilizers. Previously important point source emissions from the metals industry have been addressed by environmental legislation in many places.

Global trends of metals emissions

Metal emissions caused by non-metal sources are expected to increase. The main driving forces are the predicted growth of population and welfare. This growth leads to a higher demand for food and energy, potentially linked to increased agricultural fertilizer use and fossil fuel consumption.
Metal emissions can also derive from the disposal of metal-containing wastes: either waste from primary metals production like tailings, and waste rock material or from landfilled End-of-Life products. These waste flows constitute a relatively modest source of metal emissions with moderate expected growth. In the future a mitigation of anthropogenic metal emissions related to primary metal production can be expected when End-of-Life recycling rates increase.

For most metals with a growing demand End-of-Life recycling rates are increasing. However, due to time lag, the share of secondary production remains low as long as total demand keeps rising. This means that emissions related to mining, production and use will probably rise as well, although at a slower pace than production itself.
For metals with a declining use (arsenic, cadmium, mercury and to some extent lead), emissions from old stocks dominate. An environmentally sound End-of-Life management for these metals is required, focusing on closing cycles but also on a final sink to store unwanted waste streams.

Policy Messages

→ **Reduce local metal emissions** from the metals sector

→ **Reduce metal emissions** from non-metal sources

→ **Secure final sinks** for certain metals

Closed and rehabilitated mine site in Keretti, Finland. Today a golf course.

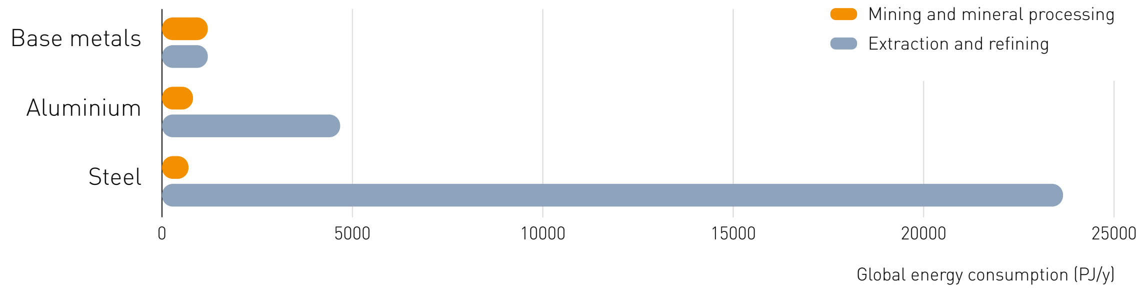
Metals production and energy use

Energy use for global metals production

The global metals sector shows a tremendous impact on the world's energy consumption, as primary metals production is responsible for 7 – 8 % of the total global energy use. The energy requirement varies significantly from 20 MJ (steel) to 200,000 MJ (platinum) per kg of metal produced. Still, due to their large production volumes steel, aluminium and other base metals account for the largest share in absolute terms.

Primary metals production

The production of metals from their ores involves several stages. In each stage, impurities are separated and the concentration of metal in the product increases. Each stage is hence linked to energy use which occurs through direct combustion of (fossil) fuels for heat, or through the use of largely fossil-based electricity. Chemicals are required in various stages, which also require energy in their production.
Physical parameters such as the ore grade (concentration of target metal in the mined ore) and the depth of a deposit determine how much ore must be mined and how far it must be lifted, and hence the energy requirement. Chemically, nearly all metals in nature are bound in stable minerals so that energy has to be supplied to isolate and convert them into the pure metallic state needed for products. These physico-chemical parameters determine a theoretical lower limit to energy requirement. In practice, energy requirements are many times higher than this theoretical limit. However, the wide-spread use of today´s best available technologies (BAT) can significantly reduce the energy demand and future technological developments will further tap the theoretical potential of a factor 2 – 20 energy efficiency improvement.



Global energy consumption in PJ/a of primary metal production, „Norgate and Jahanshahi, 2010".

Mining and mineral processing

Metal energy use begins with mining: open pit mining involves the removal of the overburden while for underground mines shafts have to be dug. Subsequently, the ore has to be hauled to the surface. The following beneficiation steps serve to remove the non-metallic waste rock and involve comminution and flotation of the ore. Especially grinding is linked to high energy consumption due to the very small required particle sizes.

Extraction and refining

After beneficiation the metal extraction is accomplished by pyrometallurgy, which essentially involves the application of heat, or hydrometallurgy, which is based on leaching with chemical agents. Depending on the metal and intended applications, further refining is carried out. In some cases, e. g. aluminium, considerable amounts of energy are needed for the reduction of the oxides to their metallic state.

Fabrication

The refined metal in the form of billets or ingots is sent to fabrication and manufacturing plants, where it is first turned into semi-finished products such as sheets, coils, bars, or pipes which are then further shaped into a final product, such as a washing machine.

Metals production and energy use

Metals production and energy use

Declining ore grades

Ore grades determine the energy demand of the first two steps of the metals' life cycle: mining and mineral processing. After mineral processing (beneficiation) a concentrate of specified grade is produced so that the subsequent steps remain unaffected by the initial grades. However, in the first two steps lower ore grades lead to exponentially higher energy use: more ore has to be mined, smaller particle sizes are needed, and the required concentration factor increases.

Throughout the twentieth century, historical long-term trends evidence substantially declining ore grades in almost every metals sector of the global mining industry. The reasons behind this are various: firstly, rich and easily accessible deposits have been mined to some extent. Secondly, technological progress makes the mining of lower grade ores economically viable. Thirdly, the demand for metals has been rising steeply. The clear linkage with scarcity and market prices is the subject of future UNEP IRP reports. These reasons still hold; therefore, a further decline of ore grades is to be expected.

Recycling

Secondary production of metals requires significantly less energy per kg metal produced as fewer steps are involved. Notably, the energy used in mining, milling, concentrating, and transporting ore to a smelter is saved. Moreover, in most cases the initial concentration of the desired metal in an EoLproduct is considerably higher than in natural ores. An additional major benefit is the fact that scrap metal is already in metallic form so that the energy for reduction is avoided. On the other hand, recycling requires collection, sorting and separation of scraps which forms a challenge and creates additional energy demand particularly for post-consumer scraps.

Energy savings for secondary compared to primary production are reported to range from 60 – 75 % for steel and zinc to over 90 % for aluminium and platinum group metals. Recycling therefore is a very important part of any sustainable metals management.

Policy Messages

→ **Improve recycling** as key to sustainable metals management

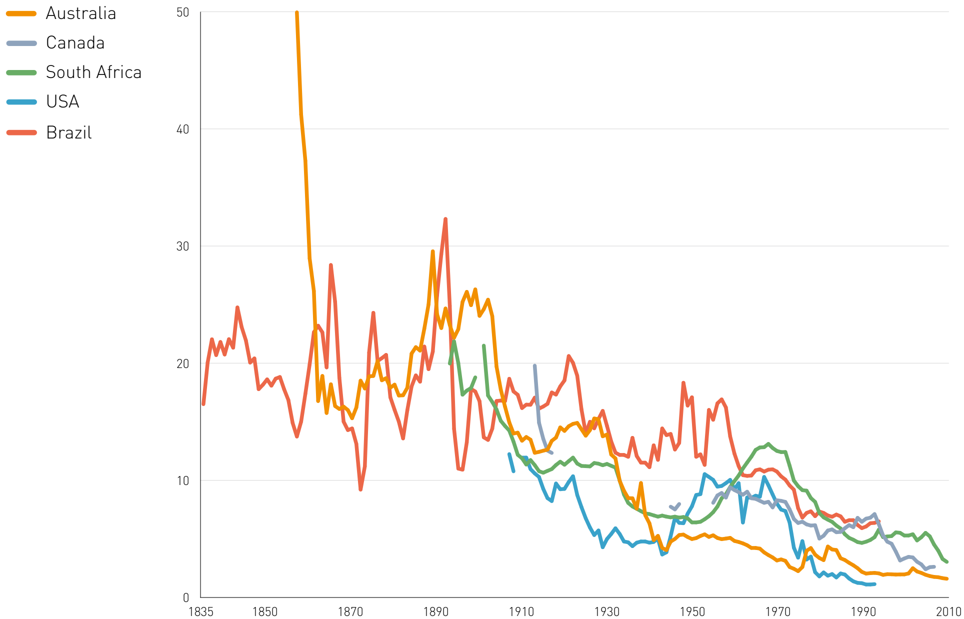
→ A **more energy-efficient** global primary metal sector remains a "must" for the decades ahead

Future developments of metals-related energy use

Future energy requirements for metal production mainly depend on the following factors:

- Continued increase of demand will increase energy requirements
- Processing of lower ore grades will increase energy requirements.
- Remote deposits will require more transportation energy.
- Improvement of technology will decrease energy requirements.
- Increased contribution of secondary supply will decrease energy requirements.

Despite significant potential for increasing energy efficiency by using current and future BAT, the rising demand combined with declining ore grades is expected to lead to an increase in the energy demand related to metals production in the future.



Long-term trends in processed gold ore grades (g/t Au) for select countries (data from CMSA, 2010; Craig & Rimstidt, 1998; Machado & Figueiroa, 2001; Mudd, 2007; Natural Resources Canada, var., including updated data for Australia to 2010).

Environmental impacts of metals




As **key results** for sustainable metals management the outlook in this summary booklet presents the four areas of attention identified by Report 3.

Taking a life cycle perspective

When considering the environmental impacts related to anthropogenic metal flows a life cycle perspective obligatory. Impacts on the environment occur along the whole life cycle: in the different stages of primary production, during the use of metal and metal-containing products and at their End-of-Life.

Impacts of primary production: mining and extraction

Important impacts of the metals´ life cycles occur in the first stages of the life cycle: mining, beneficiation, primary metal extraction and refining. Thus, they are relevant for primary production only. While it is clear that the impacts per kg are highest for metals that appear in their ore in low concentrations (e.g. PGM), it has also been shown that due to the sheer magnitude of their cycles the production of bulk metals (iron and steel, followed by Al, Cr, Cu, Ni, Zn) still has the largest impact.

The effects materialize in all relevant environmental categories with long-term consequences:

Land | The occupation of land for mining sites as well as the establishment of the necessary ancillary infrastructure (roads, housing) is linked to clearing of vegetation and erosion. The mine wastes (tailings and waste rock) require large dumps and tailing ponds, up to several square kilometers, for storage.

Water | Impacts on water are due to the large quantities of water consumed for processing ore, dust suppression and potable purposes. Moreover, mining and extraction operations have the potential to contaminate ground- and surface water resources by leaching of toxic substances or because of extreme pH values, e.g. through acid mine drainage (AMD).

Air | Emissions to air stem from the use of energy sources (direct ones such as diesel and indirect ones such as coal-fired electricity), blasting operations and process emissions. Beside the globally relevant greenhouse gas emissions, mainly sulfur dioxide, heavy- or radioactive metal containing dust and particulates are of local concern due to their damaging effects on ecosystems and human health.

Biodiversity | The degradation of landscape and ecosystems is linked to local biodiversity losses.

Principal environmental aspects and impacts of primary metals production.

Environmental impacts of metals

Environmental impacts of metals

Impacts of the use of metals

The only impacts that can be directly related to the use of metals are the emissions from corrosion in the use phase. The other use phase impacts are mostly related to energy: here, the application of metals may contribute to the use of energy, but it may also enable sustainability and resource efficiency, depending on the application.

Impacts of recycling

Most importantly, recycling replaces primary material thereby preventing impacts related to primary production from occurring. This includes large energy savings, and the avoidance of some of the risks related to mining, as well as lowering the embodied energy of products. Still, recycling is also related to environmental impacts resulting from the necessity for a collection infrastructure and recovery processes, which also require energy and potentially process chemicals.

Impacts of final waste disposal

An environmentally sound metals management should strive to minimize losses from the metal cycle by promoting resource efficient product design, optimized for resource recovery at the End-of-Life, as well as increased collection of EoL goods through informed consumer behaviour and recycling best available techniques.

Nevertheless, there will be inevitable losses with those fractions where the efforts of recovery exceed the related benefits. The two main options for these fractions are landfill and incineration after which metals are either present in the slag or, following off-gas cleaning, in the flue dust. The major impacts of landfill are linked to potential contamination of soil and water bodies by leachate so that modern landfill designs include measures to minimize this problem.

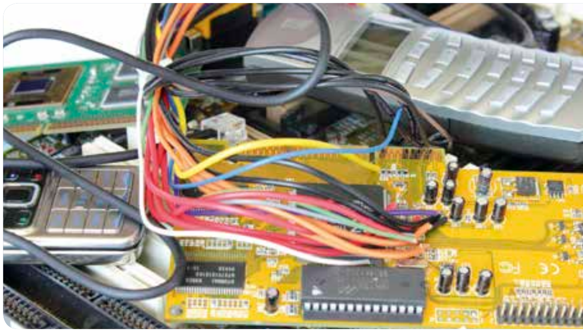
Policy Messages

→ **Enforce** strict **environmental impact assessment (EIA)** of metal mining and extraction projects

→ **Foster** local policies **on mining site management and implementation**

→ **Promote** implementation of **BAT**

→ **Guarantee** sound environmental **monitoring and assessment** in all phases



Measures to reduce the impacts of primary metals production

In order to reduce the impacts related to primary metals production a number of measures can be taken along all phases of mining (site development, mining, closure, and after-closure) and primary extraction. These include the treatment and stabilization of metal-bearing soils, the prevention and treatment of contaminated water, the control of the amount and character of emissions to the atmosphere including abatement measures, and the reclamation of disturbed land, including efforts to restore biodiversity, after closure.

Policy Messages

→ **Support waste prevention**, recycling and the use of BAT for final disposal

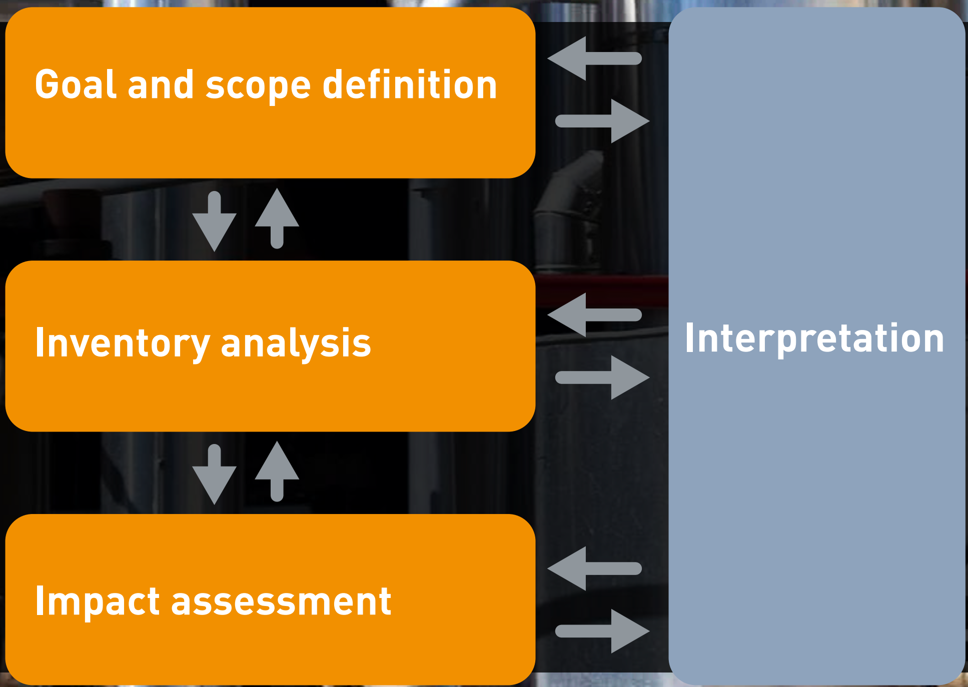
Measures to reduce impacts at the End-of-Life stage

Measures to reduce the impact of metals use at the End-of-Life stage emanate from the complex interactions between product design, best available techniques and recycling systems. This requires the holistic assessment of these interactions in order to show where and how maximum resource efficiency can be achieved while minimizing the impact of metals and materials. UNEP IRP Report 2b addresses these questions in detail.

The realization of identified potentials then requires the combined effort of all stakeholders (producers, suppliers, consumers, policy makers). Some promising initiatives in this field include new forms of interaction between supplier and consumer, exchange/replacement services, and deposit schemes. Directives and legislations provide a regulatory framework either on the production side (e.g. EU ecodesign directive) or at the End-of-Life (e.g. the EU WEEE directive). Future reports will need to address this point.

As a general rule, the first aim should be to prevent the occurrence of waste. If the options for re-use and recycling are then fully exploited, final waste treatment should be designed in a way that minimizes the emissions of metals to the environment.

The **LCA framework** according to the ISO 14040/ 14044 series (ISO, 2006a)



Life cycle assessment of metals

Life cycle thinking (LCT) is the process of taking into account in decision making, as far as possible and, for example, all resources consumed and all environmental and health pressures that are associated with the life cycle of a product, considering the extraction of resources, production, use, re-use, transport, recycling, and ultimate waste disposal (JRC, 2007).

Why LCA?

Life cycle approaches provide information based on the analysis of the entire life cycle of metals: production (of primary pure metal and metal-containing products), use, and End-of-Life (reuse, recycling or disposal). Various practical applications of life cycle thinking (LCT) already exist, within which life cycle assessment (LCA) proves to be a key factor for a successful implementation and application. In this context, UNEP provides substantial support through its commitment in the UNEP/SETAC Life Cycle Initiative. Life cycle information is indispensable for decision-making, e. g. in the political or business context. For metals, the relevance is especially high, as LCA for specific applications proves that, due to their high energy intensity, they often contribute significantly to the life cycle impact.

Depending on the goal of the LCA only single stages may be relevant, e. g. for answering the question of which EoL treatment is preferable for a given product. Another example is the so-called cradle-to-gate LCA, used to determine the impact of a unit of metal as input for the manufacture of products “at factory gate”, with the aim to discover priority metals from an environmental point of view. The most comprehensive application, however, is the comparative LCA of products or services with the same given functionality, based on the assessment of all stages in order to avoid shifting of burdens from one stage in the life cycle to another.

Product life spans, material efficiency, substitution

Among others, comparative assessments are needed to detect the real effects of longevity, material efficiency and substitution. By way of example, the positive effect of longevity (less frequent product manufacturing) is opposed by possible higher requirements during manufacture; material efficiency saves environmental impacts in the production stage, but the trend towards miniaturization poses a big challenge to recycling; metals may be substituted by generally less energy-intensive materials, such as ceramics or plastics, but these may have shorter life spans or be less readily recoverable at the End-of-Life. This clearly shows the need for case-by-case LCA studies in order to optimize the overall system.

Life cycle assessment of metals

Life cycle assessment of metals

Trade-off between production and use phase

Although metals may show high impacts during production, their use can contribute to the reduction of overall life cycle emissions if it leads to savings in other stages. Hence, the identification of the best solution requires the integration of all stages in the assessment. Prominent examples in the context of modern technologies can be found in the automotive and energy sectors.

CCS: current (2007) mix extended with carbon capture and storage on fossil fuel based powerplants

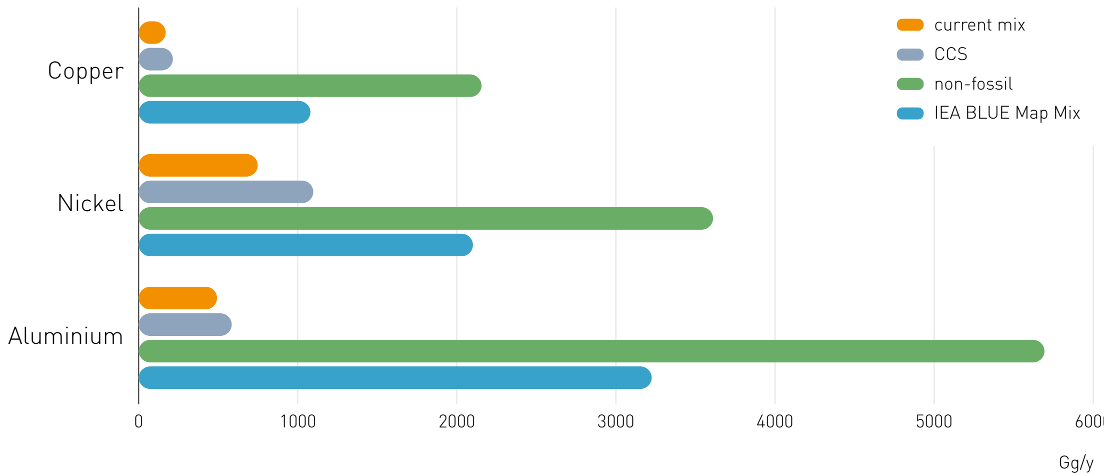
Non-fossil: mix of solar, wind and hydropower

IEA Blue Map: mix according to Shell Blue Map scenario, including fossil fuels as well as renewable energy sources.

Metals in the automotive sector

Lowering the carbon footprint of the automotive sector can be driven by lowering vehicle weight which lowers energy consumption over its life time. There are various initiatives in this regard, which range from multi-material concepts or the substitution of steel by the lighter aluminium to new steel types being used. Another important contribution is expected to come from the implementation of renewable energy-based electromobility. However, on the production side this requires specialty metals like cobalt, lithium, and rare earths for the necessary batteries and electric motors. Reaching high recycling rates for all valuable materials and especially metals contained in these vehicles is hence a must.

Demand for metals for the global electricity system under various scenario assumptions (Kleijn et al., 2011) .

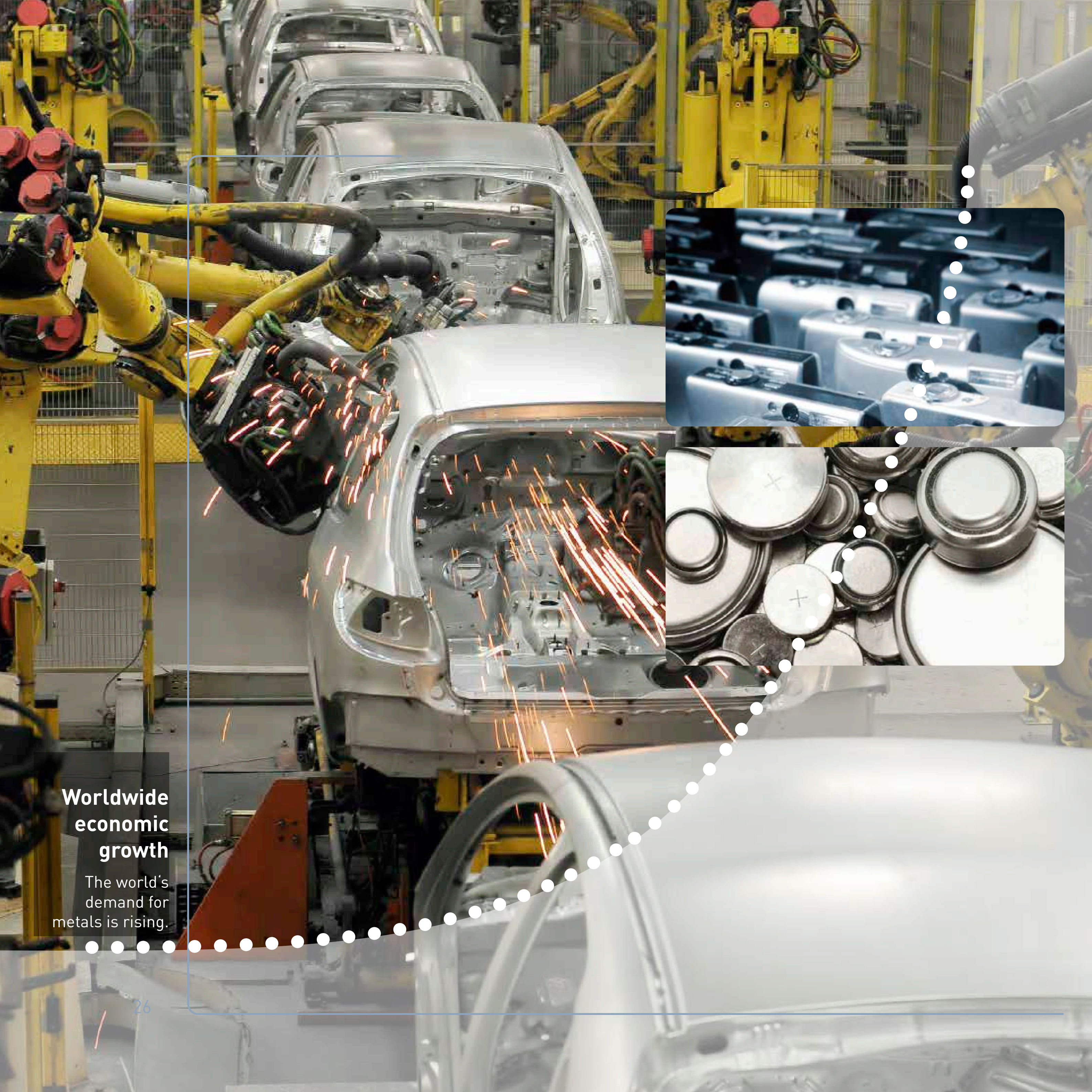


Metals in the energy sector

In the energy sector the so-called "sustainability enabling" metals, like rare earths, indium, and copper, enable the change of the energy mix from mainly fossil-based energy carriers to less carbon-intensive technologies like wind and solar power. Thus the shift towards a renewable energy system entails that the material, and especially metal, intensity of energy production will increase substantially. This is illustrated by the graph on the next page which shows the demand for copper, nickel and aluminium for global power supply under various technology scenarios. These examples demonstrate that it is not only the material content of the product that has to be considered but rather the system output and how its use/functionality promotes sustainability. Metals used smartly in various applications ensure less energy demand worldwide. Consequently, an overall systemic picture is required to best evaluate the most "sustainable" concepts, products, designs, processing systems, etc.

Methodological considerations

In order for LCA to provide reliable guidance, methodological choices play – alongside sound input data – a crucial role. Especially for metals a salient example is allocation: as more than one metal is produced from most ores during LCA a decision has to be taken as to how the emissions and extractions of the upstream chain have to be allocated to the different metals outputs. This decision has the potential to greatly influence the outcome and is thus of utmost importance for the comparability of the results between case studies.



Worldwide economic growth

The world's demand for metals is rising.

Outlook

Life cycle perspective for metals

The ongoing rising global demand for metals leads to increasing environmental impacts. Hence a life cycle perspective for metals is necessary which has to lead to sustainable metals management in order to address the global challenges adequately.

- Local impacts of mining
- Non-metal sources
- The need for a final sink
- Life cycle energy use

Local impacts of mining

Currently the mining and extraction of metals is often the cause of severe impacts on the local environment like leaching of toxic and sometimes radioactive substances into the ground- and surface water and ecosystem degradation. Further serious risks (e. g. related to tailings dam breaches) can cause disastrous devastation like a few years ago in Hungary. Although a zero impact is impossible, advanced mining concepts have the potential to drastically reduce the risks and impacts on the environment: during mining development, mining operations and after closure of the mines. UNEP should play a major role in the years ahead to foster multilateral negotiations and agreements on a sustainable mining of metals.

Non-metal sources

Metal emissions are not only caused by the metals industry itself. An increasing share of metal emissions to the environment comes from non-metal sources such as fossil fuels and phosphate fertilizer. For some metals this is currently the major source. Especially in agriculture, closed-loop accumulation can lead to high concentrations of metals in soils. A sustainable metals management therefore should assess and quantify these sources and develop counter-strategies. The shift to renewable energies and an extensive agriculture with reduced use of chemical fertilizers will constitute major contributions to sustainable metals management.

Life cycle energy use

The global primary metals sector (mining, extraction and refining) is currently responsible for 7 – 8 % of the total global primary energy consumption. The existing scenarios predict further significant growth of the global metals demand which will aggravate the

Outlook

challenges of energy use and global warming potential. Faster implementation of best available technologies (BAT), a higher share of renewables in the energy mix as well as increased shares of secondary metals help to mitigate the increase of the environmental impacts to a certain amount. Nevertheless, according to current predictions, the world is facing a higher overall amount of energy use for metals production in the future. This challenge means that UNEP bears the important responsibility of working intensely on the metals issue, also in a medium and long term, to support politics, societies and industry in taking all available measures to reduce the environmental impacts from the growing metals sector. These measures include implementation of BAT and its development by appropriate legislative framework as well as promoting higher End-of-Life recycling rates of metals by supporting the development of the necessary infrastructure, especially optimized collection schemes for End-of-Life products.

Conclusion

A continued global rise in metals demand is expected in the decades ahead, following urbanization and build-up of infrastructure in developing countries and the adoption of new technologies in the energy and industrial system. This potentially increases the environmental impacts due to mining, extraction and refining of primary metals. Improved End-of-Life recycling rates provide secondary metals for the market and thus mitigate the environmental impacts of overall metal production. However, secondary production can only have a significant share in supply when global demand levels off. This may happen in the more distant future when developing countries have built up their infrastructure. For the next decades, primary production will still provide the major part of supply. Therefore a reduction of environmental impacts in the global primary metal sector remains a "must" in the decades ahead and should constitute a main policy focus.

Important tools like LCA, which are essential to support the strategy of sustainable metals management, depends on the availability of information on the production processes and all relevant necessary inputs (energetic and material resources) and outputs (products, waste, emissions). These data are already available for a broad variety of metals albeit showing some rather large differences between various data sources. A further step needs to be taken by all stakeholders that ideally leads to comprehensive, industry-based, transparently documented inventory data.

Categories of Metals

Ferrous Metals

V – Vanadium
Cr – Chromium
Mn – Manganese
Fe – Iron
Ni – Nickel
Nb – Niobium
Mo – Molybdenum

Non-Ferrous Metals

Mg – Magnesium
Al – Aluminum
Ti – Titanium
Co – Cobalt
Cu – Copper
Zn – Zinc
Sn – Tin
Pb – Lead

Precious Metals

Ru – Ruthenium
Rh – Rhodium
Pd – Palladium
Ag – Silver
Os – Osmium
Ir – Iridium
Pt – Platinum
Au – Gold

Specialty Metals

Li – Lithium
Be – Beryllium
B – Boron
Sc – Scandium
Ga – Gallium
Ge – Germanium
As – Arsenic
Se – Selenium
Sr – Strontium
Y – Yttrium
Zr – Zirconium
Cd – Cadmium
In – Indium
Sb – Antimony
Te – Tellurium
Ba – Barium
La – Lanthanum
Ce – Cerium
Pr – Praseodymium
Nd – Neodymium
Sm – Samarium
Eu – Europium
Gd – Gadolinium
Tb – Terbium
Dy – Dysprosium
Ho – Holmium
Er – Erbium
Tm – Thulium
Yb – Ytterbium
Lu – Lutetium
Hf – Hafnium
Ta – Tantalum
W – Tungsten
Re – Rhenium
Hg – Mercury
Tl – Thallium
Bi – Bismuth

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THIS BOOKLET SUMMARIZES Report 3: Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles of the Global Metal Flows Working Group. The full report is available on CD-Rom (see page 31 of this summary booklet). UNEP's International Resource Panel addresses the metals recycling challenge comprehensively.

The global metals production shows tremendous impact on the world's energy use, as primary metals production is responsible for 7–8% of the total global energy use. Furthermore primary metal production causes severe local environmental impacts like groundwater pollution, mine wastes, air emissions (greenhouse gases, sulphur dioxide etc.), land use, biodiversity loss etc. Wider implementation of Best Available Technologies (BAT) is needed reducing the environmental impacts of primary metal production. Improved End-of-Life recycling rates provide secondary metals for the market and thus mitigate the environmental impacts of overall metal production. But secondary production only can have a significant share in supply when global demand levels off. This may happen in the more distant future. For the next decades, primary production will still provide the major part of supply. Therefore a "greener" global primary metal sector remains a "must" for the future.