
# Metals, construction minerals and biomass as primary raw materials

The economic, environmental and social impacts of the production of primary raw materials are varied and complex. Different raw materials call for different approaches in order to make their extraction and production more environmentally responsible and socially equitable. It is therefore key to a sustainable raw materials policy to define resource-specific goals and devise actions tailored closely to the issues at hand.

It is also important to look at how raw materials are produced and processed in Germany, Europe and the rest of the world and what legal frameworks apply. A sustainable resource policy cannot focus only on the production of primary raw materials: it is also important to use raw materials for as long as possible and to recycle them. This involves considering underlying national and international conditions while also remembering that different raw materials present different problems when it comes to recycling.

## Impacts and risk potentials of primary raw materials

The first step is to analyse the impacts and risk potentials of different raw materials in economic, environmental and social terms.

- **Economic:** Are there supply risks and what is the significance of the resource for the European economy?
- **Environmental:** What environmental issues, such as emissions of greenhouse gases and other pollutants, are associated with production of the raw material? How does production affect the water balance and the acidification of soils? How much land take is involved?
- **Social:** What is the position with regard to occupational safety and child labour? Does the mining of resources support corrupt regimes or violent conflicts?

“Hotspots” in which there are particularly undesirable impacts in these terms provide the basis for the subsequent definition of raw material-specific targets. For example, the production of iron and steel impacts on multiple hotspots: greenhouse gases and large-scale land take cause environmental degradation. Targeted measures, such as a greater focus on the refurbishment of buildings rather than new-build in order to reduce raw material requirements, can address several problématiques simultaneously.

## Distinguishing between bulk and non-bulk raw materials

Raw materials can be categorised on the basis of similar hotspots. As a first step, a distinction can be made between bulk raw materials (BRM) and non-bulk raw materials (NBRM).

Sand, gravel, cement, iron, copper and potash are examples of bulk raw materials. Their negative environmental impacts arise from the high demand for them and the vast scale of the extraction that is therefore required. Many of the efficiency potentials in relation to their extraction have already been exploited. A strategic objective is to reduce primary demand and increase the proportion of secondary raw materials from recycling.

**Figure: Clusters of bulk raw materials**

Öko-Institut e.V.

**Clusters of bulk raw materials (BRM)**
High demand and enormous production volume cause environmental effects

| | BRM 1 Cluster | BRM 2 Cluster | BRM 3 Cluster | BRM 4 Cluster | BRM 5 Cluster | BRM 6 Cluster |
|---|---|---|---|---|---|---|
| Cluster name | Domestic construction minerals | Construction materials | Principal bulk metals | Industrial salts | Other bulk metals | Other bulk raw materials |
| Cluster representative | Gravel | Cement | Iron / steel | Potash | Chromium | |
| Raw materials | Sand<br>Gravel<br>Natural stone<br>Clay<br>Gypsum | Quicklime<br>Cement | Iron / steel<br>Aluminium<br>Copper | Potash<br>Rock salt | Zinc<br>Lead<br>Chromium<br>Manganese | Sulphur<br>Titanium dioxide<br>Fluorspar<br>Barite<br>Phosphate<br>Special sands |

Source: Oeko-Institut

Non-bulk raw materials, such as rare earths, lithium and platinum, are usually needed only in small quantities, but they are nevertheless indispensable for many green technologies. Their extraction often causes considerable environmental damage and involves unacceptable working conditions. Promoting innovative methods of producing these non-bulk raw materials and putting pressure on manufacturers to guarantee fair wages and safe working practices in their supply chains are appropriate strategies here.

**Figure: Clusters of non-bulk raw materials**

Öko-Institut e.V.

**Clusters of non-bulk raw materials (NBRM)**

They are only needed in small quantities, but are nevertheless irreplaceable for many green technologies. Their promotion often causes considerable environmental damage and unacceptable working conditions.

| | NBRM 1 Cluster | NBRM 2 Cluster | NBRM 3 Cluster | NBRM 4 Cluster | NBRM 5 Cluster | NBRM 6 Cluster |
|---|---|---|---|---|---|---|
| Cluster name | Rare earths | Easily recyclable materials | Conflicts & small-scale mining | Particular potential landscape risk | Phase-out materials | Other non-bulk raw materials |
| Cluster representative | Neodymium | Platinum | Tin | Lithium | Cadmium | |
| Raw materials | All rare earths:<br><br>Praseodymium<br>Scandium<br>Europium<br>Terbium<br>Erbium<br>Thulium<br>Yttrium<br>Cerium<br>Neodymium<br>Samarium<br>Gadolinium<br>Dysprosium<br>Ytterbium<br>Lutetium<br>Lanthanum<br>Holmium | Ferrous metals (molybdenum, nickel, niobium)<br><br>Non-ferrous metals (magnesium, cobalt, tin)<br><br>Precious metals (ruthenium, rhodium, palladium, iridium, platinum, silver, gold)<br><br>Rhenium<br>Tungsten<br>Cadmium | Cobalt<br>Tin<br>Silver<br>Gold<br>Tantalum<br>Tungsten | Lithium | Cadmium<br>Mercury | Graphite<br>Beryllium<br>Gallium<br>Selenium<br>Arsenic<br>Zirconium<br>Antimony<br>Bismuth<br>Tellurium<br>Germanium<br>Strontium<br>Indium<br>Barium<br>Thallium<br>Hafnium<br>Titanium<br>Vanadium<br>Osmium |

Source: Oeko-Institut

The classification of raw materials in various clusters helps with the formulation of resource-specific or cluster-specific goals, because the raw materials in a cluster have at least one common hotspot, such as occupational safety and child labour or land take.

Using one raw material as a “cluster representative” enables detailed measures and instruments to be drawn up so that the targets can be achieved. These measures address the often multi-layered and complex challenges within the cluster and are aimed at boosting sustainability in the production of primary raw materials.

## The example of metals: Steel calls for different strategies to neodymium

The bulk metals include the bulk raw materials steel and aluminium. The most important resource-specific goal here is an absolute reduction in primary demand. This can be achieved by increasing the recycling percentage and by direct material savings. For example, a modal shift in transport away from private vehicles would significantly reduce the number of cars and thus require fewer resources.

Green technologies, including electromobility and wind turbines, are dependent on key raw materials such as rare earths, although these are only needed in small quantities. Neodymium, for example, is essential for the permanent magnets in wind turbines and is also used in mobile phones, laptops and other electronic products. The transition to sustainable energy will increase the demand for these non-bulk raw materials.

## Producing rare earths sustainably

The production of rare earths gives rise to extensive environmental and social problems. The production process requires large quantities of water and chemicals and creates toxic sludge. Safety standards for workers in the producing countries are usually inadequate, and corruption is a further risk. Economic risks must also be considered: some 85 percent of the world's neodymium comes from China, which thus has a monopoly position.

In the case of neodymium there are various strategies that can be adopted usefully. The first step should be to ensure that the rising demand for the technology metal is met from sustainable and certified sources. Both environmental protection and human rights must be monitored throughout the supply chain. In addition, the recovery rate – currently just one percent – needs to be increased significantly. Extending the useful life of electronic products would help to at least dampen demand.

## The example of construction minerals: More recycling, less new building

Gravel, sand and natural stone are the most important domestic construction materials. They are all characterised by high weight and relatively low value. Transport over long distances is therefore not worthwhile, which means that the German construction industry sources these materials almost exclusively within the country and usually within the local region.

The main problems associated with the extraction of resources in this raw material cluster are the risks of land take and landscape degradation. Gravel pits and stone quarries leave lunar-like landscapes that take decades to restore.

One way of tackling this is to increase the use of secondary material. For example, crushed concrete can replace gravel in structural engineering. Extending the useful life of buildings is equally important – refurbishment should be prioritised over new-build. In the new building sector itself, erecting multi-occupancy dwellings is significantly more resource-efficient than the construction of detached houses. In the case of natural stone, appropriate measures include asphalt recycling and reducing the amount of road building.

In the self-funded project "Germany 2049 – Transition to a sustainable use of raw materials", Oeko-Institut researchers have examined the issue in detail and analysed the problems and potential solutions.

*Deutschland 2049 – auf dem Weg zu einer nachhaltigen Rohstoffwirtschaft* [Germany 2049 – Transition to a sustainable use of raw materials]: Final report of the Oeko-Institut's self-funded project

## The example of biomass: Replenishable but not infinitely available

In contrast to the primary raw materials discussed above, biomass is a renewable resource. It comprises an extensive group of resources ranging from wood to plant-based feedstocks for the production of textiles, bioplastics and paper. Food and energy crops are also renewable resources.

Nevertheless, the global availability of biomass is limited by the availability of land for its production. In many cases it competes with the use of land for other purposes, such as growing food. Furthermore, the use of biomass does not automatically contribute to climate change mitigation. For example, if forests are cleared in order to grow energy crops, the climate balance is negative. In addition, monocultures of biomass can have an adverse effect on biodiversity.

It is therefore important to scrutinise the entire value chain and analyse the overall balance of biomass use in a particular field of application. Strategies for sustainable biomass production include increased recovery of wastes and residues, more efficient use of the valuable resources and coupling of different biomass uses. For example, wood should be used first in furniture-making or construction and only at the end of its useful life for energy generation.

## Study: Producing lithium-ion batteries more sustainably

As part of the Fab4Lib project funded by the German Federal Ministry of Education and Research (BMBF), Oeko-Institut researchers and 17 scientific and industrial partners have been studying the key raw materials needed for e-mobility.

On the basis of the latest global mobility scenarios, they calculated the battery capacity – in terms of gigawatt hours – needed for the growing electrification of the transport sector. They forecast a substantial increase in the demand for lithium and cobalt and also for nickel, copper, graphite and silicon. The research team calculated whether global resources of the key raw materials are sufficient and profiled the environmental and social consequences of production.

The researchers conclude that global reserves of the key technology metals are sufficient to meet demand, although temporary bottlenecks could occur as a result of the dynamic development of electromobility that is anticipated. To make Germany more independent of global developments in battery cell production, they recommend establishing cell production capacity in Germany or at least in Europe. At the same time, Germany should strive to become less dependent on raw material imports. Building up a comprehensive recycling system would lay the foundation for this.

*Gigafactories für Lithium-Ionen-Zellen – Rohstoffbedarfe für die globale Elektromobilität bis 2050* [Gigafactories for lithium-ion cells – Resource demand for global electromobility to 2050]: Short study by the Oeko-Institut on behalf of the German Federal Ministry of Education and Research (BMBF)

## The MoCa project: Recovering rare earths from mining residues

Oeko-Institut researchers are among the five German and three Brazilian partners in a research team that is investigating the extraction of rare earths from the tailings of a niobium ore mine. The German Federal Ministry of Education and Research (BMBF) is funding the research project "MoCa - Development of a production chain for rare earth elements from tailings of the ultramafic alkali-carbonatite complex Catalão/Goiás".

Tailings are fine-grained residues from ore production. They are usually contaminated by toxic substances and they settle as deposits in sedimentation tanks or are retained by dams. If one of these dams breaks, as occurred at the Brumadinho iron ore mine in Brazil in 2019, the consequences are catastrophic. But even in the absence of such a disaster, the storage of tailings causes severe environmental damage.

The project team is investigating modern production technologies for extracting a concentrate of rare earths from the tailings that arise in niobium mining. The Oeko-Institut is responsible for analysing and evaluating the environmental impacts of the various processes developed by the project.

MoCa: Development of a production chain for rare earth elements from tailings of the ultramafic alkali-carbonatite complex Catalão/Goiás: Project commissioned by BMBF

## Further information

[Global Stakeholder Platform for Responsible Sourcing (RE-SOURCING): Project description on the website of the European Commission]

[The European innovation partnership (EIP) on raw materials: Topic page on the website of the European Commission]

## Contact

**Stefanie Degreif**
Deputy head of Division
Resources & Transport

Oeko-Institut e.V., Office Darmstadt
Phone: +49 6151 8191-125
Mail: s.degreif@oeko.de

**Dr. Matthias Buchert**
Head of Division
Resources & Transport

Oeko-Institut e.V., Office Darmstadt
Phone: + +49 6151 8191-147
Mail: m.buchert@oeko.de

**Dr. Hannes Böttcher**
Senior Researcher
Energy & Climate

Oeko-Institut e.V., Office Berlin
Phone: +49 30 405085-38
Mail: h.boettcher@oeko.de

Oeko-Institut is a leading independent European research and consultancy institute working for a sustainable future. Founded in 1977, the institute develops principles and strategies for realising the vision of sustainable development globally, nationally and locally. Oeko-Institut is represented at three locations in Germany – Freiburg, Darmstadt and Berlin.