Construction aggregates, metals and biotic materials: recycling and recovery

The building and transport sectors use large quantities of primary raw materials. Recycling therefore has a key role to play in reducing consumption and conserving resources in these sectors. In a circular economy, end-of-life (EOL) products are treated not as waste but as resources.

Different raw materials require very different treatment pathways, so appropriate strategies need to be developed for each specific material. With aggregates such as gypsum or concrete, Germany's European neighbours are leading by example, with better-functioning systems, as well as higher recycling rates, as shown in the examples below.

The regulations on waste management and recycling adopted at national, European and global level provide the general framework. Sustainable extraction of primary raw materials is also important; the relevant legal provisions and the specific characteristics of the extractive materials must be considered in this context.

Keeping construction materials in the loop

The construction sector is particularly material-intensive. At the same time, mineral construction waste, such as concrete, bricks, clinker stone, mortar residues, tiles and ceramics, is one of Germany's largest waste fractions. For the building sector, high-quality recycling of as much of this waste fraction as possible should therefore be the goal.

The refurbishment or demolition of buildings generates large volumes of gypsum waste in the form of plaster boards. At the same time, more than two million tonnes of gypsum are used annually in the production of new plaster boards. A 30% admixture of recycled gypsum is the problem-free technical limit. When recovering this material, careful separation of gypsum plaster boards from other building waste is important in order to increase the quantity and quality of reuse in construction waste streams.

Concrete contains a high proportion of gravel, another primary raw material. A very good substitute for gravel is processed mineral construction waste, such as concrete rubble or scrap bricks. Whereas builders here in Germany use only around 1% recycled concrete, the figure for Switzerland is already 7%. Experience in Switzerland has shown that in 90% of all structural engineering projects, the use of recycled material is feasible with no negative impact on quality. Corresponding guidelines and a nationwide scheme for the processing of building rubble are needed to unlock this potential.

Recycling can work in road-building too

Around a quarter of the 40 million tonnes of asphalt used in Germany annually comes from waste material, making this another area of untapped potential. However, the contracting authorities in the public sector are often reluctant to allow the use of recycled asphalt, especially for regional and district roads, as the quality of this product is not always guaranteed.

Improved quality assurance and assessment, along with appropriate specifications, may provide a remedy here. For example, Baden-Württemberg has made maximum recycling the construction standard for its regional roads. Between 70% and 95% of the asphalt base and binder layers must consist of waste aggregate; the specified minimum for the asphalt overlay is 40-50%.

Metal recycling: vital for the transition to green mobility

Together with numerous other measures relating to traffic prevention and a shift in the modal split, electric vehicles will play a key role in future-proof mobility. Electric vehicles are powered by batteries which contain metals such as lithium, cobalt, nickel and graphite. Platinum is a necessary component of fuel cell vehicles. All these resources are in short supply and are concentrated in a small number of countries. Furthermore, their extraction often causes significant harm to human health and the environment.

Alongside more sustainability in raw materials extraction, combined with corporate due diligence, a substantial increase in the recycling rate for these technology metals is needed. A sustainable circular economy for e-mobility requires a nationwide recycling system for lithium-ion batteries.

Battery recycling for resource conservation

It would then be feasible to collect and recycle these precious raw materials at both European and global level. This is not an unrealistic ambition, as traditional lead-acid battery recycling programmes have shown. A global recycling system has been established, enabling most of the lead-acid batteries produced today to be recycled. According to figures from the German Federal Environment Agency, Germany's recycling operations achieved a recycling efficiency of around 81% for lead-acid batteries in 2018.

For platinum, the recycling rate in the vehicle sector is already above 50%, resulting in a drop in platinum prices. The ambition is to increase the rate to 80%.

Some companies in Belgium and Germany are showing how battery recycling can work. The process starts with the manual disassembly of lithium-ion batteries. The cases, cables and other components are then sent to conventional recycling facilities for recovery of the aluminium, copper and other metals.

The battery cells themselves require more complex treatment, involving a pyrometallurgical process at very high temperatures. This produces alloys containing a high proportion of cobalt, nickel, copper or lithium; the precise composition depends on the raw material and type of facility. The alloys are then processed at other specialised facilities and the battery-grade raw materials are extracted in their elemental form.

Battery recycling is a complex process that requires substantial energy inputs. Nevertheless, initial life cycle assessments highlight the benefits. If the energy consumption, CO_2 emissions and chemical residues from battery recycling are compared with those of primary raw materials extraction, recovery is clearly the more sustainable option.

Biotic raw materials: organic waste, wood, textiles

Some raw materials are biogenic in origin. These materials are replenishable in the sense that they are not derived from finite resources, but this does not mean that their availability is unlimited. Here too, sustainable management – such as cascading – supports resource conservation.

In order to make optimum use of organic waste and garden clippings from the green bin, it is important to collect these waste fractions separately from disposable plastics and packaging. Sorting has been mandatory for organic waste in Germany since 2015 but is not yet being implemented nationwide. The organic residues are composted – with no additional energy input – for subsequent use in agriculture, horticulture and the manufacture of soil substitutes. Local fermentation plants then convert the organic residues into biogas, a useful energy source. The fermentation residues are oxygenated and used as compost.

Wood classed as green waste can be burned in combined heat and power (CHP) plants. This is often the final staging post for scrap timber as well, although some scrap timber is so heavily impregnated with wood preserver that it is not safe to burn and therefore has to be disposed of as hazardous waste. Untreated scrap timber can find a new lease of life as chipboard. However, this is a form of downcycling; in other words, it is reused as a lower-quality product.

As for textiles and garments, the quality of primary products has declined dramatically in recent years with the advent of “fast fashion”. As a result, clothing collection bins often fail to cover their costs as there is no longer a market for the sorted garments. Instead of a sustainable cycle, a waste disposal problem is slowly emerging here.

Various studies and research projects conducted by the scientists at the Oeko-Institut look at how recycling can help to conserve precious resources. Some examples are given below.

Study: Life cycle assessment of the recycling of gypsum plaster boards

On behalf of the German Federal Environment Agency (UBA), a consortium of researchers from the Oeko-Institut, Prognos AG and the Federal Institute for Materials Research and Testing (BAM) assessed the legal, technical and economic framework for gypsum recycling in Germany and five other European countries. The project team developed scenarios, carried out comprehensive life cycle assessments and devised strategies.

In some European countries, gypsum recycling schemes have been in place for some years, partly because the energy industry in these countries is less reliant on coal-fired power generation compared with Germany. In 2016, 60% of demand in Germany was covered by gypsum as a by-product of flue gas desulphurisation (FGD) systems in electricity production at coal-fired power plants. After Germany’s exit from coal, the gypsum supply from coal-fired power plants will no longer be available in these quantities.

The life cycle assessment, conducted as part of the study, shows an ecological advantage of recycling gypsum plaster boards in most cases compared to the supply of FGD gypsum and natural gypsum. Transport distances are significant in this context: additional recycling plants in Germany would shorten transport distances and further improve the ecological balance of recycled gypsum.

Various factors can help to push up recycling rates for gypsum. Higher prices of landfilling building rubble generally lead to increased separation of gypsum plaster boards. Dry storage of the material is also important in order to avoid the costs and energy inputs for subsequent drying. There are already good approaches for successful gypsum recycling in Germany, which should be supported and expanded.

Life cycle assessment of the recycling of gypsum plaster boards: study by the Oeko-Institut, Prognos AG and the Federal Institute for Materials Research and Testing (BAM) on behalf of the German Federal Environment Agency (UBA)

Synthesis paper: Strategies for a sustainable supply of raw materials for the electric vehicle sector

In a study commissioned by Agora Verkehrswende, researchers at the Oeko-Institut investigated how the rising demand for raw materials for the expanding electric vehicle sector can be met in a sustainable manner.

One of the key findings is that rapid expansion of electromobility is feasible and that global resources are available in sufficient quantities for this purpose. However, temporary supply bottlenecks and the associated price increases are possible, particularly for cobalt and lithium. Furthermore, the extraction of raw materials is inherently associated with environmental and social problems.

The researchers therefore recommend a substantial increase in recycling of battery raw materials. To that end, it is essential to reform the EU Batteries Directive and develop a global recycling system for lithium-ion batteries. More research is needed in the area of battery technology in order to promote material efficiency, the use of substitutes for critical raw materials and the improvement of recycling techniques.

Further information

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

Aktualisierte Ökobilanzen zum Recyclingverfahren EcoBatRec für Lithium-Ionen-Batterien [Updated life cycle assessments for the EcoBatRec recycling process for lithium-ion batteries]: Study by the Oeko-Institut on behalf of the German Federal Environment Ministry (BMU)

Contact

Dr. Matthias Buchert
Head of Division
Resources & Transport

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

Stefanie Degreif
Deputy head of Division
Resources & Transport

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

Günter Dehoust
Senior Researcher
Resources & Transport

Oeko-Institut e.V., Office Berlin
Phone: +49 30 405085-355
Mail: g.dehoust@oeko.de

Dr. Winfried Bulach
Senior Researcher
Resources & Transport

Oeko-Institut e.V., Office Darmstadt
Phone: +49 6151 8191-144
Mail: w.bulach@oeko.de

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