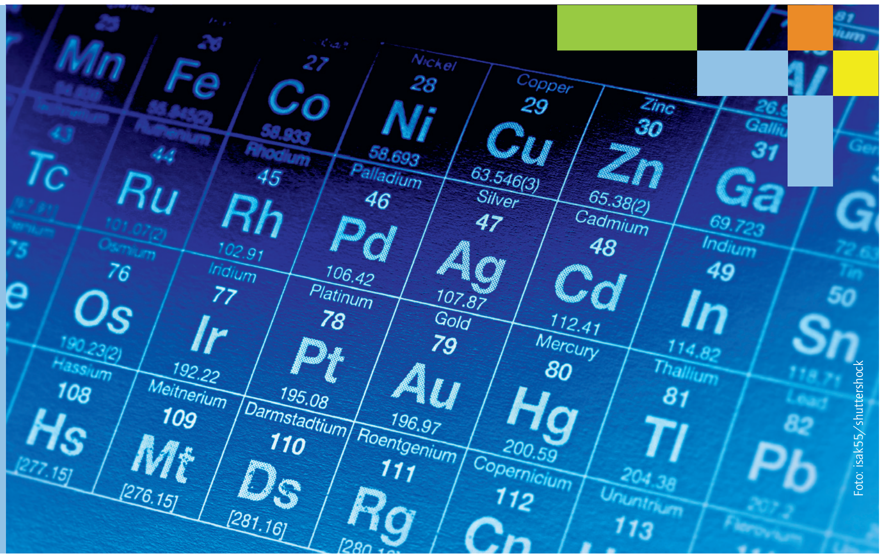
acatech POSITION PAPER
Executive Summary and Recommendations

Framework Conditions for the Future of Materials

Analysis and recommendations

acatech (Ed.)



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Almost every product throughout the whole of industry relies on innovative or conventional materials that have been tailored to its specific requirements. acatech has analysed the legal framework and the current status of the conventional classes of material that are most important to German industry. The study concludes that Germany must work to become more efficient in its use of energy and materials with the aim of establishing a closed-loop system.

This will require ongoing, evidence-based discussion – not least at a policy level – of how to achieve the right balance between providing the materials that are indispensable to our modern society and protecting the environment and people's lives and health. Based on these findings, the authors have formulated a series of recommendations for policymakers, science and industry, with the aim of promoting sustainable resource use as part of a circular economy.

Framework conditions at a glance

Regulation: energy and raw material prices, emissions trading

The materials industry is one of Germany's most energy-intensive industries. The research community and industry have already invested a lot of effort into improving the energy efficiency of materials production. The factors with the greatest influence on the global competitiveness of the materials industry are Germany's Renewable Energy Sources Act (EEG) and the EU Emissions Trading System (EU ETS).

Security of supply: the availability of raw materials

Germany has few raw materials of its own. While the stone, gravel and sand feedstock for the glass industry and the cement and concrete manufacturing industry can be sourced locally, all Germany's other materials industries are reliant on imported raw materials. Furthermore, when not only new products but also used goods and scrap are exported, the used materials remain abroad and cannot be recycled and reused in Germany.

Sustainability: recycling, material efficiency and suitability for a closed-loop system

Sustainability and material and energy efficiency are important considerations in both the production and the use of materials of all kinds. Products' lifespan, repairability and recyclability are also key to sustainable lifecycle management.

Current status of selected material classes

Steel

As a relatively energy-intensive sector, the iron and steel industry is one of the world's largest emitters of CO_2. As a result, its global competitiveness is strongly influenced by electricity prices and environmental regulations. Exemptions from and caps on energy surcharges and levies remain important to the iron and steel industry, since technical limitations make further manufacturing process optimisations unlikely in the near future. The industry believes that the development and utilisation of new types of steel offers the best prospect of achieving higher reductions in its CO_2 emissions.

Non-ferrous metals: Aluminium and copper

Aluminium and copper are traded on the London Metal Exchange and are thus subject to fierce global competition. Their price is largely driven by the price of electricity. Were it not for the special dispensations granted to German aluminium manufacturers, the cost of the electricity used in the production process would already exceed the market price for aluminium. The industry therefore regards the energy transition as a significant challenge. Since the feedstock for copper and aluminium production has to be imported from abroad, manufacturers' room for manoeuvre also depends on raw material prices.

Synthetics and Plastics

The energy transition also poses a challenge for the entire commodity chemicals industry. While many companies currently receive compensation for electricity costs, it is doubtful whether it will be possible to maintain their exemption from the EEG surcharge in the future. Alongside high energy prices, industry representatives are also concerned about the security of the energy and synthetics supply. The importance of switching from oil-based to bio-based chemicals is therefore underlined.

Glass

The glass industry's most energy-intensive companies are partially exempt from the EEG surcharge and grid charges. They also receive higher free allocations under the EU Emissions Trading System by virtue of being on the carbon leakage list. Physical and technical reasons mean that it is not feasible to reduce the glass industry's greenhouse gas emissions. However, Germany's abundant primary raw material resources (silica sand) are a major plus in terms of security of supply and sustainability. Thanks to 100% recycling with no loss in quality, there is also an adequate supply of recycled glass as a secondary raw material.

Concrete, cement and stone

The cement industry uses large quantities of fuel, while burning the raw material mix generates high CO_2 emissions. Although the cement industry currently receives free allocations under the EU Emissions Trading System, a reduction in carbon leakage protection post-2020 could result in production being transferred to countries outside the European Union. New types of cement, binding agents and building materials such as carbon fibre reinforced concrete could provide attractive, energy- and resource-efficient alternatives to conventional materials. Security of supply is not an issue, since all of the raw materials used in the cement industry are predominantly sourced from within Germany.

Composites – special carbon fibre reinforced plastics

The production of carbon fibres requires more energy than other competing materials. The subsidisation of energy prices in competing industries such as the aluminium sector puts the carbon fibre industry at a competitive disadvantage. However, it is still a young industry, and it has already managed to cut the amount of energy used in the production of carbon fibres by fifty percent in the last ten years. New technologies, materials, modelling techniques and processes promise further major reductions in energy consumption in the future.

Functional materials

Functional materials are a diverse group of materials with special electrical, magnetic, acoustic, optical or biological and chemical properties. Functional materials are key components in energy storage, conversion and transport applications like smart grids. While the necessary raw materials such as rare earth elements are found in several locations around the world, the market is dominated by China. For most strategic metals, Germany is 100% dependent on imports.

Recommendations at a glance

1. Create conditions that enable fair, innovation-based competition for the German materials industry

National or European regulations on issues such as emissions trading, limits geared towards protecting the environment and electricity prices should not be allowed to jeopardise the global financial competitiveness of Germany's materials industry. Against a backdrop of emissions trading and rising energy prices as a result of the EEG surcharge, the materials industry remains reliant on exemptions to prevent it from relocating to countries where lower production costs often go hand in hand

At a glance

- In its annual internal survey on technology issues, acatech – National Academy of Science and Engineering identified "the materials of the future" as one of the most important topics of the next few years.
- Based on the results of a survey and a review of the literature, acatech analysed the framework conditions relating to regulation, security of supply and sustainability for the following 7 material classes: steel; non-ferrous metals; synthetics; glass; concrete, cement and stone; composites; and functional materials.
- Both everyday and innovative products and technologies rely on new or conventional materials that have been tailored to their specific requirements. Moreover, competition between different materials is a key driver of innovation across all sectors of the economy.
- Energy prices and carbon emissions trading are critically important for almost all materials. Furthermore, as a country that (with some exceptions) has few raw materials of its own, Germany is dependent on the availability of raw materials and on international trade.
- The authors' chief recommendation for policymakers is that they should enable fair and open competition between different materials against a backdrop of rising energy prices, growing regulation and increasingly tough competition from other parts of the world.
- The authors call on science and industry to continue developing innovative materials. This will require ongoing, evidence-based discussion of the balance between the production, use and recycling of these materials and the need to protect the environment and people's lives and health.
- Policy decisions must ensure that the development of economic prosperity and growth is compatible with the protection of citizens and the environment. The effects of policy decisions on the materials industry should be established scientifically and communicated in a transparent manner.
- The recommendations encompass everything from the implementation of circular economy principles and digitalisation projects to the analysis of regulatory goals, the implementation of the ecodesign and recycling directives, the funding of interdisciplinary research, a call for businesses to be bolder when it comes to using innovative materials, and the need for more effective communication.

with lower climate, environmental and health standards. In order to enable fair, innovation-based competition for the German materials industry, it will not only be necessary to grant exemptions from the EEG surcharge but also to ensure that the number of CO_2 certificates on the market is no higher than necessary.

2. Establish a closed-loop system and recycle scrap and used goods as part of a circular economy model

Scrap and used goods from the domestic market account for a significant proportion of the materials used to make new products. However, this proportion could be increased by optimising the extent to which they are fed back into the resource and material cycle. It may be necessary to place export restrictions on scrap and functioning used goods, especially for those critical raw and industrial materials where there is a threat to security of supply in Germany. Action must be taken to ensure that final disposal of raw materials through dumping and incineration is no longer a cost-effective solution – to do otherwise would be unacceptable, not only from an environmental and economic perspective but also in view of Germany's growing raw material dependency. Increased investment in research is required to reduce the amount of raw materials lost in this way as far as possible. It is also necessary to consider the ethical dimension. Germany exports used goods and waste to developing countries, where they are broken down and recycled in conditions that pose a threat to human health and the environment. On the other hand, by exporting functioning used goods it is often possible to extend both their total lifespan and their period of use.

3. Apply the Ecodesign Directive to the entire product lifecycle

At present, the Ecodesign Directive applies primarily to the energy and materials used during a product's manufacture and first use phase. However, the product's lifespan, repairability and recyclability are also key factors in its total energy and material consumption. Standardised interfaces e.g. for power supplies and different types of connector are also critical to material and resource efficiency – nowadays, perfectly functional power supply units are often thrown away together with faulty appliances. Policymakers should therefore extend the scope of the Ecodesign Directive to the entire product lifecycle, based on the relevant materials science evidence. The corresponding research requirements are outlined in Recommendation 7.

4. Extend the Ecodesign Directive to all industries

Sustainable product lifecycle management calls for everyone involved in a product's development to be pulling in the same direction. This is essential in order to achieve closed material and resource cycles, and will only be possible if the fundamental principle of the Ecodesign Directive is extended to all industries. At present, all means of transport are excluded from the Directive. It is therefore necessary to review whether or not the exemptions for motor vehicles, rail vehicles, aircraft and ships are justified.

5. Planned regulations should be checked for conflicting goals and amended as necessary

Some directives and regulations have conflicting goals. One example is the conflict between saving materials through miniaturisation and efficient material use. While reducing the size of something like electrical device components undoubtedly saves materials, the use of a wide range of materials in smaller and smaller spaces increases product complexity. The individual material content can get so small that it becomes unprofitable or in some cases even impossible to recycle the component. We need more R&D to identify conflicting goals like this from an early stage. Other conflicts occur at the interface between chemical, product and waste legislation – the restrictions on the use of recycled plastics in food packaging are a case in point. Regulations resulting in conflicting goals that prevent the overall aims from being achieved should either be avoided or reviewed and, if necessary, revoked. Policy decisions are the only way of resolving these conflicts.

6. Promote and establish systematic digitalisation across all aspects of materials science and engineering

Materials engineering plays a vital role in digitalisation – without it, it would be impossible to keep developing smaller, more powerful microchips. By the same token, digitalisation also enables advances in materials science and engineering. Digital databases and simulations facilitate the search for materials suited to specific applications and accelerate the development of new materials. In order to assist materials research, it is therefore necessary to promote digitalisation across all aspects of the materials value chain, from research to products and recycling.

7. Strengthen research into recycling and increase the corresponding funding

Materials researchers and product developers need to cooperate more closely on the recycling of industrial and raw materials (see also Recommendation 8). Cooperation will be especially important with regard to metals from thin-film technology such as indium, gallium, europium and tantalum, as well as certain metal catalysts. The conflicting goals alluded to in Recommendations 3 and 5 can only be prevented if materials researchers and product developers collaborate on recycling methods. Moreover, technically feasible and economically viable recycling methods have yet to be developed for the majority of functional materials in particular. Research funding should place greater priority on this aspect. Both the research community and policymakers must buy more strongly into the notion of a systemic materials cycle as part of a circular economy. They will also need to consider the potential waste legislation and recycling ramifications of how materials are classified under product law.

8. Material – Engineering – Manufacture: strengthen interdisciplinary cooperation and close the gaps between materials engineering and the finished product

Overall, Germany has a good set-up with regard to research funding for the (further) development of conventional and novel materials. Funding should continue to be targeted at the promotion of strong interdisciplinary research between the fields of materials engineering, product development and manufacturing technology. It is impossible to create a component without materials, engineering and manufacturing – neglecting any one of these aspects will damage Germany's competitiveness. The necessary continuity between basic research and applied engineering may call for longer project durations, depending on the project's goals. It will also be important to support pilot projects at universities and research institutions, the development of demonstrator projects, the establishment of innovation labs and a greater number of validation projects. These requirements should be taken into account by funding programmes, funding agencies and the organisations running the projects.

9. Taking the plunge with innovative materials

Businesses are frequently reluctant to use new, innovative materials due to the high financial risks and the need to apply different norms and standards. New materials also often require significant adjustments within the business, such as changes to the established production process, product processing methods and work organisation model. Skills developed over several years suddenly become redundant, while new skills have to be learned. The problem is illustrated by companies' reluctance to use innovative fibre optic cables in the telecoms sector. In the short term, it was cheaper for them to continue laying conventional copper cables, since these did not require new procedures or equipment and employees did not have to learn new skills. This is one of the reasons why it is now taking so long to upgrade Germany's telecommunications network. Companies must therefore find the courage to start using innovative materials sooner. This will require closer cooperation between researchers and users, while policymakers will need to create the relevant incentives in public infrastructure projects.

10. More effective and targeted communication

You cannot have innovative products without innovative materials. Innovative materials may not always be particularly eye-catching, but they are nonetheless indispensable. Innovations often go virtually unnoticed by policymakers and the public, particularly in the case of conventional materials such as steel and glass. When materials do make it into the headlines it tends to be in a negative context, as in the case of plastic waste or when insulation materials catch fire and cause a building to burn down. Industry associations, businesses and technical experts must get better at communicating the positive qualities and innovative potential of "their" materials, while at the same time engaging in the public and policy debate to promote more efficient use of materials as part of a circular economy.

Methodology

This acatech POSITION PAPER is the product of two years' work by the project group. Its content is based on a comprehensive review of the literature, an expert workshop and an acatech survey in which experts in the field of materials science and engineering and representatives of the relevant associations were interviewed about the framework conditions for the materials of the future. A core team of some 25 experts in Germany took part in the project, including several leading figures from research institutions, industry and the relevant associations. The project was funded by the acatech Förderverein.

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