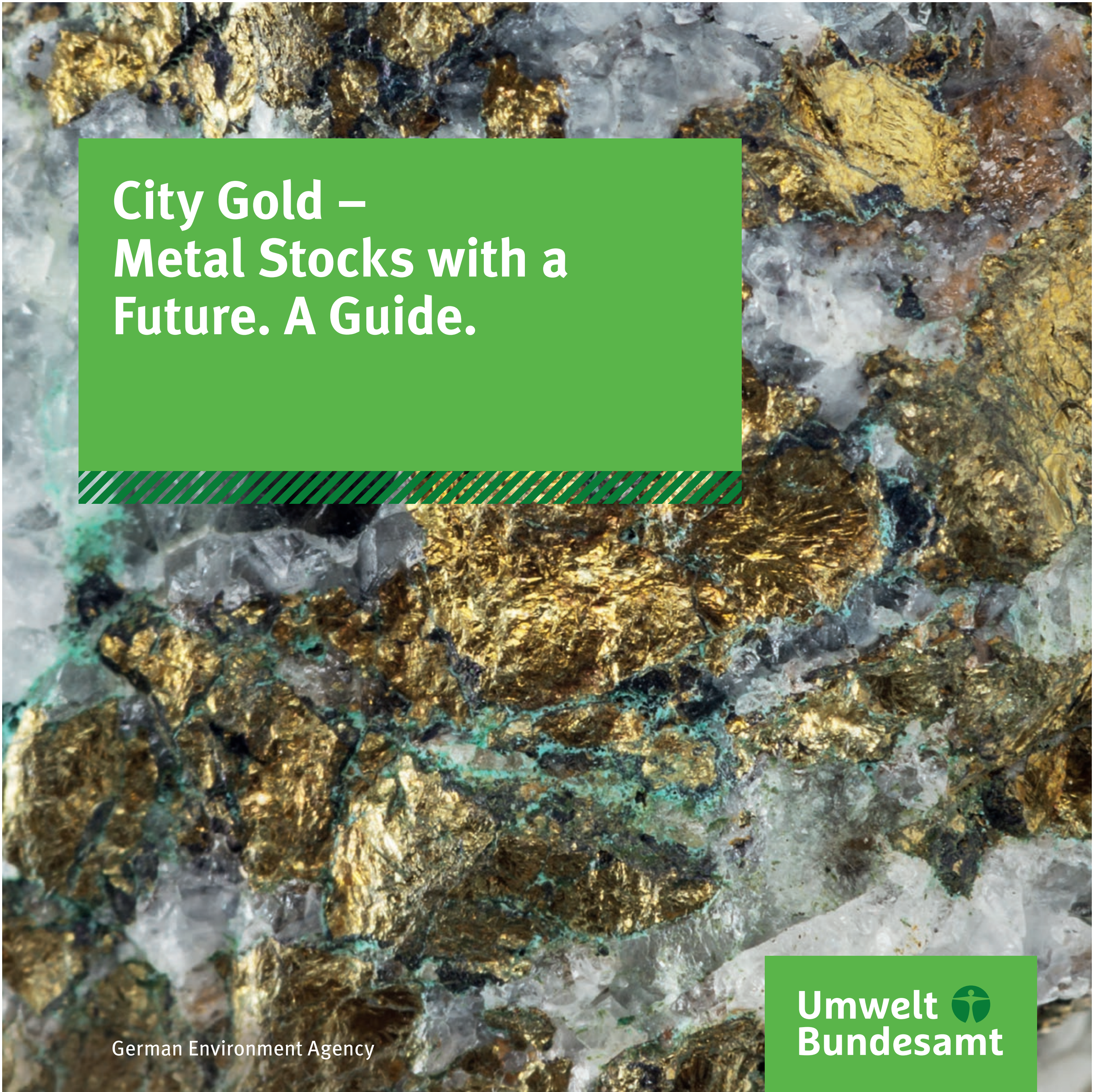

City Gold – Metal Stocks with a Future. A Guide.

German Environment Agency

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City Gold – Metal Stocks with a Future. A Guide.
Results of the Project Mapping of the Anthropogenic Stock III

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As at: December 2021

FOREWORD

The anthropogenic stock in Germany is a treasure trove for meeting our raw material needs that are growing every year. With the strategy of urban mining – extracting secondary raw materials from buildings, infrastructure, vehicles, and other durable goods – this treasure trove can be used ever more successfully and systematically.

Urban mining saves primary raw materials and robustly reduces environmental impacts along the entire value chain. It is a necessary means to expand the raw-material base for the Energiewende (energy transition) and Verkehrswende (transition in transportation) as well as for the other major key technologies of the 21st century following good environmental, labour, and social standards. Resource conservation, climate protection and securing raw materials go hand in hand.

The German Environment Agency launched the project series Mapping of the Anthropogenic Stock (KartAL) in 2011 to improve the knowledge and decision-making basis of the secondary raw materials industry and to improve the quality of urban mining in Germany. Within the third project in this project series, two guidelines were developed that are intended to convey potentials, challenges, and solutions for optimized urban mining. In the present publication, this is done using the example of metals and its alloys.

At this point, I would like to express my sincere thanks to all those involved in business, administration and science whose willingness to engage in dialogue has contributed significantly to these important findings.

I wish you a stimulating read.

Prof. Dr. Dirk Messner
President of the German Environment Agency

The project Mapping of the Anthropogenic Stock III (KartAL III)

The strategic project series on the anthropogenic stock

In recent years, the German Environment Agency has implemented a number of projects on anthropogenic deposits in Germany. With the help of these technical and methodological foundations and approaches, the course is to be set for successful urban mining. In this context, the dialog-oriented research project Mapping of the Anthropogenic Stock III – Establishment of material flow management with the integration of recycling chains to qualitatively and quantitatively increase the recycling of metals and mineral building materials (KartAL III, FKZ: 3716 35 3230), which is summarized here, has made a systematic and participatory contribution to further developing the circular economy into a resource-conserving material-flow economy.

Material groups in focus and central questions

The project focuses on two groups of materials:

- Mineral construction and demolition waste: Concrete, sand-lime bricks, porous and lightweight concrete, bricks, flat glass, insulating materials, gypsum building materials, plasters and mortars, tiles and ceramics.
- Base and special metals: brass, zinc, tin, aluminium, magnesium, rare earths in magnets, and stainless steels and their alloying elements.

These material groups were investigated by Öko-Institut (metals) and ifeu Heidelberg (construction minerals) with regard to the following questions:

- Where are sensitive value-adding stages in the circular economy of the respective materials?
- What influences prevent high-quality recycling?
- How can problematic situations be resolved in a promising way?

Dialogue forums

To discuss and answer these core questions, six dialogue forums were held for both material groups with selected experts from business, administration, and science. These events had an emphatically interactive character. Work was carried out intensively in small groups, and opinions were constantly incorporated through participant voting. In this way, the project could prioritise the most important points and reach an understanding with the participants on a broad level. The success of this participation format was confirmed at a large closing event.

Volume flow forecasting with the DyMAS model

The work was supported by comprehensive volume flow forecasting in order to identify relevant waste streams whose improved recycling could have a major positive effect on resource-saving value chains. This forecast includes modelling of future developments for the materials under consideration, considering important trends such as electromobility or changes in construction methods. The expected return flows of materials from the anthropogenic stock and the influences of technologies and losses on recovery potentials are thus represented. For this work, the project partner Ifu Institute used the DyMAS system (Dynamic Modeling of Anthropogenic Stocks), which has already been successfully applied in previous projects on anthropogenic stocks under the German Environment Agency. Within the framework of this project, the model was adapted and refined for the material flows under consideration.

„The recycling of non-ferrous metals in Germany is a valuable contribution to the protection of the climate and resources and supplies the economic cycles with high-quality metals. The growing anthropogenic stock in Germany offers potential for increasing shares of secondary metals in metal production and for the manufacture of new products. The increasing complexity of old scrap, however, requires the increased use of new and innovative processing methods in order to optimally exploit this „metal treasure" for the future"

Rainer Buchholz | WirtschaftsVereinigung Metalle | Head of Waste Management and Resource Efficiency

„Waste electrical and electronic equipment in Germany can now be treated by professional reprocessing companies and the material flows can be separated in such a way as to ensure the recycling of important metals with high recovery rates. A significant increase in the collection rate of of WEEE in Germany is a prerequisite for the further growth of this important aspect of the circular economy and for the supply of secondary metals."

Guido Sellin | ELECTROCYCLING GMBH | Managing Director

„The demand for sustainable metals of the future from primary and recycled production is rapidly growing. As a multi-metal recycler, we bring valuable raw materials back into the cycle without any loss of quality. The real challenge is to get ahold of these treasures; our consumer and durable goods are becoming more and more complex and fragmented. Here we would like to see more producer responsibility for a more efficient circular economy."

Roland Harings | Aurubis AG | CEO

Overview – Investigated Metals and Alloys

The focus of project research is on the important, non-ferrous metals aluminium, magnesium, zinc and tin, as well as stainless steel and the alloys brass and neodymium-iron-boron magnetic materials. The figures given in this publication exclude other metals such as conventional steel, copper, etc.

The seven metals and alloys investigated are found in a wide variety of infrastructure and products in the anthropogenic stock. After intensive analysis with the support of experts from the metal industry, the following application sectors were identified as significant. The overview lists examples of the goods contained in and the main metals/alloys in each case.

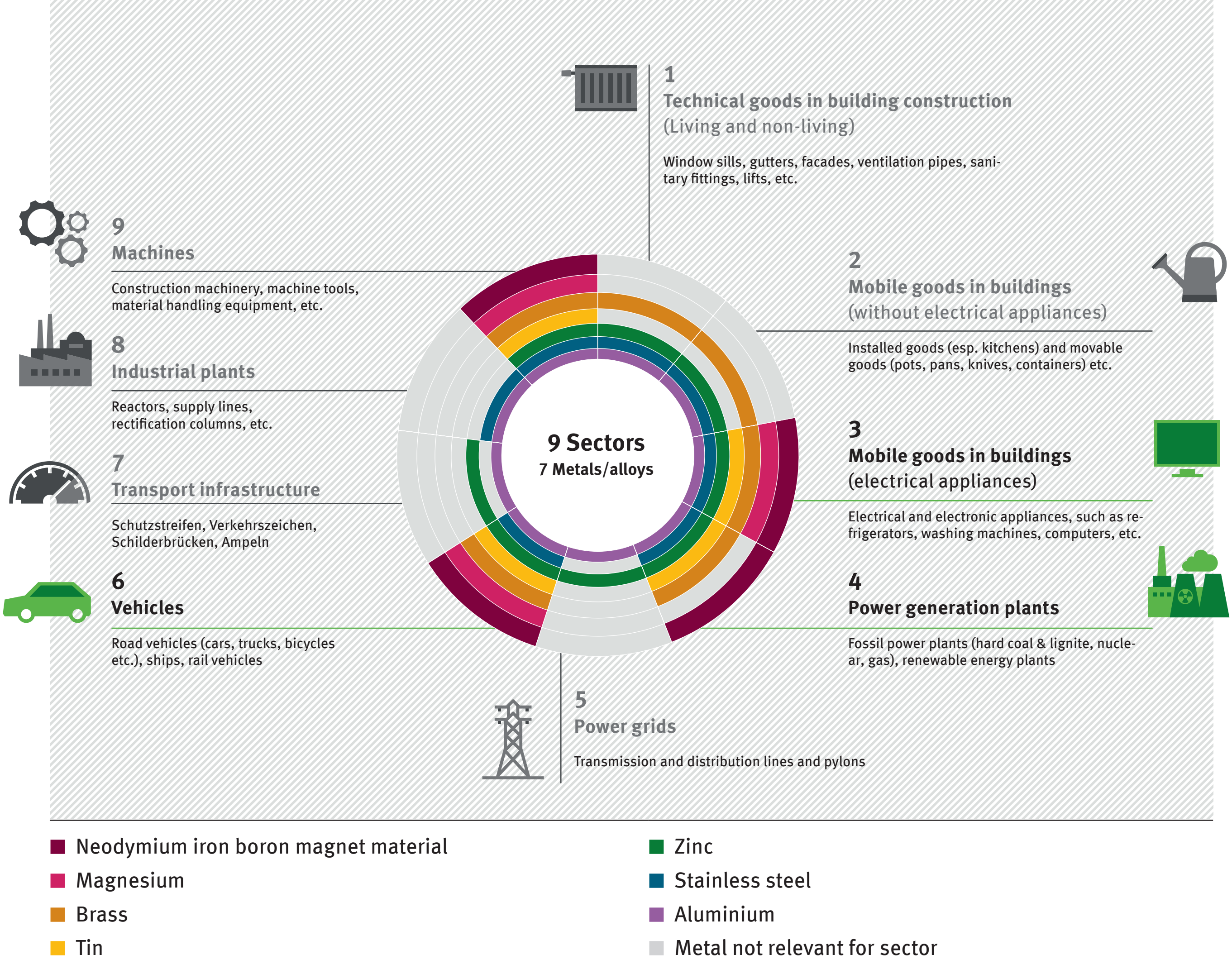
Figure 1 shows the very different patterns that each of the nine application sectors have for demand of the seven metals/alloys studied. The spectrum ranges from sectors such as transport infrastructure, which only play a role for two metals (aluminium and zinc), to sectors such as vehicles, which are relevant for all seven metals/alloys.

The following pages present stock developments in the anthropogenic stock as well as the expected development of the outflows to the circular economy for the years 2020, 2030 and 2040, looking at in particular the three important application sectors 3 electrical appliances, 4 power generation plants and 6 vehicles.

Figure 01

Goods sectors considered in the study and their contained metals and alloys

The anthropogenic stock in Germany



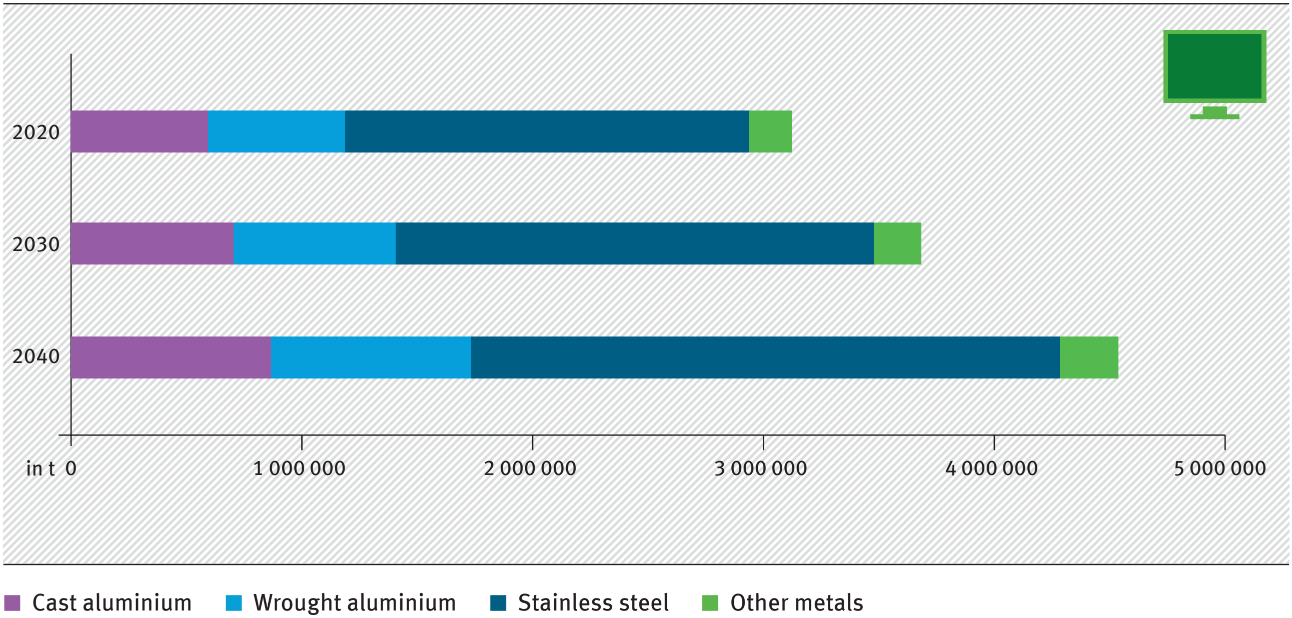
Source: Öko-Institut e. V.

Stock Development and Material Withdrawal by Metals/Alloys – Sector 3 Electrical Appliances

As the following graph shows, Germany's metal stock in the electrical appliances sector including electronic appliances from 2020 to 2040 is expected to grow strongly, by 45.7 % or from 3.1 million tonnes to 4.5 million tonnes. Stainless steel accounts for the largest share, followed by wrought and cast aluminium.

Figure 02

Material stock sector 3 mobile goods in buildings (electrical appliances) 2020–2040 in tonnes

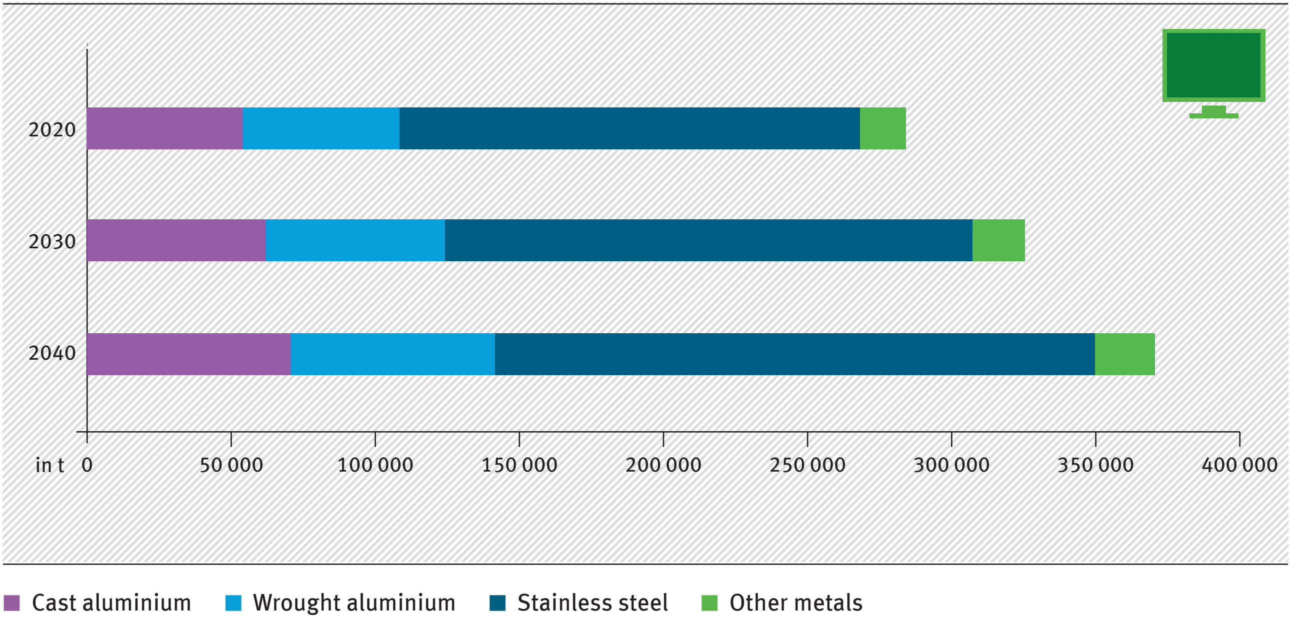


Source: Öko-Institut e. V.

The continuous replacement of electrical appliances resulted in withdrawal of the available materials of around 280 000 tonnes in 2020, mainly dominated by losses of stainless steel of around 160 000 tonnes. The annual amount of material lost from the overall stock is expected to increase up to year 2040, amounting to approximately 370 000 tonnes (+30.3 %).

Figure 03

Material withdrawal sector 3 mobile goods in buildings (electrical appliances), 2020–2040 in tonnes per year



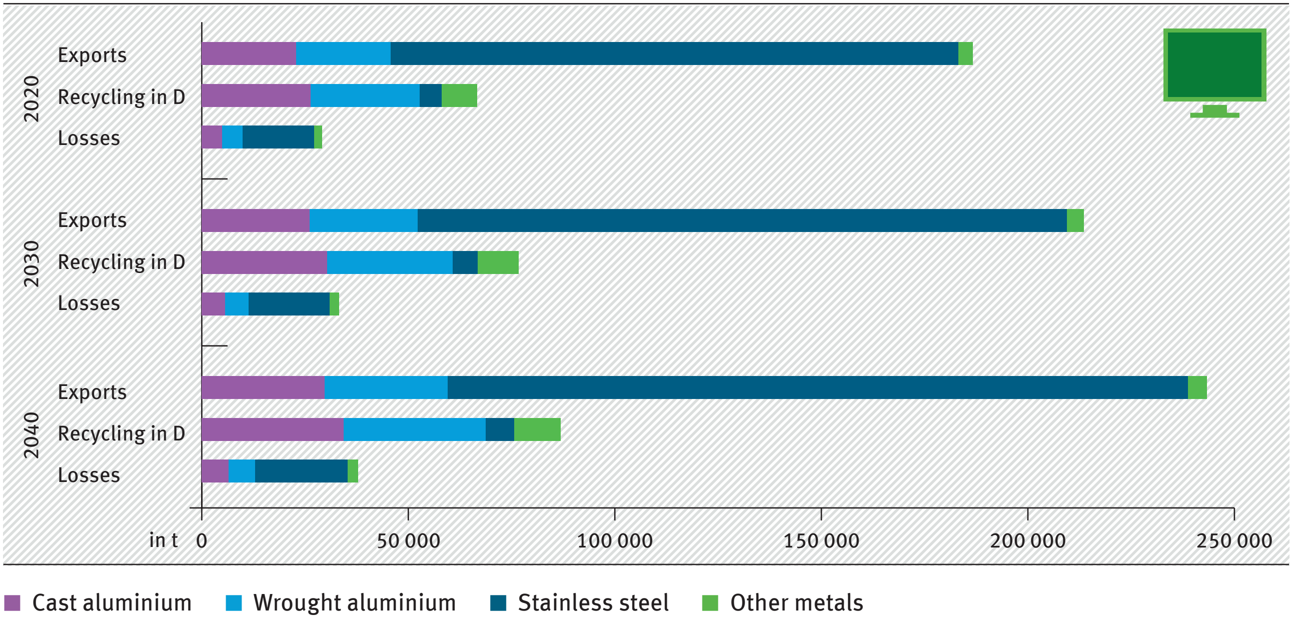
Source: Öko-Institut e. V.

Stock Development and Material Withdrawal by Metals/Alloys – Sector 3 Electrical Appliances

Figure 04 shows the fate of metals from sector 3 after recycling for the years 2020, 2030 and 2040. It is clear that the largest quantities of these materials are exported, which can be explained by the high export quota of stainless steel. Aluminium, both wrought and cast alloy, holds the largest share of recycled metals in Germany. The losses are mainly through stainless steel, which unintentionally ends up in carbon steel recycling.

Figure 04

Material fate sector 3 mobile goods in buildings (electrical appliances) in tonnes per year



Source: Öko-Institut e. V.

Reflection on Potentials, Obstacles and Recommendations for Action – Sector 3 Electrical Appliances

Research results for the electrical appliances sector have clearly shown that a large part of the waste from the anthropogenic stock does not enter the circular economy in Germany but is instead exported to other EU countries and outside the EU. Recycling activities do take place outside Germany and the EU, but often under poorer environmental and working conditions and with a loss of resources.

Accordingly, Germany does not reach its collection targets for e-waste: in 2018, only 43 %was reached – the 45 % target was missed. Yet as of 2019, a target of 65 % must be achieved under the WEEE Directive!

Since the majority of old electrical appliances do not leave Germany or the EU as waste but as second-hand goods, the definition and distinction between waste and second-hand goods is crucial. This is because electrical waste that is classified as waste may not be exported to developing countries; used goods, on the other hand, may.

With the latest revision of the EU's WEEE Directive and its transposition into the German Electrical and Electronic Equipment Act (ElektroG), an attempt was made to make it more difficult to export electrical consumer goods that are actually waste.

In view of the modest collection results of e-waste in Germany so far, it is urgently recommended to carry out a comprehensive evaluation of the effects of the above-mentioned revisions. If the effects are not sufficient, the administrative framework must be adapted at the European and German level.

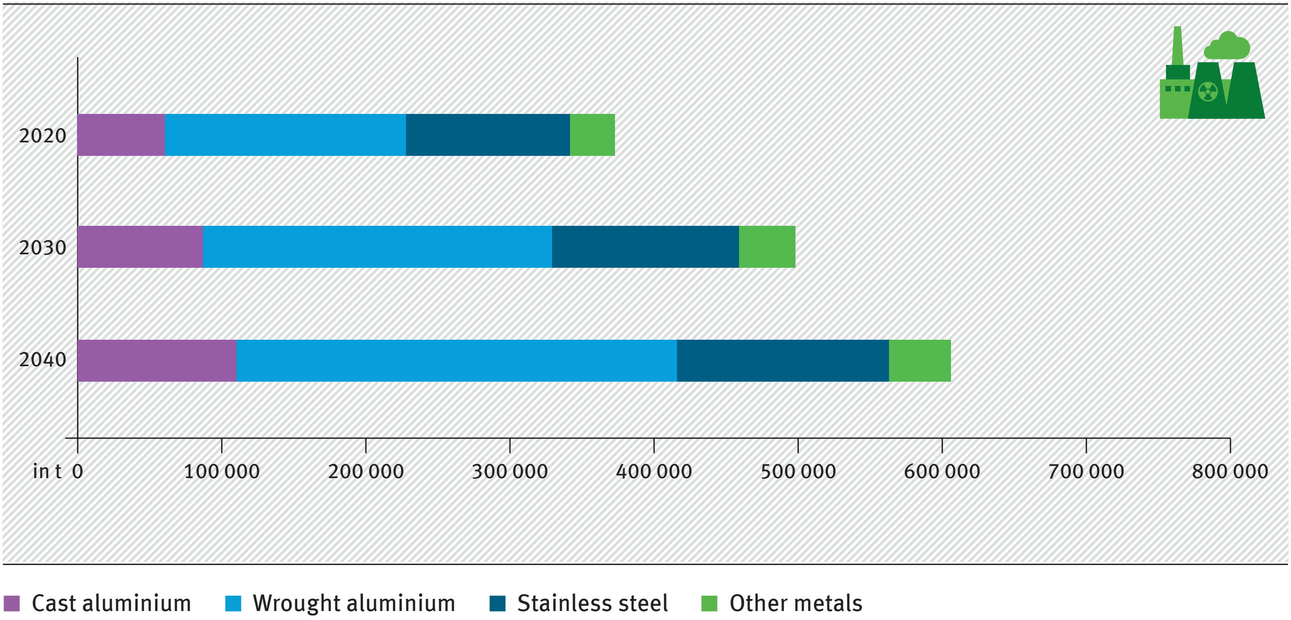
This is essential for improving the recycling economy, as even moderate increases in the collection rate for e-scrap would lead to noticeable increases in secondary metal recovery in Germany from this sector.

Stock Development and Material Withdrawal by Metals/Alloys – Sector 4 Power Generation Plants

The 2020 material stock in sector 4 is 370 000 tonnes, the largest part from aluminium (wrought alloy) at around 167 000 tonnes and stainless steel with around 114 000 tonnes . The material stock is expected to increase to around 600 000 tonnes by 2040 (+62.7 %).

Figure 05

Material stock sector 4 power generation plants: conventional and renewable energy plants 2020–2040 in tonnes

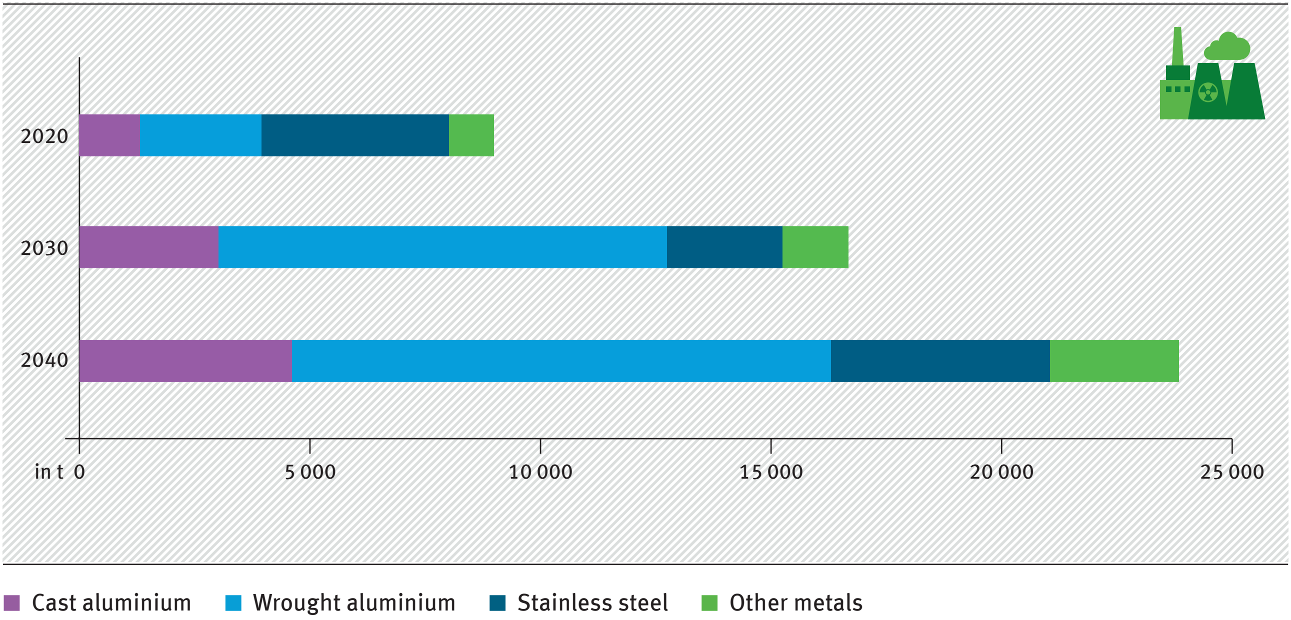


Source: Öko-Institut e. V.

The need to replace photovoltaic panels (PVP) and renovate wind power plants as part of restructuring the power plant fleet (i. e. dismantling nuclear and fossil fuel power plants) will have different effects on future material extraction. It is expected that these changes may amount to around 9 000 tonnes of waste in 2020, much of which comes from the replacement demand for stainless steel of around 4 000 tonnes and for aluminium (wrought alloy) of 2 600 tonnes. The loss of materials from the stock is expected to increase until the year 2040, amounting to about 24 000 tonnes (+165 %).

Figure 06

Material withdrawal sector 4 power generation plants: conventional and renewable energy plants 2020–2040 in t/a



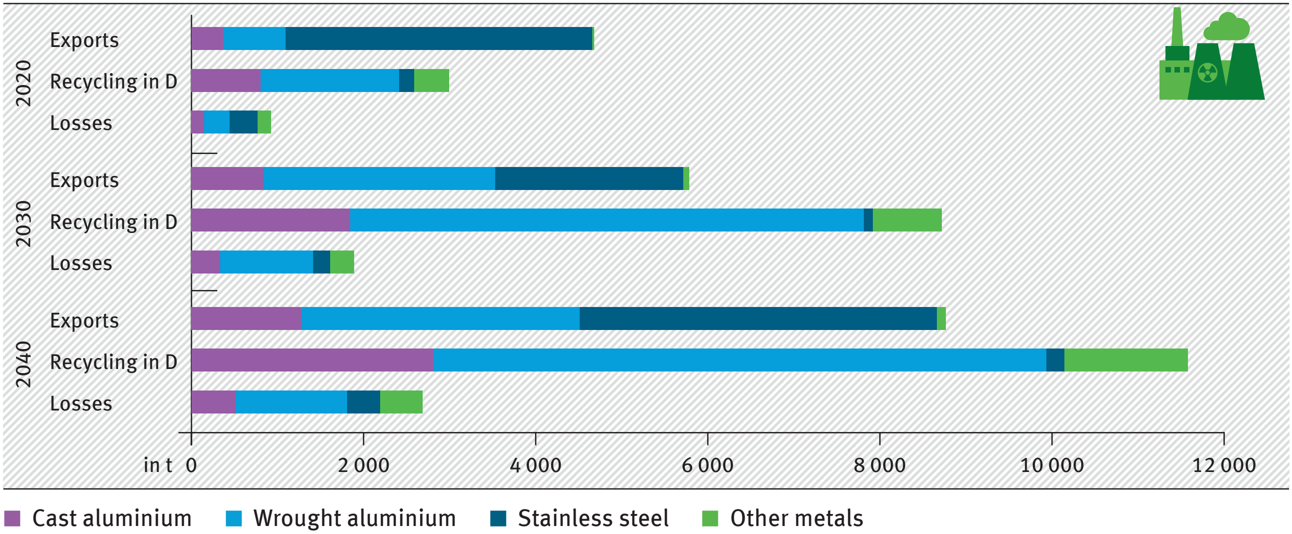
Source: Öko-Institut e. V.

Stock Development and Material Withdrawal by Metals/Alloys – Sector 4 Power Generation Plants

The figure shows the expected fate of metals from sector 4 after recycling for the years 2020, 2030 and 2040. It is clear that the largest quantities are exported, which can be explained by the high export rate of stainless steel. Aluminium, both wrought and cast alloy, accounts for the largest share of recycled metals in Germany. Since the Qutput flows of aluminium from the anthropogenic stock in sector 4 are foreseen to increase significantly by 2040, the quantities of recycled metals from sector 4 would also increase significantly in absolute terms. The losses are dominated by stainless steel, but also by the two aluminium alloys. Overall, the losses compared to export and recycling are only around 10 % of the material withdrawal.

Figure 07

Material fate sector 4 power generation plants: conventional and renewable energy plants in tonnes per year



Source: Öko-Institut e. V.

Reflection on Potentials, Obstacles and Recommendations for Action – Sector 4 Power Generation Plants

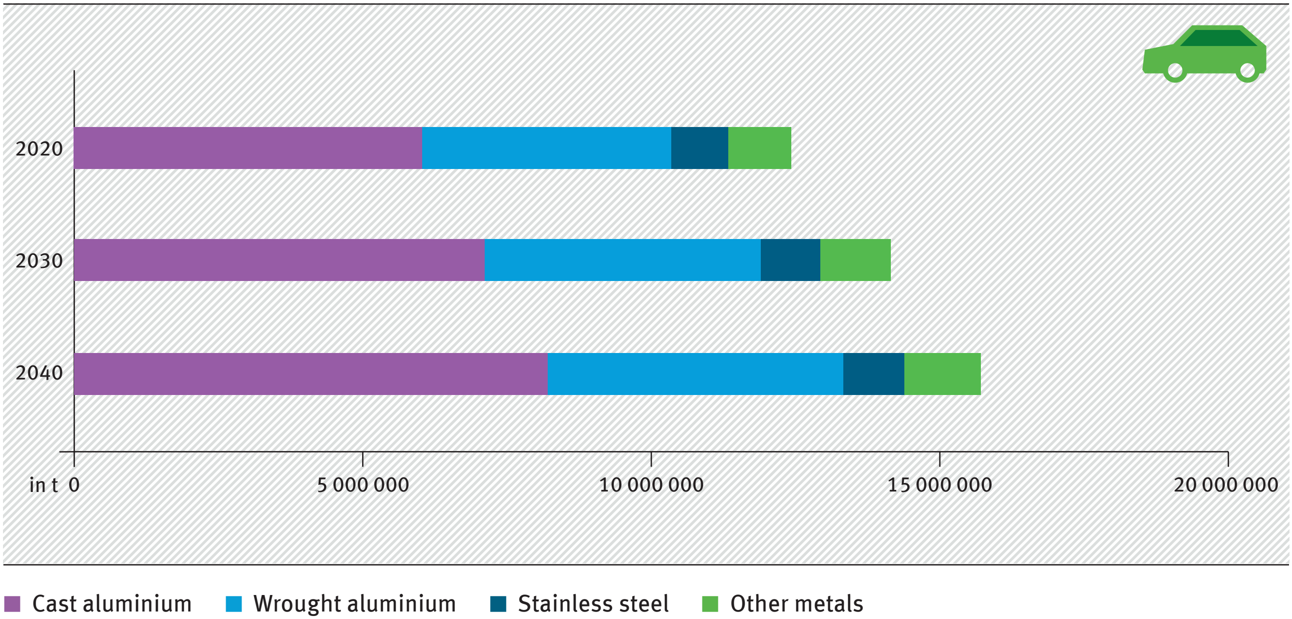
The relatively high export rate of the power generation sector coming out of the anthropogenic stock is almost exclusively due to the fact that stainless steel recycling now takes place to a large extent in other EU countries. Stainless steel is therefore not lost but is to a large extent recovered. The prerequisite for this is ensuring careful dismantling and good separation of the material quantities from dismantled photovoltaic panels and wind power plants, which are foreseen to increase sharply by 2040. An important measure to ensure proper separation is to equip the scrap processing plants with modern spectroscopic detection processes for efficient separation of metal scrap.

Stock Development and Material Withdrawal by Metals/Alloys – Sector 6 Vehicles

The 2020 material stock in sector 6 is 12.4 million tonnes, with 10.3 million tonnes of aluminium, 6 million tonnes of cast alloy and 4.3 million tonnes of wrought alloy. The material stock is expected to increase to almost 16 million tonnes by 2040 (+26.4 %).

Figure 08

Material stock sector 6 vehicles 2020–2040 in tonnes

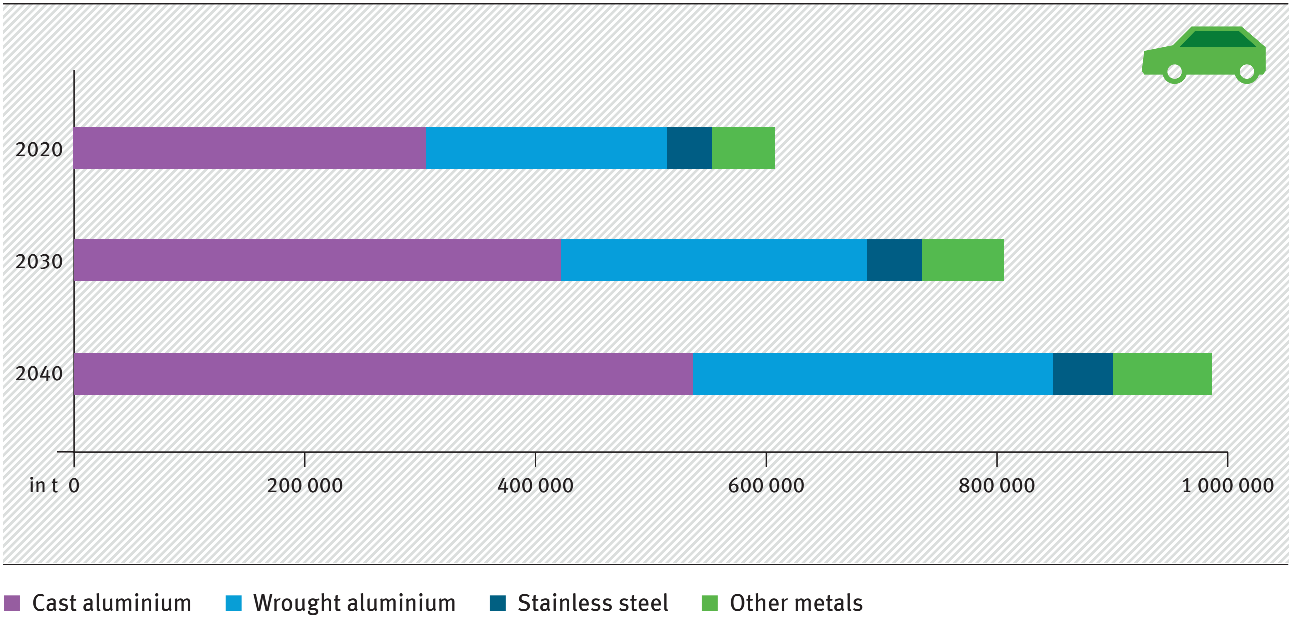


Source: Öko-Institut e. V.

The continuous replacement of older vehicles, depending on the type of vehicle, is expected to result in about 600 000 tonnes of materials in 2020 being taken from the stock. and will be mainly due to aluminium outflows of about 514 000 tonnes. Material extraction is foreseen to increase until the year 2040, at which point it is expected to amount to almost one million tonnes (+62.3 %).

Figure 09

Material withdrawal sector 6 vehicles 2020–2040 in tonnes per year



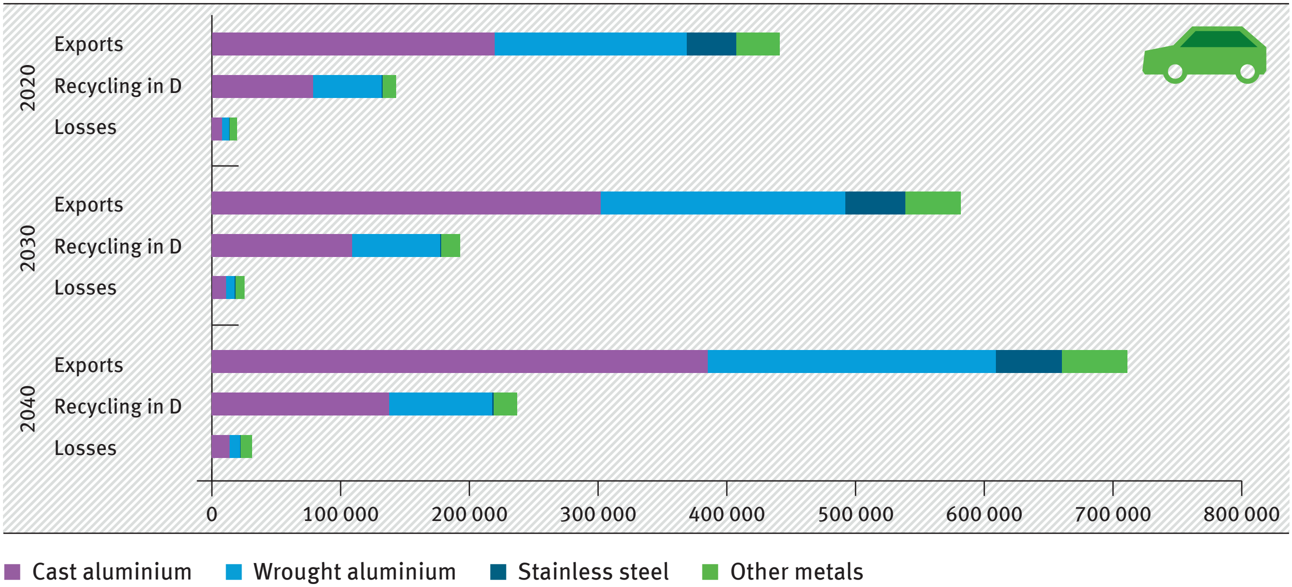
Source: Öko-Institut e. V.

Stock Development and Material Withdrawal by Metals/Alloys – Sector 6 Vehicles

The graph below shows the fate of metals from sector 6 after passing through the recycling process for years 2020, 2030 and 2040. It is clear that the largest quantities are exported; there is a high export quota of used cars, which contain all the metals examined and also form by far the largest product group among vehicles. This high used-car export rate explains the high and growing export flows of aluminium and stainless steel. Aluminium from vehicles can be recycled very well in most cases, so that the losses here are very low.

Figure 10

Material use sector 6 vehicles in tonnes per year



Source: Öko-Institut e. V.

Reflection on Potentials, Obstacles and Recommendations for Action – Sector 6 Vehicles

Comparable to the results for sector 3 electrical appliances, sector 6 vehicles sees a high volume of exports after the removal of materials from Germany's anthropogenic stock. The reason for this is not least the high outflow of used cars to other EU Member States, but also to countries outside the EU.

The export of non-functional end-of-life vehicles (ELV) to non-OECD countries is legally regulated by the ELV Directive. There is still a need for more clearly defined regulations and procedures by the EU to prevent the export of alleged "used vehicles" more efficiently. With the Correspondents' Guidelines No. 9 on shipments of waste vehicles , information is already available that has been coordinated throughout the EU, such as the Waste Shipment Regulation

However, these regulations are not binding for the national customs authorities. With the aim of creating a higher level of legally binding force, the application of the Correspondents' Guidelines No. 9 should be included in the revision of the End-of-Life Vehicles Directive. Preparatory work on the revision of this Directive already started in 2021.

Conclusion and Recommendations for Action

The following two graphs show the stock development and withdrawal of the selected metals/alloys for all the nine sectors together.

The stocks of all metals/alloys considerably increase up to year 2040, which underscores the growing potential of the anthropogenic stock.

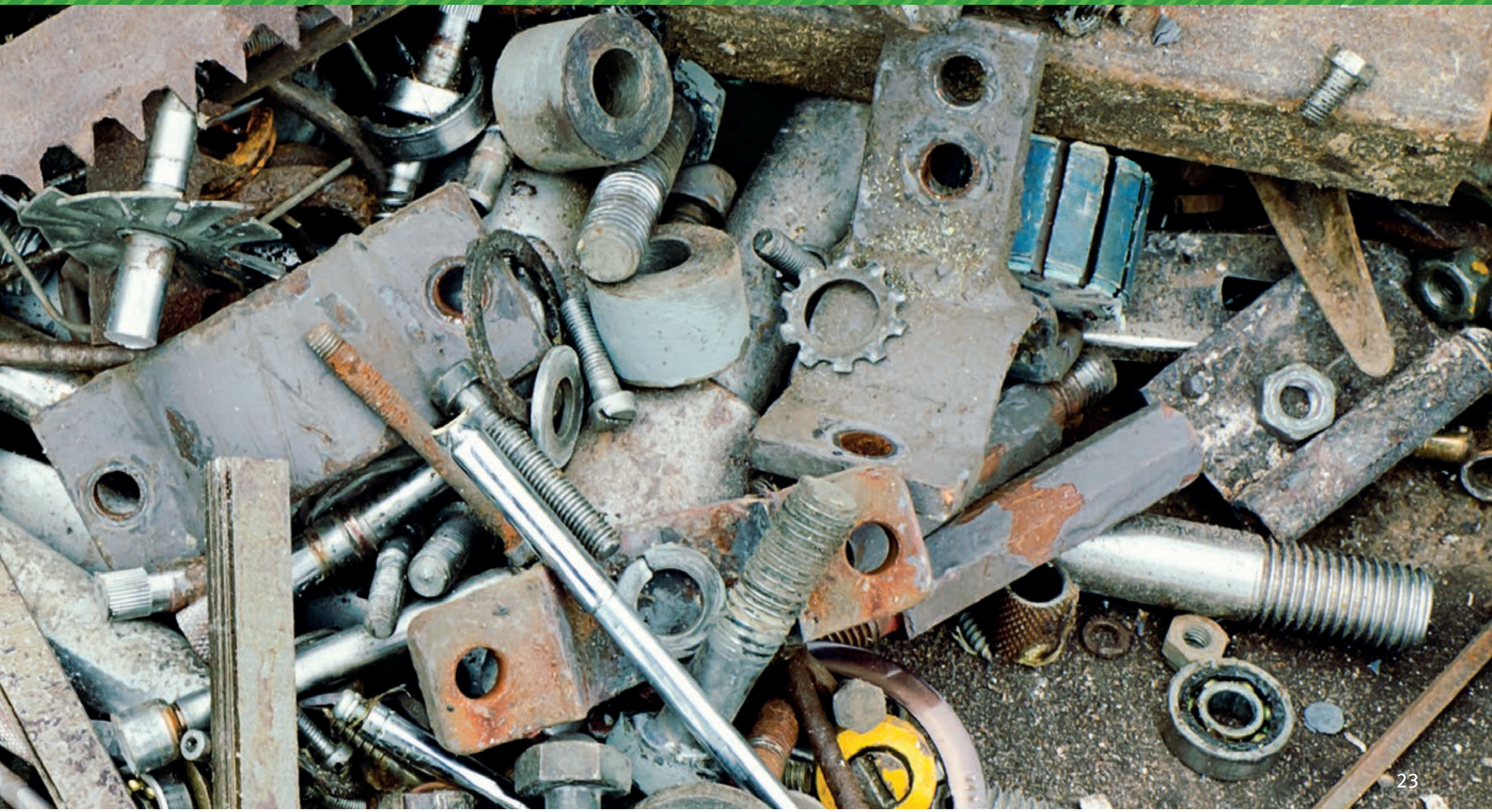
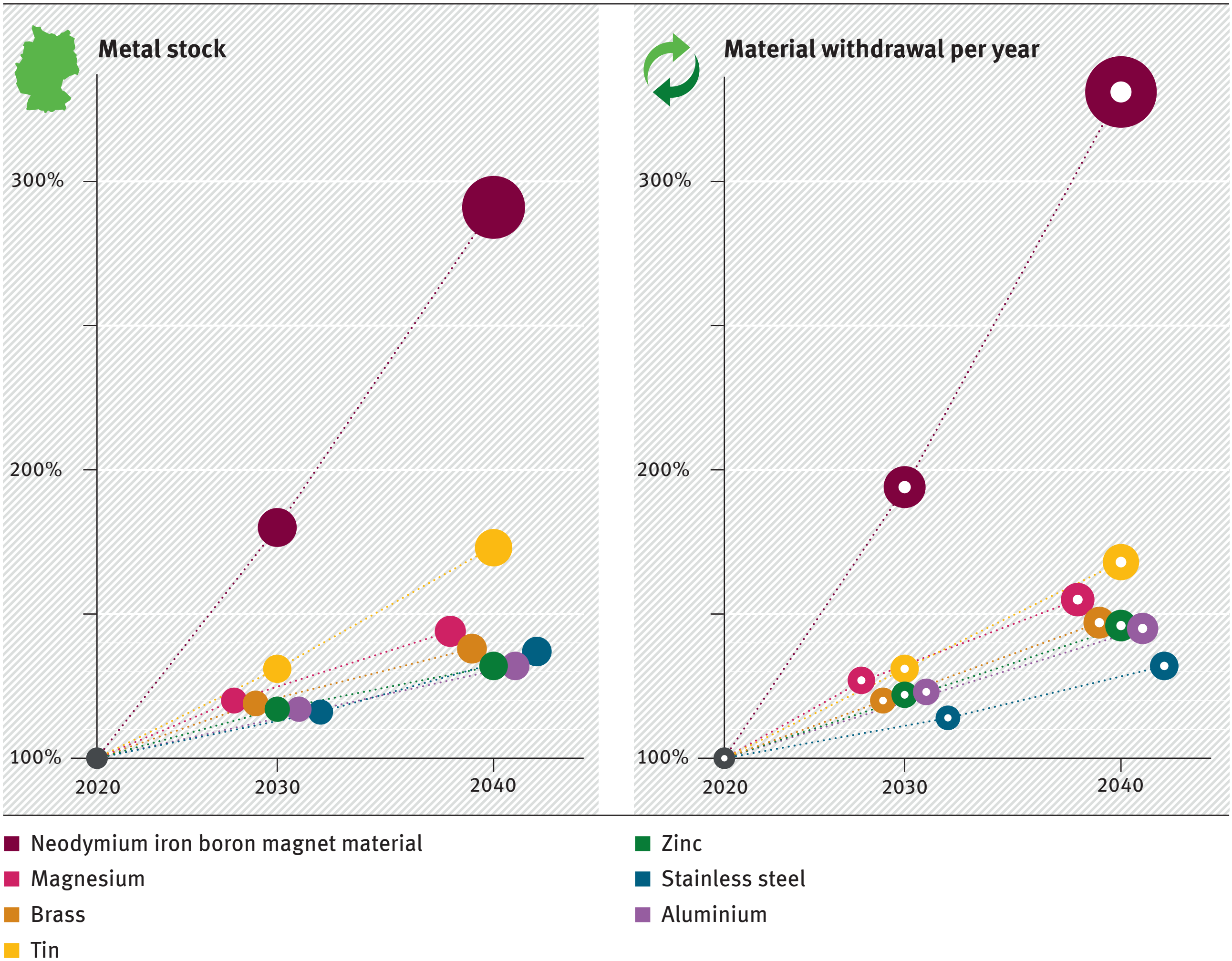


Figure 11

Total material stocks and material withdrawal in Germany for the years 2030 and 2040

Percentage change from 2020



Source: Öko-Institut e. V.

Synopsis

The “KartAL III” project demonstrates the growing relevance of the anthropogenic stock for the secondary raw materials industry in Germany. These potentials for the secondary raw material economy are prospectively fed by the growing stock and the growing material withdrawal from the stock. However, the recycling options for the examined metals and alloys are completely different compared to the examined construction industry. In many cases, recycling metals and alloys is a long-standing practice with correspondingly established infrastructure. However, there is still potential for optimisation, especially for tin, brass and neodymium-ethylene-boron magnet material.

Above all, the challenge is to secure to a greater extent the growing recycling potentials for the domestic recycling industry. Especially the results from the application sectors 3 mobile goods in buildings (electrical appliances) and 6 vehicles indicate a high export rate of secondary materials that is often in the form of used goods. However, this observation has for years been critically assessed from the perspective of illegal waste export, as frequently inadequate controls at seaports lead to a diffuse but quantity-relevant export of end-of-life appliances to developing countries. In recent years, regulations at the EU level to introduce stricter standards for WEEE, such as better demarcation, have not yet been able to prove their success.

Recommendations for Action to Improve Urban Mining

Technical:
The use of modern detection methods – such as X-ray transmission measurement (XRT), laser-induced breakdown spectroscopy (LIBS) and X-ray fluorescence spectrometry (XRF) – in scrap processing in Germany must be promoted to significantly better separate the increasingly complex scrap mixtures into readily usable fractions. Since the investment costs for the purchase and installation of these modern processes represents a hurdle for plant operators, it is strongly recommended that funding agencies and banks be encouraged to overcome these investment hurdles by granting loans at preferential conditions and providing subsidies.

Slags, especially from waste incineration plants, contain relevant quantities of various non-ferrous metals that have so far not been separated and recovered or only inadequately. Since new technological ground must be broken in order to improve metal recovery from waste incineration slags, the German Federal Government is recommended to launch a specific research and development programme.

Regulatory:
At the regulatory level, there are still opportunities to further improve recycling metals from the anthropogenic stock. In addition to the necessary improvements to the EU's End-of-Life Vehicle Directive that are described above, the Ministry of the Environment is recommended to carry out a comprehensive evaluation study to examine the effects of the amendments to the German ElektroG from 2015, in particular as concern exports to developing countries. Finally, for the secondary raw materials industry, a detailed investigation of the objective burdens placed on recycling companies by the Renewable Energies Act is relevant to achieve relief as needed for recycling companies with electricity-intensive processes.

Informative:
To raise awareness, the German Environment Agency and the German Mineral Resources Agency (DERA) are urged to initiate and implement an information platform on selected metal recycling topics. The setting of topics and their elaboration, e. g. in the form of brochures, should be accompanied by an expert advisory board with representatives from the metal industry, authorities and environmental associations. Furthermore, it is recommended that the German Environment Agency, in cooperation with Germany's Federal Institute for Occupational Safety and Health (BAuA), set up and continuously moderate a round table to find an urgently needed compromise between chemicals, waste and product legislation aimed at preventing counterproductive regulations that make recycling unnecessarily difficult or even impossible.

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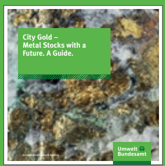

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