Federal Ministry
for Economic Affairs
and Climate Action

The Federal Government's Lightweighting Strategy

bmwk.de

Imprint

Publisher
Federal Ministry for Economic Affairs
and Climate Action (BMWK)
Public Relations
11019 Berlin
www.bmwk.de

Current as at
October 2023

This publication is available for download only.

Design
PRpetuum GmbH, D-80801 Munich

Central ordering service for publications of the Federal Government
Email: publikationen@bundesregierung.de
Tel.: +49 30 182722721
Fax: +49 30 18102722721

Contents

1 Summary

As climate change picks up speed, we need technologies that ensure the transformation of our economy, the resource-efficient creation of added value and a sustainable and resilient raw materials supply, whilst also strengthening the competitiveness of Germany as an industrial hub.

This is where lightweighting as a transformational technology comes in! Lightweighting seeks to deliver products that use less material and energy than other products – by relying on weight optimisation, circular design and advanced manufacturing methods – and still have equal or even better properties. It focuses on technologies, methods and products where materials cycles are highly optimised, allowing materials to last several lifecycles and natural resources to be used efficiently. Lightweighting reaches across all parts of the value chain. Whether it is design, manufacturing, use, recycling or reuse – all of these stages form part of a material-efficient and sustainable lightweighting approach. Lightweighting covers different industries and materials and is thus relevant for the automotive industry, aviation, mechanical and plant engineering, energy, construction and others. Lightweight technology also addresses social needs. For example, lightweight design can be used to extend existing buildings upwards, thus allowing for the creation of additional housing.

The Federal Government's Lightweighting Strategy, which is enshrined in the Coalition Agreement, is to make a key contribution to reducing greenhouse gas (GHG) emissions and the use of primary resources. In order to realise its full potential, the Strategy will need to combine responsible use of resources with the principle of circularity. The implementation of the Strategy will also help address dependence on energy and raw material imports, make industry more innovative and create jobs directly in Germany. The Strategy thus responds to the changed circumstances of the last few years and uses lightweighting as a tool for strengthening economic resilience [1, [1]] and technological sovereignty [2, [2]].

The Strategy takes a holistic approach that covers different industries and materials and addresses all three dimensions of sustainability, namely ecology, economy and society. It also seeks to create a better understanding of and raise awareness for the benefits of lightweighting and thus make it easier for these benefits to be implemented. The Strategy is based on the Federal Ministry for Economic Affairs and Energy's Lightweighting Strategy of January 2021[3] and has been compiled under the lead responsibility of the Federal Ministry for Economic Affairs and Climate Action based on systematic coordination with other Federal Ministries. Matters of special importance to the lightweighting community[4], which were identified in a survey[5] have also been taken into account in the Strategy

As the Federal Government has already been providing support for lightweighting very successfully across various areas, there is a sound basis to build

1 Economic resilience (cf. [1]) is the ability of an economy to adopt preparatory measures for crisis management, mitigate the direct consequences of a crisis and adapt to changed circumstances.

2 Technological sovereignty (cf. [2]) refers to the goal and the ability to develop key-enabling technologies on an equal footing internationally and shape technological development in a self-determined manner.

3 https://www.bmwk.de/Redaktion/EN/Publikationen/Technologie/lightweighting-strategy.html

4 The term 'lightweighting community' refers to the stakeholders who helped devise the Federal Ministry for Economic Affairs' Lightweighting Strategy of 2021, namely company representatives, (state-level) industry associations, scientists and others.

5 48 persons took part in the survey, with around 40% of the participants belonging to the field of business and research and the rest of the participants to industry associations and other interest-representing organisations.

upon. The Strategy is to pool ongoing activities strategically and enhance them in a targeted manner. It also includes new measures, for example for expanding ecological and economic measurability and for user-oriented communication of the benefits of lightweighting.

The Lightweighting Strategy centres around eight packages of measures, which will be looked at more closely in chapters 4.1 to 4.8. The individual projects mentioned as part of these packages will be implemented by the relevant Ministries on their own responsibility and subject to the funds available. The packages of measures cover the following fields of action, objectives and flagship projects:

1. We will realise end-to-end funding along the entire innovation chain and make use of synergies between individual funding programmes so as to further improve the funding environment for lightweighting.

   Flagship project: Funding across ministries covering the entire innovation chain.

2. We will speed up the transfer of knowledge and technology from research to industrial practice by connecting the relevant lightweighting stakeholders, by providing funding for cooperation across industries and materials and by conducting studies and implementing regulatory sandboxes and demonstration projects.

3. We will use regulation, for example in the area of ecodesign, to strengthen the use of lightweighting, not least with regard to the circular economy, and will assess the possibility to integrate lightweighting in public contracts and procurement procedures.

   Flagship project: Including lightweighting in the new Ecodesign for Sustainable Products Regulation as a parameter for materials efficiency.

4. We will foster innovation in lightweighting through standardisation.

5. In order to make our economy more resilient, we will not only use lightweight solutions to reduce absolute materials consumption but also diversify our raw materials supply and strengthen technological sovereignty.

   Flagship project: Updating the Technology Transfer Programme for ‘Lightweighting and Materials Efficiency’.

6. In order to improve the measurability of the positive impact that lightweighting as a cross-cutting technology has on our climate, the environment, the economy and society, we will provide funding for the development of quantitative instruments and key performance indicators.

   Flagship project: Improving the measurability of the economic significance of lightweighting.

7. We will make use of targeted public outreach campaigns and network creation in order to raise awareness of the various potentials of lightweighting among experts and the general public.

   Flagship project: Creating a customer-oriented communication strategy.

8. In order to strengthen international competitiveness in a sustainable manner and forge international alliances on lightweighting, we are helping companies target sales markets abroad and are promoting mutually beneficial international cooperation on lightweighting.

   Flagship project: Establishing a joint activity programme on lightweighting at the European level as part of the European Lightweighting Network (ELN).

2 Introduction

2.1 Why we need lightweighting!

If we want to preserve our prosperity within the limits of our planet, a resource transition is needed.

A successful resource transition requires reducing the primary consumption of raw and manufactured materials which are processed or produced in a way that negatively affects the climate. This means that we need to reduce the absolute materials use, expand the circular economy and replace materials which are particularly greenhouse gas-intensive. Materials efficiency and resource conservation are key for protecting our prosperity within the limits of our planet.

Global consumption of raw materials has more than tripled since 1970.[3] The Earth Overshoot Day – which marks the day on which humanity has used up all of the natural resources that Earth can regenerate in a year – is occurring ever earlier in the year. Whilst in 1970, it was 2 December, the 2022 Earth Overshoot Day fell on 29 July. According to a forecast published by the OECD, global raw materials consumption could double once more between today and 2060.[4] It is an established fact that there is a direct link between global raw materials consumption and climate change: around half of global GHG emissions can be attributed to the extraction and processing of raw materials.[5] Also, a resource transition is an important factor not only for climate action but also for economic resilience. The amount of raw materials we consume influences our economy's level of dependence on imports. Import bottlenecks can have various impacts on the creation of added value and thus on the prosperity of our society – as has been made clear by the geopolitical challenges experienced in recent times, which have led to the breakdown of supply chains, rising prices and supply bottlenecks, for example in the construction and automotive industries.

Against this backdrop, it is clear that we need to break the link between economic growth and raw materials consumption. This is where lightweighting comes in as a transformational technology: lightweight solutions help make more efficient use of raw materials. This starts with product design, which accounts for 80 per cent of the environmental footprint of a product[6] and thus needs to consistently focus on materials efficiency and the circular use of materials.

Lightweight technologies help address the challenges of our time: climate action, technological progress, resilient value chains and the resource-efficient satisfaction of various social needs.

Lightweighting stands for a reduction of materials use, for example through innovative design methods, manufacturing technologies and materials or through materials substitution. As a design philosophy that is independent of the material or product used, lightweighting has the ability to unlock potential for environmental protection, climate action and resource conservation. By making efficient use of resources, lightweighting can reduce carbon emissions already during the manufacturing process. More lightweight cars, planes, ships and trains also require less energy to move, which helps reduce emissions also during the utilisation phase. If lightweight products and materials are used in a circular way, lightweighting can reduce greenhouse gas emissions holistically across the entire lifecycle.

Lightweight technologies and materials are playing a key role for delivering innovative and internationally competitive products and for trans-

forming Germany into a carbon-neutral industrial hub. The energy transition is the most prominent example for this: high-performance lightweight materials are being used in renewable energy installations such as modern wind turbines, where they allow for the use of very long and thus powerful rotor blades. Lightweight solutions extend the use cases for solar PV, improve their usability and provide better possibilities for storing and transporting the hydrogen generated from renewable sources.

In addition, lightweighting helps to increase the economic resilience of Germany as an industrial hub. As lightweight solutions use less material, they help ensure that scarce resources remain available. In addition, the use of primary raw materials and thus the dependence on raw material imports can be reduced to the extent that the lightweight products and materials also become circular. Another economic benefit is the reduction of materials cost through material-efficient manufacturing methods.

Finally, lightweighting has benefits for all of us in our daily lives – whether it is in housing, mobility, healthcare or leisure. For example, new lightweight design concepts for buildings provide possibilities for infill development by extending existing buildings upwards in densely populated urban areas and thus address the urgent need to create new housing. The use of climate-friendly lightweight materials in the construction materials industry is to help further decarbonise and transform the sector. Reducing the weight of e-vehicles can increase their range. In the medical devices industry, lightweight solutions – for example lightweight prostheses and orthoses – can directly improve patient therapy and treatment. In the sports and leisure industry, too, there is great demand for lightweight materials, which combine low specific weight with great robustness and durability, for example in bicycle manufacturing.

2.2 Taking stock of lightweighting activities

A cross-cutting technology with great reach

The automotive and transport sectors, mechanical and plant engineering and the areospace industry are the greatest drivers of innovation in lightweighting. But the importance of lightweighting is increasing in many other sectors as well, from construction, energy technology, agricultural machinery, leisure, sports and medical devices all the way to the paper industry.

Examples of lightweight materials include plastics, metals such as aluminium, magnesium, titanium, scandium and steel, natural materials such as timber, cellulose and basalt and also a wide range of composite materials. If the right kind of construction method, design and manufacturing technology is used, lightweighting potential can be tapped with almost any material. The cross-cutting nature of lightweighting is highlighted not only by its wide range of use cases but also by the large number of relevant technology fields, reaching from bionics and digitisation all the way to the development of advanced materials.

The Federal Ministry for Economic Affairs and Climate Action's Lightweighting Initiative

As lightweighting covers a wide range of industries, materials, technologies and use cases, it also has a broad base of stakeholders from business and academia, from trade unions, industry associations

and networks. The transfer of knowledge across different materials and technologies between the different stakeholders is key for the enhancement of lightweighting. The Federal Ministry for Economic Affairs and Climate Action is therefore providing support for this dialogue, for example under its Lightweighting Initiative, which has been active since 2016. The offices of the Lightweighting Initiative serve as a central point of contact for companies from all parts of Germany and around the world. Various dialogue formats have been established as a result. These include an annual conference – the Lightweighting Summit –, the Lightweighting Forum and the LEICHTBAUATLAS.DE networking platform with its constantly growing number of national and international organisational profiles. Regular workshops on issues such as internationalisation, digitisation and current scientific developments are also organised, giving the community an opportunity to engage in dialogue on specific subjects. The Lightweighting Initiative is supported by a strategy advisory board made up of renowned representatives from all stakeholders groups, which is providing input on the future enhancement of lightweighting.

Lightweighting activities in Europe and around the world

Progress in lightweighting is driven not only by networking activities spanning different materials and industries but also by international dialogue, including knowledge transfer, strategic cooperation and joint projects. This allows German companies to implement technological innovation projects together, target new markets abroad and become more competitive. A targeted approach to international networking, which takes account of the geopolitical developments including the risks and opportunities involved, can thus create considerable added benefit for society.

The Federal Government is providing funding for international networking in lightweighting at different levels and via various formats. One example is the European Lightweighting Network (ELN), which was initiated by the Federal Ministry for Economic Affairs and Climate Action as part of the German Presidency of the Council of the EU in 2020. The ELN fosters dialogue between the public sector, business and academia in Europe about the challenges addressed by and objectives pursued by lightweighting. The goal is the development of joint European objectives that will strengthen lightweighting in Europe. For this goal to be achieved, additional networks and cross-border projects on research funding are being launched via the ELN and joint activities initiated to establish a European research agenda, a European lightweighting strategy and a lightweighting hub in Brussels.

Another goal is the continuous strengthening of the role of lightweighting in the context of resource efficiency at G7 level. During the German G7 Presidency in 2022, the Federal Ministry for Economic Affairs and Climate Action organised a workshop on resource efficiency and the circular economy together with the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. The agenda centred around best practice examples illustrating the potential of material-efficient lightweighting solutions.

In addition, there are also various programmes for small and medium-sized enterprises (SMEs) from the lightweighting sector, which cover aspects such as business initiation, delegation trips, match-making and notworking. Under the Federal Ministry for Economic Affairs and Climate Action's Market Entry Programme (MEP), SMEs can receive funding for project-related measures. The Foreign Trade

Fair Programme (AMP) is an export marketing instrument that allows SMEs to present themselves at joint trade fair stands at favourable conditions. The MEP and the AMP both offer industry-specific services for countries with relevance for the lightweighting sector.

2.3 The Lightweighting Strategy

The Federal Government's Lightweighting Strategy seeks to strengthen and utilise lightweighting across ministries

In order to create an environment in Germany that is conducive to the future enhancement of lightweighting as a transformational technology, close coordination within the Federal Government – beyond the responsibilities of individual ministries – is needed. Based on the Coalition Agreement of 2021 and the Climate Action Status review of January 2022, the Federal Government's Lightweighting Strategy was compiled under the lead responsibility of the Federal Ministry for Economic Affairs and Climate Action (BMWK) in close coordination with the Federal Ministry of Labour and Social Affairs (BMAS), the Federal Ministry of Food and Agriculture (BMEL), the Federal Ministry of Health (BMG), the Federal Ministry for Digital and Transport (BMDV), the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), the Federal Ministry of Education and Research (BMBF) and the Federal Ministry for Housing, Urban Development and Building (BMWSB). One of the targets set out by the Coalition Agreement of 2021 is the absolute reduction of primary raw materials consumption. Lightweighting can make a contribution to this. The interdisciplinary importance that lightweighting has was highlighted further through its integration in the Federal Government's Climate Action Programme 2030 to implement the Climate Action Plan for 2050.

Regarding substance, the Federal Ministry for Economic Affairs and Climate Action's Lightweighting Strategy of January 2021, which was compiled with participation from a wide range of stakeholders, has served as a basis for this Strategy. The present Strategy has been supplemented by aspects of sustainability, with a special focus being placed on climate and resource conservation, circularity/recycling and economic resilience. In addition to this, it places a stronger focus on new approaches such as improving ecological and economic measurability and communicating the benefits of lightweighting in a consumer-oriented manner.

Regarding specific priorities, the measures devised and the input provided by the other Ministries (see above) have been used to update, expand and supplement the substance of the Federal Ministry for Economic Affairs and Climate Action's Strategy. The contributions from the lightweighting community in both business and academia, which have been collected as part of a survey, have also been taken into account in the Strategy.

3 The objectives of the new Lightweighting Strategy

The Federal Government's Lightweighting Strategy seeks to unlock the potential for transformation, resilience and innovation of lightweighting technologies and materials by working across ministries and thus make a substantial contribution to meeting the goals set out under the Green Deal. It focuses on reducing greenhouse gas emissions and resource use and on strengthening Germany as an industrial hub by supporting innovation in lightweighting.

Fine-tuned and effective communication[6] is to raise awareness for the benefits of lightweighting among political decisionmakers and stakeholders in business, academia and society, and encourage them to make use of lightweighting. Lightweighting technologies need to be given greater visibility and priority in the political and social discourse so that their potential for sustainability can be broadly and consistently harnessed. In addition, the Strategy has been given a suitable structure to accompany its implementation (cf. Chapter 5).

Lightweighting is to become even more established, allowing for even broader industrial use – in this legislative term and beyond. For this to be achieved, funding is to be provided for German companies and research institutes for the development of innovative lightweight technologies that will make them leaders in the global race to deliver forward-looking solutions for the transformation. The technological prowess and competitiveness of Germany's industrial base are to be expanded in the long term. Innovation in lightweighting is to create and safeguard future-proof jobs in Germany and lightweight solutions are to be used to help make people's lives easier.

Taking this into account, the Lightweighting Strategy sets out a coherent approach that combines the three dimensions of sustainability. The following chapters describe how the opportunities of lightweighting are to be used in this legislative term and beyond for each of the three dimensions of sustainability.

3.1 Ecology: Making efficient use of resources, promoting greenhouse gas neutrality and the circular economy

Lightweighting is a holistic design philosophy that seeks to optimise weight and reduce materials use and which can thus make various contributions to climate action and resource conservation. This approach has obvious benefits, especially when it comes to moving objects: lightweight cars, trains, ships and planes use less energy, which means fewer GHG emissions.

However, the benefits of lightweighting are not limited to moving objects. Lightweighting also has great potential for reducing production-related greenhouse gas emissions in the construction industry. The construction industry uses large amounts of raw materials which impact the climate. And also in other sectors, such as mechanical and plant engineering, material-efficient lightweight solutions – including the use of innovative design principles and manufacturing methods and the selection of suitable materials – can help to considerably reduce primary resource consumption in the production phase. In many cases, the functionalities of the products and components can be improved or extended.

6 The principle of 'fine-tuned and effective communication' relates both to the current public outreach strategy as such (cf. Chapter 4.7) and the better illustration of the potential of lightweighting by strengthening economic and ecological measurability (cf. Chapter 4.6).

However, it is not enough to look at lightweighting's benefits in the production and utilisation phases: the entire lifecycle needs to be taken into account. In order to ensure that lightweighting solutions are not only material and energy efficient but holistically sustainable, consideration needs to be given also to what happens with the material after the end of the utilisation phase. It is thus important to ensure the circularity and recyclability of lightweight materials – particularly of composites, which merge different materials – if possible by providing for a recyclable design already during product development. This requires holistic and circular approaches, which also take into account further possibilities to use secondary materials. It should also be ensured that the variety of polymer materials used in a single product or component is reduced, as this makes recycling a lot easier.

In order to deal with lightweight materials which cannot be recycled in a way that is environmentally sound, strategies for improving the properties of a product, substituting critical raw materials and supplementary procedures need to be developed. These include, for example, approaches from industrial bioeconomy. In industrial bioeconomy, fossil-based products and processes are being replaced by bio-based products, production procedures and business models. These can also be an enabler for lightweighting as bio-based lightweight materials from sustainable biogenic resources help reduce GHG emissions, ideally are circular and can thus store GHG emissions for longer time periods.

In addition, lifecycle analyses are to be used to provide for a holistic assessment of the climatic and environmental impacts. This is to allow manufacturers to make evidence-based decisions – as early as during the product development stage – that will result in the lowest possible net carbon and material footprint across a product's entire lifespan. Accounting approaches need to examine lightweighting as holistically as possible and also take into account negative impacts such as rebound effects.

3.2 Economy: Modernising Germany's industrial base and strengthening economic resilience

As lightweighting is used in a large number of different sectors and companies along the entire value chain and has an impact on various processes and jobs, it is of great importance to the economy. This is especially true for the major industries in Germany such as automotive, aerospace, construction, mechanical and plant engineering and energy.

By continuing to develop new solutions for reducing weight and materials use and for improving the functioning of components, lightweighting is constantly delivering new innovations. This helps ensure that Germany continues to be globally competitive as a provider for sustainable and climate-friendly systems, opens up new sales markets and unlocks potential for economic growth. It also helps modernise and strengthen Germany as a business location.

By combining the reductions in materials use delivered by lightweighting with the substitution of critical raw materials (for example by using bioeconomic approaches) and circular economy, the amount of foreign imports can be reduced and the diversification of the raw materials reinforced. Lightweighting thus strengthens the resilience of the Germany economy in the face of stretched international supply chains and existing dependencies. In order to make the German economy less

dependent on raw materials from abroad, the Lightweighting Strategy supplements the Raw Materials Strategy, which sets out the corresponding measures.

3.3 Society: Improving quality of life, creating future-proof jobs

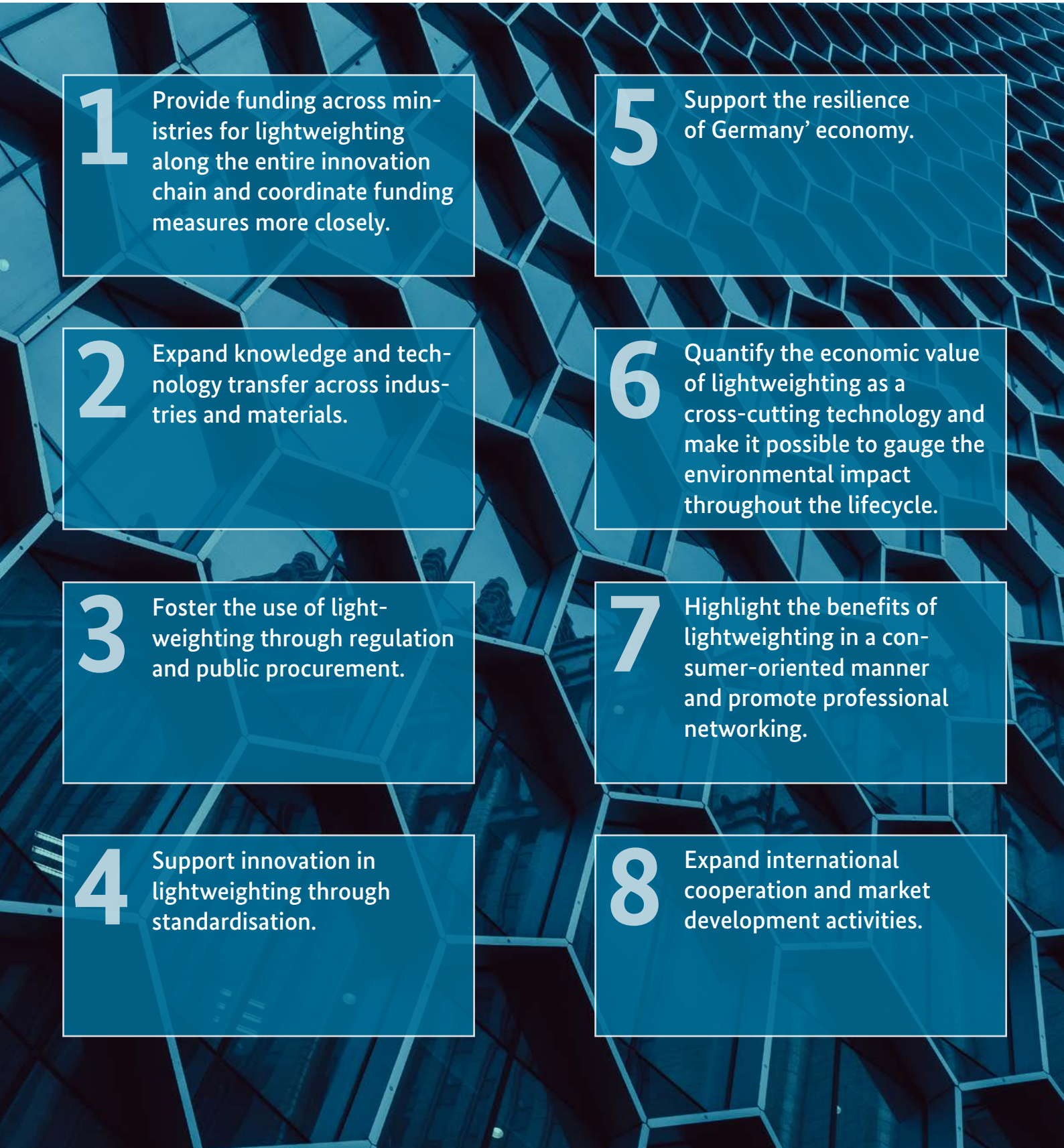
Lightweighting as a sustainable technology also plays an important role for society. In some areas, this role is obvious, for example where mitigating climate change improves the living prospects of future generations on all continents or where lightweighting-based value creation protects existing jobs and creates new ones.

Beyond these larger interrelations, lightweighting very specifically influences people's daily lives and wellbeing. For example, by extending existing buildings upwards using lightweight design, for example with timber, sustainable housing can be created in a relatively short amount of time. In this way, some 1.1-1.5 million apartments could be added to existing residential buildings dating from the 1950s to 1990s.[7]

In the area of healthcare, the use of lightweight technology can have a positive impact on patient therapy and treatment. Medical devices such as lightweight walking frames or innovative protheses using lightweight design improve quality of life just as much as titanium implants, which are already widely used for their excellent biocompatibility.

4 Packages of measures

The Lightweighting Strategy is essentially made up of eight packages of measures, which are explained in more detail below:



1 Provide funding across ministries for lightweighting along the entire innovation chain and coordinate funding measures more closely.

2 Expand knowledge and technology transfer across industries and materials.

3 Foster the use of lightweighting through regulation and public procurement.

4 Support innovation in lightweighting through standardisation.

5 Support the resilience of Germany' economy.

6 Quantify the economic value of lightweighting as a cross-cutting technology and make it possible to gauge the environmental impact throughout the lifecycle.

7 Highlight the benefits of lightweighting in a consumer-oriented manner and promote professional networking.

8 Expand international cooperation and market development activities.

4.1 Provide funding across ministries for lightweighting along the entire innovation chain and coordinate funding measures more closely

Germany's lightweighting sector is already doing well in important areas of research, development and technology. Given lightweighting's cross-cutting nature, there are various industry and technology-specific funding programmes that relate to lightweighting. These programmes have been supplemented since 2020 by the Federal Ministry for Economic Affairs and Climate Action's *Technology Transfer Programme for Lightweighting,* which focuses on the transfer of knowledge and technology across different industries and materials. In 2023, a revision of the funding basis will give the new *Technology Transfer Programme for Lightweighting and Materials Efficiency* a stronger focus on materials efficiency and the circular economy.

The Federal Ministry for Economic Affairs and Climate Action is responsible for funding and development issues as well as investment promotion. In this context, it has developed programmes such as the *European Recovery Programm (ERP) – KfW* promotional loan programme, the ERP Digitisation and Innovation Loan, the ERP-Mezzanine for Innovation programme, the KfW loan for growth and the KfW syndicated loan for *Sustainable Transformation*.

Objective:
We are seeking to continue to improve the funding environment for lightweighting. To this end, we want to make use of synergies between the different funding programmes and give existing funding programmes an even more consistent focus on the potential of lightweighting. A special focus is being placed on providing funding for SMEs as engines for innovation and economic growth in Germany. We need to assist SMEs and startups as these develop and market innovative lightweight solutions.

On investment, we are seeking to provide easier access to capital for investment in the lightweighting context and provide for longer-term investment loans at attractive rates. We want to continuously enhance our financing instruments and adapt them to actual demand.

Measures:

Flagship project: Funding across ministries covering the entire innovation chain

The successful development and widespread implementation of innovative lightweighting approaches require a holistic understanding of innovation. The Federal Government's Lightweighting Strategy thus dovetails the activities and measures of individual ministries in order to provide for cross-ministry funding along the innovation chain – from basic research, industrial research and experimental development all the way to market launch.

Basic research paves the way for the development of novel production methods and materials, the precise use of which often cannot be foreseen at this stage. These first steps preparing the development of novel production methods and materials can be funded, for example, via measures open to all activities or measures focusing on a particular material category (e.g. bio-based materials, hybrid materials or functionally-integrated lightweight materials). Under the Federal Ministry of Education and Research's *Future of Value Creation – Research on Production, Services and Work* programme and its predecessor programmes, funding has been provided for basic research on lightweighting solutions in multimaterial design, in particular for e-vehicles, under the 'Research and Technology Centre for the Development of Resource Efficient Lightweight Solutions in E-Mobility' research cluster (FOREL). The programme now focuses on the dynamics of value chain systems and on individual aspects of these systems. For example, it looks at ways to design a data-driven and circular value chain.

Another funding programme launched by the Federal Ministry of Education and Research is 'From Material to Innovation' which includes funding measures such as *'MaterialNeutral – Resource Sovereignty Through Materials Innovation', 'Innovative SMEs: Materials Research'* and the *Ministry's 'NanoMatFutur'* competition for young researchers in materials science. 'MaterialNeutral' seeks to make use of materials innovation (e.g. secondary or alternative raw materials or life cycle material engineering) to harness existing potential for resource efficiency and promote closed material cycles, which is of great importance for delivering lightweighting solutions that are highly efficient and resource and carbon-neutral. The *'Innovative SMEs: Materials Research'* funding measure provides funding for specific research projects by small and medium-sized companies. The *'NanoMatFutur'* competition gives young researchers the possibility to establish their own research group at a university or research institute. Under the last two funding measures, lightweighting solutions for mobility, energy, construction and infrastructure are being examined.

Once feasibility has been established, the next step is industrial research, which looks at the development of new products, methods and services. This is followed by experimental development, which culminates in a demonstration under real-life conditions to prove functionality. This is where the Federal Ministry for Economic Affairs and Climate Action's *Technology Transfer Programme for Lightweighting,* which focuses on industrial research and experimental development, comes in. Under the Federal Ministry for Economic Affairs and Climate Action's *Energy Research Programme,* funding is provided for research and development for lightweight technologies in the context of energy technology applications (such as wind turbines) or with a focus on energy savings across the entire lifecycle of a product.

Frequently, additional efforts are needed for a technology's commercial deployment. Investment measures can make a valuable contribution here (e.g. via the Federal Ministry for Economic Affairs and Climate Action's *Federal funding programme for energy and resource efficiency in the German economy).*

Both the funding structure, which takes account of the different stages of technological maturity, and previously unused thematic overlap with existing funding activities hold great potential. For example, funding is being provided for different methods for the recycling of metals, mineral construction materials and plastics, which are not yet specifically geared towards lightweight materials (for example under the Federal Ministry of Education and Research's *"Research for Sustainability (FONA³)"* programme). In this context, the provision of targeted follow-up funding could facilitate the use of recycled materials in

lightweighting and the adaptation of recycling methods to suit lightweight products. There is also overlap with funding activities which focus on cross-cutting issues such as digitisation (such as the Federal Ministry of Education and Research's MaterialDigital initiative or the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection's *DigiRess* programme), standardisation (such as the Federal Ministry for Economic Affairs and Climate Action's *WIPANO* scheme) or spinoffs from research (such as the Federal Ministry for Economic Affairs and Climate Action's *EXIST* programme). Programmes providing investments grants for pioneering projects that evolve the state of the art in a particular sector and show to other companies in that sector or beyond how innovative technology can be used for the benefit of the environment, can also be relevant for lightweighting (for example the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection's Environmental Innovation Programme).

The Federal Government's Lightweighting Strategy also drives forward the implementation of a viable staged funding structure between the ministries. The relevant funding activities will be continuously assessed in terms of their compatibility with follow-up funding and thematic overlap. As new funding activities with a link to lightweighting are being devised, possible overlap will be taken into account. We will also expand the existing dialogue between the Federal Ministry of Education and Research and the Federal Ministry for Economic Affairs and Climate Action and establish regular meetings at the technical level between the relevant ministries in order to better coordinate lightweighting-related funding programmes.

Measures:

- By implementing the new funding guideline for the *Technology Transfer Programme for Lightweighting and Materials Efficiency,* we will integrate the funding priority 'digitisation and automation' into the Federal Ministry for Economic Affairs and Climate Action's relevant initiatives on Industrie 4.0, particularly those focusing on the digitisation of industrial value chains.

- By continuing the Federal Ministry for Economic Affairs and Climate Action's I*ndustrial Bioeconomyfunding* programme, we will provide support for the decarbonisation of lightweight products and the manufacturing methods associated with these in the short and medium term by allowing for the use of bio-based raw and residual materials in lightweighting and by scaling up bio-based products and methods from the lab to industrial scale.

- Under the Federal Ministry of Education and Research's Biologisation of Technology funding activity, we will assess the extent to which biological principles (beyond bionics) can be used generally and specifically to design and develop new lightweight materials and lightweighting methods. Following a broad-based competition of ideas, specific applications will now be developed in industry-led collaborative research projects.

- We will assess how we can promote the use of circular bio-based plastics, composite materials and solid biomass, including in particular timber, in lightweighting, for example as part of the Federal Ministry of Food and Agriculture's Renewable Raw Materials funding programme, and how the necessary raw materials can be provided in a sustainable manner (for example in the context of the National Bioeconomy Strategy under the Federal Ministry of Education and Research's *'Innovative SMEs: Bioeconomy'* funding programme or the Federal Ministry of Food and Agriculture's *'Renewable Raw Materials'* funding programme.

- We will assess the extent to which lightweight products (such as bio-based ones) can store carbon in the long term and thus qualify for the European Commission's planned certification of negative emissions and we will look at whether such aspects can be taken into account in the funding.

- We will assess how funding can be provided for innovative carbon-reinforced concrete structures, where there is no permanent bond between the carbon and the concrete, for example for prestressed concrete structures using 'unbonded post-tensioning' or for carbon reinforcements outside the concrete structure, e.g. the Rippmann Floor System.

- We will assess whether and how funding can be provided for the use of lightweight concrete that is based on recycled mineral construction waste.

- We will assess how the funding for circular materials that can reduce construction waste and substitute harmful and scarce construction materials, including through the use of new planning and manufacturing methods from lightweighting, can be integrated in the Federal Ministry for Housing, Urban Development and Building's *Future of Building* innovation programme, with a view to meeting the Federal Government's climate and resource conservation targets.

- We will assess how the results of the project 'Strategy for the resource-efficient and safe production of lightweight structures (KORESIL)' funded by the Federal Ministry of Education and Research can be taken into account in the thematic areas of the *Future of Value Creation – Research on Production, Services and Work* funding programme.

- As part of the Federal Ministry for Economic Affairs and Climate Action's *New Vehicle and System Technologies* programme, we will assess the performance of new lightweighting technologies for use in the mobility sector.

- Via the *German Aviation Research Programme for the Climate,* we will assess how the objective to deliver an aviation industry that is largely free of emissions but just as safe can be achieved by 2050 by realising further considerable reductions in the specific weight of aircraft through the consistent use of lightweight technologies (materials efficiency, weight optimisation, functionality, lifetime and circularity) in aircraft and products used in aircraft technology.

- We will assess how lightweight technologies can be better taken into account in the aerospace industry, for example for the construction of spacecraft and launchers.

- We will assess how we can explicitly address lightweighting under the new 'climate-neutral ship' funding priority in the revision of the *Maritime Research Programme*. This is because use of lightweighting technology in the maritime industry is increasing due to its potential to improve energy efficiency.

- We will continue to provide information services on the Federal Government's investment funding activities that exist and organise workshops where any additional specific lightweighting requirements can be discussed.

4.2 Build knowledge about lightweighting, accelerate the transfer of knowledge and technology across industries and materials and put it on a permanent footing

4.2.1 Transfer of knowledge and technology

Transferring knowledge and technologies from the lab to real-life application is of major importance as it reduces time-to-market, which is critical for companies. Lightweighting is no exception to this. A continuous transfer of up-to-date scientific discoveries and state-of-the-art technologies is necessary to support companies, especially SMEs, as they develop and use lightweight solutions. Beyond this, digital capabilities and skills are key to harnessing the full potential of lightweighting. This applies to capabilities for seamless digital interconnection and for the automation of process chains as well as the use of digital twins for optimising materials, processes or procedures. Additive manufacturing and progressive recycling solutions and better product cycle management in lightweighting would be unthinkable without digital solutions.

Objective:
We want to accelerate the transfer of knowledge, materials and technology across industries and materials involved in lightweighting, so that innovative solutions can be developed and new markets opened up. The objective is to speed up the process of turning new insights from lightweighting into sustainable and competitive innovations for the markets of tomorrow. We want to put SMEs, in particular, in a position where they can use sustainable and profitable lightweighting solutions.

Measures:

- We will continue to support regulatory sandboxes, such as the National Lightweighting Validation Center in Dresden, which make it possible to demonstrate the capabilities of sustainable lightweight technologies on an industrial scale.

- It is the Federal Government's objective to create a Regulatory Sandbox Act so as to offer uniform and innovation-friendly conditions for regulatory sandboxes and to open up new scope for testing innovations. We are in the process of assessing whether lightweighting is a field that fits in here and can be given new scope for testing innovations.

- We will also promote lightweighting in the Mittelstand-Digital network.

- We are assessing possibilities for the German Agency for Transfer and Innovation (DATI) to support inter-industry transfers of expertise in the field of lightweighting.

- In the aerospace sector, we will create synergies in automated manufacturing technologies

through cooperation with the automotive industry and synergies in liquid hydrogen storage through cooperation with the space industry.

- We will continue the digitisation workshops taking place as part of the Lightweighting Initiative, in which state-of-the art scientific approaches and research findings, ongoing research initiatives and funding programmes to improve digitisation in materials science and materials engineering are publicised and disseminated.

- We will support players from science and business as they develop and make available data-based development methods that can be used across sectors and materials and AI-based tools for lightweighting, e.g. through the reformed Technology Transfer Programme (TTP) for Lightweighting and Materials Efficiency.

4.2.2 Studies

Targeted research studies can identify opportunities and challenges in certain fields of lightweighting and point the way towards possible solutions. In this way, they allow for knowledge to be built and for evidence-based political action. This is particularly true of potentials studies that come up with specific scenarios for application.

Objective:
We want to commission research studies to highlight the specific potential of lightweighting in the context of the various dimensions of sustainability.

Measures:

- We will use the study on advanced materials to identify their additional potential and ways of using this to lower greenhouse gas emissions, reduce the consumption of resources and improve energy efficiency levels. We will use the study as a basis for a concept for advancing the field of advanced materials.

- We will commission a study into the potential of additive manufacturing for climate action and the conservation of resources in the context of structural engineering.

- We will commission a study into the potential of lightweight top floors for creating more housing capacity by adding new floors to existing buildings.

- We will commission a study into the potential of saving operational and transport energy in the area of transporting construction products, particularly moveable buildings technology (e.g. lifts) and temporary structures and buildings.

- We will commission a study into the potential of replacement of high-tensile steel in the construction sector, including building engineering and civil engineering in terms of economic viability, effects on the climate and resilience.

4.2.3 Initial and Further Training

As an innovative construction philosophy and state-of-the-art technology, lightweighting permanently requires skilled workers with the required training so as to ensure interdisciplinary cooperation across the various fields of technology, materials and manufacturing processes. Lightweighting

creates new jobs, safeguards existing ones and offers skilled workers career prospects into the future.

Objective:
We want to continuously improve initial and further training for lightweighting and keep the focus on sustainability, future requirements and interdisciplinary work. We also want to improve access to qualification measures in lightweighting so that the industry can benefit from a greater pool of labour skilled in lightweighting.

Measures:

- We want to work closely with the social partners to continue to embed the concept of lightweighting and especially the underlying intention of resource and materials efficiency in the process of updating the relevant training curricula.

- With regard to existing and arising needs for labour skilled in lightweighting, we want to assess whether these might justify or require the development of a new profession accessible by dual vocational training, or of new additional qualifications or regulated further training courses.

- We will animate associations involved in lightweighting to actively approach relevant companies to raise awareness for the potential of lightweighting and encourage them to offer vocational training places for professions in the field of lightweighting.

- We are following the changes in required skills and qualifications for technical staff working in the maintenance of aircraft and products used in aircraft technology. We will use workshops to share experiences about the special requirements for lightweighting and, if necessary, assess whether training standards should be adjusted accordingly.

- We will support the members of the lightweighting community as they improve access to technological fields by introducing demonstration projects at schools as part of vocational guidance.

4.3 Foster the use of lightweighting through regulation and public procurement

4.3.1 Regulation

Regulatory requirements for the use of lightweighting can give rise to additional innovations in lightweighting, which can contribute to target achievement under the Green Deal. The statutory requirements relating to lightweighting are still highly fragmented and scattered across different industries. Also, some innovations in lightweighting are developed in regulated industries and thus require multiple approvals. Any regulatory projects should therefore be mindful of potential delays of required approval procedures and seek to avoid any disproportionate administrative requirements for SMEs and startups. Also, there already are provisions at EU level governing relevant lightweighting sectors including civil aviation, which is why the need for national regulations is limited to a few exemptions.

Objective:
Where necessary, we want to use regulation to encourage the use of lightweighting; particularly by imposing requirements on ecodesign.

Measures:

Flagship project: Including lightweighting in the new Ecodesign for Sustainable Products Regulation as a parameter for materials efficiency.

The draft for the Ecodesign for Sustainable Products Regulation tabled by the European Commission in late March 2022 is designed to make the EU a forerunner on regulations for environmentally-friendly and recyclable products. The envisaged scope of application of the Regulation significantly exceeds that of the existing Ecodesign Directive, covering almost every physical product.

In the field of ecodesign, lightweighting can be an important tool to reduce the consumption of materials in manufacturing. In this context, it is important to ensure that other criteria for ecodesign, such as recyclability are also met.

We will therefore seek to embed suitable parameters on lightweighting in the draft for the Ecodesign Regulation, so that the European Commission can also use lightweighting criteria for the improvement of materials efficiency in products as it designs its requirements for ecodesign. This can be done using synergies with the bodies working on the Ecodesign Regulation.

4.3.2 Public procurement

The public sector is under particular obligation to help reach the targets designed to mitigate climate change and conserve resources. Public sector institutions are under obligation to use the funds entrusted to them by citizens as efficiently as possible. They are also under special obligation to lead by example. With an annual procurement volume worth hundreds of billions of euros every year, the public sector can play an enormously important role in supporting the introduction and dissemination of green and climate-friendly forward-looking technologies such as lightweighting. Even though there already are several ways in which sustainability aspects can play a part in public procurement,[7],[8] this was done in only 12.5% of public-sector contracts and/or concessions in the first semester of 2021.[9]

Objective:
We want to embed sustainable lightweighting in public procurement procedures wherever it is possible and makes sense. Public procurement bodies should always have these transformational technology in mind and thus promote innovation. For this purpose, we want to establish quantifiable sustainability criteria for lightweighting that can be used in public procurement procedures, whilst at the same time doing everything possible to avoid unnecessary further bureaucracy and reduce the amount of existing bureaucracy where possible.

7 In 2020, the Federal Environment Agency provided a very good overview of specific criteria that can be used at federal or *Länder* level (cf. [8]). In legal terms, there already is a manifold basis for strengthening product groups that make sense from an environmental point of view (which is also true of products using lightweighting): Provisions on the use of environmental aspects can be found, among others, in section 97(3) Act against Restraints of Competition and section 2(3) Rules of Procedure Governing Supply and Service Contracts Below the EU Thresholds. Similarly, section 13 Federal Climate Change Act also stipulates that public procurement must take into account the targets for climate action. In more specific terms, section 45 Closed Substance Cycle and Waste Management Act (KrWG) stipulates that resource-efficient and energy-efficient products/procedures etc. be given preferential treatment. This means that public procurement bodies can already design their procurement decisions to have a stronger, strategic environmental effect. As part of their right to determine the details of the contract they can, for instance, specify that such products/materials must be used. Also, public procurement bodies can increasingly use award criteria that ensure that costs are calculated per product life cycle (etc.).

Measures:

- As we embark on the complete review of procurement law ("transformation of procurement package"), we will assess the extent to which sustainability aspects can be rendered more binding in procurement procedures. This could also have a positive effect on the use of lightweighting, e.g. as calls for tenders and award procedures could be made using unambiguous and relevant criteria on the use of innovative lightweight solutions to promote climate action through innovative lightweight solutions.

- We are educating and informing officials in charge of procurement about the possibility to embed sustainability criteria linked to lightweighting (e.g. life cycle costs) in calls for tenders. Perhaps an encouragement for the contracting and procurement bodies to consult the existing instruments (e.g. information material) provided by the Centre of Competence for Sustainable Procurement (KNB) or the Coordination Body for a Climate-neutral Federal Administration (KKB) could help identify any blind spots or gaps.

- We continuously ensure that voluntary commitments by public-sector contracting bodies or else administrative provisions sufficiently take into account sustainability criteria related to lightweighting and will expand these further as necessary.

- We are using new federal buildings and the modernisation of federal buildings to create positive examples of how lightweighting strategies can be put into practice. Leading by example in this way can help raise awareness for what is possible and dispel insecurity to give rise to interest, acceptance and concrete action.

4.4 Support innovation in lightweighting through standardisation

Standards impose certain requirements to be met by products, services and procedures and ensure clarity regarding their properties. Most importantly, they serve to effectively disseminate successful R&D work into wider use and to quickly establish innovation on the market. They also create a uniform basis for comparison, including in international competition. Standardisation is especially important for horizontal technologies such as lightweighting, as they facilitate cooperation whilst also fostering competition. Altogether, standards make a recognisable contribution to economic output. At national level, there are standards committees on various fields of expertise. Technical challenges in lightweight construction that ought to be addressed through standardisation include noise protection, fire protection, and heat protection in summer.

Objective:
We want to place a special focus on the standardisation of sustainability aspects in lightweight construction so as to uphold Germany's leading position in climate action and resource efficiency through lightweighting, and strengthen the economic weight of this sector.

Measures:

- We are putting the task of identifying needs for standardisation in lightweighting on a permanent footing. We are continuing the cooperation between the relevant standardisation organisations and technical rule-makers (e.g. German Institute for Standardization (DIN), Association of German Engineers (VDI), inspection and certification bodies (e.g. TÜV)) and federal institu-

tions (e.g. Federal Institute for Materials Research and Testing (BAM).

- Under the revised Technology Transfer Programme for Lightweighting and Materials Efficiency (TTP for Lightweighting and Materials Efficiency) we are providing funding for R&D into the standardisation of lightweight materials and technologies (including the necessary collection, review and provision of data in dedicated data spaces).

- Under the revised TTP for Lightweighting and Materials Efficiency we are providing funding for the development of standardised or standardisable measurement and test methods of new lightweight materials and for resource-efficient technologies and process automation.

- Under the revised TTP for Lightweighting and Materials Efficiency we are providing funding for the groundwork on standards and guidelines, standardisation and conformity assessment processes (e.g. certification).

- We are looking into possibilities of embedding suitable standardisable lightweighting criteria in concepts for a digital product passport.

- We will be offering the lightweighting community information and participation events on standardisation. In this way, we want to support experts as they feed their expertise into standardisation bodies and also encourage new experts to get involved in relevant standardisation projects.

4.5 Support economic resilience and technological sovereignty through lightweighting

Lightweighting can make Germany more economically resilient, mainly by reducing its use of primary raw materials and through substitution. This can be achieved through materials efficiency, recycling and by replacing materials derived from fossil fuels with biogenic materials and recycled materials, and by substituting other critical commodities. This will allow for the reduction of dependencies on commodities imports through a reduced need for these commodities and a diversification of sources and for a more sustainable and resilient commodities supply.

Economic resilience requires technological sovereignty to strengthen and safeguard forward-looking and sustainable value chains in Germany. Securing expertise, promoting innovative developments and supporting the use of key-enabling technologies in Germany is essential to safeguard industrial economic activity in Germany. This is especially true of technologies including lightweighting that have the potential or are even necessary to address the major challenges of our time, such as climate change, the digital revolution, and the scarcity of energy and resources. For an economy to reach technological sovereignty, it is essential to have the relevant expertise and its own independent development and manufacturing capabilities and capacities, and to do research at a level that can compete internationally.

Objective:
We also want to harness the potential of lightweighting for greater materials and energy efficiency to reduce one-sided dependencies on raw materials imports and to strengthen our economic

resilience by ensuring a diversified and sustainable supply of raw materials. For this purpose, we want to use lightweighting to reduce the absolute use of materials, but also diversify the raw materials used for lightweight construction and their supply chains. Aluminium, magnesium, scandium and titanium, in particular, are important commodities for lightweighting. Furthermore, we want to strengthen Germany's technological sovereignty, especially by encouraging those links in the lightweighting value chain that are especially important for the transformation to establish themselves or remain established in Germany.

Measures:

Flagship project: Revising the Technology Transfer Programme (TTP) for Lightweighting and Materials Efficiency

The implementation of a new funding guideline for the TTP for Lightweighting and Materials Efficiency is to help diversify the supply with raw materials and help reduce existing dependencies. For this purpose, the funding guideline focuses on lightweighting and materials efficiency, which allow for a reduction in the amount of material used as soon as during the manufacturing process. The intended funding for new approaches to recycling in lightweighting, too, will reduce the amount of primary raw materials required through largely closed materials cycles and high-value recycling. Finally, funding is also provided for the targeted replacement of scarce materials and the most critical raw materials so as to prevent materials scarcity.

- In the light of a geopolitical situation that is constantly changing, we are analysing the value and supply chains of the German lightweighting industry to identify critical dependencies. In particular, we are focusing on supply chains affected by European sanctions imposed in response to the war of aggression waged by Russia against Ukraine (cf. Regulation (EU) No. 833/2014 in its current version) and on countries with autocratic governments, such as the People's Republic of China, which are increasingly using their economic relations to advance their political goals. We are raising awareness among economic agents for the risks resulting from this and are increasingly creating incentives for a diversification of supply chains and sources.

- We will put the continuous cooperation between the German Mineral Resources Agency (DERA) at the Federal Institute for Geosciences and Natural Resources (BGR) and the participants of the Lightweighting Initiative on a permanent footing and expand it (e.g. by modelling the flow of commodities, monitoring availabilities and evaluating the availability of alternative materials).

- We are reviewing the development of concepts for urban mining of materials used in lightweighting, i.e. we are exploring to what extent secondary raw materials from anthropogenic deposits can be used in lightweighting.

- We are supporting the establishment of technologies designed to be sustainable and of sustainable lightweighting value chains by fostering R&D projects and international cooperation in Germany and Europe (e.g. for the manufacturing of biogenic carbon fibres, the recycling of carbon fibres).

4.6 Quantify the economic relevance of the horizontal technology of lightweighting; make it possible to measure ecological effects across the entire lifecycle

4.6.1 Environmental footprint, materials and environmental data

There is a great need for digital and standardised methods of analysis that allow for the impact of lightweight materials and products on the climate and the environment to be monitored along their entire lifecycle and in a transparent manner, and to highlight potential for further improvement to the optimum. This need is especially pronounced among SMEs as these often lack the capacity for the cost-intensive development, adjustment or adoption of complex methods. This need also extends to practical, streamlined digital instruments for analysis and documentation.

Suitable methods include ecological footprinting (also known as life cycle assessments). Where life cycle assessments are used as planning instruments, they allow manufacturers to take decisions early on in product development that ensure that materials, design and construction methods are combined in a way that results in the lowest possible carbon and materials footprint along the lightweighting product's entire life cycle. Environmental footprints help identify potential conflicts between the objectives of materials efficiency, optimised weight, functionality, safety and security, reliability, durability and recyclability early on and weigh these objectives against each other so that sustainable and economically viable solutions can be found.

A digital product passport can be a possibility for a standardised approach to environmental footprints, and can make it significantly easier to determine these. It could make it possible to use environmental data in a simple and traceable way to manage production processes on the one hand and to comply with official reporting requirements on the other. Simulation, modelling and digital twins are already being used successfully in some areas. The concept of a Digital Product Passport on the basis of relevant materials data for the entire life cycle is also being pursued by manufacturing and materials research.

In the field of buildings, in particular, a digital building resources passport and the raw materials input (RMI) are standardised approaches to determine the environmental footprint of buildings. The building resources passport can be used to record environmentally-relevant information about a building and the type and amount of building products used in its construction. In this way, this instrument can support resource management (type and amount of resources/energy consumption in manufacturing and use) and recycling (information on the use and re-use of products and materials). The RMI is a reliable indicator for the amount of materials used in a building and can significantly improve the planning of buildings in a way that conserves resources. Beyond this, the RMI is to ensure that statistics can also be used by the EU and the Federal Statistical Office so that environmental footprinting can also serve as an active contribution to the creation of a materials register.

Objective:
We support the development and the use of environmental footprinting for lifecycle-based decision-making for sustainable materials and product development in lightweighting. In line with the rel-

evant regulations on ecodesign, we also want to promote sustainable innovations in lightweighting by introducing a digital product passport and by better recording and processing materials and environmental data.

Measures:

- In the context of the reviewed TTP for Lightweighting and Materials Efficiency, we are supporting the development of improved environmental footprinting (including methods, data and models), approaches to the standardisation of environmental footprinting and holistic approaches to footprinting (taking into account the technical, economic, ecological, political and social context), which also measure negative effects such as the rebound effect.

- As we assess environmental footprints and approaches to footprinting, we will draw on the insights of the German 2023 Circular Economy Standardisation Roadmap, which lists obstacles and challenges for the transformation from a standardisation angle and also sets out the standardisation requirements for seven key economic sectors in Germany.

- We are looking into whether and how an integrated digital resource and environmental data management system covering the entire value chain can be established. Digitisation can make an important contribution to transparency and sustainable supply chain management.

- We support the process of drawing up standardised determination procedures for scope-3 greenhouse gas emissions from the field of lightweighting.

- In preparation of a digital product passport, we are analysing potential methods for the tracing and the recovery of lightweight materials and components, so that these can be fed back into the cycle.

- For the purpose of recording, assessing and steering the use of resources at the level of individual buildings, we are looking into introducing a digital building resources passport and a raw materials indicator into the 'Sustainable Building' seal of quality.

4.6.2 Ecological and economic benefits

Ecological footprints look at lightweighting from the angle of the individual product. Also required are instruments that are suitable for quantifying the ecological and economic benefits of lightweighting at a higher level of abstraction, i.e. e.g. per sector or across the entire economy. In this way, estimates about the reduction of greenhouse gas emissions achieved by lightweighting or key figures on positive employment effects and on turnovers of given products or industries can be used as a sound basis for political decision-making. The ability to provide key figures at an over-arching level also makes it possible to take a holistic view on the opportunities and challenges in the field of lightweighting.

Suitable instruments for analysis are required to measure and quantify the sustainability effects of lightweighting in its dimensions of the environment, economy and society. So far, scientific methods and instruments for measuring the total reductions in greenhouse gas emissions achieved by lightweighting are only at a rudimentary stage. In the context of the TTP for Lightweighting, for instance, an expertise estimated the potential for

lowering greenhouse gas emissions in the industrial sector at a cumulated 2.3 million tonnes of CO_2 equivalents by 2030. However, this figure is highly uncertain given the R&D character of the TTP for Lightweighting. The delayed development and ramp-up of technologies mean that greater reductions of greenhouse gas emissions are only to be expected in the long term, with the adoption of the technologies. In the economic field, too, there are only estimates about the effects of lightweighting on the economy. A McKinsey report from 2012, for instance, found that the market for the lightweight materials of aluminium, carbon fibres and high-tensile steel will grow to be worth more than €300 billion by 2030 [10].

Objectives:
We want to bring quantitative approaches to the measurement of the ecological, economic and social potential of lightweight solutions to application so as to create a sound basis for political decision-making and allow for a holistic overview of the effects of lightweighting

Measures:

Flagship project: Improve the measurability of the economic significance of lightweighting

Sectors that are essential for Germany, including mobility, machinery and plant construction and energy, are pushing hard to develop new lightweight technologies. This momentum makes it safe to assume that lightweighting is of high relevance for business at large and its competitiveness. However, this relevance can currently not be quantified. Due to the horizontal nature of lightweighting, the standard calculations and statistics (such as the national accounts) do not capture the economic effects of lightweighting. Without sound figures, it is likely that the economic and industrial relevance of lightweighting is being underestimated, also in political terms. Numeric data is also important to bring political and economic activities in line with the economic relevance of lightweighting and assign the required funds to them. We want to support economic players as they demonstrate the economic importance of lightweighting and do so in terms that are empirically sound and relevant in terms of economic policy.

- We are supporting the development of analytical instruments and systems of indicators designed to capture the effects of lightweighting across the three dimensions of sustainability.
- Rendering the effects of lightweighting measurable, relevant in terms of economic policy and easy to understand is to help make this transformational technology a central theme. Making the use of lightweighting transparent and tangible for experts from all kinds of markets and also for non-experts can contribute to informed decision-making among customers and a rise in demand for resource-efficient and sustainable lightweight products.
- The quantification of the effects of lightweight technologies is also to be used for convincing PR work and help inform the public about climate-friendly products and technologies.

4.7 Make the benefits of lightweight construction visible to consumers and promote professional networking in lightweight construction

4.7.1 Public relations for the professional community

The lightweight construction professional community consists mainly of representatives from industry, science and interest groups, and in recent years it has been increasingly strengthened by stakeholders with an environmental policy agenda. Due to the diversity of sectors, technologies and materials, there is consequently a large number of stakeholders. An interdisciplinary exchange and networking between these stakeholders is of strategic importance especially for cross-sectoral and cross-material knowledge and technology transfer (cf. 4.2.1).

Objectives:
We want to use targeted activities to support the cross-sectoral and cross-material dialogue of lightweight construction stakeholders and the formation of robust lightweighting networks.

Measures:

- The Lightweighting Summit of the Federal Ministry for Economic Affairs and Climate Action will continue to be a flagship event for the lightweighting sector. The Lightweighting Summit takes place annually as a top national or international meeting of lightweight construction stakeholders at HANNOVER MESSE trade fair, and includes new key topics each year.

- We will continue to use the Lightwieghting Forum as a central platform for the lightweighting – community that can use it to professionally discuss and work on current developments. This event takes place once a year and offers its participants a networking platform where they can listen to specialist presentations and exchange views.

- Using the Lightweight Construction Atlas, we continue to offer support to companies and research institutions looking for lightweighting expertise, cooperation partners and suppliers on a national and international level. The Lightweighting Atlas is a digital database that organisations can use to present their lightweighting procedures and activities.

- We will expand the commitment of the Federal Ministry for Economic Affairs and Climate Action in the area of demonstration competitions by introducing patronages. Demonstration contests aim at showcasing practical procedures and applications and at demonstrating the contribution of lightweight construction as a key technology for a GHG-neutral economy. This is intended to expand the interest of companies in lightweight technologies and to promote the networking between lightweight construction stakeholders.

4.7.2 Public relations for the non-professional community

When looking at the broader society, public relations pursue a different goal than the one created for professionals. Here, we would like to show the benefits of lightweight construction to the public and promote a long-term, active demand for lightweight construction products and give further impetus to lightweight technologies.

Objectives:
Through easy to understand PR, we also want to communicate the advantages that lightweight

construction brings for a sustainable, climate-friendly and at the same time competitive economy.

Measures:

Flagship project: Create a consumer-oriented communication strategy

We want to create a consumer-oriented communication strategy, in order to make society more aware of and better understand the benefits of lightweight construction. The strategy is to identify different target groups depending on their use of lightweight construction and help find appropriate ways to address these groups (for instance regarding their triggers which make them use lightweight construction or access information). This is particularly relevant, because lightweight construction represents a rather complex technology sector that cuts across many horizontal issues and therefore requires simple and at the same time explanation-oriented communication. For this purpose, we provide the necessary communication tools (for example explanatory videos, graphic images etc.) and distribute them on all relevant online and offline communication channels.

4.8 Expand international cooperation and market development activities

Internationalising activities in the lightweight construction sector is a key objective of the Federal Ministry for Economic Affairs and Climate Action Lightweighting Initiative. This has enabled us to already launch many international initiatives. These include, in particular, the founding of the ELN and the anchoring of lightweight construction in the market development and export market instruments of the Federal Ministry for Economic Affairs and Climate Action such as the MEP and the AMP.

Objectives:
We would like to expand and complement these international endeavours in the lightweight construction sector. To this end, we support an ambitious EU Free Trade agenda in order to use the diversification of trade and supply relations for the opening of new markets. Together with the EU we support the rules based multilateral trade system with the WTO at its core, in order to further support international knowledge transfer, strategic cooperation and the market development of German companies abroad. We will consider geopolitical developments and associated risks when selecting the countries for our international activities in the field of lightweight construction.

Measures:

Flagship project: International activation of lightweight construction potential through intensive cooperation in the European Lightweight Network (ELN)

Only together can we master international challenges. This is why we want to particularly strengthen productive cooperation with our European partners within the ELN and promote the introduction of a European Lightweight Strategy and a Lightweighting Hub in Brussels. Together we will expand networking between

the European Lightweight Cluster Alliance (ELCA), the European Lightweight Association (ELA) and the ELN. With this stronger interconnection between industry, science and policy at European level, we can shape a more robust alliance for the protection of resources and for climate action.

- We are reviewing how a closer exchange with African countries can be organised through the Africa Business Network and are launching studies on the potential of lightweight construction technologies and solutions in specific African countries.

- We will continuously include lightweighting in events of the UN Global Compact and the United Nations Commission for Europe (UNECE).

- We are reviewing whether lightweight construction can be part of the Manager Training Programme of the Federal Ministry for Economic Affairs and Climate Action. The Manager Training Programme specifically teaches SME - managers how to initiate business and economic cooperation with German companies. German SMEs also use the MP to explore new markets in development and emerging countries. The MP is currently being implemented with 17 partner countries worldwide.

- We are reviewing whether lightweight construction can be included in bilateral Administrative Partnerships (APs) with other countries to promote lightweight construction policy. Bilateral APs can include support for the establishment and expansion of efficient ministries and organisations, the adaptation of laws, guidelines and procedures, and the training and further education of administrative staff.

- We promote European and transnational research cooperation. The new funding guideline of the TTP "Lightweight Construction and Material Efficiency" is intended to enable European cooperation in research and development, such as EUREKA, as well as transnational ERA-NET networks.

- We are building on the efforts of the German G7 Presidency in 2021, especially within the framework of the "G7 Berlin Roadmap on Resource Efficiency and Circular Economy", to further establish lightweight construction as an approach to increasing material efficiency at G7 level.

- We are consolidating and deepening our cooperation with South Korean partners as a result of the 2-year joint MEP project with South Korea. The cooperation will be geared in particular to lightweight construction activities that benefit climate action.

- We support and consolidate the trade fair presence of lightweight construction stakeholders and lightweight construction development within the framework of joint stands funded by the ministry. This happens, for example, through such programmes of the Federal Ministry for Economic Affairs and Climate Action as the AMP and the Young Innovators programme, the Ministry's trade fair participation at Green Tech and HANNOVER MESSE trade fair as well as the annual trade fair tour of the JEC.

5 Implementation

Stakeholders and responsibilities

The Federal Ministry for Economic Affairs and Climate Action and the bodies of the Lightweight Construction Initiative are the key stakeholders in implementing the above mentioned measures in a targeted manner. The Federal Government's lightweight construction strategy is implemented in cooperation with the Federal Ministry of Labour and Social Affairs (BMAS), the Federal Ministry for Housing, Urban Development and Building (BMWSB), the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), the Federal Ministry for Digital and Transport (BMDV), the Federal Ministry of Food and Agriculture (BMEL), the Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Health (BMG). The ministries involved implement their measures within the framework of their respective ministerial responsibilities on their own responsibility and subject to available budgetary funds.

Interministerial exchange and progress assessment

The cross-cutting technology of lightweight construction benefits from an interdisciplinary approach and from an exchange of knowledge between the stakeholders. This also applies to the ministries. The aim is therefore to provide a platform for the exchange on lightweight construction between the ministries and divisions involved via a joint meeting held once in each legislative period.

In addition, the Federal Ministry for Economic Affairs and Climate Action intends to introduce indicators to measure its progress when implementing each package of measures. In doing so, the Ministry wants to make the impact of lightweight construction activities more measurable, also when implementing the strategy as a whole. The indicators and progress are to be presented at the above meeting and, if possible, extended to the ministries involved.

Interfaces with other political strategies, laws and programmes

At the national level, the lightweight construction strategy of the Federal Government supports, among other things, the achievement of goals in accordance with the Federal Climate Action Act (KSG), as well as the goals of the Industrial Strategy provided for in the Coalition Agreement, the National Biomass Strategy, the National Bioeconomy Strategy, the National Circular Economy Strategy, the National Raw Materials Strategy and the key issues paper of the Federal Ministry for Economic Affairs and Climate Action on a sustainable and resilient supply of raw materials and the Federal Government's timber construction initiative. At European level, the Federal Government's lightweight construction strategy is part of the EU Green Deal.

6 Annex

List of Abbreviations

AMP	Foreign Trade Fair Programme
AP	Administrative partnership
BMAS	Federal Ministry of Labour and Social Affairs
BMBF	Federal Ministry of Education and Research
BMDV	Federal Ministry for Digital and Transport
BMEL	Federal Ministry of Food and Agriculture
BMG	Federal Ministry of Health
BMUV	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
BMWK	Federal Ministry for Economic Affairs and Climate Action
BMWSB	Federal Ministry for Housing, Urban Development and Building
EEW	Federal funding for energy and resource efficiency in business
ELN	European Lightweighting Network
ERP	European Recovery Programme
EU	European Union
GHG	Greenhouse gas
JEC	the JEC group is a non-profit organisation dedicated to promoting composite materials and fostering their applications globally
KfW	German promotional bank
LuFo Klima	German Aviation Research Programme (Climate)
MEP	Market entry programme
MP	Manager Training Programme
R&D	Research and Development
RMI	Raw Material Input

TTP Lightweight construction	Technology Transfer Programme Lightweight construction
TTP “Lightweight construction and material efficiency”	Technology Transfer Programme “Lightweight construction and Material Efficiency” (revised version)

Bibliography

[1] Henrik Brinkmann, Friedrich Heinemann, Christoph Harendt, Justus Nover (2017); Ökonomische Resilienz – Schlüsselbegriff für ein neues wirtschaftspolitisches Leitbild? [Economic resilience – key principle for a new economic vision?]; Wirtschaftsdienst; accessed at: https://www.wirtschaftsdienst.eu/inhalt/jahr/2017/heft/9/beitrag/oekonomische-resilienz-schluesselbegriff-fuer-ein-neues-wirtschaftspolitisches-leitbild.html (26 January 2023, 18 hrs).

[2] Federal Ministry of Education and Research (BMBF); Technologische Souveränität [Technological sovereignty], accessed at: https://www.bmbf.de/bmbf/de/europa-und-die-welt/innovationsstandort-deutschland/technologische-souveraenitaet/technologische-souveraenitaet_node.html (19 January 2023, 18:00 hrs).

[3] International Resource Panel, Global Resources Outlook 2019, https://www.resourcepanel.org/reports/global-resources-outlook (26 January 2023, 18:00 hrs).

[4] OECD, Global Material Resources Outlook to 2060, https://www.oecd.org/publications/global-material-resources-outlook-to-2060-9789264307452-en.htm (26 January 2023, 18:00 hrs).

[5] International Resource Panel, Resource Efficiency and Climate Change, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change (26 January 2023, 18 hrs).

[6] Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), „Ökologische Produktgestaltung (Ökodesign)“ [Ecological product design (ecodesign)] https://www.bmuv.de/themen/nachhaltigkeit-digitalisierung/konsum-und-produkte/oekologische-produktgestaltung-oekodesign.

[7] Karsten Ulrich Tichelmann, Dieter Blome, Tanja Ringwald, Deutschlandstudie 2019, Wohnraumpotenziale in urbanen Lagen Aufstockung und Umnutzung von Nichtwohngebäuden. [Potential for living space in urban locations – upward extension of existing buildings and conversion of non-residential buildings.]

[8] a) Thomas Schneider, Becker Büttner Held; Vanessa Schmidt, Berliner Energieagentur, Berlin UBA Texte 188/2020, „Rechtsgutachten umweltfreundliche öffentliche Beschaffung“, Aktualisierung 2020, Dessau-Roßlau 2020. [Legal opinion on environmentally friendly public procurement”, revised 2020, Dessau-Roßlau 2020] b) Thomas, Schneider Becker Büttner Held; Vanessa Schmidt, Berliner Energieagentur, Berlin; UBA Texte 126/2020, „Regelungen der Bundesländer auf dem Gebiet der umweltfreundlichen Beschaffung“, Aktualisierung 2020, Dessau-Roßlau 2020. [“Regulations of the Länder in the field of environmentally friendly procurement”, revised 2020, Dessau-Roßlau 2020.]

[9] BMWK, „Vergabestatistik Bericht für das erste Halbjahr 2021“, Berlin, Oktober 2022. [Procurement statistics report for the first half of 2021]

[10] Ruth Heuss et al., McKinsey & Company, “Lightweight, Heavy Impact”, February 2012, accessed at: https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/automotive%20and%20assembly/pdfs/lightweight_heavy_impact.ashx.