Benchmark on Environmental Regulations in the North-West-Europe Region

Deliverable 3.1 – Working group on policy: goals and guidelines

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Introduction

Current challenges in the context of climate change – primarily with regard to CO_2 emissions and circularity – are dominating political action at European and national level. This first benchmark on environmental regulations is therefore intended to provide a general overview of directives, regulations and policy priorities on national level that will affect future sustainable lightweight design. This could help companies to address environmental regulations and to make transport greener by reducing CO_2 emissions throughout the entire value chain and improving material circularity. Transportation is responsible for about 28% of the total EU greenhouse gas emissions with aviation accounting for 3.8% of total emissions and road transport 20.4%.[1] The scope of consideration includes directives, regulations and policy priorities in the field of automotive and aviation with regard to five cross-cutting areas within lightweight, see Figure 1.

Figure 1: Addressed cross-cutting areas within lightweight

In the following, a brief overview is first given at the European level. Then, the relevant regulations and directives as well as policy priorities are described on a country-specific level in order to be finally compared on a multinational level. The benchmark should be understood as an overview and an indicator of national priorities.

Goals and Policy Actions Regarding Environmental Regulations at EU Level

Towards limiting global warming, the European Commission (EC) is driving different activities to reduce CO_2 emissions and improve circularity of materials. These actions are based on the 17 Sustainable Development Goals (SDG) of the United Nations (UN). Among others, the following actions of the EC affect lightweighting in the field of automotive and aviation:

- European Green Deal and Climate Action Plan,
- Circular Economy Action Plan and Sustainable Products Initiative and Digital Product Passport,
- Innovation instruments

The **European Green Deal** is "an ambitious package of measures ranging from ambitiously cutting greenhouse gas emissions, to investing in cutting-edge research and innovation, to preserving Europe's natural environment"[2]. It comprises main actions and a roadmap to further reduce greenhouse gas emissions and to achieve climate neutrality in the EU by 2050. According to the European Green Deal the transport greenhouse gas emissions have to be reduced by 90% by 2050 compared to 1990 levels. Key measures include new standards for vehicles to reduce CO_2 emissions from transport and the promotion of innovative low-carbon technologies. The limits of carbon dioxide emissions for **passenger cars** and **light commercial vehicles** (vans) are regulated in the Regulation (EU) 2019/631[3]: from 01.01.2020 the EU fleet-wide target for the average of emissions of new passenger cars is 95 g CO_2/km and of new light commercial vehicles 147 g CO_2/km. From 01.01.2025, the emissions for both cars and vans have to be reduced by 15% compared to the target for 2021. From 01.01.2030, the emissions for cars have to be reduced by 37.5% and for vans by 31% compared to 2021. To reduce the greenhouse gas emissions in **aviation** the EU is proposing to revise the emissions trading system (ETS). In the focus

[1] Make Transport Greener – Factsheet: https://ec.europa.eu/commission/presscorner/detail/en/fs_21_3665
[2] https://ec.europa.eu/clima/eu-action/european-green-deal_en
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02019R0631-20210301

of accelerating aviation's decarbonization is the use of sustainable aviation fuels (SAF) to reduce the greenhouse gas emissions by 13% in 2030. In 2025, 2% of SAF are to be mandatory, rising to 63% by 2050.[4] The Advisory Council for Aviation Research and Innovation in Europe (ACARE) declared in the Flightpath 2050 goals to cut the CO_2 emissions per passenger kilometer by 75% and NOx by 90% in comparison to the level of the year 2000.[5]

Complementary to Climate Action Plan, the **Circular Economy Action Plan**[6] focuses on the circularity of materials in four categories: "Sustainable Product Policy", "Key Product Value Chains", "Less Waste, More Value" and "Cross-Cutting Actions". In the context of lightweight design, this comprises sustainable product design and circularity in production processes as well as creating EU market for secondary raw materials. The transition should be driven by research, innovation and digitalization. To make products more resource efficient and sustainable the scope of the Ecodesign Directive 2009/125/EG[7] is going to be widen by the Proposal for Ecodesign for Sustainable Products Regulation[8] on 30 March 2022. Expanding the focus of circularity means not only recycling, but also to improve product durability, reusability, upgradability and reparability and reduce carbon and environmental footprints. In addition to this, Directive 2005/64/EC[9] regulates reusability, recyclability and recoverability of motor vehicles: they have to be "reusable and/or recyclable to a minimum of 85% by mass and are reusable and/or recoverable to a minimum of 95% by mass". The **Circular Cars Initiative** has identified two main levers of circular economy in the automotive sector affecting lightweighting: material circularity and lifetime optimization.[10] Since CO_2 emissions in the use phase are decreasing with battery-electric vehicles and the utilization of renewable energies for charging, the importance of lightweight design for reducing emissions will increase, especially with regard to resource efficiency and recycling or circularity.[11] Thus, carbon emissions of material production need to be assessed over the entire life-cycle and low-carbon and circular materials are required. One enabler to promote material circularity is a consistent and closed information flow throughout the entire product life-cycle. This should be enabled by a **Digital Product Passport** in the context of "making sustainable products the norm" and new upcoming regulations on ecodesign.[12] From 01.01.2026, each industrial battery and electric vehicle battery with a capacity higher than 2 kWh shall have a battery passport.[13]

To mobilize research and foster innovation in the field of climate action the EC established the **Innovation Fund** for the demonstration of innovative low-carbon technologies.[14] From 2020 to 2030 38 billion Euros are available to support highly innovative technologies and big flagship projects in the fields of energy intensive industries, renewables, energy storage and carbon capture, use and storage. More specific to lightweight design is the new research and innovation funding program **Horizon Europe (2021-2027)** with a budget of around 95.5 billion euros.[15] One of the six main research areas in in the field of global challenges is Climate, Energy and Mobility and another Digitalization, Industry and Space.[16] Within the work program 2021-2022[17] lightweight has been mentioned in different calls, for

[4] Make Transport Greener – Factsheet: https://ec.europa.eu/commission/presscorner/detail/en/fs_21_3665
[5] https://acare4europe.org/sites/acare4europe.org/files/attachment/acare-strategic-research-innovation-summary-2-interactive-fin_0.pdf
[6] https://ec.europa.eu/environment/pdf/circular-economy/new_circular_economy_action_plan.pdf
[7] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0125
[8] https://ec.europa.eu/environment/publications/proposal-ecodesign-sustainable-products-regulation_en
[9] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32005L0064
[10] https://www3.weforum.org/docs/WEF_Circular_Cars_Initiative_Paving_the_Way_2021.pdf
[11] http://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf
[12] https://ec.europa.eu/commission/presscorner/detail/en/IP_22_2013
[13] https://www.gs1.eu/news/eu-green-deal-sustainable-batteries-for-a-circular-economy
[14] https://ec.europa.eu/clima/eu-action/funding-climate-action/innovation-fund/policy-development_en
[15] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en
[16] https://www.horizont2020.de/einstieg_horizont_europa.htm
[17] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-7-digital-industry-and-space_horizon-2021-2022_en.pdf

example, in "Advanced lightweight materials for energy efficient structures", "Ensuring circularity of composite materials", "Functional multi-material components and Structures", and "2D-material-based composites, coatings and foams".

In the following sections the country-specific regulations and policy priorities of the North-West-Europe region are described. The national long-term strategies of EU Member States can be found on the official website of the European Union[18].

[18] https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en#strategies

Germany

Compared to the EU, Germany is already aiming for net greenhouse gas neutrality in 2045. In the **Federal Climate Change Act** are two levels on the path to neutrality defined. In the **coalition agreement** of the new government of December 2021 climate protection and resource efficiency are main pillars. In the focus are CO_2 neutral cars and lightweight design in the aerospace or aviation sector.[19] To achieve this ambitious target the Federal Ministry for Economic Affairs and Climate Action have started different initiatives and funding programs in the fields of lightweighting, resource efficiency, and circular economy. In the opening balance sheet climate action in January 2022 a holistic and interdisciplinary lightweight strategy for all industries, materials, and manufacturing processes was announced. Along with material circularity, lightweighting is seen as an enabler for resource efficiency and the reduction of carbon dioxide emissions. Figure 2 shows the understanding of lightweighting as an interface discipline in the fields of technology, materials, and manufacturing processes.

Figure 2: Understanding of lightweighting as an interdisciplinary discipline; © 2022 FEDERAL MINISTRY FOR ECONOMIC AFFAIRS AND CLIMATE ACTION (https://www.bmwi.de/Redaktion/EN/Infografiken/leichtbau.html)

Existing Subsidies and Incentives; Innovation Instruments related to Sustainable Lightweighting

In Germany most of the activities in lightweighting are centrally coordinated in **"The Lightweighting Initiative"** funded by the Federal Ministry of Economic Affairs and Climate Action.[20] This initiative elaborates practical guidelines for industry and government and supports especially small and medium-sized companies, for example, by initiating national and international cooperation. In this regard, the **"Technologietransfer-Programm Leichtbau"** (*Technology Transfer Program Lightweighting*) was established in April 2020 with a total funding budget of 300 million euros to support cross-industry knowledge and technology transfer as well as to develop new approaches and solutions in the field of lightweight design. This funding program focuses, for example, on digitization and automation of processes, innovative design principles as well as sustainability and recycling in order to reduce CO_2 emissions and to improve resource efficiency along the entire value chain.[21] Towards a circular economy, the Federal Ministry of Education and Research published in December 2021 an announcement –

[19] https://www.bundesregierung.de/resource/blob/974430/1990812/04221173eef9a6720059cc353d759a2b/2021-12-10-koav2021-data.pdf?download=1
[20] https://www.bmwi.de/Redaktion/EN/Publikationen/Industry/lightweighting-initiative.html
[21] https://www.bmwi.de/Redaktion/DE/Artikel/Technologie/technologietransfer-programm-leichtbau.html

MobilKreis[22] – for the funding of projects on sustainable mobility and the creation of circular value chains. Resource efficiency and recyclability are also gaining in importance in materials development and will lead to a strategic realignment framework program "**From Materials to Innovation**" and, thus, public funding in materials science or research.[23] One target is to establish so-called Material-Hubs in the field of battery materials and recycling strategies, resource efficiency and sustainability, and new processes for production and further handling of materials. A funding program for the establishment and implementation of hubs for supporting transformation processes in automotive value chains to increase resource and energy efficiency towards sustainable production processes.[24] This funding program supplements, among others, the program "Zukunftsinvestitionen Fahrzeugindustrie" KoPa 35c (*Future Investments in the Automotive Industry*), that subsidizes R&D projects, for example, in the areas of production modernization and new vehicle and system technologies.[25,26] In the field of aviation, the Federal Ministry for Digital and Transport launched the "Innovative Luftmobilität" (*Innovative Air Mobility*) funding program to support R&D in the field of Unmanned Aircraft Systems, amongst other things to reduce emissions.[27] In the 3rd call published in the aviation research program, among other topics, the focus is on reducing primary energy requirements, the use of resources by lightweight design as well as on reduction of manufacturing times and costs with the primacy of closed-loop material cycles.[28]

In the next years there will be several funding programs and incentives for pushing research and development projects in the industry and science due to the central anchoring of the topics resource efficiency, lightweight design, and circular economy in the coalition agreement and the strategies of several ministries such as the Federal Ministry of Economic Affairs and Climate Action, the Federal Ministry of Education and Research, and the Federal Ministry for the Environment, Nature Conversation, Nuclear Safety and Consumer Protection. A starting point for this was the "G7 Workshop on Resource Efficiency and Circular Economy" held in March 2022 that included also a session on lightweighting or sustainable lightweight design.[29]

Relevant Directives, Regulations and Policy Priorities in relation to Sustainable Lightweighting

The directives, regulations and policy priorities in Germany are generally aligned with those of the European Commission and the Intergovernmental Panel on Climate Change (IPCC). The emission goals and measures on the path to climate neutrality are described for each sector in the **"Klimaschutzplan 2050"**[30] (*Climate Protection Plan 2050*) published in 2016. Lightweight design is identified as an effective measure for reducing emissions in the transportation sector. As mentioned above, Germany intends to become climate-neutral in comparison to the EU by 2045. The first level targets a 65% reduction of greenhouse gas emissions by 2030, the second level a reduction of 88% by 2040, in each case compared to the level of 1990.[31] In addition to carbon dioxide, the definition of greenhouse gases also includes methane, nitrous oxide, Sulphur hexafluoride, nitrogen trifluoride, hydrofluorocarbons, and perfluorocarbons. The sector targets for annual emission volumes are determined or regulated in the

[22] https://www.bmbf.de/bmbf/shareddocs/bekanntmachungen/de/2021/12/2021-12-09-Bekanntmachung-MobilKreis.html
[23] https://www.bmbf.de/SharedDocs/Publikationen/de/bmbf/5/658278_Eckpunktepapier_zur_Foerderung_der_Materialforschung.html
[24] https://www.bmwk.de/Redaktion/DE/Downloads/F/foerderbekanntmachung-aufbau-und-umsetzung-transformations-hubs-automobilindustrie.html
[25] https://www.bmwk.de/Redaktion/DE/Textsammlungen/Industrie/zukunftsinvestitionen-fahrzeughersteller-zulieferindustrie.html
[26] https://www.bmwk.de/Redaktion/DE/Downloads/F/aenderung-der-richtlinie-zur-foerderung-von-forschungs-und-entwicklungsprojekten-20210316.html
[27] https://www.bmvi.de/SharedDocs/DE/Anlage/K/bundesanzeiger-foerderung-drohnen.pdf?__blob=publicationFile
[28] https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2022/04/20220428-schub-fur-die-klimaneutrale-luftfahrt-3-forderaufruf-im-luftfahrtforschungsprogramm-veroffentlicht.html
[29] https://www.bmuv.de/en/service/events/event/g7-workshop-on-resource-efficiency-and-circular-economy
[30] https://ec.europa.eu/clima/sites/lts/lts_de_de.pdf
[31] https://www.gesetze-im-internet.de/englisch_ksg/englisch_ksg.html

"Bundes-Klimaschutzgesetz" (*Federal Climate Protection Act, CPA*) since December 2019.[32]. In transport, the annual emission volumes have to be reduced from 150 million tons CO_2-equivalents in 2020 to 85 in 2030.[33] Since 2021 the CO_2 emissions in transport and building sector are also part of the national emissions trading system. As a result, each ton of emitted CO_2 costs initially a tax of 25 euros, that rise gradually to 55 euros in 2025.[34] Table 1 shows the path to a climate positive society for transportation.

Table 1: Representation of the total annual reduction targets for the transport sector in Germany according to the CPA[35,36]

Field of Action	Mio. Tons of CO_2-equivalents	Percentage Reduction of Emissions			
	2020	2030	2040	2045	From 2050
Transport/ Mobility	150	≥ 65%	≥ 88%	climate neutral	climate positive

The "Circular Economy Initiative Deutschland" presented a **circular economy** scenario for the reduction of greenhouse gas emissions based on the RESCUE scenarios proposed by the Federal Environment agency in December 2021. A key finding is that achieving the ambitious climate targets is only possible through a combination of climate protection activities and circular economy measures such as durable design, remanufacturing and both lightweight and resource efficient design. Based on this circular economy scenario, up to 16% of the greenhouse gas emissions in the mobility sector could be saved from 2018 to 2030. But there is not yet a proper legal framework for circular economy in Germany.[37] However, there are some regulations and directives that might provide a basis for its elaboration.[38] In the field of waste management the EU Directive 2018/851 regulates that 65% of the municipal waste has to be recycled in 2020. There are also product group-specific directives, for example, for packaging, electronics, and end-of-life vehicles (EU: Directive 2000/53/EC, Germany: End-of-life Vehicle Ordinance). From 2015 on, the targeted recovery rates for reuse/recycling are at least 85% and for reuse/recovery at least 95%.[39] These rates have been regularly surpassed in Germany, with one exception in 2019 (recovery rate of 93.6%).[40] In addition to this, the already mentioned Ecodesign Directive (2009/125/EC) has been implemented in Germany and adjustments regarding requirements for resource efficiency and durability have been planned by 2021.

For the future implementation of standards and policy instruments in the field of circular economy, DIN, DKE and VDI have started an initiative on elaborating a Standardization Roadmap Circular Economy in October 2021 with key topics such as digitalization, batteries and plastics.[41] In this context, the digital product passport in electromobility is seen as an important element that corresponds to the efforts at the European level in the "Sustainable Products Initiative" of the EC. To create an alliance for secure and standardized data exchange in Germany to create a basis for closing the loop towards a circular economy, for example, by the digital product or battery passport the Catena-X Automotive Network have been established.[42]

[32] https://www.bmuv.de/en/law/federal-climate-change-act/
[33] https://www.bmuv.de/fileadmin/Daten_BMU/Bilder_Sharepics/mehrklimaschutz/sektorziele_emissionen.pdf
[34] https://www.bundesregierung.de/breg-de/themen/klimaschutz/co2-bepreisung-1673008
[35] https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/klimaschutzplan_2050_bf.pdf
[36] https://www.bmuv.de/fileadmin/Daten_BMU/Bilder_Sharepics/mehrklimaschutz/sektorziele_emissionen.pdf
[37] https://www.acatech.de/publikation/circular-economy-roadmap-fuer-deutschland/download-pdf?lang=en
[38] https://www.acatech.de/wp-content/uploads/2019/07/Circular_Economy_EN.pdf
[39] https://www.bmuv.de/en/topics/water-resources-waste/circular-economy/types-of-waste-waste-flows/end-of-life-vehicles/legislation-in-germany-end-of-life-vehicle-ordinance
[40] https://www.bmuv.de/en/topics/water-resources-waste/circular-economy/statistics-on-the-different-areas-of-waste-management/statistics-on-end-of-life-vehicles
[41] https://www.din.de/de/forschung-und-innovation/themen/circular-economy/normungsroadmap-circular-economy
[42] https://catena-x.net/de/

Netherlands

With the first Circular Economy Program in 2016[43] and the formation of the Dutch Climate Agreement in 2019, the Netherlands started its economy wide sustainable transition. The government's goals were 50% less materials use in 2030 (Circularity Program, 2016) and 49% reduction of greenhouse gasses in 2030 (Climate Agreement, 2019[44]). There has not been much attention for light-weight materials in mobility within these policy frameworks.

Regarding the climate goals and policies, lightweighting is not seen as an important option in reducing fuel consumption i.e. reducing emissions. The Dutch climate policy focusses its attention mainly on zero-emission energy carriers such as electricity and green hydrogen. In that area, the importance of lightweighting is in reducing the overall weight of the vehicle weight in compensation for the weight of the battery pack and alternative drivetrain. In that way it enables alternative drivetrains to adhere to existing regulations (specifically surrounding road safety) that do not take battery weight into account. This is necessary with regards to light weight commercial vehicles such as delivery busses and taxi busses to stay within defined limits of different regulations such as the weight standards in the EU driver license directive and to prevent being taxed as a heavy weight vehicle under taxation schemes such as the new truck tax. Of course, improved performance and material saving independent of government policy are also part of the rational.

Regarding the circular economy, the Dutch government is working with other public authorities, knowledge institutions and environmental organizations, industry, trade unions, financial institutions and other civil-society organizations to find smarter and more efficient ways of using raw materials. The government has set out three goals aimed at making the Dutch economy circular as quickly as possible:

1. Ensure production processes use raw materials more efficiently, so that fewer are needed.
2. When new raw materials are needed, use sustainably produced renewable (inexhaustible) and widely available raw materials, like biomass – raw material made of plants, trees and food waste. This will make the Netherlands less dependent on fossil fuel resources, and it is better for the environment.
3. Develop new production methods and design new products to be circular.

The ambition is for the Dutch economy to be completely circular by 2050. The last update of the circular economy program is the 2021-2023 plan.[45] There have been some tangible results – one is the province-by-province map of circular economy plans, in which the Dutch provinces present their goals for achieving a circular economy. Enabling transition flows to cross provincial and international borders is of ongoing importance, and will require collaboration on implementation, legislation and further development of circularity.

Another example is the CIRCO program, which encourages circular design by companies and designers of products and services. As of mid-2021, a thousand companies had attended a Circular Business Design Track, in which they received help in developing a circular business proposition for their product, equipment, structure or service.

The current program addresses a set of themes:

[43] https://www.government.nl/topics/circular-economy/circular-dutch-economy-by-2050#:~:text=The%20Netherlands%20aims%20to%20have,and%20raw%20materials%20are%20reused
[44] https://www.government.nl/documents/reports/2019/06/28/climate-agreement
[45] Updated Circular Economy Implementation Programme 2021-2023 (Summary) | Report | Government.nl

- Circular strategies, such as reuse, circular design, sharing, lending and repair. There is a specific focus on **front end of the supply chain** enablers;
- **Consumer conscience** and campaigns with public-private partnerships;
- Taking away **financial barriers** by promoting new business models, public and private financing and legislation on products and their use. Together with Invest-NL and the financial sector, efforts are being made as part of the Dutch central bank DNB's Sustainable Finance Platform to create a level playing field for circular initiatives;
- "Impact through a focus on **raw materials flows**", meaning examining the raw material flows with the greatest impact on climate, biodiversity, pollution and security of supply. The government is now making studies of the resource flows;
- "**product group level management**" often give parties in the chain a better idea of what they can do to adjust raw materials consumption or reduce environmental impacts. A joint process has now been initiated of setting specific targets for each project group and drafting implementation plans.

The current coalition has set out to create new policy and regulations around the circular economy (see next subsections).

Existing Subsidies and Incentives; Innovation Instruments related to Sustainable Lightweighting

There are various general innovation instruments in the Netherlands, none is specifically designed for lightweight materials. The innovation landscape in the Netherlands is very much fragmented. There are many instruments for various stages of the product development lifecycle and there is a one-stop shop for application to all these instruments. However, there is little integrated coordination and reviews of the entire landscape of innovation programs and subsidy schemes. Various programs exist in parallel with different goals, scopes and sizes, application requirements and means of financing. This section will discuss instruments with sectoral and cross-sectoral scope, instruments for large companies and instruments for SME's.

There is for example a R&D instrument for mobility in which cross-sectoral projects (between road mobility, shipping and aviation) are financed. Whilst an innovation project around light-weight materials could be a project within its scope, there are currently no such projects.[46,47]

Another important cross-sectoral innovation instrument is the National Growth Fund, through which, between 2021 and 2025, the government will invest €20 billion in projects that ensure long-term economic growth.[48] Successful applicants for this fund are broad sectoral initiatives that often span the complete supply chain. Ones of those initiatives is called Duurzame MaterialenNL (Sustainable MaterialsNL) which focusses on reducing material waste. The initiative focusses on scaling lab technologies with a package of €200 million for a consortium of 300 collaborating parties from business and knowledge institutes. Their proposal is focused on polymer-based materials which are also relevant to the mobility sector.

The government wants to further strengthen Dutch innovative top sectors, their innovation ecosystems and their international position. The government, private sector, universities and research centers are working together in the Top Sector Alliance for Knowledge and Innovation (TKI) to make top sectors even stronger. Participants in this program are mainly large companies. The Netherlands has nine top sectors amongst which "Chemicals", "Logistics" and "Energy". The alliance looks for ways to

[46] Phone call with Jan Bessembinders, Beleidssecretaris Milieu en Circulaire Economie VNO-NCW. Phoned at June 9 2022
[47] https://open.overheid.nl/repository/ronl-31cf2737-a99a-407b-89ea-8136ed2fa3ec/1/pdf/kabinetsreactie-op-de-pbl-integrale-circulaire-economie-rapportage.pdf
[48] https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2022/05/17/bijlage-1-ienw-beleidsprogramma-2022/bijlage-1-ienw-beleidsprogramma-2022.pdf

get innovative products or services onto the market. There are various initiatives within this framework, amongst which:

- National science agenda: The Ministry of Economic Affairs and Climate Policy's National Science Agenda identifies focus themes for scientific research in the years ahead. It looks at questions like: What areas hold promise for the Dutch science sector? How can science help find solutions to social issues? How can science create economic opportunities for innovation?
- Innovation Attaché Network: Innovation attachés are based at Dutch embassies and consulates. They assist Dutch companies doing business abroad. For instance, by introducing them to potential partners, like research institutions or other companies.
- The Smart Industry initiative (in Dutch): aims to strengthen Dutch industries by promoting the use of cutting-edge IT and technology, like 3D printing, nanotechnology and robots.

Whereas the TKI's are directed at large companies, the Innovative Future Fund is another government initiative for SME's. Through its Future Fund the government is making additional money available for innovative SMEs and vital research for the future. From 2018 the fund will make €5 million available annually. Its initial capital will be €200 million.

There is also a tax credit for research and development (the WBSO). You may apply for the WBSO R&D tax credit for R&D activities. The WBSO R&D tax credit offers support for 2 different types of projects:

- Development project: This category covers the development of technically new physical products, physical production processes or software (or parts thereof).
- Technical-scientific research: This category covers explanatory research of a technical nature.

For startups there is also a customary salary scheme and the share option program within the WBSO.

Relevant Directives, Regulations and Policy Priorities in relation to Sustainable Lightweighting

There are no national directives, regulations or policy priorities for light-weight materials, though there has been some government interest in circularity, as mentioned before. Circularity for the economy as a whole (rather than targeted at mobility specifically) is in fact a broad policy ambition since the first circularity program in 2016.[49] In general, the Dutch government has more attention for recyclability of materials, than for their weight.

Circular economy policies until now have largely focused on bringing parties (in business) together through voluntary cooperation agreements and non-binding targets regarding circularity and resource efficiency.[50] There are two main examples within the mobility sector:

- Auto Recycling Nederland (ARN) brings together around 300 Dutch market parties to collaborate on recycling of cars and their batteries.
- Scooter Recycling Nederland (SRN) cares for the recycling of scooters.

The Netherlands Environmental Assessment Agency (PBL)'s first Integral Circular Economy Report (ICER), a Public Value Review, the recommendations of the Circular Economy Refection Group and the "red threads" paper of the Circular Economy Accelerator all show that the foundation has been laid for the transition to a circular economy. The next phase will require a sharper vision, an enhanced policy focus, more binding measures and a clearer division of roles. This will make it possible to reverse the trends in raw materials use, reduce environmental impact and ensure raw materials supply security.

[49] https://open.overheid.nl/repository/ronl-557dba19-8ad2-4f20-8ce9-6f0a973b90e9/1/pdf/concretisering-doelen-circulaire-economie.pdf
[50] https://open.overheid.nl/repository/ronl-557dba19-8ad2-4f20-8ce9-6f0a973b90e9/1/pdf/concretisering-doelen-circulaire-economie.pdf

We expect that the coming years will lead to more policies and regulations being implemented by the Dutch government around circularity of materials. The current government wants to act on the recommendations of the PBL and other knowledge institutes. By striving for clearer goals and responsibilities, regulation and pricing, market development, knowledge and innovation, the government seeks to promote a circular economy. One of the more important initiatives is a possible tax on polymer plastics.

Belgium

The complex structure of the Belgian political landscape leads to the separation of initiatives, subsidy rules, regulations, etc. at the regional levels: Flanders, Wallonia and Brussels capital Region. There are only few incentives that are organized at a federal level. Belgium's Federal Institute for Sustainable Development is nevertheless actively working on integrating the circular economy principles into public procurement.[51] On a federal level, it is also worth mentioning that an investment deduction exists for SME's to make productive investments.[52] The investment deduction reduces the amount on which tax must be paid. The amount of the deduction is determined by the percentage of the investment, and can range between 8 and 25%. Two large pillars in this program are investments that tackle energy efficiency and environmentally friendly investments for research and development.

Existing Subsidies and Incentives; Innovation Instruments related to Sustainable Lightweighting

Although some of the below mentioned funding programs do not explicitly mention the application of lightweighting, it is a strong bonus when applications refer to the beneficial impact they can make resource efficiency, CO_2 reduction and circularity aspects overall.

The *transregional* funding scheme BEL-COO[53] is targeted at interregional technological development projects between SMEs and LE's in Flanders, Wallonia, and Brussels. The scope of the research is broad, provided that the partners can show the clear economical value, positive impact on the respective region, and valorization of the results. Additionally, companies should show that the research activities are of high technical risk and are necessary for the project's success. Maximum amount of funding is limited to 500k€ for both Wallonia and Flanders.

In *Flanders* subsidies are organized and allocated by VLAIO[54] (Flanders Innovation & Entrepreneurship). Several subsidy schemes exist for Flemish organizations, and most of them are generally applicable (not focused on lightweight solutions only). The most important and interesting ones for SME's are:

COOCK (Collective R&D and Collective Dissemination of Knowledge): Companies are increasingly challenged to quickly respond to economic and societal challenges, but many do not have sufficient own resources or research capacity for doing so. For them, collective knowledge acquisition and transfer is an important tool for innovation. Offering new technology and knowledge helps Flemish companies which are not actively engaged in research themselves to innovate and implement research results. COOCK projects aim to valorize research results by accelerating the introduction of technology and knowledge to a broad group of companies. Projects can be submitted within the framework of the annual COOCK call, the calls of the Flemish cluster policy or of a CORNET call.

Development projects: With the Development Project subsidy, Flanders Innovation & Entrepreneurship aims to support enterprises in developing these new/innovative products, services, etc. As Flanders Innovation & Entrepreneurship grants this subsidy with the intention of promoting economic growth, it is important that enterprises can prove the potential and the importance of their projects in the short term. Only development projects that deviate from the day-to-day business of an enterprise and that help acquire novel knowledge and insights for a certain industry will qualify for this subsidy. In addition, entrepreneurs should be able to describe the possible challenges of the development process and the ways in which they aim to tackle these, as well as being able to substantiate, which resources they will need and the ultimate outcome and effects they expect the project to have (both on the Flemish economic system and in their company).

[51] https://ec.europa.eu/environment/ecoap/sites/default/files/field/field-country-files/eio_country_profile_2018-2019_belgium.pdf
[52] https://finance.belgium.be/en/enterprises/corporation-tax/tax-benefits/investment-deduction#q8
[53] https://www.vlaio.be/nl/subsidies-financiering/ontwikkelingsproject/wat-is-een-ontwikkelingsproject/bel-coo
[54] www.vlaio.be

ICON (Interdisciplinary Cooperative Research): This is a type of project in which an ad hoc and balanced consortium of one or more research organizations and at least three mutually independent Flemish companies develop new knowledge that can be applied practically and thus contributes to economic and possibly broader social added value in Flanders. The Flemish industrial partners can call on the support of VLAIO (Agentschap Innoveren & Ondernemen).

Two new formulas were created by VLAIO, with a high focus on **circular economy and sustainable innovations**, "living labs circular economy" and "circular manufacturing industry: life cycle extension".

Living labs[55]: Through this call, broad and diverse partnerships can apply for the subsidy of a living labs project on circular system solutions in the construction or manufacturing industry. Through multi-stakeholder and multi-level collaborations, the project ensures the elaboration, testing, implementation and scaling up of circular solutions. The partnership consists of at least three partners, at least one of which is a company, and may also include knowledge institutions, governments, non-profit organizations and sector federations. The project should contribute to the Flemish ambition to evolve towards a circular economy. In the Flemish Energy and Climate Plan, it is envisaged to reduce our material footprint by 2030 with 30%, as well as to drastically decrease our greenhouse gas emissions by 2030. Projects can receive between 300k€ and 1M€.

Circular manufacturing industry: life cycle extension[56]: Through this call, broad and diverse partnerships can apply for the subsidy of a pilot project on life extension in the manufacturing industry. The partnership consists of at least one company (preferably a SME) and may also include knowledge institutions, governments, non-profit organizations and sector federations. Similar to the former call, the project should contribute to the Flemish ambition to evolve towards a circular economy. This kind of projects are highly focused on dissemination and can receive a maximum of 100k€ subsidy.

In *Wallonia* there are further funding programs that are listed below.

Cheques Technologiques: this funding program is specifically made for SME's. SME's implemented in Wallonia have the possibility to explore new technologies, to have the guidance of research institutes, to realize feasibility studies or prototypes, to validate a new process, a new product or a service by tests and analysis. The companies can receive 45k€ per 3 years.

Projet Pôle: companies implemented in Wallonia have the possibility to explore new technologies, to have the guidance of research institutes, to realize feasibility studies or prototypes, to validate a new process, a new product or a service by tests and analysis. It is about the acquisition, combination, shaping and use of existing scientific, technological, business and other knowledge and techniques to produce designs, devices or drawings for the development of new, modified or improved products, processes or services. Projects may last for 3 years and can receive a maximum funding of 4M€.

Relevant Directives, Regulations and Policy Priorities in relation to Sustainable Lightweighting

Below information is based on a report by the Eco-Innovation Observatory[57].

Innovation research: The Flemish government has initiated the Green Deal instrument[58], a voluntary agreement between partners and the Flemish Government to pursue specific environment related goals, making use of the dynamics, creativity and knowledge of the different partners.

Circular Flanders is the hub of the Flemish circular economy. It is a partnership of governments, companies, civil society, and the knowledge community that will act together. The Government of Flanders has set the circular economy as one of the seven transition priorities and appointed the OVAM (the

[55] https://www.vlaio.be/nl/subsidies-financiering/living-labs-circulaire-economie
[56] https://www.vlaio.be/nl/subsidies-financiering/circulaire-maakindustrie-levensduurverlenging
[57] https://ec.europa.eu/environment/ecoap/sites/default/files/field/field-country-files/eio_country_profile_2018-2019_belgium.pdf
[58] www.greendeals.be

Public Waste Agency of Flanders) as the initiator of Circular Flanders. It has launched yearly 5 million euro calls for innovative projects during the last years. **Speerpuntclusters** are demand driven innovation clusters pursuing a few big initiatives with a budget of up to 500,000 €/year. They strive to help with some of the big challenges in the field of eco-innovation on energy and sustainable chemistry. In addition, they tackle issues regarding the eco-innovation of materials, logistics and food, namely Catalisti[59] and Flux 50[60], but also VIL[61] (logistics) and Flanders Food.

Plastics: In 2018, the plastics industry in Flanders invested 1.5M € million in the construction of a modern machine park at the T2 campus in Genk, Flanders. At this training centre, called Training Lab Kunststoffen, around 1,000 professionals and students are trained in plastics processing every year.[62] The Training Lab Kunststoffen is one of the most well-equipped plastics training centres in the Benelux. The machine park hosts 500 square meters of high-tech training infrastructure and state-of-the-art equipment and installations for plastics processing. At the lab, plastics processing companies and machine builders collaborate to ensure that over 1,000 professionals and students per year can work with the latest equipment in a realistic setting and under the guidance of experienced instructors. The Training Lab Kunststoffen is an initiative of Flanders' chemical sector federation essenscia vlaanderen, alongside sectoral training organizations PlastIQ and Co-valent, 10 machine constructors, the city of Genk, the regional technological centers of both Antwerp and Limburg, Flanders' service for employment and vocational education (VDAB) and practical training provider Syntra Limburg.

Innovation and research in circular economy: Various industrial and applied research programs support eco-innovative projects. The 2019 Win2Wal Program (Win-Win Wallonia)[63] aims to stimulate strategic research carried out within universities, higher education institutions or their associated research centers, upstream of projects identified by Walloon companies. In this context, "Strategic Research" is defined as any research project applied downstream of basic research, in one of the areas identified in the Smart Specialization adopted by Wallonia, including the circular economy (ecosystem, recycling, recovery of by-products), the industry of the future (machine learning, advanced manufacturing, biotechnologies, etc.), new materials (new metal alloys, composites, advanced materials, etc.), nutrition, connected objects (e-health, construction 4.0, smart cities, etc.), digital technologies (big data, blockchain, IA). The budget per call is 10 million €, the grant from the university or the research center is 100%, plus a part of the partner company.

The WALInnov program[64] supports research projects with a high scientific and technological potential oriented towards the needs of one or more companies. The projects are in the fields of chemistry and materials, health, mechanics and engineering and information and communication technologies, or in the fields covered by the six clusters (aerospace, agribusiness, life sciences, mechanical engineering, logistics and green chemistry) or the transversal axes of the Marshall Plan 4.0 (relating to digital, circular economy and creativity). The program promotes the market uptake of clean technologies and products or services that reduce environmental risks and minimize pollution and the use of resources and energy (and in that sense lightweight solutions).

Innovation research and education: The "Cellule éco-conception"[65] is an association representing SMEs and Self-Employed individuals. It was funded by the Brussels Region to raise awareness and coach Brussels small businesses who want to innovate with their business models using ecodesign or product-service system (functional economy) approaches.

[59] www.catalisti.be
[60] www.flux50.com
[61] https://vil.be/
[62] https://www.flandersinvestmentandtrade.com/invest/en/news/new-plastics-training-center-opens-in-genk-flanders
[63] https://www.polemecatech.be/fr/news/programme-win2wal-win-win-wallonia-appel-2019/
[64] https://www.unamur.be/recherche/services-adre/financements/region-wallonne/walinnov
[65] https://www.ucm.be/Environnement/Accompagnements/Eco-conception

France

The existing funding instruments as well as relevant regulations and policy priorities in France are described in the following two sub-sections.

Existing Subsidies and Incentives; Innovation Instruments related to Sustainable Lightweighting

In France, there are a large number of calls for projects to finance innovation. These calls for projects are sometimes very specific and target a market, a sector, a material, a concept, but they can also be less specific and open to different types of markets. It should be noted that the French territory is divided into regions which themselves have funds dedicated to innovation. They can therefore also propose calls for regional projects (they will not be presented here). Finally, there are also advantages for individuals so that they acquire the latest generation equipment (especially automotive) that is more respectful of the environment. Table 2 presents all of these calls for projects according to different criteria.

Table 2: Overview of relevant funding instruments in France

Funder	Open call / Date	Sector	Topics	Budget	Specifications
French State	Plan de relance (2020-2022)	Automotive	Investment	600 M€	Link
French State	Plan de relance (2020-2022)	Aviation	Investment	300 M€	Link
ADEME (National Agency for Ecological Transition)	Orplast (open)	Not specific	Polymer recycling (plastics and elastomers)		Link
ADEME	Hydrogen Strategy (until 2030)	Transports	Several open calls: Technological brick[66], expansion of the sector, search for new engines and fuels, storage	9 Md€	Link
French State	Decree 2022-615 du 22/04/2022[67]	Automotive	Investment, CO_2 emission < 50 g/km	Only ZCR	Link
French State	Plan de relance (2020)	Automotive	Investment	180 M€	Plan de relance p.93
French State	Conversion and ecological bonus (open)	Automotive	Investment	-	Link
French State	Electric bollard installation (open)	Automotive	Investment	-	Link
Companies (by french law)	Public transport subscritpion	Transport	Reduction of CO_2 emission	-	Link
ADEME	i-Nov open call 9th edition (03/2022) Waiting 10th edition	Transport	Renewable energies, storage and energetic system like hydrogen; sustainable, smart mobility	1 M€ à 5 M€	Link
French State / National Agency for Public Research	Generic open call	Transport, materials, energy	All scientific subjects, low TRL		Link
French State and French Region	PIA 4 régionalisé: Innovation project	Transport, materials, energy	All scientific subjects; Circular economy		
ADEME	PIA 4 : Recycling (2022-2023)	Not specific	Recyclability, recycling and incorporation of recycled materials[68]		Link
France (French Innovation Bank)	Diversification projects of subcontractors in automotive (09/2022)	Automotive	Hydrogen, electrical engines, new materials; diversification of skills for another market	-	Link
France 2030[69]		Not specific	Lots of axes (see link)		Link
BPI France	AAP CORAM[70] (18/11/2022)	Automotive	Electrical/hydrogen vehicles; innovative materials, assembly, CE, reduction of CO_2 emission	-	Link

[66] https://agirpourlatransition.ademe.fr/entreprises/aides-financieres/20201013/inodemo-h22020-176
[67] https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000045640111
[68] https://www.ecologie.gouv.fr/intervention-barbara-pompili-presentation-strategie-pia-4-recyclabilite-recyclage-et-incorporation
[69] https://www.iea.org/countries/france and https://www.gouvernement.fr/france-2030
[70] https://www.bpifrance.fr/nos-appels-a-projets-concours/appel-a-projets-coram-2022

Relevant Directives, Regulations and Policy Priorities in relation to Sustainable Lightweighting

Relevant directives, regulations and policy priorities are described below on a sector-specific basis: firstly, for the automotive sector and secondly, for the aviation sector.

In terms of regulations for manufacturers, France applies European texts, in particular the CAFE, Corporate Average Fuel Economy, concerning CO_2 emissions. Since 2020, regulations require all AUTO manufacturers to produce new vehicles emitting less than 120 g/km of CO_2 under pain of penalties. The Green Deal (Fit for 55) adds restrictions and requires that from 2035, only vehicles with none CO_2 emissions be produced and sold in order to achieve carbon neutrality by 2050, see also *The Paris Agreements, COP21*. This therefore means banning the sale of new internal combustion vehicles in Europe from 2035. Large groups are targeted from 2022, while SMEs and ETIs will be affected by this text in 2026. This involves declaring the turnover relating to green activities. The two main axes are CO_2 emissions and recyclability. The greater the share of activity linked to respect for the environment, the more banks will be likely to lend to companies. In summary, more generally France applies European terms and regulations.

Nevertheless, France has implemented a sticker allowing each car to be categorized according to the pollution it generates. This sticker is mandatory in urban areas. In this way, large cities are establishing Low Emission Zones (urban tolls in other large European cities) and regulating the types of car that can circulate according to the sticker.[71]

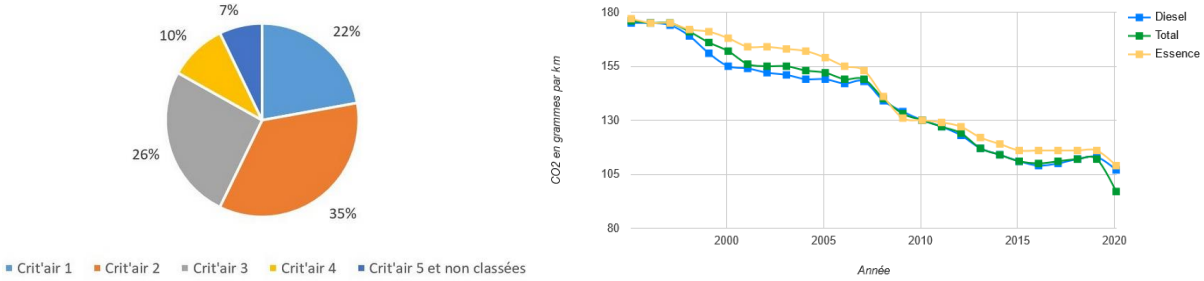

Figure 3. Distribution, on 1st January 2020, of the car fleet according the Crit'air vignette related to the engine pollution[72] (left) and Evolution of the average rate of CO_2 emissions in France about new private vehicule sold in France (right)[73]

Figure 3 (left) shows that the French vehicle fleet is made up of more than a third of Crit'air 2 vehicles and more than 50% of Crit'air 1 and 2 vehicles. France is also implementing an ecological transition policy to reduce emissions from internal combustion engines and encourage the purchase of light electric vehicles. In Figure 3 (left and right) the trend towards reducing emissions is represented. Thanks to this policy, in 2019 the cumulative sales of electric and plug-in hybrid vehicles increased by 38% compared to 2018. The graph below shows the share of new vehicles sold according to their engine in 2020 compared to 2019.

Figure 4 shows the reduction in the ratio of internal combustion engines, whether petrol or diesel. A comparison between 2019 and 2020 shows an increase in the share of electric and hybrid motors. In addition to this, with the aim of controlling pollutant emissions including NO_x (< 80 mg.km^{-1}), particles by mass and number, unburned hydrocarbons and carbon monoxide, France implemented in 2016 an independent commission to analyze the results and issue recommendations.[74] Note that motorized vehicles in France are subject to regular technical inspection. The first takes place 4 years after the purchase of a new vehicle, then the other checks take place every 2 years. Pollutant emissions in particular are checked in order to identify vehicles that are not in compliance with the legislation.[75]

[71] https://www.ecologie.gouv.fr/certificats-qualite-lair-critair
[72] https://www.statistiques.developpement-durable.gouv.fr/382-millions-de-voitures-en-circulation-en-france?rubrique=58&dossier=1347
[73] https://carlabelling.ademe.fr/chiffrescles/r/evolutionTauxCo2
[74] https://www.ecologie.gouv.fr/controle-des-emissions-polluants
[75] https://www.ecologie.gouv.fr/controle-technique-des-vehicules

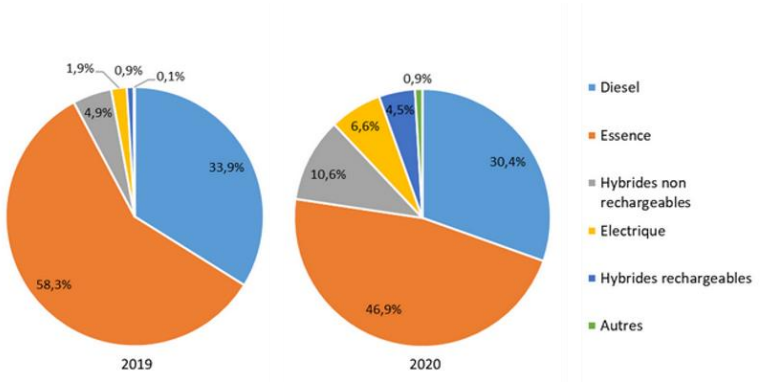

Figure 4. Motorization of new vehicles sold in 2019 and 2020[76]

In terms of **circular economy**, the European Taxonomy shows in particular restrictions on basic plastic materials.[77] In France, the AGEC law which initially aimed to put an end to single packaging (especially plastic) will be extended to different sectors such as transport. Indeed, decree no. 2022-474 of April 4, 2022[78] provides for the obligation for delivery platforms with more than 50 workers to respect a minimum share, which increases over time, of very low-emission two- or three-wheel vehicles, bicycles and electrically assisted bicycles. The objective is to reach 100% of very low-emission vehicles by 2030. For the linking, from July 2023 and until the end of 2024, the share of bicycles, electrically assisted bicycles, and vehicles very low-emission two- or three-wheel motor vehicles will have to achieve at least 20%. This transition continues over the following years: 50% from 2025, 80% from 2027 and 100% from 2030.

In 2016, CO_2 emissions relating to **air transport** accounted for 2% of global emissions. Although this proportion is low compared to other sectors, the sector has demonstrated its desire to reduce its emissions for more than 50 years.

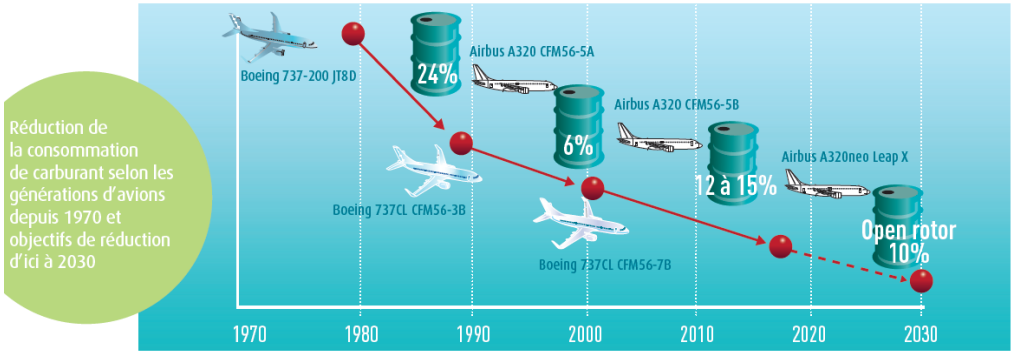

Figure 5: Evolution of the fuel reduction since 1970 for Boeing and Airbus and objectives to 2030[79]

The European Commission also hopes to support the development and the increased use of sustainable fuels in aviation. The "ReFuelEU Aviation" regulation aims to force fuel suppliers to increase the share of low-carbon fuels when refueling aircraft at airports in European Union countries.[80]

Regarding the aeronautical component in France, President Macron announced in the major France 2030 plan that he wanted France to be the first country to develop a low-carbon aircraft by 2030. An envelope of €1.2 billion will be allocated to carry out this global project.[81] Calls for projects will be published over time by 2030.

[76] https://www.statistiques.developpement-durable.gouv.fr/essor-des-ventes-de-voitures-neuves-motorisations-alternatives-en-2020
[77] https://eur-lex.europa.eu/legal-content/FR/TXT/HTML/?uri=CELEX:32021R2139&from=EN#d1e32-12-1
[78] https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000045470632
[79] Ministère de la Transition écologique et solidaire (2018): Direction Générale de lÁviation civile – Aviation & Changement Climatique
[80] https://www.touteleurope.eu/environnement/pacte-vert-europeen-les-12-mesures-proposees-par-la-commission-pour-une-reduction-des-emissions-carbone/
[81] https://www.gouvernement.fr/france-2030-le-gouvernement-detaille-le-volet-aeronautique-du-plan

Italy

Today the major pillar for Italian growth and development is represented by The National Recovery and Resilience Plan (*Piano Nazionale di Ripresa e Resilienza*, PNNR). This plan is part of the Next Generation EU, the recovery fund for the COVID-19 pandemic covering the period until 2026. The Plan is developed around three strategic axes shared at a European level: digitization and innovation, ecological transition, and social inclusion. It is an intervention, also aligned to the EU Green Deal, that aims at repairing the economic and social damage caused by the pandemic crisis, contributing to addressing the structural weaknesses of the Italian economy, and leading the country along a path of ecological and environmental transition.

Existing Subsidies and Incentives; Innovation Instruments related to Sustainable Lightweighting

The **National Recovery and Resilience Plan**, definitively approved on July 13 2021, includes a package of investments and reforms divided into six missions, managed by different ministries. This plan is planned for the 2021-2026 timeframe, includes 134 investments (235 if sub-investments are counted) and 63 reforms, totaling 191.5 billion euros from the Next Generation EU fund.

The *PNRR* proposal focuses on the three axes of intervention shared at the European level: digitization and innovation, ecological transition and social inclusion. The National Recovery and Resilience Plan (PNRR), under "Mission 2: Green Revolution and Ecological Transition," (managed by The Minister for Ecological Transition) includes the component (M2C2), "Renewable Energy, Hydrogen, Grid and Sustainable Mobility," with resources of 23.78 billion euros. This component is in turn divided into five areas of intervention, including: *Domain 4*, on the development of more sustainable local transport, which carries a total expenditure forecast of 8,580 million euros; and *Domain 3*, relating to experimentation with hydrogen for road and rail transport and investment in electric buses, with a projected expenditure of €830 million.

The proposed *Plan for Ecological Transition* (PTE) has been submitted to Parliament and is under consideration by the VIII Environment Commission (AG 297), which gave its opinion on December 15 2021. The Plan outlines the main objectives of Italy's environmental policies, also in order to provide a conceptual framework to accompany PNRR interventions. Sustainable mobility is included among the eight areas of intervention in the ETP, as a significant part of the actions aimed at decarbonization concerns the transport sector: greater use of rail traffic, the use of lower-impact fuels and, starting in 2030, that at least 50 percent of motorizations be electric in order to hit the full decarbonization target.

The decree of the Ministry of Economic Development aims to incentivize with 300 million euros from the PNRR the development in Italy of an autonomous industrial supply chain in the bus sector, strengthening the competitiveness of companies in the production of electric vehicles and promoting investment in research and development of technologically innovative components to be used in the construction and assembly of modern, safe and environmentally sustainable road transport vehicles. A goal that is counted on to be achieved by supporting all players in the supply chain, from large manufacturers to small and medium-sized enterprises involved in components. Facilities will be granted to companies that submit investment programs aimed at creating innovative, high-tech products. From sensors to digital systems, including those integrated into individual vehicle components, for continuous monitoring and predictive maintenance, assisted driving, fleet management, transportation safety and bus-ground dialogue, as well as the development, standardization and industrialization of charging systems aimed at the production and deployment of electric buses.[82] This makes operational the intervention envisaged in the PNRR to support the green and digital transformation of the bus industry,

[82] https://www.mise.gov.it/index.php/it/198-notizie-stampa/2043340-pnrr-incentivi-per-produrre-autobus-elettrici-dal-26-aprile-le-domande

in accordance with the MIMS decree of November 29 2021. As part of the PNRR, the Ministry of Universities and Research has issued a call (Mission 4, Component 2, M4C2) for supply chain research measures that includes "proposals for action to strengthen research facilities and create "national champions" of research and development on certain key enabling technologies" and covers investments of 1.6 billion euros.

Through this call, the **MUR** is funding **five National Centers** which are aggregations of universities and EPRs, desirably organized as Foundations or Consortia, with the possible involvement of other public and private entities, engaged in research activities, highly qualified and internationally recognized, united by common strategic research objectives and interests, which relate to enabling technologies, coherent with the priorities of the PNRR and the European Union's Strategic Research Agenda. The five National Centers are dedicated to frontier research related to technological areas around these themes: Simulations, calculation and high-performance data analysis, Agriculture Technologies, Development of gene therapy and drugs with RNA technology, **Sustainable mobility** and Bio-diversity.

Specifically, the national center dedicated to **Sustainable Mobility**, conducts research and promotes national and international-level innovation on the set of models and technologies that contribute to transportation systems and infrastructure (land, water, and air, including autonomous) for people and goods, sustainable mobility, and decarbonization.[83] For example, the Center develops research and technologies for: electric-based mobility; manufacturing processes and sustainable lifecycle of accumulators and batteries; photovoltaics integrated into the vehicle or charging stations; energy and system efficiency; new materials, particularly lightweight materials; new propulsion and motion processing systems; sustainable reduction of dissipation in each component and all chemical-physical emissions (including submarine noise); autonomous vehicles, smart actuators, sensors and navigation control systems; artificial intelligence component and simulation models, etc. In addition, the Center develops and promotes research and innovation, including based on the latest developments in digital technologies, for new integrated and inclusive strategies and for mobility services in public, private and hybrid transportation. The Center contributes to achieving the climate-related goals of the NRP.

So, most of actual actions and policies to support Italian competitiveness derive or are linked to the plan including the National Research Program (*Programma Nazionale per la Ricerca*, PNR).[84] As is evident from the above, inside the Program there are two topics, Sustainable Mobility and Climatic Change Mitigation having the aim to promote green, and climate-neutral mobility in which lightweighing is one of the possible actions. Among the research priorities it is possible to found "lightweighting technologies for vehicles, trains and naval".

The National Research Program is in an initial phase of implementation and will operate through different instrument to support creation of new infrastructures, partnerships and research projects. On the main topics will be developed National Center of Competence where University and Industry could collaborate to develop the sector. Among the other one of the National Center of Competence will be devoted to Sustainable Mobility and will be the reference for lightweight and energy efficient transport means. According to the general principles and policies described above, in Italy the Regions elaborates specific Smart Specialization Strategy (S3) to valorize the territory and the competencies. For example, in Piedmont Region the specialization is on Aerospace and Mobility both of them having needs of innovative materials and strategies for lighweighting.

Relevant Directives, Regulations and Policy Priorities in relation to Sustainable Lightweighting

Relatively to the advanced materials and processes for different fields of application, Italian policies are aligned with the two EU pillars and objectives of decarbonization (Net Zero CO_2) and Circular

[83] https://www.mur.gov.it/it/news/giovedi-07102021/pnrr-le-linee-guida-iniziative-sistema-missione4-componente2
[84] https://www.mur.gov.it/sites/default/files/2021-08/4.AllegatoEsteso_Digitale.pdf

Economy within 2050. Although Italy has already demonstrated a commitment in decarbonization with a CO_2 reduction of 17% in the period from 1990 to 2018 (from 516 to 428 CO_2 eq. Mton), most of the actions were ad-dressed to agriculture and farming and less on energy and transport. So, it is expected for the next period a pushing in energy efficiency and CO_2 reduction of transport. Some sectors are completely change the approach compared to the recent past, for example the automotive industry, also driven by political policies, are rapidly moving towards fully electrified vehicles. The energy efficiency of the electrified vehicles will be a matter of competitiveness and lightweight approach will be pursued by the producers.

A Proposal for an EU Regulation to strengthen CO_2 emission performance standards for new passenger cars and new light commercial vehicles, in line with the Union's increased climate ambition (COM(2021)556), is under consideration by the IX and VIII committees in the ascending phase as part of the European "Fit for 55" strategy.

Budget Law 2022 (Law No. 234 of 2021, Art. 1, para. 392) established a Sustainable Mobility Strategy Fund for fighting climate change and reducing emissions for the implementation of the European "Fit for 55" strategy, with a total allocation of €2 billion. The subsequent Decree Law No. 4 of 2022 included the autonomous provinces of Trento and Bolzano among the beneficiaries of the fund.[85] *Decree Law No. 17 of 2022*, to promote the reconversion, research and development of the automotive sector establishes a fund at MISE with an allocation of 700 million euros for the year 2022 and 1,000 million euros for each of the years 2023 to 2030.

Legislative Decree No. 187 of Nov. 8 2021, implementing **Directive (EU) 2019/1161** on the promotion of clean and energy-efficient road transport vehicles (AG 278), which establishes measures to promote and stimulate the market for environmentally friendly and energy-efficient vehicles, as well as to enhance the transport sector's contribution to the environment, climate and energy policies of the European Union, was issued following the opinion given by the House Committees IX and VIII on Oct. 6 2021.

Among the regulatory interventions to encourage the development of clean, electric and hybrid road mobility are the so-called ecobonus subsidies, adopted since the Budget Law for 2019 (Law No. 145 of 2018, paragraph 1031): these are subsidies for the purchase of electric or hybrid vehicles, with or without scrapping a polluting vehicle, in the years 2019, 2020 and 2021.[86]

[85] https://www.comune.livorno.it/lavoro-sviluppo-economico/piano-nazionale-ripresa-resilienza-pnrr/pnrr-progetti-del-mise
[86] https://temi.camera.it/leg18/temi/l-innovazione-nel-trasporto-stradale-e-la-mobilit-sostenibile.html

Luxembourg

Luxembourg has the highest gross domestic product per head in the EU and the employment is increasing by 3.1% per year. The banking sector has the largest share with 25.7%. However, a special focus lies on the 40,000 SMEs with 250,000 employees, which is nearly half the residents of Luxembourg.[87] From an ecological view, Luxembourg is supporting many different ecological projects to reduces human influence on nature: Initiatives for avoiding pesticides[88] or projects to reduce the CO_2 footprint at local parties[89] show the high significance of sustainability in Luxembourg politics.

Existing Subsidies and Incentives; Innovation Instruments related to Sustainable Lightweighting

"The Luxembourg National Research Fund (NRF) is the main funder of research activities in Luxembourg."[90] The aim of the NRF is to provide a sustainable research system and to reach "scientific leadership in key areas"[91]. They offer the three key research funding programs CORE, OPEN and INTER. Further, the NRF offer researchers different possibilities for funding work under the ATTRACT, PEARL and KITS strategy[92]. Information about financial support different businesses is organized by the Ministry of Digitalization[93]. SMEs can offer project support, but they must applicate with extensive information documents regarding a description of the project, the location of the project and the total project costs.

The technical research work is conducted at the Luxembourg Institute of Science and Technology (LIST)[94]. They focus on Environmental Research & Innovation (ERIN), IT for Innovative Service (IT IS) and Materials Research and Technology. In the last area, Luxembourg invites researchers and SME to develop space and lightweight materials[95].

In 2020 Luxembourg organized the Lightweight Symposium 2020[96] with the aim of creating a network of lightweight experts in the disciplines of space industry, automotive industry, aviation industries and other industry from e. g. the mobility sector.

Relevant Directives, Regulations and Policy Priorities in relation to Sustainable Lightweighting

Important directives in Luxembourg for support and information can be found on the ministry's websites. Since the political structure is flat, the websites of the ministries contain deep information about support projects and news. Especially the Ministry of Digitalization and the Ministry of the Environment, Climate and Sustainable Development offer much information about scientific and invest programs.

The funding of Research Institutes is done by the NRF. The support of SMEs is conducted by Le Gouvernement Du Grand-Duché De Luxembourg[97], which offers great possibilities for SME to applicate for financial help. In case the application contains sustainable topics, the application has good chances for being granted, because the sustainability is on high focus at the Luxembourg 2030 agenda.[98]

[87] https://www.cc.lu/en/thematic-dossiers/luxembourg-economy
[88] http://www.ounipestiziden.lu/
[89] https://www.greenevents.lu/de/das-projekt/
[90] https://www.fnr.lu/what-we-do/
[91] https://www.fnr.lu/what-we-do/
[92] http://www.innovation.public.lu/en/financer/excellence-scientifique/recherche-publique/index.html
[93] https://guichet.public.lu/en/entreprises/financement-aides.html
[94] https://www.list.lu/
[95] https://www.researchluxembourg.org/en/defence-technologies-call-focusing-on-space-and-lightweight-materials/
[96] https://www.luxinnovation.lu/event/lightweight-symposium-2020/
[97] https://guichet.public.lu/fr.html
[98] https://bne.lu/tipps/

United Kingdom

After passing the Climate Change Act 2008, which committed the UK to a reduction of greenhouse gas emissions by 80%, in 2019 the Climate Change Act 2008 (2050 Target Amendment) Order 2019 was passed. Hereby the target of 80% reduction was adapted to 100%, meaning that the UK committed to a net zero by 2050.[99] The UK wants to take the lead to set an example for a global net zero and became the first major economy in 2019 to legislate a binding target to reach net zero by 2050.[100]

With a Ten Point Plan from 2020, covering for example clean energy, transport, nature and innovative technologies, the United Kingdom aims on becoming the home of the new Green Industrial Revolution to create and support 250,000 British jobs.[101]

In 2020 the Advanced Propulsion Centre (APC) developed an automotive technology roadmap in collaboration with the industry and was published by the UK Automotive Council to define critical targets and pathways to achieve more sustainable vehicles. By this the automotive sector should be supported to deliver new solutions and foster collaborative Research and Development opportunities.

Figure 6: Key technologies driving lightweighting opportunities for automotive applications[102]

Existing Subsidies and Incentives; Innovation Instruments related to Sustainable Lightweighting

The non-profit organization Advanced Propulsion Centre (APC) provides funding and support for projects to enable the development of new technologies that will help to achieve green transport.[103,104] For example with the Technology Developer Accelerator Programme (TDAC) the APC supports start-ups, spinouts as well as SMEs with up to £135,000 of a combined grant funding, business mentoring and technical support for companies developing technologies that support the development of zero-emission vehicles or net-zero carbon automotive products.[105] The APC claims to have funded 170 projects, supported 402 organizations and by that to have 288 million tons of CO_2 reduced.

The Centre for Research into Environmental Science and Technology (CREST) provides support for businesses based in and/or trading from Shropshire or Telford and Wrekin with fewer than 250 employees. Hereby the SMEs can receive for example specialized business innovation support, access to academic experts and state-of-the-art laboratories.[106]

[99] https://lordslibrary.parliament.uk/climate-change-targets-the-road-to-net-zero/
[100] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf
[101] https://www.gov.uk/government/news/pm-outlines-his-ten-point-plan-for-a-green-industrial-revolution-for-250000-jobs
[102] https://www.apcuk.co.uk/app/uploads/2021/09/https___www.apcuk_.co_.uk_app_uploads_2021_02_Exec-summary-Technology-Roadmap-Lightweight-Vehicle-final.pdf
[103] https://www.apcuk.co.uk/about/
[104] https://en.wikipedia.org/wiki/Advanced_Propulsion_Centre
[105] https://www.apcuk.co.uk/technology-developer-accelerator-programme/
[106] https://www.gov.uk/business-finance-support/centre-for-research-into-environmental-science-and-technology-crest-shropshire-and-telford-and-wrekin

Through Innovate UK, a part of UK Research and Innovation, business-led innovations in any part of the UK are supported. Therefore, Innovate UK provides a support in networking, helping with the access to expertise and equipment or with financial loans and grants.[107] Recently Innovate UK is offering small and micro businesses a share of a grant of up to £50,000 for innovations with a focus on net zero or self-driven health care.

Relevant Directives, Regulations and Policy Priorities in relation to Sustainable Lightweighting

In 2013 the Office for Low Emission Vehicles (OLEV) published a strategy for ultra-low emission vehicles in the UK.[108] With this strategy the Government aimed to inform on the reasons, as well as the opportunities and challenges that arise with the transformation of the vehicles. This publication included the progress up until 2013 as well as the strategic approach for the future and the government's commitments, e.g. the funding commitment for the time period from 2015 until 2020 of over £500 million.[109]

As already mentioned, the Climate Change Act 2008 with the adaptation of 2019 states the target of net UK carbon account for 2050 is 100% lower than the 1990 baseline. [110]

Until on December 31 2020 the transition period ended, the regulations for CO_2 emissions of vehicles had been set on a European-wide level. Afterwards these regulations were retained in the UK law. Only minor technical adjustments had been done. Accordingly, the fleet-wide average of CO_2 emissions target of 95 g CO_2/km for the new car fleet and the equivalent target of 147 g CO_2/km had been adopted. Since the testing procedure had been replaced, the targets had been converted to the new procedure. By 2025, both fleet-wide targets will need to be reduced by 15% compared to 2021 and by 2030 the new car fleet will require a reduction of 37.5% while new vans need to be reduced by 31% compared to 2021. [111] Additionally, the UK has committed to ending the sale of new petrol and diesel cars by 2030. On top of the, all new cars and vans need to be fully zero emission at the tailpipe by 2035.[112]

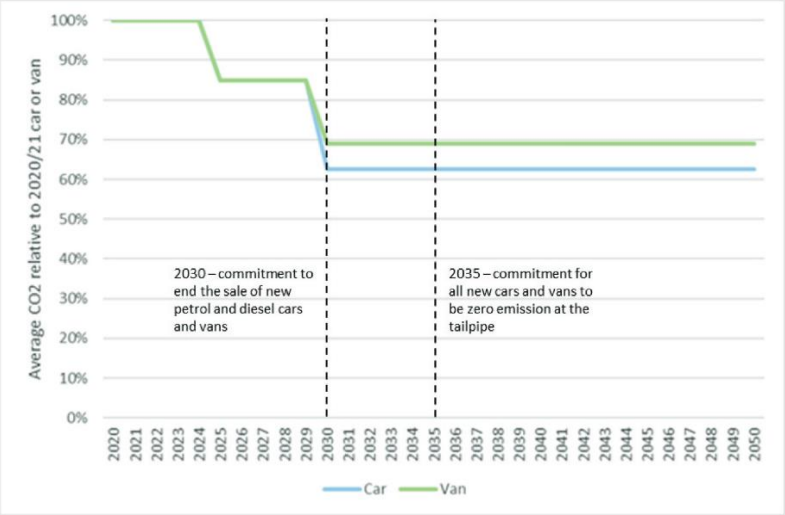

Figure 7: Average new car and van CO_2 targets in relation to the 2020 baseline[113]

[107] https://www.ukri.org/councils/innovate-uk/our-support-for-business-innovation/
[108] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/239317/ultra-low-emission-vehicle-strategy.pdf
[109] https://www.gov.uk/government/news/government-drives-forward-plug-in-car-revolution
[110] https://www.legislation.gov.uk/ukpga/2008/27/section/1
[111] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1007466/green-paper-on-a-new-road-vehicle-CO2-emissions-regulatory-framework-for-the-United-Kingdom-web-version.pdf
[112] https://www.gov.uk/government/consultations/consulting-on-ending-the-sale-of-new-petrol-diesel-and-hybrid-cars-and-vans/outcome/ending-the-sale-of-new-petrol-diesel-and-hybrid-cars-and-vans-government-response
[113] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1007466/green-paper-on-a-new-road-vehicle-CO2-emissions-regulatory-framework-for-the-United-Kingdom-web-version.pdf

Switzerland

Due to its geographical location, Switzerland is directly affected by the consequences of global warming, for example by melting glaciers. The government has therefore developed a comprehensive action plan to reduce greenhouse gas emissions in all sectors. Two-thirds of the total environmental impact arises in the areas of food and agriculture, housing and building as well as mobility (12%). To reduce the environmental footprint various measures for resource savings are summarized in a strategy paper, including activities in the context of eco-design in line with EU directives and promotion of projects in environmental technology and cleantech sector.[114] In Switzerland, the people have a right of co-determination in votes, initiatives and referendums, so this can prevent laws from coming into force. This is what happened with the CO_2 Act in 2021. Existing incentive and promotion programs as well as regulations in the context of lightweight construction are described below.

Existing Subsidies and Incentives; Innovation Instruments related to Sustainable Lightweighting

In Switzerland, funding programs are based on the federal law on a promotion of research and innovation (V-FIFG), requiring that thematic funding programs must serve a nationwide interest.[115]

The Solution-oriented research for development (SOR4D) program aims on several of the 17 Sustainable Development Goals of the United Nations and subsidizes projects that address climate change and its effects and managing natural resources sustainably. It has an overall budget of CHF 19.3 million is open for all disciplines and should encourage interdisciplinary collaboration.[116] To strengthen international cooperation with Sweden, there is the Swiss-Swedish Innovation Initiative (SWII) that funds projects for example in additive manufacturing, new material technologies or manufacturing processes.[117] Furthermore the Innosuisse – Swiss Innovation Agency initiated several funding programs to support different R&D activities also in the area of lightweight design and sustainability. These includes innovation projects in the areas of Energy & Environment and Engineering (Impulse Program Swiss Innovation Power)[118] as well as cross-border innovation projects such as the Eurostars that aims at strengthening the competitiveness of, in particular, SMEs by developing innovative products and services in cooperation with partners from 33 European countries or Canada, South Africa and South Korea.[119]

Unlike in the last years of Horizon 2020, Switzerland is currently not among the eligible countries in the Horizon Europe program. Swiss institution can participate in most applications for Horizon Europe, but do not receive any funding. Therefore, the Swiss State Secretariat for Education, Research and Innovation (SERI) provides 6.15 billion euros in national funding for the participation of institutions from Switzerland in Horizon Europe.[120] In addition to this, competitive project funding for start-ups and SMEs was established as a transitional measure for Horizon Europe, as these are also not eligible for funding from the European EIC Accelerator.[121]

Relevant Directives, Regulations and Policy Priorities in relation to Sustainable Lightweighting

In general, the regulations in Switzerland are based on those of the EC. The target values for reducing CO_2 emissions are defined in the Federal Act on the Reduction of CO_2 Emissions (CO_2 Act, 2011).[122]

[114] https://www.bafu.admin.ch/dam/bafu/de/dokumente/wirtschaft-konsum/fachinfo-daten/massnahmen-des-bundes-fuer-eine-ressourcenschonende-zukunftsfaehige-schweiz-gruene-wirtschaft.pdf.download.pdf/Bericht_DE_zu_BRA_2020-06-17.pdf
[115] https://www.fedlex.admin.ch/eli/cc/2013/814/de
[116] https://www.snf.ch/en/Fb19rz5iYXpbuPyy/funding/programme/sor4d-programme
[117] https://www.swii.org/index.php
[118] https://www.innosuisse.ch/inno/en/home/promotion-of-national-projects/innovation-projects/impulse-programme-innovation-switzerland.html
[119] https://www.innosuisse.ch/inno/en/home/promotion-of-international-projects/eureka.html
[120] https://www.nksgesundheit.de/de/Liste-der-Assoziierten-und-Drittstaaten-in-Horizont-Europa-veroeffentlicht-2468.html
[121] https://www.innosuisse.ch/inno/en/home/promotion-of-national-projects/swiss-accelerator.html
[122] https://fedlex.data.admin.ch/filestore/fedlex.data.admin.ch/eli/cc/2012/855/20210101/de/pdf-a/fedlex-data-admin-ch-eli-cc-2012-855-20210101-de-pdf-a.pdf

Across sectors, the targets are a 20% reduction in emissions by 2020 compared to 1990 levels, and a further 1.5% per year on average from 2021. The earnings from the CO_2 tax are allocated to the Technology Fund (up to a maximum of CHF 25 million per year) that is administered by the Federal Department of the Environment, Transport, Energy and Communications. The Confederation uses the resources from the Technology Fund to guarantee loans to companies if they use them to develop and market equipment and processes, inter alia, to reduce greenhouse gas emissions, to enable the use of renewable energies or to promote the careful use of natural resources. In 2021, with the approval of the Paris Agreement, a new regulation reduction targets were intended. The revised CO_2 Act aims to reinforce Switzerland's current climate policy and further reduce CO_2 emissions by 2030 through a combination of measures such as financial incentives, investments and new technologies as well as higher costs for producing large amounts of CO_2. The target of this Federal Act was a reduction of the greenhouse gas emissions by 50% in 2030 compared to the level of 1990.[123] However, the Swiss electorate voted on the Federal Act on the Reduction of Greenhouse Gas Emissions in June 2021. The result of the vote was against the Act with 51.6%.[124] The development of CO_2 emissions from new passenger cars is also not in line with the set limits and significantly exceeded the target value of 95 g CO_2/km in 2020 with 124 g CO_2/km.[125]

Table 3: Representation of the total annual reduction targets for the transport sector in Switzerland according to the Federal CO_2 Act (Swiss electorate voted against the federal act)[126]

Field of Action	Benchmark of CO_2 emissions	Reduction targets of CO_2 emissions		
		2021-2030	2030	2050
All sectors	Year 1990	Ø 35%/year	50%	climate neutral

In order to promote the topics of lightweight design and circular economy in Switzerland and to raise awareness of them, various initiatives and interest groups exist. One example is the Circular Economy Switzerland Charter initiative, which aims to establish topics such as durable and recyclable design, maintenance, repair, reuse, refurbishment, recycling and cascade use in industry.[127] Another initiative exists in Composites United Switzerland, which focuses on promoting the application of high-performance fiber composite technologies (composites) in Switzerland and gathers members along the entire value chain.[128]

[123] https://www.fedlex.admin.ch/eli/fga/2020/2013/de
[124] https://www.admin.ch/gov/en/start/documentation/votes/20210613/co2-act.html
[125] https://www.bafu.admin.ch/bafu/de/home/themen/thema-klima/klima--daten--indikatoren-und-karten/klima--indikatoren/indikator-kli-ma.pt.html/aHR0cHM6Ly93d3cuaW5kaWthdG9yZW4uYWRtaW4uY2gvUHVibG/ljL0FlbURldGFpbD9pbmQ9S0wwND-kmbG5nPWRlJlBhZ2U9aHR0/cHMlM2ElMmYlMmZ3d3cuYmFmdS5hZG1pbi5jaCUyZmJhZnUlMm/ZkZWZyaXRl-biUyZmhvbWUlMmZ0aGVtZW4lMmZ0aGVtYS10cmFl/Z2Vyc2VpdGUl-MmZ0cmFlZ2Vyc2Vpd-GUtLWRhdGVuLS1pbmRpa2/F0b3Jlbi11bmQta2FydGVuJTJmdHJhZWdlcnNlaXRlLS1pbmRp/a2F0b3JlbiUyZmluZGl-rYXRvci10cmFlZ2Vyc2VpdGUucHQuaH/RtbCZTdWJqPU4=.html/
[126] https://www.fedlex.admin.ch/eli/fga/2020/2013/de,https://www.admin.ch/gov/en/start/documentation/votes/20210613/co2-act.html
[127] https://circular-economy-switzerland.ch/wp-content/uploads/2020/05/CHARTA_Circular-Economy-Switzerland_DE.pdf
[128] https://composites-united.com/cluster/cu-switzerland/

Conclusion

The multinational level benchmark on environmental regulations shows that the different country-specific CO_2 emission targets – specific to the transport sector – in the NWE region are oriented on the EU Fit for 55 package and achieving net zero greenhouse gas emissions for EU countries by 2050. Germany and Switzerland are exceptions. Germany has the ambitious goal of being climate-neutral as early as 2045, whereas in Switzerland the new CO_2 Act was rejected in a referendum and the targets for maximum emissions from passenger cars, for example, have therefore not been achieved. However, there are also many directives at EU level that need to be improved or revised in the near future.

In addition to the regulations or directives relating to CO_2 emissions, many efforts and initiatives related to the Circular Economy Action Plan can be found across countries that are also aimed at increasing material and resource efficiency across sectors in the sense of a circular economy along the entire value chain. Examples include the Circular Cars Initiative, the introduction of the Digital Product Passport (e.g., for batteries) and efforts to establish new standards and norms like the Standardization Roadmap Circular Economy of DIN, DKE and VDI in Germany. It is expected that existing regulations would be expanded (such as Directive 2000/53/EC on End-of-Life Vehicles or Ecodesign Directive 2009/125/EG) as well as new regulations would be elaborated because the global carbon footprint of materials is mainly determined by extraction, production and processing. For this reason, lighweighting could be an effective lever for reducing material usage and also saving CO_2 emissions in the use phase, especially in the transport sector.

Table 4 provides an overview of selected European and national policy instruments. It includes both regulatory instruments, such as regulations and directives, and economic instruments that affects lightweighting, e.g. research funding programs.

The importance of circular economy and lightweighting with a life-cycle based perspective as a key driver for reducing greenhouse gas emissions and increasing material and thus resource efficiency have also been recognized by national governments. For this purpose, numerous national and European funding instruments or programs have been created to foster technological developments and to support an industrial (green) transformation within the area of sustainable lightweighting, for example, material substitution and development of novel materials, new technologies and strategies for recycling of material as well as product lifetime extension by new approaches for repair and reuse. However, no instances of policy were identified that directly address lightweighting in a holistic way and with a life-cycle perspective along the different cross-cutting areas (see Figure 1).

In the report of the International Resource Panel (IRP) "Resource Efficiency and Climate Change"[129] material efficiency strategies are presented for a low-carbon future that outline some of these approaches to reduce emissions through less material use and substitution of energy-intensive primary materials. Furthermore, the IRP requires a life-cycle based assessment of emission reduction strategies in order to could better consider synergies across different sectors and trade-offs (e.g. increased material-related emissions of specific lightweight materials). To this end, an identification of synergies and trade-offs between the different sectors and cross-cutting areas is required and needs to be focused in policy guidance. In order to identify interfaces and synergies between the various actors and disciplines and to achieve an effective reduce of greenhouse gas emissions, a cross-sector dialog of experts involved in the value chains is essential.

[129] https://www.resourcepanel.org/file/1966/download?token=dNgPqfZE

Table 4: List of exemplary directives and national funding instruments that directly affect lightweighting

Category	Name	Cross-Cutting Area			Sector[130]		Country								
		Material Extraction/ Development	Design, Manufacturing[131] and Assembly	Recycling	Automotive[132]	Aerospace[133]	European Union	Germany	Netherlands	Belgium	France	Italy	Luxembourg	United Kingdom	Switzerland
Directives/ Strategies	Circular Economy Action Plan	X	X	X	X		X								
	Regulation 2019/631 – CO_2 emission performance standards for cars and vans	X	X		X		X								
	Regulation EC 715/2007 on type approval and access to vehicle repair and maintenance information		X	X	X		X								
	Directive 2005/64/EC type approval for reusability, recyclability and recoverability		X	X	X		X								
	Directive 2000/53/EC on End-of-Life Vehicles			X	X		X								
	Ecodesign Directive 2009/125/EG		X	X			X								
	2010/75/EU Industrial Emissions Directive	X	X				X								
	Directive 2019/1161 on the promotion of clean & energy-efficient road transport vehicles		X				X								
	EU Emissions Trading System	X	X	X	X	X	X								
	EU taxonomy for sustainable activities[134]	X	X	X	X	X									
	Carbon Tax Germany	X	X	X	X			X							
	Circular Economy standardization roadmap	X	X	X	X	X		X							
	ISO/TC 323 Circular economy[135] (not active)			X			X								
	…														
Funding Instruments/Incentives	Horizon Europe[136]	X	X	X	X	X	X	X	X	X	X	X	X	(X)	(X)
	European Green Deal Investment Plan[137]														
	Technologietransfer-Programm Leichtbau	X	X	X	X			X							
	Konjunkturpaket (KoPa) 35c		X	X	X			X							
	Transformation-Hubs Automotive Industry, MobilKreis	(X)	X	X	X			X							
	Innovative Luftmobilität	(X)	X			X		X							
	3. Förderaufruf Luftfahrtforschungsprogramm	X	X	X		X		X							
	SOR4D	X	X	X	X	X									X
	SWII	X	X		X	X									X
	VLAIO	X	X	X	X	X				X					
	Projet Pôle		X		X	X				X					
	Orplast			X	X	X					X				
	ADEME			X	X	X					X				
	AAP CORAM	X	X		X						X				
	Duurzame MaterialenNL	X		X	X	X			X						
	The National Recovery and Resilience Plan	X	X	X	X	X						X			
	Programma Nazionale per la Ricerca, PNR	X	X	X	X							X			
	CORE, OPEN and INTER	X	X	X	X	X							X		
	CREST		X	X	X	X								X	
	…														

[130] For transport related taxonomies, see also: https://ec.europa.eu/sustainable-finance-taxonomy/activities/sector_en.htm?reference=6
[131] https://ec.europa.eu/sustainable-finance-taxonomy/activities/sector_en.htm?reference=3
[132] https://transport.ec.europa.eu/transport-modes/road_en
[133] https://transport.ec.europa.eu/transport-modes/air_en
[134] The Taxonomy Regulation establishes six environmental objectives: Climate change mitigation, Climate change adaptation, The sustainable use and protection of water and marine resources, The transition to a circular economy, Pollution prevention and control, The protection and restoration of biodiversity and ecosystems (https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en#regulation)
[135] https://www.iso.org/committee/7203984.html
[136] "The UK will participate in all parts of the Horizon Europe programme with the only exception of the EIC Fund (which is part of the EIC Accelerator of Horizon Europe that provides investment through equity or other repayable form)." https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/guidance/list-3rd-country-participation_horizon-euratom_en.pdf
[137] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_17