point of view | 01-2022

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THE DECARBONISATION OF MOBILITY

The levers Europe has at its disposal to reduce the gaps in climate target attainment

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The levers Europe has at its disposal to reduce the gaps in climate target attainment

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Purpose and fundamental mission of the company: Management consulting in the context of the mobility ecosystem

Foreword

Modern society is in the grips of a huge challenge. Achieving climate goals while maintaining prosperity, employment and quality of life is now the focus of action for politicians, entrepreneurs, civic society and NGOs alike. Particularly the mobility sector, with a significant share of global greenhouse gas emissions, is shifting into focus.

As a management consultancy, dealing with the issues surrounding tomorrow's mobility ecosystem, we are convinced that the solution to today's challenges lies in the principle of continuous development. Modern, digital and collaborative approaches are what will lead our society into a successful future. That is why we use our expertise from working with automotive manufacturers and suppliers, energy providers and public institutions, to develop necessary measures for the challenges of our time and to assess them in terms of their impact and implementation.

With regard to the decarbonisation of mobility, we have accordingly identified three effective levers and analysed their potential: The change in drive technology, the increase in occupancy levels and the anticipation of mobility needs. On this basis, it is possible to develop a broad catalogue of measures that can close the gaps in achieving the climate targets and decarbonising mobility

The following study is aimed at decision-makers and future shapers, and is intended to support their assessment of the long-term efficacy of measures. The targeted use of limited resources and budgets is essential.

Alexander Hotowy
Co-Founder and Managing Partner
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accilium

accilium is a management consultancy based on the idea that nothing lasts unless it is designed to evolve. This fundamental idea, coupled with the know-how gained from working with automotive manufacturers and suppliers, energy providers and public institutions, enables us to take on the major challenges of mobility and develop viable approaches and solutions together with our partners and customers to drive digitalisation forward.

Deeply rooted in the automotive industry, accilium has gained experience in all three core areas along the value chain of an Original Equipment Manufacturer: R&D and production, as well as distribution and aftersales. However, in order to develop future mobility concepts, we choose to venture beyond the boundaries of the car manufacturer and into sectors such as energy suppliers and public services, which we consider essential for building the mobility ecosystem of the future. An ecosystem that is environmentally friendly, convenient and, above all, unconditionally customer-centric.

Our mission is to accelerate the mobility transition and we are pursuing this with relentless vigour, which can be divided into three parts:

- We support the leading players in the mobility ecosystem (car manufacturers and suppliers, energy providers, public sector) in making their organisations fit for the future.
- We help those new players entering (or wanting to enter) the mobility market to develop and calculate go2market strategies.
- We provide information on the trends of electrification, the shared economy, autonomous driving, and digitalisation in the form of our “Thought Leadership on Mobility of the future” to allay society’s concerns about the mobility revolution taking place.

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1. Introduction

1.1 Global and national discourse in climate policy

As a central challenge of our modern society, man-made climate change is increasingly becoming the focus of attention.In the face of advancing globalisation, industrialisation and urbanisation, the climate crisis has long ceased to be a national problem, but is of concern to state leaders, entrepreneurs, civil society and NGOs alike. Climate change is described by the internationally recognised IPCCC as “widespread, rapid and intensifying”, leaving no doubt that the observable changes in the world’s climate must be reduced, in particular, by a rapid reduction of carbon dioxide (CO2) as well as other greenhouse gasesd.[1]

With the adoption of the Paris Climate Agreement in 2015, the World Climate Conference has become arguably the most significant body internationally, which, at the time, committed to a maximum of 1.5 degrees of global warming compared to the pre-industrial era. Even if the displeasure in the ranks of climate activists was clearly noticeable, numerous political declarations of intent followed, which, at least in theory, are supposed to counteract climate change. It should be emphasised that the decision taken in Paris in 2015 was not only confirmed, but subsequently specified and sharpened. Global CO2 emissions are to be reduced by 45% by 2030 compared to 2010 and **net zero emissions** are to be achieved globally by 2050.[2] These detailed requirements, supplemented by the need for national long-term mitigation strategies, will from now on be the benchmark against which nation states will have to measure themselves. In addition to this process of concretisation, the commitment to zero-emission vehicles (Zero Emission Vehicle Pledge) and the new regulation of emissions trading are particularly worthy of mention with regard to this article. Emissions trading also offers the possibility of setting binding upper limits for greenhouse gases and gradually reducing them.

As a result of the new regulations, all transferred emission allowances must be accounted for, which should render duplicate counting ineffective and thus lead directly to a greenhouse gas reduction.

However, it is not only at a global level that plans for climate neutrality are being negotiated; in the European Union, there are also a number of legislative projects worth mentioning in this regard. In particular, the **“European Green Deal”** should be highlighted as one of the six priorities of the European Commission in December 2019. As a growth strategy for the European Union, this deal aims to move the EU towards a climate-neutral, fair and prosperous society with a modern, resource-efficient and competitive economy to achieve climate neutrality by 2050.
In December 2020, this ambitious plan was endorsed by the European Council, with EU heads of state adopting the binding EU target of a net reduction of at least 55% in EU greenhouse gas emissions by 2030 compared to 1990 levels. In the context of the European Climate Change Act, which was adopted by the EU Parliament and Council in June 2021, the goal of climate neutrality by 2050 was adopted as formal EU law. The law also aims to ensure that all EU legislative projects contribute to this goal, as well as that all sectors of the economy and society make their contribution.

[1] Federal Agency for Civic Education – COP 26: UN Climate Change Conference in Glasgow
[2] European Commission (2021) – EU Emissions Trading Scheme (EU ETS)
[3] European Council (201 9) – A European Green Deal - Consilium

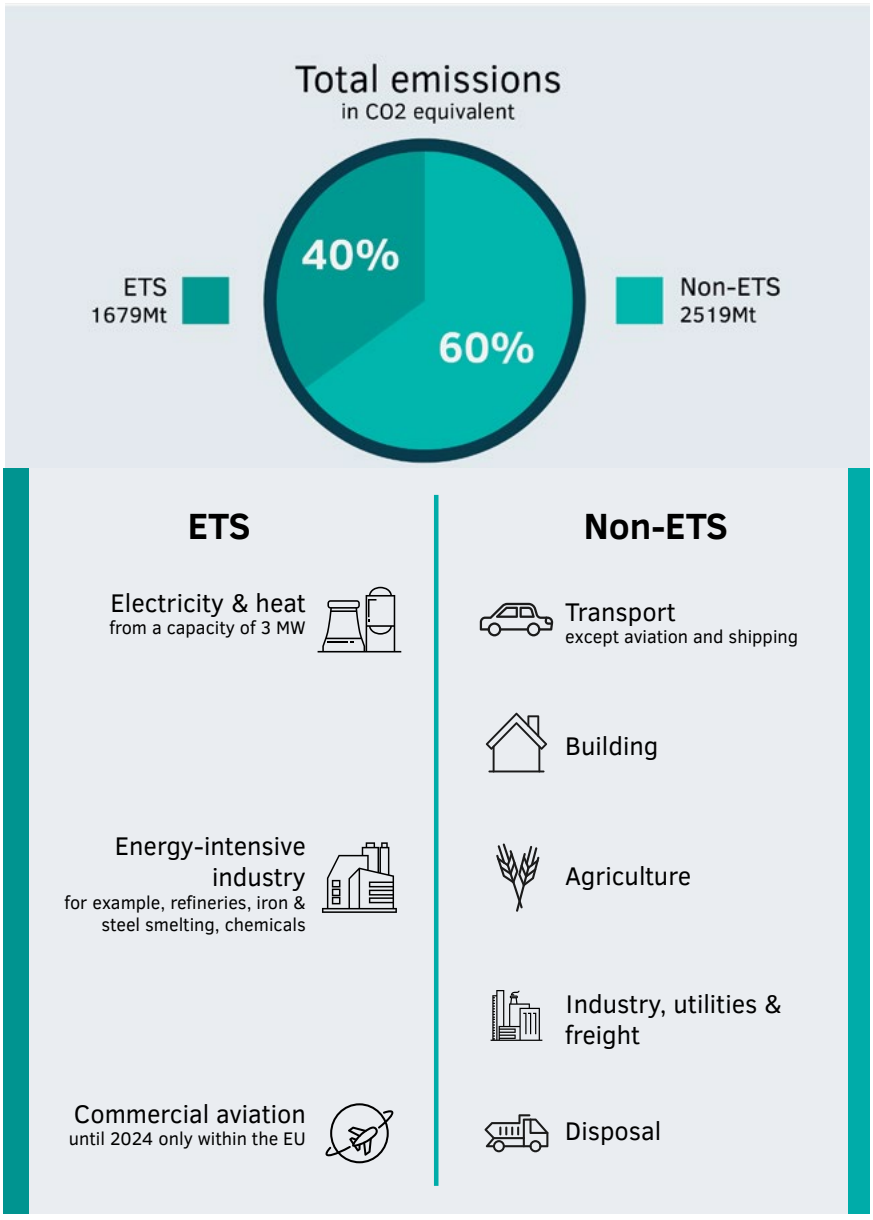

Figure 1: Overview of sectors inside and outside the European Emissions Trading Scheme (ETS); source: European Council (2021)

In July 2021, the European Commission presented further legislative proposals under the title **"Fit for 55"** covering a wide range of topics, such as the energy sector, the transport sector and taxation issues. Again, these are legislative proposals intended to pay towards the goals of the European Green Deal. In particular, a significant reduction of greenhouse gases shall be achieved through heightened ambitions, underpinning the EU emissions trading system previously described. As well as through stricter target benchmarks in the areas of aviation, construction and transport (incl. fleet targets for new vehicles). As a very successful policy tool, approximately 35% of emissions have been saved in the ETS sectors since the ETS was launched in 2005 until 2019, according to the European Commission. .[4]

In addition to the political framework conditions outlined so far, relevant laws and political declarations of intent are also increasingly found in the national political landscape for the countries relevant to the study – Germany and Austria. For example, in Germany, the coalition agreement cementing the power-sharing arrangement behind the so-called "traffic light coalition" was signed only recently. This alliance for "freedom, justice and sustainability" has been described in the chapter "Climate protection in a social-ecological market economy" in extensive detail with around 30 pages, which once again impressively underlines the enormous relevance of climate policy. Achieving the Paris climate protection goals is described as the "top priority", and controversial issues such as the end of the combustion engine and the phasing-out of coal also make climate protection a top priority.

A similar picture is also painted in the government programme entitled "Borne out of Responsibility for Austria". Here, the fight against climate change and compliance with the Paris climate goals are set as a core element. Furthermore, the chapter "Climate Protection, Infrastructure, Environment & Agriculture" is the highest maxim, like in Germany. Even if political declarations of intent are not yet reducing CO2, they are an important prerequisite for effective implementation. As a central ambition, the Austrian federal government anchored climate neutrality by 2040 as part of the coalition agreement and, accordingly a "Paris-compatible CO2 budget" with "corresponding paths to reducing greenhouse gases" [5] In summary, it can be said that an ambitious climate policy has arrived at all levels. In order to ensure that the urgent warnings of science regarding possible "points of no return" do not become reality, the focus remains, in particular, on the development of the effects of measures.

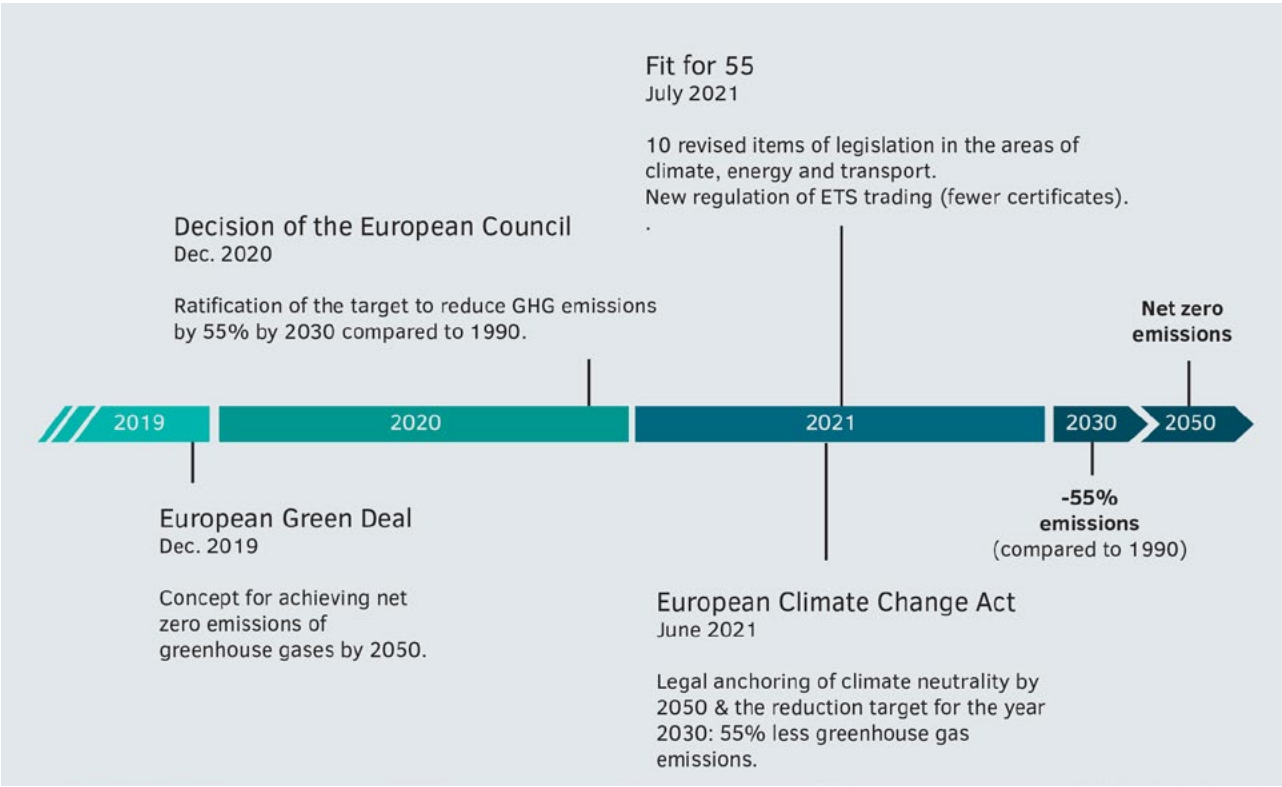

Figure 2: Overview of relevant EU climate policy legislative initiatives

[4] Europäische Kommission (2021) – EU-Emissionshandelssystem (EU-EHS)

[5] Federal Chancellery of Austria (2020) – Borne out of Responsibility for Austria. Government programme 2020-2024

1.2 Mobility sector as an emissions driver

Mobility is one of the cornerstones of modern society and the engine of global economic development. Accordingly, the transportation sector is responsible for about 25 % of greenhouse gas emissions worldwide, of which road transport accounts for roughly 18 %.[6] In the EU, the share of CO2 emissions caused by road transport is significantly higher at around 26 %.[7]
Even for the geographical focus on Germany and Austria, the decarbonisation of mobility remains an enormous challenge, as mobility represents the area with the greatest need for action on the path to achieving the EU climate targets. In Austria, for example, the transportation sector emitted approximately 50% more CO2 in 2020 than in the reference year 1990.[8] Although the total greenhouse gas emissions in the transportation sector in Germany remained constant (+ 0.4%) until 2019, but, considering the ambitious climate targets, this is, of course, far from sufficient.[9]

Due to the large share of the mobility sector in national and global CO2 emissions, there are also political objectives in this sector that should subsequently contribute to the climate goals.

For Austria, the "Mobility Master Plan 2030", published by the Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology in 2021, is worth mentioning. Within the framework of the master plan, a target picture has been established for 2040 in which the mobility system is "sustainable, climate-neutral and safe".[10] Furthermore, the goal of achieving climate neutrality in the transport sector by 2040 is also set out. In particular, the current 61% share of motorised private transport from 2018 must be reduced to a maximum of 42% of total passenger transport in the modal split. In order to get from the current level of around 24 million tonnes to 0 tonnes of CO2 equivalent will clearly require an enormous effort, especially in view of the fact that emissions have risen significantly since the reference year 1990.

Looking at the neighbouring country Germany, the coalition agreement previously cited provides some insight into the intended transport policy of the new federal government. "The necessary decisions" are to be taken in order to achieve the "climate protection targets for 2030 and 2045 with the aim of decarbonising the mobility sector". Envisaged are, for example, the expansion of rail passenger and rail freight transport, the increase of passenger numbers in public transport and the support of digital mobility services.

To achieve the climate targets set by the European Union, the Climate Protection Act – which came into force on 31 August 2021 – created the legal framework for significantly stricter emission reductions. Accordingly, the adjusted reduction target for 2030 has been raised by 10 % to 65 % compared to 1990, to be able to achieve complete climate neutrality in 2045.[11] Under the Act, greenhouse gas emissions from the transportation sector must fall to 85 million tonnes of CO2 equivalent by 2030, almost half (-48%) of 2019 levels. Likewise, clear goals have been set at national level, which will have to be evaluated in the near future.

However, the transition from a largely fossil fuel-driven transport sector to a sustainable, multimodal mobility offer is proving difficult for the broad population. From economic and political resistance to technical hurdles and deeply rooted behavioural patterns, various challenges need to be overcome in order to accelerate the decarbonization of mobility and thus effectively combat climate change. Henceforth, **it is insufficient to simply make minor adjustments, as it is necessary to implement different approaches with short- and long-term effects in parallel and integrate them into an overarching concept.** The problems and measures considered in the study are therefore intended to draw a holistic picture of the current situation and to elicit specific recommendations for action with regard to an effective decarbonisation of mobility.

[6] Statista (2021) – CO2 ~emissions. Share of traffic
[7] Federal Statistical Office (2021) – Road transport: EU-wide CO2 carbon dioxide emissions up 24% since 1990
[8] VCÖ (2021) – VCÖ on EU climate target: In Austria, the greatest need for action is in the area of transport as a climate polluter
[9] Federal Environment Agency (2021) – Climate protection in transport VCÖ on EU climate target: In Austria, the greatest need for action is in the area of transport as a climate polluter
[10] Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology (2021)
[11] The Federal Government (2021) – Climate Protection Act: Climate neutrality by 2045

2.Status quo, forecasts and targets regarding CO2 in transport

The target set by the policy makers is ambitious. Due to the complexity of the issue at hand and the many political, economic and social levers in play, a forecast on the achievement of the target is extremely challenging. Nevertheless, the challenge of CO2 reduction in transport for the EU, as well as its Member States, can be systematically analysed on the basis of various data sources. In particular, the following data is required:

- Measured historical data on CO2 emissions from the transport sector
- Valid forecasts on the further development of CO2 emissions
- Policy target curves that are consistent with climate targets

2.1 Measured historical data on CO2 emissions

The CO2 emissions in the transportation sector within the European Union and its Member States are calculated on the basis of fuel sales in the respective EU countries. Based on the type of fuel, the CO2 emissions per vehicle can be reliably calculated, therefore fuel sales can be used as a suitable indicator for CO2 emissions. This parameter is independent of the exhaust gas aftertreatment or the efficiency of the combustion engine.

Although it is often underestimated, this is a constant variable which can only be reduced by lowering real consumption in liters per 100 km. The EU's method of calculating CO2 emissions is based on fuel sales at petrol stations and does not take into account where the CO2 is actually emitted. A cheaper fuel price when compared to direct neighbouring countries leads to so-called fuel tourism, which can burden the CO2 footprint of a country, although the CO2 is actually partly emitted in another country. In Austria, this effect is considerable.

The historical data forms the basis for the EU's target derivation in the Green Deal and is regulated under Regulation (EU) 2021/1 1 19 of the European Council of 30 June 2021 establishing the framework for achieving climate neutrality. This is explained under point 3.

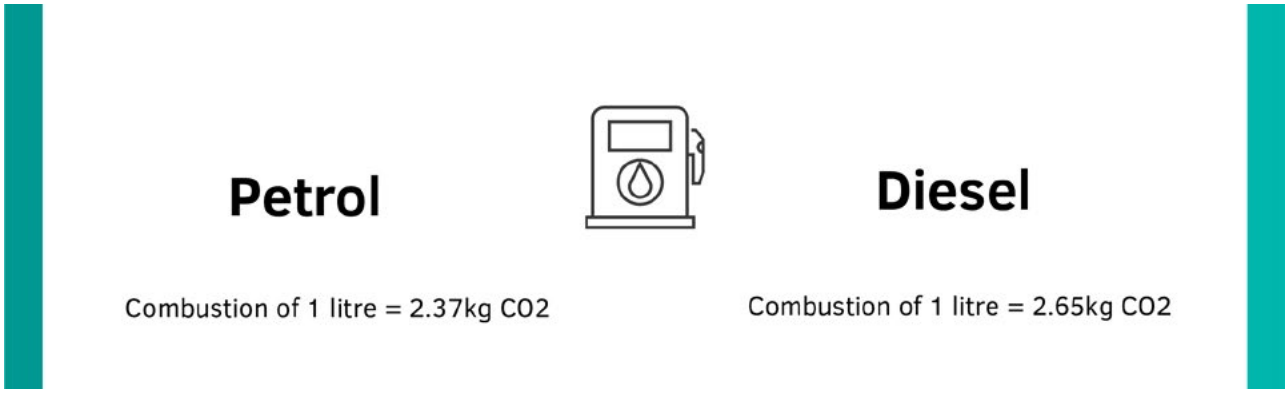

Figure 3: CO2 emissions by fuel type

2.2 Valid forecasts on the further development of CO2 emissions

To estimate a possible "target attainment gap" (difference between politically agreed CO2 targets and the projection of real emitted CO2 emissions), forecast data for the next 15 to 20 years is deemed necessary, in addition to measured historical data on CO2 emissions. From the resulting gap, the need for action as well as the definition of possible action measures can be conducted.

Forecast data from the European Environment Agency – which is based on the EU Regulation "Governance of the Energy Union and Climate Action" of 2018 – is used as a suitable data basis for the calculations described below. As part of this survey, EU countries are required to submit biennial projections of anthropogenic greenhouse gas emissions broken down by gas/gas groups. The survey distinguishes between the scenarios "With existing measures (WEM)" and "With additional measures (WAM)".As the European Union's targets must be achieved through national legislation, the WEM category includes measures that correspond to at least one of the following categories:

- National legislation already in force
- One or more voluntary agreements
- Allocation of financial resources to the measure
- Existence of an official government decision within the framework of a clear implementation commitment

The WAM scenario also lists measures that are currently being discussed and have a "realistic chance" of being adopted and implemented. For the calculations in the context of this study, the WEM scenario is used, as this has a higher probability of reducing real emissions in terms of the unfolding of effects. Based on current CO2 values and existing policy measures, a future forecast of the development of CO2 emissions by sector up to 2040 is derived by the Member States themselves. For this purpose, each policy measure is listed, parameters and factors are derived and a forecast model with estimates of the impact on the development of CO2 emissions is developed from it. These data and forecast values are checked for their quality by the European Topic Centre for Climate Change Mitigation and Energy and adjusted if necessary.

[12] Fuel tourism – Wikipedia

[13] European Commission (2018) – Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 201 8 on the Governance of the Energy Union and Climate Action

2.3 Policy target curves that are consistent with climate targets

All 27 EU Member States have committed to making the EU the first climate-neutral continent by 2050. They have agreed to reduce emissions by at least 55% until 2030 compared to 1990 levels. In the regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 on establishing a framework for achieving climate neutrality, the „Sustainable and Intelligent Mobility Strategy“ is addressed. This strategy sets a target of achieving a 90% reduction in transport emissions by 2050. The strategy put forward 82 initiatives to make the transport system smart, competitive, safe, accessible and affordable, while simultaneously reducing CO2 emissions. Other targets – such as 30 million zero-emission vehicles on Europe's roads by 2030 and 100 climate-neutral European cities – are also part of the strategy. .[14]

These politically defined targets for CO2 reduction of 55% by 2030 and 90% by 2050 shall be presented again as examples with regard to the degree of tension, without presenting and verifying the legally binding nature as well as the national and sectoral targets in detail. If, in the future, a legally binding EU instrument for the payment of penalties by the Member States in case of failure to meet the CO2 transport targets comes into force, the regions which have realized the necessary processes and measures at an early stage will benefit from this. Similar to the introduction of the mandatory requirement on EU fleet targets for car manufacturers, a massive transformation process will then take place in the public administration sectors.

[14] European Commission (2020) – The transport system in transition

2.4 Target attainment gaps in the EU, Germany and Austria

In the following section, the three curves – consisting of historical CO2 data from 1990 onwards, CO2 forecast data based on current decisions on measures, and target curves for the transport sector derived from the EU Green Deal and the national targets from Austria and Germany – are combined. This presentation is intended to serve as an example of the magnitude of the target attainment gap, without claiming to be complete in terms of the current decision-making situation, or the absolute values of the target and forecast data. The presentation's accuracy is sufficient for a discussion of the implementation levers to be derived from this, and to convey an order of magnitude vis-a-vis the target attainment gap.

If considering the data points previously outlined for the 27 EU countries, it quickly becomes evident that, for the period up to 2040, there is a significant gap between the projected development of CO2 emissions and the politically desired route, particularly given in the context of the Green Deal. Evidently, it has not been possible to reduce CO2 emissions in transport by the beginning of the 2020s. On the contrary, an increase from about 642 million tonnes of CO2 in 1990 to about 749 million tonnes of CO2 in 2020 has been observed. Judging by the actual increase in emissions over the last 20 years, it is apparent that far more intensive efforts are needed if the goal of climate neutrality shall be reached by 2050.

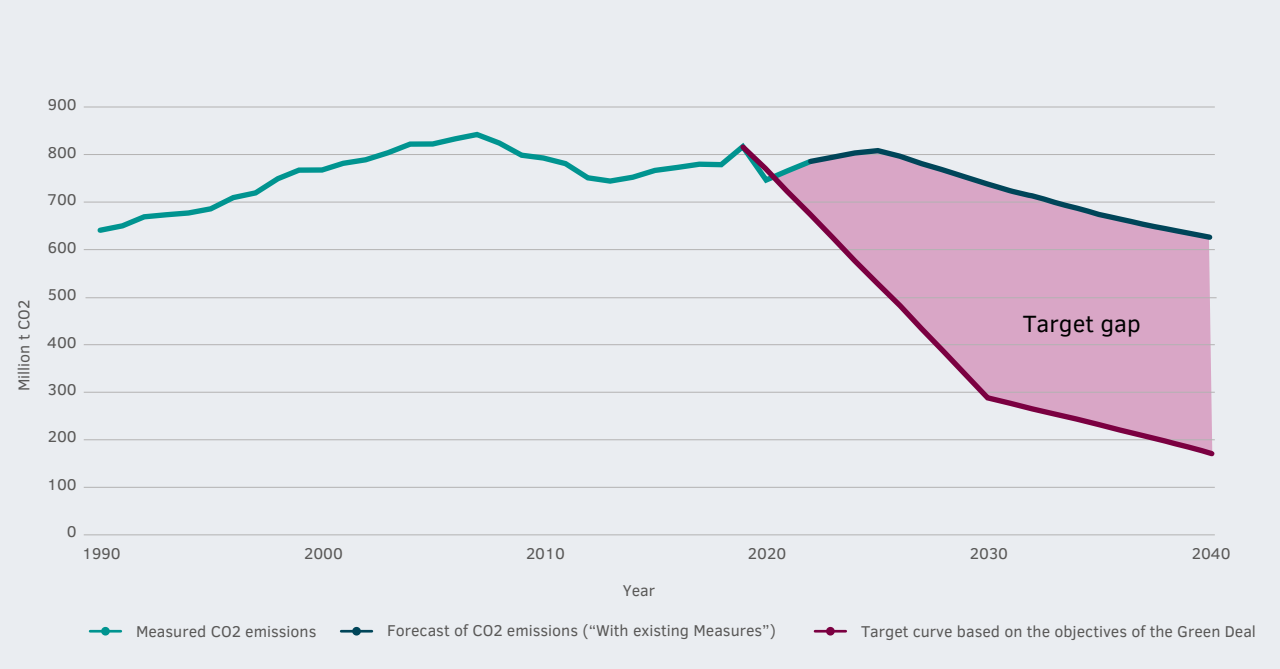

Figure 4: Exemplary target attainment curve for the EU

EU

The projected data up to 2040, aggregated from the forecasts of the EU Member States and published by the European Environment Agency, also underline this assumption. If we look at the projected CO2 emission data for 2040, it can be seen that a reduction compared to the status quo is to be expected, but that we would find ourselves almost exactly at the 1990 baseline. With more than 600 million tonnes of CO2 from the transport sector alone, the emissions target of approximately 176 million tonnes of CO2 derived from the Green Deal would be a long way off and would be clearly missed..

Germany

A similar picture emerges when applied to Germany as a case study. Between the years 1990 and 2020, CO2 emissions in the transportation sector were kept around the level of 160 million tonnes of CO2, which essentially means stagnation over the last 20 years at a constantly high level. In order to reduce emissions in the future, a number of measures have been adopted, which are reflected by the forecast data up to 2040. With the goal of saving around 65 million tonnes of CO2 in the transportation sector over the next nine years, for example, the CO2 emission-dependent vehicle tax, the expansion of local public transport and the promotion of electric vehicles and their charging infrastructure have been initiatedcht.[5]

However, if we also consider the political target of achieving a CO2-neutral transport sector in Germany by 2045, it becomes clear that the efforts outlined will be insufficient. In 2040, this would mean a difference of around 51 million tonnes of CO2 between the forecast and the legislatively anchored figure, and thus miss the political target by a factor of four. Similarly to the European Union, there is an increased need for action here, which must be dealt with by the Federal Republic of Germany.

Austria

In the context of CO2 emissions in the transport sector, the Austrian model is also not yet on the way to climate neutrality. The gap between the political target and the forecast data is significant here as well. The fact that the usual reference value from 1990 of just under 15 million tonnes of CO2 is far below the status quo of approximately 25 million tonnes of CO2 emissions, is particularly significant here. In relative terms, Austria has thus emitted significantly more CO2 in recent years than the European average. For the path towards climate-neutral mobility, this means a significantly higher need for action, which is also reflected in the coalition agreement mentioned above. With the ambitious goal of being completely CO2-neutral in the transport sector as early as 2040, the Austrian government has set itself high targets.

The application examples presented for the EU, Germany and Austria clearly show that there are considerable target attainment gaps that cannot be closed without further, target-oriented measures. In addition to regional differences, the geographical and socio-economic factors of the EU Member States must be taken into account. Especially in countries like Germany and Austria, where a significant part of the GDP comes from the automotive industry and its upstream and downstream industries, the pressure to act is immense. It is also apparent that the reductions targeted by the Green Deal are in some cases even being reinforced by the nation states, which should be viewed positively in terms of climate protection. In the context of future real CO2 reductions in the transport sector, the target achievement gaps just shown have made it evident that political declarations of intent are insufficient.

[15] The Federal Government (2021) – Less greenhouse gases in the transport sector

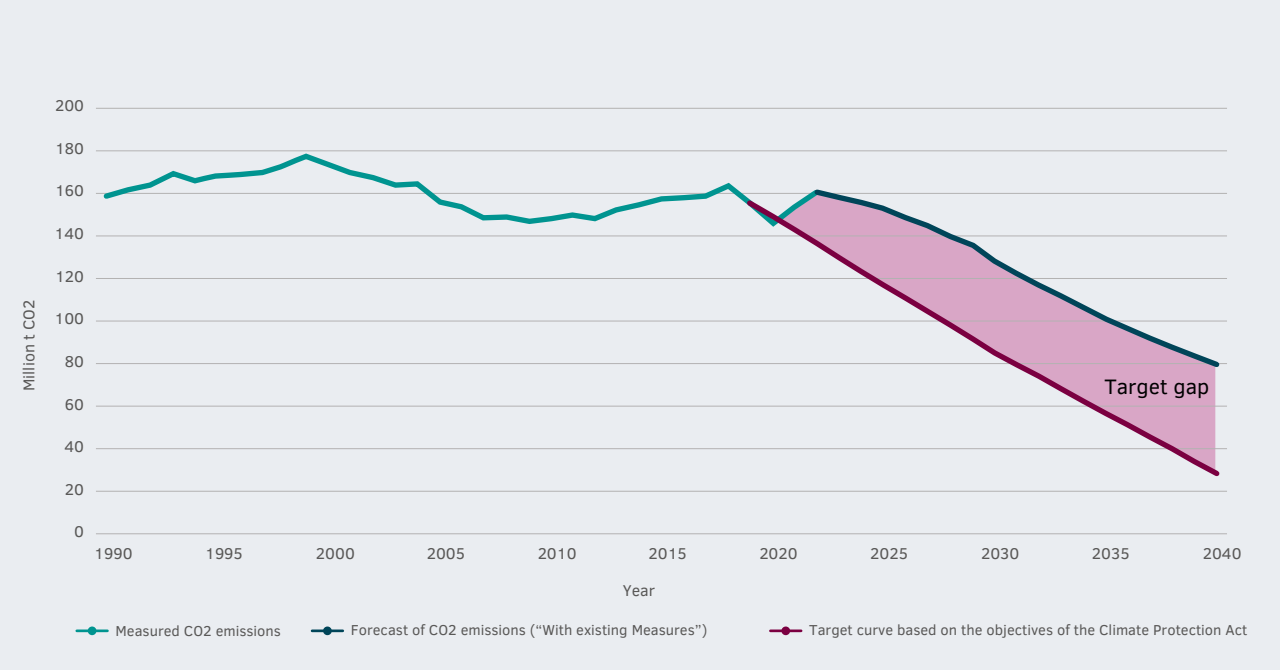

Figure 5: Exemplary target attainment curve for Germany

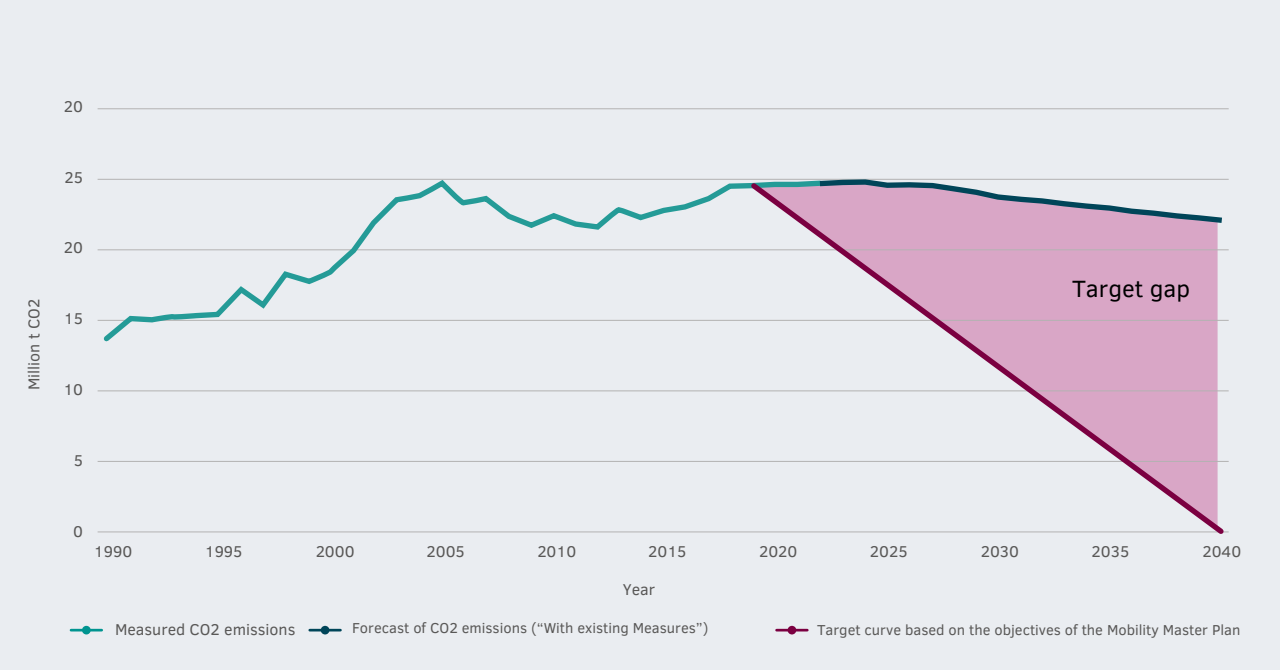

Figure 6: Exemplary target attainment curve for Austria

3. The three levers for achieving the goals and quantifying the measures

Political measures to utilize the levers are vital, but will not be considered in the scope of this study. Instead, the mechanisms of action, examples of implementation and a top-down quantification are described. In Chapter 3.1, this quantification is carried out using our own calculations based on public statistical data and is described using the example of the passenger car fleet in Germany. However, the methodology can also be applied to other transportation modes. When applying the methodology in more detail, attention must be paid to dependencies and non-linearities between and within the levers. Chapters 3.1 to 3.3 describe the three levers in more detail.

To close the identified target gaps, there are three key levers:

1. CO2-free vehicle drives
2. Increasing the occupancy level
3. Reduction of routes

These three levers are subordinate to two questions:

- How will the traffic of the future work? (Drive and occupancy level)
- Why is there even traffic? (Transport needs)

3.1 Effect of the three levers using the example of the car fleet in Germany

Regarding point 1. CO2-free vehicle drives , the central measured variable is the number of vehicles with regenerative engines. For example, for an e-car powered by green electricity with an annual mileage of 14,500 km

A share of 1 % e-cars of the total car fleet in Germany reduces ~ 1 million tonnes of CO2/year

[16] Basis of calculation:
Mobility in Germany (2017) – Publications
Federal Statistical Office (2019) – Road transport: EU-wide CO2 carbon dioxide emissions up 24% since 1990
Statista (2019) – Transport in Germany. Driving performance of passenger cars until 2019
Statista (2020) - Passenger vehicles in Germany 2020
Statista (2021) – Number of registered passenger cars in Germany
Statista (2020) – Mileage of passenger cars in Germany 2020

and the replacement of a car with an average real emission of 150 g CO2/km, a reduction of 2.2 tonnes of CO2/year can be assumed. These assumptions correspond roughly to the overall fleet average in Germany.
With a vehicle population of approximately 48 million cars in Germany, this means that an e-car share of 1% of the total vehicle population results in a CO2 reduction of 1 million tonnes of CO2/year.

Considering point 2. Increase of the occupancy rate of passengers or the loading rate of goods is used.
This is an optimization task of the mobility offers, since the mileage of the passengers or goods remains unchanged. As an example, two commuters can be used who would each drive their own cars independently of each other. The result of a carpooling arrangement would be that both commuters would have the same passenger mileage, but at the same time the mileage of the cars would be halved and thus also the CO2 emissions.
If the current average occupancy rate in Germany of approximately 1.4 per car is increased to 1.5, this results in a CO2 reduction per car of 0.15 tonnes of CO2/year. This calculation is based on the assumption that the passenger mileage of car users remains unchanged and the distance covered is 14,500 km with CO2 emissions of 150 g/km. This roughly corresponds to the data situation in Germany. With a vehicle population of about 48 million passenger cars in Germany, it can be concluded that an increase in the occupancy rate of the overall passenger car fleet by one tenth from 1.4 to 1.5 would result in a CO2 reduction of 7 million tonnes CO2/year.
What matters here is that it concerns a degressive relationship. The higher the occupancy level, the lower the savings effect. Furthermore, it must be taken into account that the occupancy rate cannot be increased arbitrarily, as people's journey purposes are different. However, in order to render the potential of increasing the occupancy level understandable, this representation is suitable.

Increasing the occupancy rate from 1.4 to 1.5 of the total car population in Germany leads to a reduction of
7 million tonnes of CO2/year.

For point 3. Reduction of distances the kilometres travelled by people and goods are considered. Meeting mobility needs while reducing passenger kilometres can also reduce CO2. For example, working from home is a good example of how person-related kilometres can be reduced despite carrying out the work activity. Assuming that the car mileage is 14,500 km with CO2 emissions of 150 g/km, and that a car driver reduces his/her daily mileage by one kilometre, this results in a CO2 reduction per car of 0.05 tonnes of CO2/year.

With a vehicle fleet of approximately 48 million cars in Germany, a reduction of 1 km per day and car driver of the entire car fleet results in a CO2 reduction of around 2.5 million tonnes of CO2/year.

It is important to note here that the distances cannot be reduced indefinitely; otherwise, people's mobility needs will not be met. However, in order to underscore the potential, this illustration is suitable.

Reducing the distance travelled by all car drivers in Germany by 1 km/ per day results in a reduction of approx. 2.5 million tonnes of CO2/year.

Application of the three levers for impact assessment

Concrete implementation measures such as e-cars, car-pooling, the expansion of bus and rail services or working from home can be assigned to one or more levers. This allows a top-down process to estimate the contribution that a measure can provide. The results are then compared with the feasibility, implementation time and implementation costs, which can be used as a top-down decision-making framework.

In the following sub-chapters, the three levers are described in more detail and some first effective measures are outlined.

3.2. CO2-free vehicle drives

Of particular importance in the mobility spectrum is the electrification of transport. The debates ranged from solving infrastructure problems to convenience and range to averting total economic losses in some industrial regions (most notably Germany). However, the target attainment gaps clearly show:

What we need is the widespread use of electromobility.

The change in drive technology is a prerequisite and foundation for emission-free mobility. In the passenger car sector, in particular, the battery-electric drive is currently emerging as the best alternative for Europe, especially when taking into account the overall efficiency – including primary energy production, infrastructure costs, implementation speed and product availability. For other regions, e.g. in the Global South, other powertrain technologies, such as renewable liquid fuels for internal combustion engines, may be the more effective solution. This is due to the electricity infrastructure being insufficiently developed oftentimes and because there is sufficient land and solar energy available for the production of renewable fuels. For HGVs and buses of various sizes, hydrogen in combination with fuel cell technology will also play a role. In the future, the issue of efficiency will become even more important, further infrastructural questions will have to be clarified and the incentive system for what is still a new driving technology will have to be pushed.

The electrification of the drive in passenger cars is a measure that can be implemented in the short term and can make a very high contribution to reducing CO2 emissions. One reason is that the EU introduced CO2 fleet limits as early as 2000, prompting vehicle manufacturers to substantially transform their businesses. This resulted in the current e-car product portfolios, which are being expanded on a monthly basis.

3.3 Increasing the occupancy level

In addition to electromobility, there is another important trendsetter in the mobility of the future – shared mobility. Shared mobility, i.e. using mobility instead of owning it, is an important prerequisite for increasing occupancy rates. Current private sector-driven business models for shared mobility, which are primarily implemented in urban areas, do not have the primary goal of increasing the occupancy rate of vehicles and thus reducing CO2. The effect of CO2-reduction often fails to be achieved. Regulatory framework can hinder to achieve this goal. Carsharing can also have the opposite effect on occupancy rates, if, for example, a large group of users chooses to turn their backs on public transport instead of simply not buying a private car. However, shared mobility services can act as valuable CO2 reduction measures when offered as part of public transport. This enables the public sector to implement services in rural regions that would not be profitable in purely market-based terms, and align the utilisation concept towards increasing the occupancy rate. As a result, publicly financed transport has an additional and valuable mobility solution in its offering, because targeted measures to promote public transport and shared mobility make a huge contribution to increasing the occupancy rate and thus to reducing CO2 emissions.

[17] Handelsblatt (2021) article – “Charging pillars: Lack of charging stations slows down electromobility”
[18] Statista (2021) – – Survey on the necessary circumstances for the purchase of an electric car in Germany 2021
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Unlike electromobility, the adaptation of occupancy levels can entail major changes in user behaviour. Therefore, the CO2-reducing effect must be seen mid-term and it requires more stamina than the electrification of a vehicle fleet. Especially the current pandemic has left its mark in terms of sharing restricted spaces for joint mobility. It will be important to sustainably reduce these in the long run. Traditional public transport with buses and trains plays an absolutely key role here and forms the backbone of these endeavours.

A strong focus will be placed on this focal point for the achievement of goals in the cooperation between the public sector and private providers. The creators and implementers of public mobility have to use new tools to fulfil their mission of "enabling mobility as a prerequisite for societal participation". Shared mobility, on-demand shuttles or ridesharing are valuable tools to respond to these new challenges and increase the occupancy rate of all modes of transport.

3.4 Reduction of routes

The prerequisite for the reduction of routes taken and thus the reduction of passenger (or goods) kilometres is the fulfilment of needs, such as doing the shopping or going to work. If these needs can be satisfied even if the distance travelled is reduced, there is a large potential for CO2 savings. The COVID pandemic has accelerated processes that might otherwise have been unthinkable for years and decades to come. Particularly in German-speaking countries, "home office" was considered an English technical term whose widespread implementation seemed completely unthinkable. It is already evident that there will be lasting change. The home office is here to stay, the commute for traditional office jobs has been minimised and there will be a home office-office split in many professional areas, even in the long term. Working from home is only one effective example of a measure. This section includes, in particular, the digitalisation of services, for example, public services ("commuting to the office") or online banking. Furthermore, the concept of a "city of short distances" is an essential measure. When it comes to reducing distances, there are measures that can be implemented in the short term, such as working from home, and in the long term, such as changes in spatial planning or urban planning.

4. Conclusion and outlook

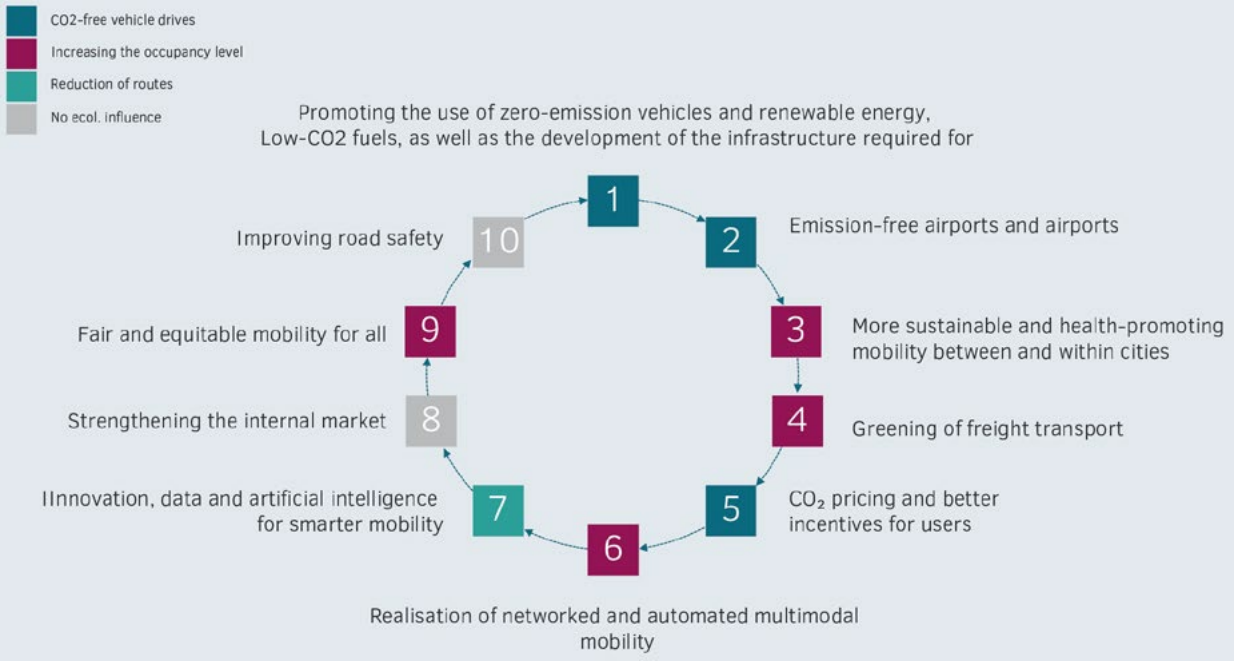
In summary, there is a huge challenge ahead of us to effectively limit man-made climate change in the mobility sector. A strong mix of measures is needed, combining the three levers of change in drive technology, increase in occupancy rate and reduction of routes.
For the decision-makers and designers, it is essential to use the limited resources and budgets available in a targeted manner. The impact of the measures must be assessed in advance and monitored during implementation. By clustering the implementation measures according to the three levers and quantifying them, this article provides a contribution to the top-down measure assessment. A wide-ranging catalogue of measures is necessary, in order to exert influence quickly and effectively. Furthermore, it is necessary to examine the potential for CO2 savings, to consider the necessary changes in behaviour, to assess the influence on spatial planning and, in particular, to shed light on the feasibility in terms of time and thus the degree of efficacy over the next 30 years.

Some measure headings are briefly presented here in conclusion. They will be examined in detail in future specialist articles dedicated to the topic. Each measure is presented according to the same approach and assigned to the levers and the flagship initiative of the European "Sustainable and Smart Mobility Strategy". To create a picture of the various measures that is as coherent as possible, the focus lies on the following questions:

- What is the estimated potential of the measure? Which target area is particularly impacted by the measure?
- What influence does the measure have on mobility behaviour?
- How quickly can it be implemented and show an impact? (Technology availability, legal situation, social consensus? Does spatial planning have to be changed for this?)

INFO

The European Union's flagship initiatives provide a broad spectrum containing fields of action for making mobility green. Not all EU initiatives have a direct impact on CO2 reduction. However, eight flagship initiatives can be assigned to one or more levers for target attainment. For future technical articles and details in this series, the flagship initiatives serve as an informative orientation anchor.



Source: Strategy for sustainable and intelligent mobility: Putting transport in Europe on course for the future (2020)

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In the series of articles on the “Decarbonisation of mobility”, the following measures, among others, are presented in detail:

1) EXPANDING PUBLIC TRANSPORT THROUGH NEW MOBILITY SERVICES

The addition of more services to the public transport can make a strong contribution to increasing the occupancy rate and thus to reducing CO2 emissions, especially in rural and peri-urban areas.

2) DIGITALISATION OF PUBLIC SERVICES

A large part of the communication between citizens and the public administration requires travelling specific routes. Physical presence requires mobility, which is why the digitalisation of these services is an important and easily influenced component of the third target area, the reduction of routes travelled.

3) REGIONAL GOODS DISTRIBUTION CENTRES

The establishment of regional, cross-provider goods distribution centres and the ongoing digitalisation of logistics processes have a major influence on increasing the loading rates of CEP services.

4) MaaS

Mobility-as-a-Service, which at its core is the digital platform for the use and provision of mobility services, is a key pillar to reduce private car ownership and thus increase occupancy rates.

5) TOURIST MOBILITY

Mobility concepts in the tourist centres have potential for all three levers. For instance, through e-mobility and multimodal mobility services, there are short- and medium-term levers, for reducing CO2 in the mobility sector.

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