

FVV PRIME MOVERS. TECHNOLOGIES.

# Efficient use of the global CO<sub>2</sub> budget in the mobility sector

Four theories based on a meta-study on life-cycle analyses



© 2020 FVV – Frankfurt/Main



The mechanisms of international climate protection policy are currently based on national emissions goals, which in turn are split into phased goals for individual sectors. The German transport sector has been set the goal of reducing its annual CO<sub>2</sub> emissions from 163 to between 95 and 98 million tonnes by the year 2030. As 95 % of CO<sub>2</sub> emissions caused by transport are the result of road traffic, the majority of the reduction will therefore have to come from this sector. A new **meta-study from FVV**, conducted by **Frontier Economics**, now scrutinises whether this sector-focussed approach will result in effective climate protection. By analysing more than 80 individual studies on the life-cycle assessment of vehicle powertrains (petrol, diesel, battery electric vehicle, fuel cell electric vehicle), four theories were derived with the objective of guiding the next steps.



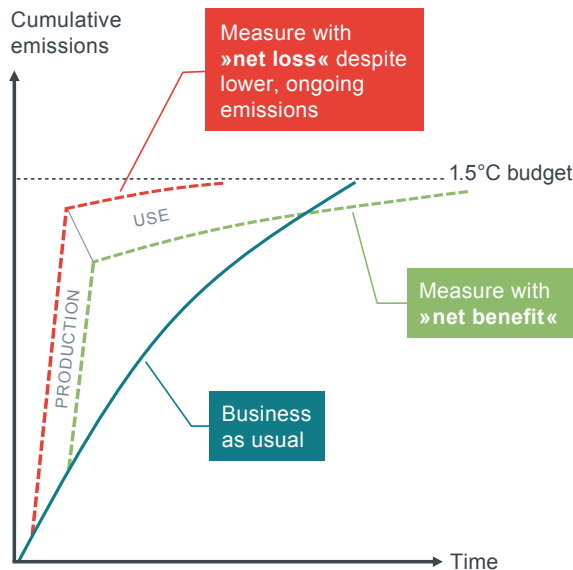
**A life-cycle assessment (LCA)** takes into account all environmental impacts during the product life cycle. In particular, these comprise production (including materials and supplied components), the use phase, disposal and recycling. The meta-study upon which this theoretical paper is based only observes greenhouse gas emissions. To improve comprehension, this text solely refers to CO<sub>2</sub> emissions. As other materials can also impact the greenhouse effect, they are considered in the form of CO<sub>2</sub> equivalents.

# 1. CO<sub>2</sub> targets must take the entire life cycle into account.

The long retention time of CO<sub>2</sub> in the atmosphere means that when short time scales are applied, the year in which it entered the atmosphere is of no significance to climate change. This means that CO<sub>2</sub> emissions accumulate to an atmospheric concentration which corresponds to the increase of the average global temperature. In order to limit the temperature increase to a maximum of 1.5 degrees Celsius compared to pre-industrial times, the remaining CO<sub>2</sub> budget for the whole of humanity to release into the atmosphere is between 420 and 580 billion tonnes according to the IPCC (Intergovernmental Panel on Climate Change). In a business-as-usual scenario, this global carbon budget would be exhausted by around the year 2030. A rapid technological shift towards particularly low-emission or even carbon-neutral vehicle powertrains would seem prudent against this background, as approximately one quarter of the annual global CO<sub>2</sub> emissions from the combustion of fossil fuels can be traced to the transport sector. However, the savings to be achieved in vehicle operation must not be used up in advance through increased »initial investments«, i.e. CO<sub>2</sub> emissions which are released into the atmosphere during vehicle production or when establishing an infrastructure.



**Conclusion:** All measures which target the reduction of CO<sub>2</sub> emissions from transport must be aligned with the impact on the remaining global carbon budget.



**Figure 1:** The conversion of powertrains and energy carriers will initially result in increased CO<sub>2</sub> emissions. This must be managed in such a manner that the emissions saved during operation will further delay the point in time when the CO<sub>2</sub> residual budget is used up.

## 2.

### An efficient CO<sub>2</sub> reduction can be achieved with various powertrains.

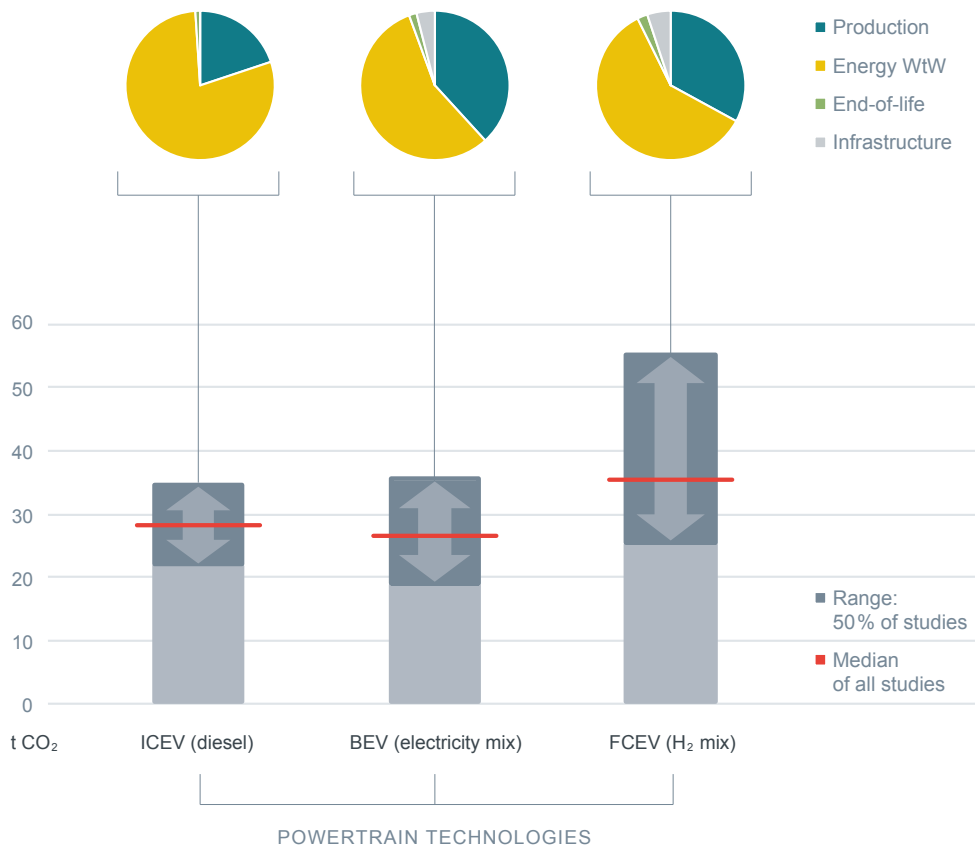
The results of life-cycle analyses have a wide scatter range. This is generally due to the fact that the selected initial parameters can significantly determine the result. An example of this is the question of which electricity mix is used for the operation of a battery electric vehicle, or how much CO<sub>2</sub> is emitted during production of different powertrain technologies. It is therefore of paramount importance that life-cycle analyses take the entire energy chain into account – from energy generation and supply, all the way up to the energy used in the vehicle. The energy expended during production and recycling at the end of the product life cycle must also be taken into account. Furthermore, the specific CO<sub>2</sub> footprint generated when establishing the necessary infrastructure was virtually ignored in previous LCA studies. The current LCA meta-study by FVV highlights the following example for cars: if only renewable energy carriers are deployed across all sectors, a vehicle powered by synthetic fuels may even have lower CO<sub>2</sub> emissions than a battery electric vehicle.



**Conclusion:** All solutions that produce a comparable CO<sub>2</sub> benefit must be supported and promoted equally.



**Life cycle emissions  
from current energy sources**



**Figure 2-A:** If cars are powered by fossil fuels, with electricity from the current energy mix or with conventionally generated hydrogen, battery electric vehicles and internal combustion engine vehicles have comparable life cycle emissions.

**Life cycle emissions**  
when using 100% renewable energy for operation



**Figure 2-B:** If only renewable energy carriers are used during operation, a vehicle powered by synthetic fuels may even have lower CO<sub>2</sub> emissions than a battery electric vehicle. There is still room for optimisation of the fuel cell.

### 3.

#### The targets for 2030 prefer electric cars, but these are only part of the solution.

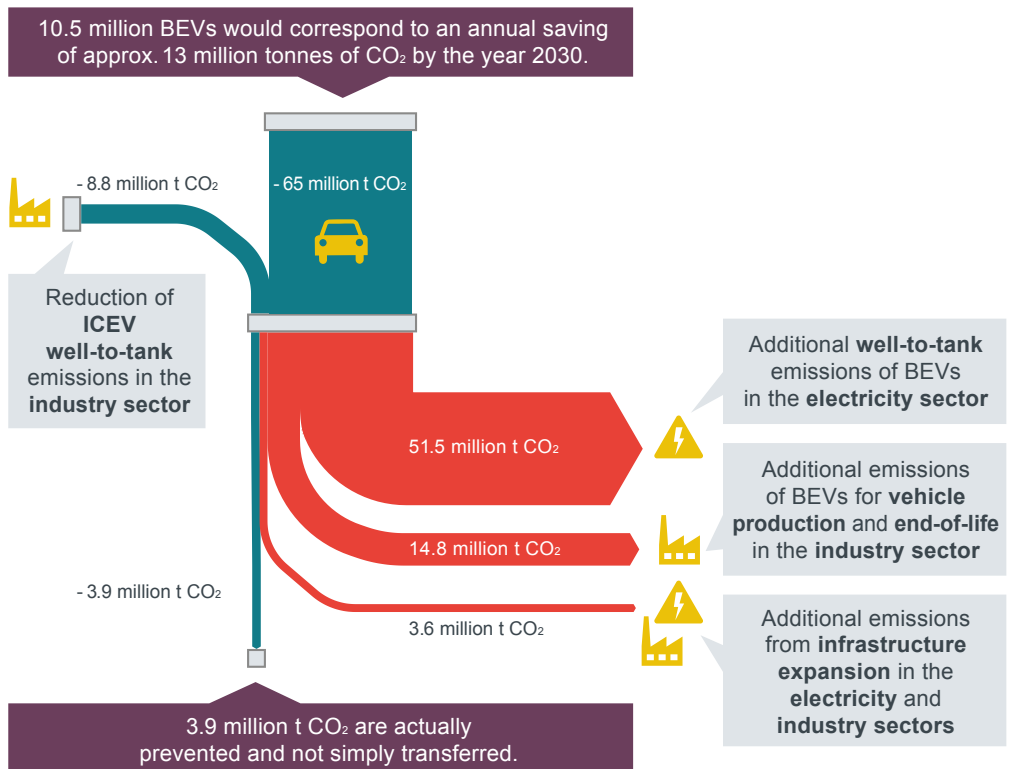
The German National Platform »Future of Mobility« (NPM) recommends introducing up to 10.5 million battery electric vehicles on the market, including plug-in hybrids, by the year 2030. According to the NPM, as battery electric vehicles do not themselves produce any CO<sub>2</sub> emissions during operation, the CO<sub>2</sub> balance for the transport sector when observed in isolation would be improved by 13 million tonnes of CO<sub>2</sub> in 2030 compared to a reference scenario with significantly fewer electric vehicles. This corresponds to a cumulative total saving of around 65 million tonnes of CO<sub>2</sub> by the year 2030. However, the impact on the remaining cross-sector CO<sub>2</sub> budget can only be determined using a life-cycle analysis. In the most unfavourable case, the amount saved from the CO<sub>2</sub> budget is not 65 million tonnes, but only 3.9 million tonnes.



**Conclusion:** The current CO<sub>2</sub> legislation with the tank-to-wheel approach means that a significant share of the CO<sub>2</sub> saved when using electric vehicles is simply transferred to other sectors instead.



### Impact of electric vehicles on the cross-sector CO<sub>2</sub> residual budget



**Figure 3:** If we assume that electromobility is ramped up evenly throughout the 2020s, this would result in a total saving of 65 million tonnes of CO<sub>2</sub> in vehicle operations. This would be boosted by savings of a further 8.8 million tonnes of CO<sub>2</sub>, which would otherwise have been generated through the production of petrol and diesel fuels for vehicles with internal combustion engines. Even if the share of green electricity continued to increase, the emissions in the energy sector would rise by 51.1 million tonnes in this scenario. The higher amount of energy expended in vehicle production would result in additional CO<sub>2</sub> emissions of 14.8 million tonnes in the industrial sector. Furthermore, the increased electricity requirement would necessitate additional investments in the infrastructure of the energy and industry sectors. It is possible to save more CO<sub>2</sub> per vehicle if the framework conditions are modified, for example if only green electricity is used for operation.

## 4.

### The mobility of the future must be diverse.

Car traffic was at the core of the FVV meta-study. However, road freight traffic, the importance of which as a secure supply of goods for the population became clear during the coronavirus crisis, has significantly higher demands, for example when it comes to mileage. Furthermore, in the current mobility system, various transport carriers are designed with fossil energy sources and internal combustion engines in mind – from mobile construction and agricultural machinery, to wide-bodied aeroplanes or container ships. It cannot be expected that a single successor technology will be available for all these applications in the short term. A monoculture based on fossil fuels cannot simply be replaced by an electric monoculture. This will result in an ever-growing variety of both powertrains and energy sources. Investments in infrastructures – or the framework conditions for investments of this kind – must therefore always consider the diversity of applications.



**Conclusion:** There is not one single solution for CO<sub>2</sub> neutrality in the mobility sector.



## Recommendations

On the basis of the knowledge gained from the FVV meta-study, we can derive four requirements for future regulations and guidelines regarding climate protection. These requirements should be **applicable across sectors, technology-neutral, global** and **designed for the long term**.



**Applicable across sectors:** In order to keep track of transfer effects, the optimum level across all sectors based on life-cycle analyses is to be targeted. The transformation paths in other sectors are to be considered here.



**Technology-neutral:** In a life-cycle analysis – without including the CO<sub>2</sub> footprint for the infrastructure – the different powertrain technologies do not display significant differences in CO<sub>2</sub> savings. In addition, technical options should be provided for converting the existing fleet to use renewable energy sources.



**Global:** The expansion of renewable energy generation is limited in Germany and in many cases is not economically viable. Therefore, energy partnerships should be entered into with other countries where it is possible to produce synthetic fuels that are easy to store and transport.



**Designed for the long term:** Climate protection, economic viability and prosperity should be brought into harmony. The CO<sub>2</sub> budget principle is to be applied to this end. The 17 Sustainable Development Goals from the UN should be considered for all measures.

The FVV briefing paper is based on the  
›Cradle-to-Grave Life-Cycle Assessment in the Mobility Sector – A Meta-Analysis  
of LCA Studies on Alternative Powertrain Technologies‹ study.

PUBLISHER: Forschungsvereinigung Verbrennungskraftmaschinen e. V.  
AUTHORS: Dr. David Bothe and Theresa Steinfurt, Frontier Economics Ltd.  
EDITION: R595 | 2020

Both publications are available online:

→ [www.primemovers.de/en](http://www.primemovers.de/en) | Science | Taking stock

→ [www.themis-wissen.de](http://www.themis-wissen.de)

**Forschungsvereinigung Verbrennungskraftmaschinen e.V.**  
Research Association for Combustion Engines

Lyoner Strasse 18 | 60528 Frankfurt/M. | Germany  
T +49 69 6603 1345 | F +49 69 6603 2345 | [info@fvv-net.de](mailto:info@fvv-net.de)

[www.fvv-net.de](http://www.fvv-net.de) | [www.primemovers.de](http://www.primemovers.de)