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## “We have to consider the return on investment”

Frontier Economics has conducted a comprehensive meta-study on life cycle CO<sub>2</sub> emissions in the mobility sector on behalf of the Research Association for Internal Combustion Engines (FVV). Dr. David Bothe, Associate Director at Frontier Economics and Dietmar Goericke, Managing Director of the FVV classify the results and explain what lessons can be learned for research and development.

**MTZ** \_ Dr. Bothe, you have carried out a meta-study of more than 80 individual studies on life cycle CO<sub>2</sub> emissions from vehicles. Can you give us a brief summary of the results?

**BOTHE** \_ The study itself is already a summary, but I think it is possible to identify a number of messages from it. The first key message is that if we want to choose a sustainable technology for powertrains

which will be CO<sub>2</sub>-neutral in the long term, it is absolutely essential for us to carry out a global, cross-sectoral analysis of the entire life cycle of vehicles. Otherwise we will not have sufficient data to be

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As a post-doc, he was a researcher and consultant at the Institute of Energy Economics (EWI) at Cologne University, where he lectured on energy and environmental economics until 2008.

Bothe has been working intensively on the impact of the green energy transition and climate targets on the energy and mobility markets. He joined Frontier Economics in 2008, has been associate director since 2016. He regularly advises businesses, industry associations and public authorities in Western and Central Europe on economic, regulatory, strategic and environmental policy issues.



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able to make the right choice. The second key message, which is made clear by the available data, is that there is no single technology that is superior to the others. Across the different technologies it is only the place and time of the emissions that vary. All the powertrain options have a similar level of emissions over their entire life cycle. If we look to the future, it may ultimately be possible for all powertrains to become CO<sub>2</sub>-neutral. That is just as true for combustion engines as it is for electric drives. There is not one technology that stands out from all the others. The third message is the conclusion that can be drawn from the study. It is clear that we can achieve CO<sub>2</sub>-neutral mobility by using a wide range of different technology options. This is a major opportunity that opens up a number of possibilities. The important thing is for political policies to be introduced that actively allow for and promote this variety of technologies. We need to ensure that the competition between the technologies is fair, in particular across the different applications and areas. This will enable the technology that is most efficient in terms of CO<sub>2</sub> to become most widely used. We need the variety and we must continue working with all the technology options. One other important but also difficult message is that we have to consider the return on investment. We have a global total CO<sub>2</sub> budget available to us before we reach the 1.5 °C limit for global warming. We need to work out how we can make the best possible use of this

budget to create a CO<sub>2</sub>-neutral economy. Solutions based on existing infrastructures will play a particularly important role. In the transport sector these include, for example, liquid fuels, where the infrastructure is already in place and we do not need to generate CO<sub>2</sub>-emissions to build a new one.

**The CO<sub>2</sub> budget you have referred to is 12.5 years. This is the elapsed time until we reach the temperature increase of 1.5 °C if our emission levels remain the same. How is this period calculated?**

## “All powertrains can become CO<sub>2</sub>-neutral”

**BOTHE** \_ This is not a new figure and we are not the first people to refer to it. But I do believe that it is one of the central factors which is often overlooked. Essentially it is the simple result of the fact that fossil CO<sub>2</sub> which has been emitted remains in circulation. When we talk about protecting the climate, we must include total amount of fossil CO<sub>2</sub> that has yet to be emitted. The key consideration is the accumulated emissions. The Intergovernmental Panel on Climate Change has calculated this budget in different models and compared it to a business-as-usual scenario for global emissions to come up with such a period, which is the amount of time that we can continue as normal before reaching the

1.5 °C limit. This budget-reference may appear to be an innovative approach because in our political objectives in particular we focus specifically on annual figures. This is a mistake. It is not about reducing the emissions for 2030 by the end of 2030, but about the cumulative emissions produced in order to achieve this reduction.

**Is it not possible to extend the budget? For example by storing CO<sub>2</sub>?**

**BOTHE** \_ As part of all the efforts to reduce the impact of climate change, Carbon Capture and Storage (CCS) and, on a less high-tech level, reforestation are being considered, but these were not relevant for our study.

**Each of the more than 80 individual studies that you referred to was produced on behalf of a client. This makes it highly likely that they were heavily influenced by the client's wishes. How meaningful can the results of your overall study be in the light of this?**

**BOTHE** \_ We have, of course, focused primarily on scientific studies that follow academic standards and therefore we expect them to be unbiased. It is often the case that studies funded by a specific client, and Frontier carries out studies of this kind too, are suspected of showing bias. I do not think that is the case with the majority of studies. However, the conditions under which certain analyses are produced always reflect a specific perspective or research interest. This means that some aspects



"It is not about reducing the emissions for 2030 by the end of 2030, but about the cumulative emissions produced in order to achieve this reduction," says Bothe

are weighted more heavily than others, depending on the subject matter. But that is precisely the appeal of a meta-analysis. We do not evaluate the studies beforehand. Instead we make a neutral comparison of their results. The quantity and the distribution of the results speak for themselves and this is what we evaluate. It enables us to find out where there are major clusters around a key result and where there is a broad spread. We can also identify whether certain statements relate to the basic conditions or the underlying assumptions. We also look closely at this, which means that certain aspects of

the studies are evaluated very differently. This is informative and also represents a special feature of our study. We have investigated a large number of individual opinions to determine their joint relevance to the results.

**Are 80 studies enough to ensure that the meta-level is meaningful? The more data you have, the more accurate the results are.**

**BOTHE** \_ We have rarely carried out a more comprehensive evaluation. You are referring more to statistical questions where random samples are taken and the extent to which they are representative of the population is analyzed. We are not

attempting to identify statistical errors. Instead we are trying to represent the entire bandwidth of the scientific studies. We could probably have achieved this with even a smaller selection.

**As part of your study, you have also looked at the calculation of emissions levels. At the moment, the legislation is based on a well-to-wheel calculation. How can we make it clear to politicians that we need to use a life cycle analysis instead?**

**BOTHE** \_ Under the terms of the fleet regulations, carmakers are required to use the tank-to-wheel calculation. At the same time, the fuel manufactur-

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ers have to work on a well-to-tank basis. This involves major risks, such as the possibility of the wrong incentives being offered or different areas of the system making plans to move in different directions. Using well-to-wheel calculations would represent a big step forward. The next obvious step would be the introduction of the life cycle analysis and an even broader perspective. Some technologies produce low levels of emissions during the consumption phase but much higher levels during production. It should be clear to everyone that the framework we need to put in place is the one which will ultimately allow us to reduce our net CO<sub>2</sub> emissions. It does not matter where and when fossil emissions are produced. We believe that if we highlight these interconnections, this fact will become more widely accepted.

**Why is the life cycle analysis not yet being used?**

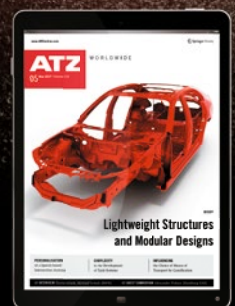
**BOTHE** \_ My theory is that it simply runs counter to the nature of current political processes and responsibilities. We need so-called sector coupling on the energy side, but also from a political perspective. At the moment, the individual sectors are working toward micro-targets. This will not function on a global scale. On a local level the targets are encouraging everyone to take a blinkered approach to achieving their goals, but this does not fulfil the requirements of the feedback mechanism and the interconnections in a global energy and carbon system.

**Dietmar Goericke, what did the FVV expect from the meta-study?**

**GOERICKE** \_ The FVV (Research Association for Combustion Engines) does not play a political role and has no intention of doing so. Our mandate is not to represent the interests of the industry in the political arena. That would go beyond our remit as a research association. Our aim with the study was to make it clear both inside and outside the industry that we should not let ourselves be carried away by the current hype about electric mobility. Because of the diesel scandal, the industry has only been able to comment in parts on developments over the last four years and has been focusing on its imminent 95 g target. As a result, it has been taking a very short-term view of the situation. The investments in electric vehicles have to pay for themselves, the

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market needs to take off and the related problems are being played down. The charging infrastructure is a huge problem and even installing a charging point in every underground garage is not a solution. It is just that it all sounds very good. For us, it was important to make it clear that this is not yet the end of the combustion engine. Of course, we are still focusing on Germany and on Europe. But it is obvious that China is changing direction. The combustion engine does have a chance if it is made CO<sub>2</sub>-neutral under specific conditions. It is not the engine that is the problem, but the fuel. We want to put the discussion back on a rational footing and we can only do this with the help of facts and a strong community that will support us and fight alongside us. As things currently stand, hardly anyone is doing that. In principle, e-fuels do not present a major technical problem. But they are being analyzed to death on the basis of their efficiency. None of the major carmakers has yet stood up and said: "This is what we want!" That is in effect the main problem.

**But we cannot simply go on as before.**

**GOERICKE** \_ No, of course not. The lesson for the powertrain developers is to cover all the options and to make all of them market-ready. In addition, the coronavirus crisis has highlighted how important

## "This is not yet the end of the combustion engine"

it is to have a robust network of suppliers. If the smaller companies, which are only responsible for parts of the system, disappear from the market, the entire supply chain will collapse. If some of our valve components and fuel injection systems come from China because no one in Germany makes them any longer, then we have a genuine problem.

**What is the situation like in the research sector? You are five or six years ahead.**

**GOERICKE** \_ Yes, we have to be, because our research is pre-competitive. Short-term research is always product-oriented and that is not what we do. We try to identify alternatives that no one else has thought of. Even large companies have

cut back heavily on their pure research activities and in some cases integrated them into advance development and production. Independent research of the kind that used to take place in the past has almost disappeared. Even at the universities, the subject of engine research is not exactly fashionable and the professorships are under widespread discussion. People are interested in a systemic approach and in complete systems. This is important, because we need sector coupling in the research field too. Subjects such as hydrogen, virtual engine development, Industry 4.0 and digital twins are of huge significance. This is where we can make a valuable contribution.

**Which technologies do you believe are the most effective way of reducing emissions of climate gases?**

**BOTHE** \_ The analyses show that all the technologies have the potential to be green. Economists are always interested in efficiency, but in economic efficiency, not necessarily physical. Combustion engines in particular have a long-term future across all the scenarios because there are often no alternatives or because moving to a different technology would not make sense in terms of the

CO<sub>2</sub> budget. In this case technologies that may have higher physical conversion losses could still be the best choice from a systemic perspective, because they can function most effectively with the existing infrastructure or with the overall system. I will refrain from mentioning a specific technology here, but I would like to emphasize that we need a mix. And the combustion engines that we have been talking about combined with liquid fuels, which in future will be renewable, have an obvious and important part to play in the overall technology mix across all the major energy scenarios that we and others have been working on.

**GOERICKE** \_ I can only confirm what David Bothe says. I think that one response from the industry must be to cooperate much more closely. We need to exploit economies of scale. No single company can make the investments needed to investigate all the options.

**Dr. Bothe, Mr. Goericke, thank you very much for the interesting insights.**

**INTERVIEW:** Marc Ziegler

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"The lesson for the powertrain developers is to cover all the options and to make all of them market-ready," says Goericke





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