



E-fuels: Niche solution for passenger cars – high demand in other sectors

- The potential use of synthetic fuels (e-fuels) in the transport sector has been a controversial discussion topic for several years. Both proponents and opponents of e-fuels have arguments on their side. In our view, weighing up these arguments suggests that regulation should *a priori* allow for technological openness so that Hayek's "competition as a discovery procedure" is possible in the first place.
- E-fuels could be a solution for some applications in passenger car transport that are not (well) served by battery electric cars (BEV). They could help reduce CO₂ emissions from new and existing vehicles. The biggest challenges for the use of e-fuels lie in availability, still-high costs and the low energy-conversion efficiency.
- Even if BEVs soon become established in the mass market in the EU, the need for climate-friendly liquid fuels in other sectors is clear. These include aviation, sea and inland shipping. In addition, pure battery-electric drives are likely to reach their limits in the foreseeable future in heavy-duty transportation, large construction machinery, agricultural equipment, and military vehicles. We believe that it therefore makes sense to support technical progress in the field of e-fuels. German companies could contribute their expertise in engineering, and countries with favourable climatic conditions for renewable energies could generate local added value.

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The potential use of synthetic fuels (e-fuels) in the transportation sector has been the subject of controversial debate for several years. In March, the Council of Ministers in Brussels voted on the final version of the new regulation on CO₂ limits for new passenger cars. From 2035, new registrations of cars and light commercial vehicles are only allowed if they emit zero CO₂. In this context, the regulation classifies battery electric vehicles (BEVs) as zero-emission vehicles, regardless of the CO₂ emissions in the electricity generation. This legislative move towards e-mobility has therefore often been viewed in the public debate as a ban on the internal combustion engine (ICE). Under current legislation, new cars with ICE may only be registered from 2035, if the fuels are 100% emission-free along the entire value chain. This includes, for example, the transportation of the fuels. It remains to be seen how this 100% mark will be defined and whether and how e-fuels can achieve it.

Climate-friendly synthetic fuels based on renewable energies (e-fuels) belong to the so-called PtX-technologies (Power-to-X). They are considered climate-neutral



because the carbon used to produce them is taken from the atmosphere. Thus, they go beyond the first-generation biofuels available today, which are blended with gasoline and diesel. In the debate in March, Germany in particular argued that e-fuels should be allowed as an option alongside BEVs after 2035. One of the arguments was the claim for technological openness. As with many energy and climate policy issues, the debate is often highly emotional. In the following, we will outline the pros and cons of the future use of e-fuels in the passenger car sector and beyond. It becomes clear that both proponents and opponents of e-fuels have arguments on their side. Weighing up the arguments, we believe that regulation should *a priori* support technological openness to allow for Hayek's "competition as a discovery procedure" to become possible.

E-fuels could offset disadvantages of battery electric cars

Let's take a look at the (potential) advantages of using e-fuels in passenger cars and light trucks. They result in part from the (current) weaknesses of BEVs. For example, synthetic fuels could be used to cover long travel distances, similar to gasoline or diesel passenger cars. Refuelling would also take only a few minutes. A major advantage of e-fuels would also be that large loads could be transported or towed over longer distances. This is particularly relevant for light commercial vehicles, which sometimes travel several hundred kilometres per day with a substantial payload. According to the Federal Motor Transport Authority, there are more than 3.1 m commercial vehicles in Germany with a gross vehicle weight of up to 3.5 tons – hardly a niche market. Consider also caravans for vacation trips, which today are mostly pulled by cars with internal combustion engines; there are almost 757,000 of them in Germany.

With e-fuels, the current infrastructure of fuelling stations and other facilities for transport and storage of liquid fuels could still be used. They could also be used in the existing fleet of cars with internal combustion engines, reducing CO₂ emissions from currently operating vehicles. This could even be achieved gradually by blending fossil fuels with e-fuels, as with biofuels today.

Need for e-fuels in some sectors is clear

Irrespective of the question of whether and to what extent e-fuels can be used in the passenger car sector in the future, it is clear that synthetic fuels are needed for a climate-friendly transport sector. This is true wherever direct electrification is technologically impossible or uneconomical – including aviation, where research is underway to develop "sustainable aviation fuels", as well as maritime and inland waterway transport. In addition, pure battery-electric drives are likely to reach their limits in the foreseeable future in heavy-duty transportation, large construction machinery, agricultural equipment, and military vehicles. This argues for the promotion of technological progress in synthetic fuels. What needs to be explored is which processes and in which countries e-fuels could be produced cost-effectively and in large quantities. After all, a major advantage of e-fuels is that they should be easy and inexpensive to transport. German companies could contribute their expertise in engineering, and countries with favourable climatic conditions for renewable energies could generate local added value.¹

¹ See IW Cologne and Frontier Economics (2018). Synthetische Energieträger – Perspektiven für die deutsche Wirtschaft und den internationalen Handel.

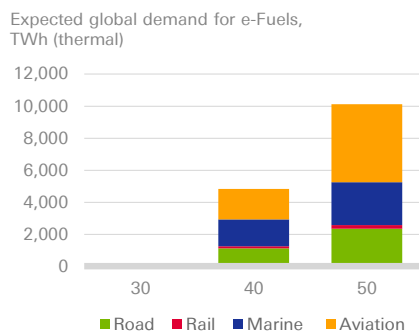


Availability problem decisive – technical and economic questions remain

The (potential) benefits of e-fuels are counterbalanced by a number of economic and technical issues. From an economic standpoint, the availability of e-fuels is the major problem. The expected demand for synthetic fuels (including green hydrogen) from hard-to-electrify sectors alone (in addition to aviation and shipping, there are industrial sectors such as the chemical industry or metal manufacturing) is projected to exceed supply many times over for the foreseeable future.² Electricity from renewable sources used to produce e-fuels cannot satisfy the increasing demand in other fields (heat pumps, e-mobility, electrified industrial processes, etc.). As overall electricity consumption is expected to increase, this competitive situation will not be easy to resolve. In addition, e-fuels production facilities would ideally need to run around the clock to achieve economies of scale. However, this is difficult to achieve with weather-dependent renewables. In sum, from today's perspective, it is not realistic to meet a broad demand for e-fuels for passenger cars.

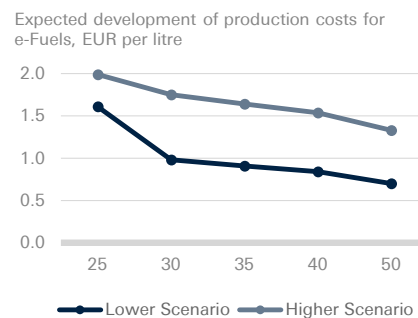
Another problematic element is the high cost of e-fuels. That said, current production costs do not necessarily provide a useful indication due to low volumes and the early stage of development of the technology. The range of predictions for future costs in the relevant literature is wide. In an optimistic scenario, the eFuel Alliance expects production costs of less than EUR 1 per litre³ in 2030, while the Potsdam Institute for Climate Impact Research (PIK) predicts production costs of around EUR 2 per litre in the medium term. These estimates do not include taxes and levies and are approximately 200% and 400% higher than the current production costs of gasoline, respectively. In the long term, both sources expect production costs to fall substantially to ideally 70 cents per litre (eFuel Alliance) and EUR 1 per litre (PIK). However, there is considerable uncertainty about the timing of cost reductions.

Figure 1: Aviation and shipping drive global demand for e-fuels



Source : dena

Figure 2: Declining production costs expected



Source : eFuel Alliance

A major technological problem – and a key reason for e-fuels' high price tag – is low energy-conversion efficiency. Currently, only about 12% of the renewable electricity used to produce e-fuels actually reaches the powertrain of a passenger car. This compares to 86% for BEVs, if powered by renewable energies.⁴ However, there is reason to hope that the efficiency factor of e-fuel use can be increased

² Cf. PIK (2023). E-Fuels - Aktueller Stand und Projektionen.

³ Cf. eFuel Alliance (2023). Costs and Outlook.

⁴ Cf. Dechema (2017). E-Fuels – Mehr als eine Option.



through technological advances. The Karlsruhe Institute of Technology (KIT) estimates that it is possible to store up to 60% of the electricity used in synthetic fuels.⁵ Still, burning e-fuels in an internal combustion engine will lead to large transformation losses in the future; this is the inefficient part of the process.

Another technological challenge lies in providing the two feedstocks needed to produce e-fuels: hydrogen and carbon. Water is often a scarce resource, especially in sunny regions where conditions are good for photovoltaics. Desalination plants are a promising solution but are energy-intensive and produce environmentally damaging by-products. Carbon can be extracted from the atmosphere using a process called Direct Air Capture (DAC). However, because of the low levels of CO₂ in the atmosphere, this process is also energy intensive and costly.

Battery and e-fuels: Complements rather than substitutes

A comparison of the advantages and disadvantages of e-fuels and battery-electric drives suggests that they may be complements rather than substitutes for one another. In terms of technology, it is likely that BEVs will be able to handle large parts of day-to-day passenger car use. However, for vehicles with high payloads or vehicles that regularly pull heavy loads, battery-electric drives may reach technological and economic limits or not be accepted by customers. As noted above, there is little doubt that high energy density liquid fuels will continue to play a role in aviation and shipping for a long time to come – and possibly in other sectors as well. In these hard-to-electrify sectors, e-fuels could help reduce CO₂ emissions, both as a substitute for fossil fuels and through blending.

For the automotive sector, e-fuels offer the potential to fill a niche. The option should not be ruled out *a priori*, especially in the spirit of the often politically postulated openness to technological developments. Neither car manufacturers nor suppliers or other players will be forced to provide ICEs or e-fuels for the EU market. In the competition between technologies, companies can decide for themselves which options to pursue. As far as the CO₂ balance is concerned, it is clear that BEVs will not be climate neutral on EU roads for many years to come. This is because fossil fuels will still play a major role in the electricity mix.

As climate-friendly liquid fuels will be needed for a number of applications in the future, we believe that government support for research and development in this area is vital. Cooperation with countries that have good climatic conditions for renewable energy is also essential. It is true that global renewable energy capacity continues to expand. However, as demand for electricity continues to rise as well, we are still a long way from having a permanent surplus of renewable electricity. E-fuels are therefore likely to be deployed only where direct electrification is not possible due to high costs and low availability.

Final remarks

Many of the arguments for the use of green hydrogen in energy transition also support the use of e-fuels in specific sectors. So, those who support green hydrogen should theoretically not reject e-fuels outright. In light of the risks of climate change, one should not rule out options that can be part of the solution.

We thank Julius Schumann for his valuable contribution.

⁵ Cf. Interview in Avenegy Suisse (2021). Alternative Treibstoffe – der lange Weg zum Ersatz der Fossilen.



Appendix 1

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