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Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Getting zero emission trucks on the road
From regional to long-haul

Comparing the costs and benefits of different technologies: A case study for Germany

Moritz Mottschall

HEC GoToWebinar, 2020-08-18

Our Profile

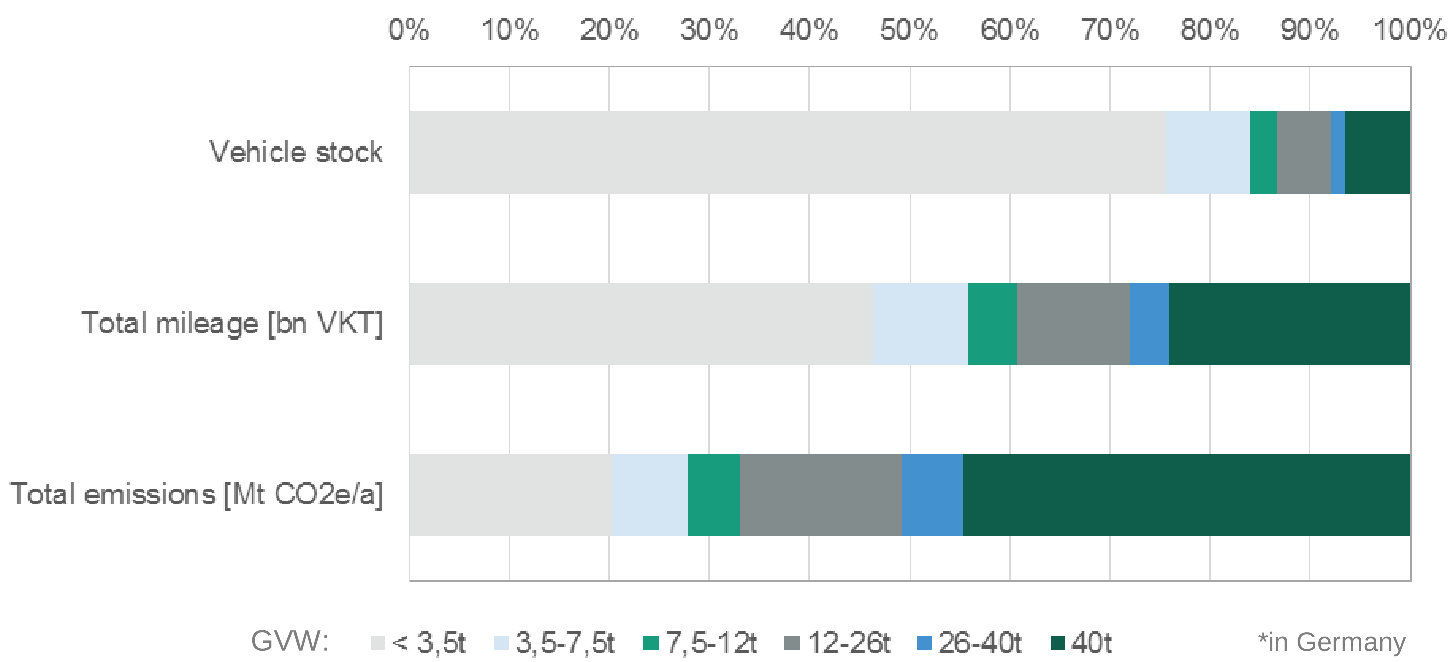
Oeko-Institut is a leading European research and consultancy institute working for a sustainable future.

- A non-profit association founded in 1977
- Offices in Freiburg, Darmstadt and Berlin
- Clients: European Union, national and state-level ministries, companies, foundations and non-governmental organizations

Decarbonisation of road freight transport: Long-haul transport of particular importance

- Light & heavy-duty vehicles responsible for about 35 % of EU transport GHG emissions
- Long-distance trucks particularly relevant in terms of GHG emissions due to high annual mileage and high fuel consumption

Vehicle stock, total mileage and CO_2 emissions of commercial vehicles*



*in Germany

Source: Fraunhofer-ISI, Öko-Institut, ifeu (2018): Alternative Drives and Fuels in the Road Freight Transport – Recommendations for Action for Germany

The challenge of zero emissions freight transport has a number of dimensions

- **GHG emissions** from road freight transport **continue to rise** in the EU
- In **regional freight transport** the **battery electric** drive is emerging as a possible solution
- In long-haul transport there is **no clear favourite** powertrain alternative to the diesel engine yet
- Long-distance transport requires **cross-border solutions**
- New propulsion technologies must enable **zero-emission** road freight transport in the **long term** – at the lowest possible economic cost

What are the propulsion and fuel options for zero emission long-haul transport?

Direct use of electricity

Battery-electric (BEV): electric drive; large battery in combination with ultra fast charger

Overhead catenary electric (OC): electric drive; electricity uptake from overhead catenary line, second drive / energy supply via hybrid powertrain **(HEV)** or smaller battery **(BEV)**

Indirect use of electricity

Fuel cell electric (FCEV): electric drive; electricity is generated in an on-board fuel cell based on hydrogen

Internal combustion engine (ICEV): conventional propulsion with hydrocarbon synthetic fuel (so-called efuel)

Excursus:
LNG as an option to reduce GHG emissions?

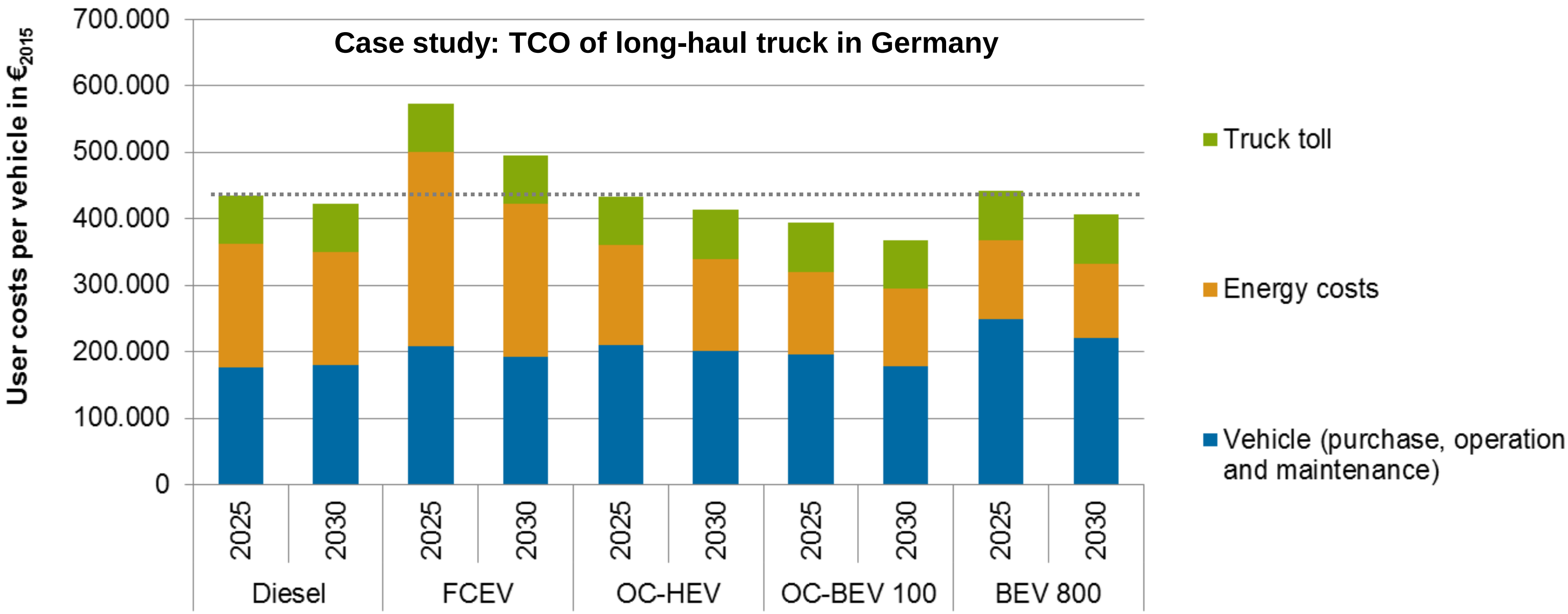
- LNG has a better CH ratio than diesel and therefore leads to lower direct CO_2 emissions (SI -5% to HPDI -20%),
- Is massively promoted in Germany (vehicle acquisition, energy tax relief, toll exemption),
- Offers the possibility to use Bio-LNG and PtG-LNG in the long term.

But

- LNG leads to high upstream GHG-emissions (e.g. production, liquefaction, transportation).
- The use of fossil LNG leads to no or only a small reduction in WtW emissions and, depending on the source of the LNG, can also lead to higher emissions.
- The potential for Bio-LNG and especially PtG-LNG by 2030 is very low in relation to total natural gas consumption.

Electric propulsion systems in long-haul transport offer near-term cost advantages

- Lower operating costs compensate for higher vehicle costs
- **BUT:** uncertainties remain regarding the development of technology costs, energy prices and regulatory / fiscal framework

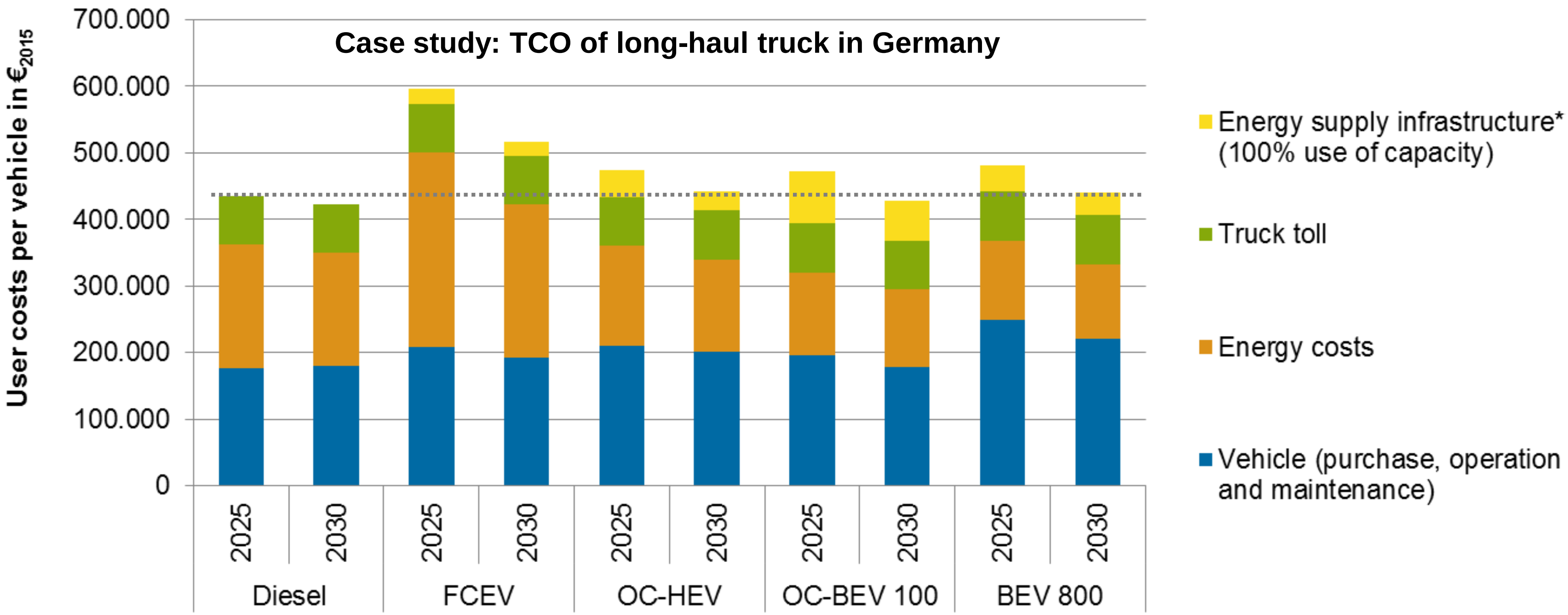


Assumptions of TCO: operation of a long-haul truck in Germany, user costs excl. VAT, 3,5% discount rate, 5 years of vehicle operation, annual mileage of 120.000 km

FCEV – fuel cell electric vehicle, OC – overhead catenary, HEV – hybrid electric vehicle, BEV 100 – battery electric vehicle 100 km electric range

Source: Öko-Institut (2018): Oberleitungs-Lkw im Kontext weiterer Antriebs- und Energieversorgungsoptionen für den Straßengüterfernverkehr. Ein Technologie- und Wirtschaftlichkeitsvergleich. Subreport of StratON project

The roll-out of alternative energy supply infrastructure needs to be pre-financed



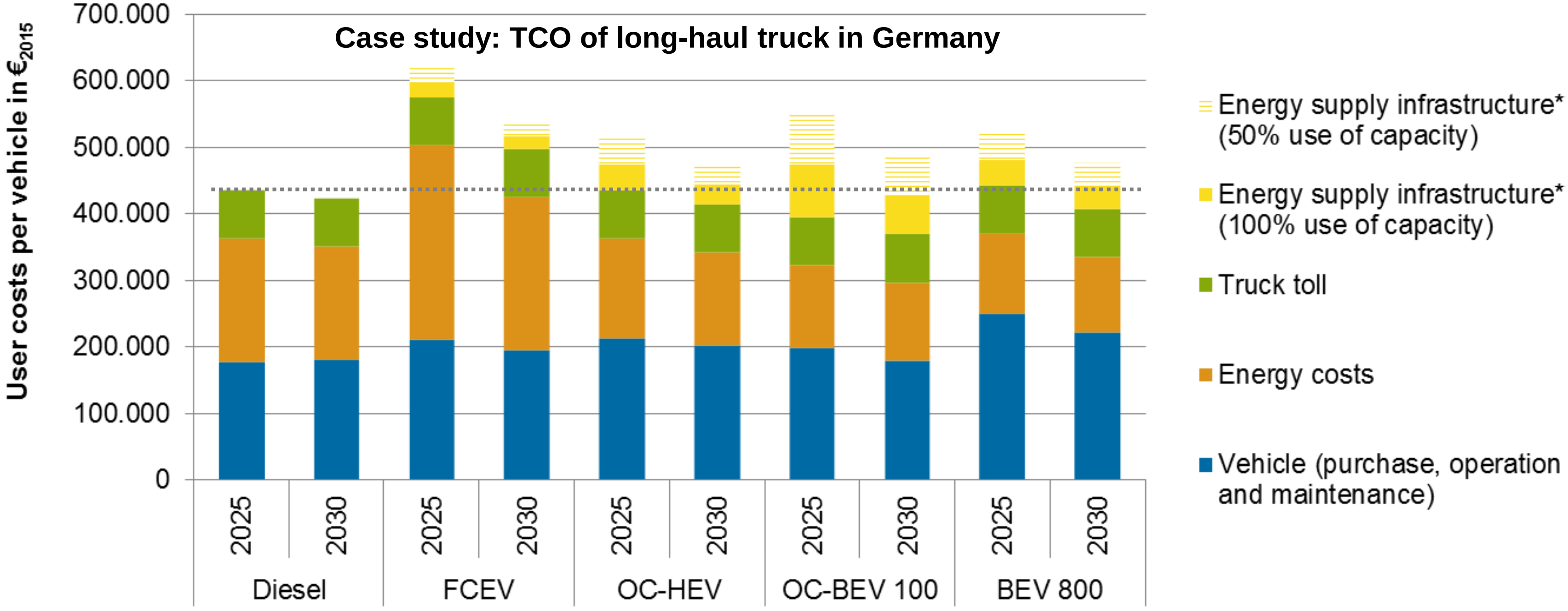
Assumptions of TCO: operation of a long-haul truck in Germany, user costs excl. VAT, 3,5% discount rate, 5 years of vehicle operation, annual mileage of 120.000 km

*Energy supply infrastructure: hydrogen filling station, overhead line system or station-based charging infrastructure

Source: Öko-Institut (2018): Oberleitungs-Lkw im Kontext weiterer Antriebs- und Energieversorgungsoptionen für den Straßengüterfernverkehr. Ein Technologie- und Wirtschaftlichkeitsvergleich. Subreport of StratON project

The roll-out of alternative energy supply infrastructure needs to be pre-financed

- Availability of energy supply infrastructure is key to market ramp-up of alternative drives
- If early users fully carry infrastructure cost, this will hinder economic operation



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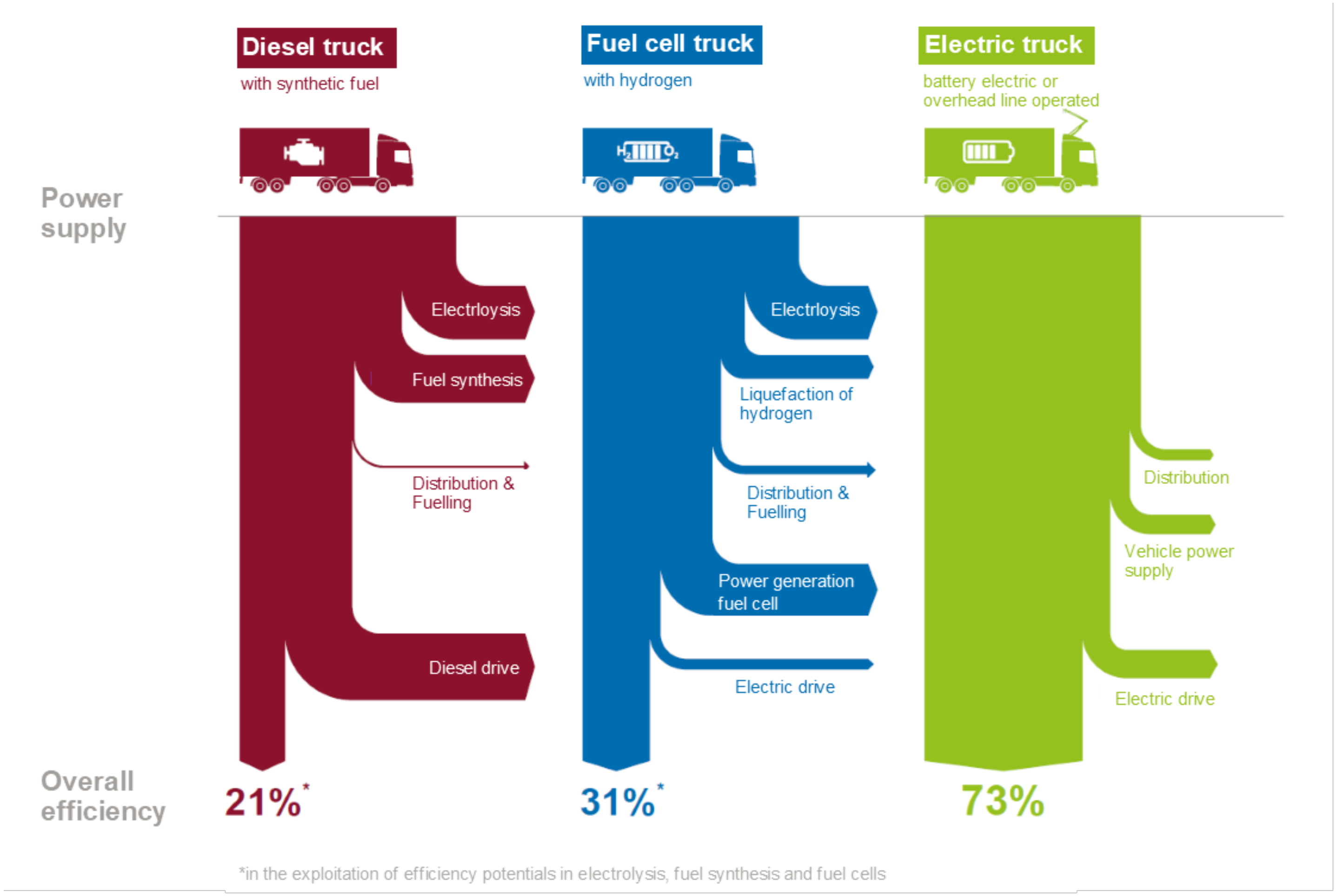
Direct use of electricity is by far the most energy efficient option for climate-neutral long-haul HDV operation

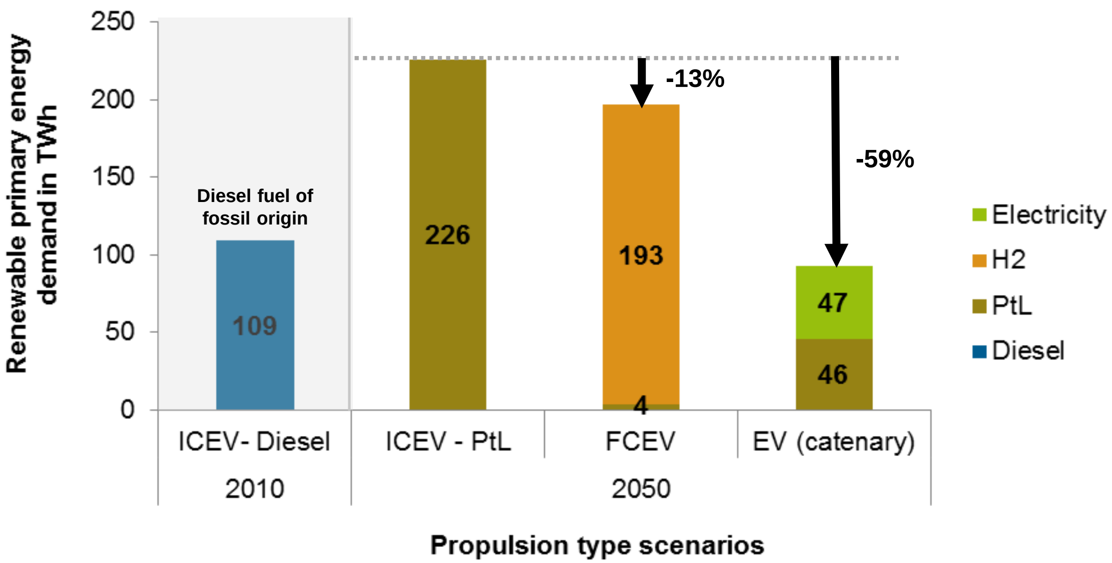


Source: own illustration, Oeko-Institut (2020)

Decarbonisation of the freight transport sector by 2050: Demand of renewable energy depends on propulsion system

- Decarbonisation of long-haul freight transport requires high amount of renewable energy
- Highest energy efficiency for direct use of electricity results in lowest additional demand
- Use of synthetic fuels (PtL, H_2) requires energy imports
- Use of synthetic fuels must be combined with sustainability criteria at an early stage

Case study: Decarbonisation of German long-haul freight transport



Net electricity generation from renewable energies in Germany 2017: **210 TWh**

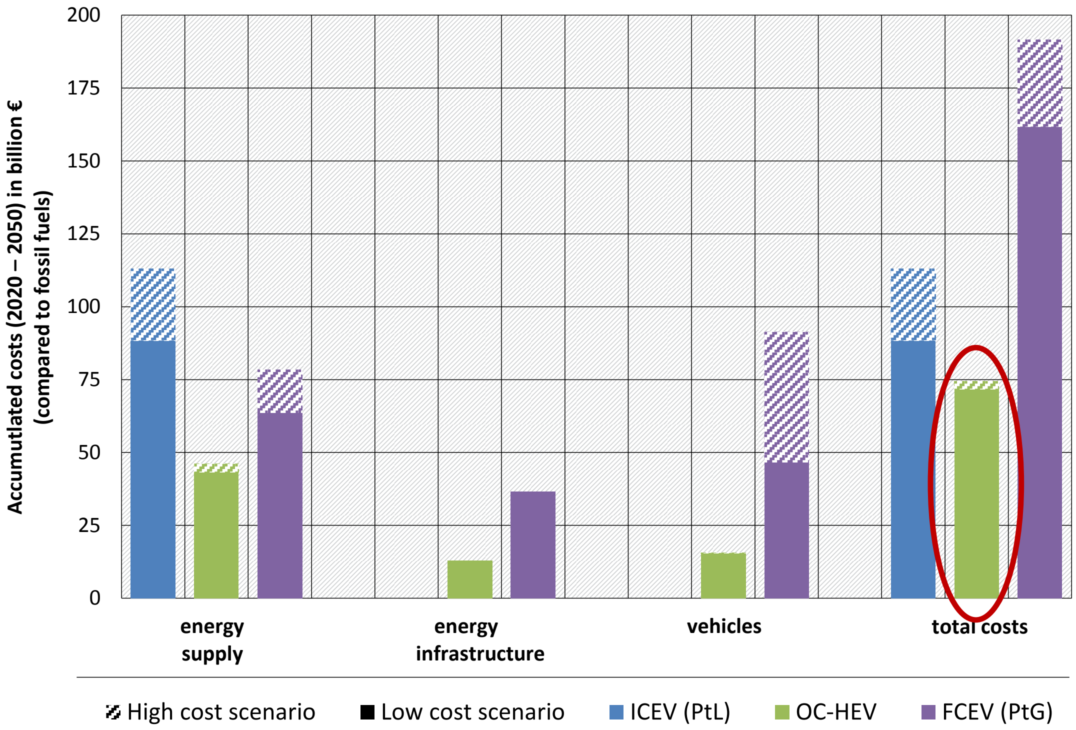
Scenario assumptions:

- All scenarios: complete decarbonisation of long-haul freight transport
- **ICEV – PtL:** Diesel replaced by imported synthetic fuel based on renewable energy –> WTT efficiency: 49%
- **FCEV:** imported hydrogen (electrolysis, liquefaction and transport) → WTT efficiency: 48%
- **EV (catenary):** OC-vehicles with 75% electric mode and 25 % conventional mode (PtL); WTT efficiency of electricity: 85 %

Source: Own illustration based on Öko-Institut et al. (2016): Erarbeitung einer fachlichen Strategie zur Energieversorgung des Verkehrs bis zum Jahr 2050. Study commissioned by the Federal Environment Agency (UBA)

Overall costs of carbon neutral road freight transport until 2050: energy costs of particular importance

Case study:
Decarbonisation of German long-haul freight transport



Source: Öko-Institut et al. (2016/2019): Erarbeitung einer fachlichen Strategie zur Energieversorgung des Verkehrs bis zum Jahr 2050. Study commissioned by the Federal Environment Agency (UBA)

Overall costs of carbon neutral road freight transport until 2050: energy costs of particular importance

Case study:
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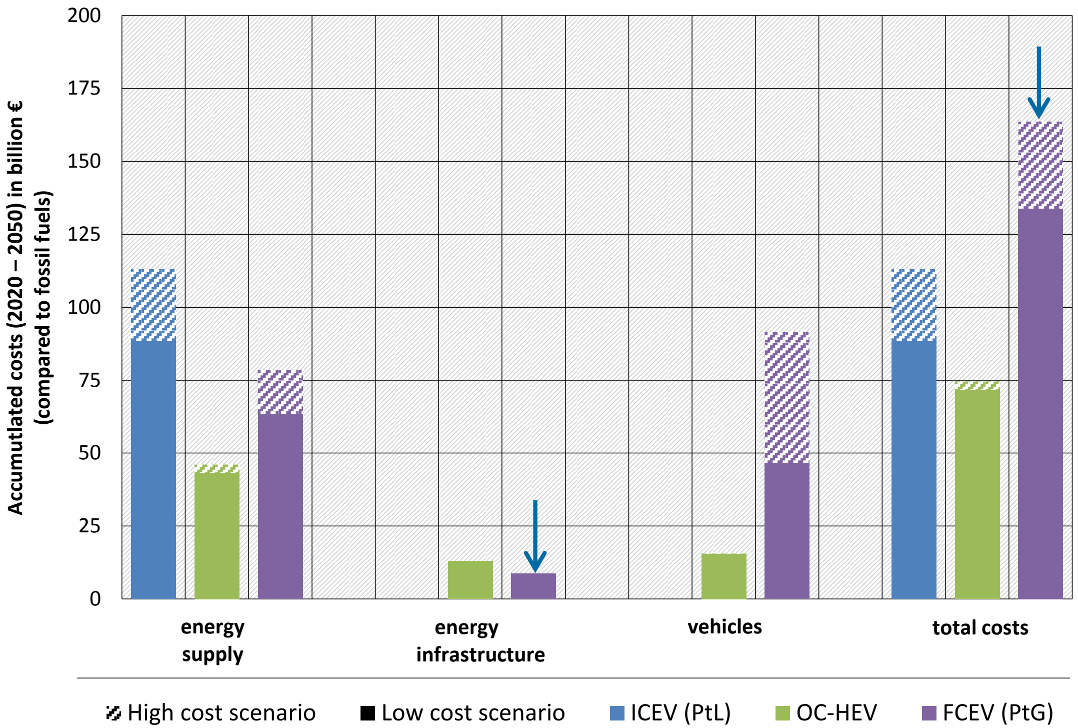
Sensitivity:

Low investment costs for H_2 infrastructure



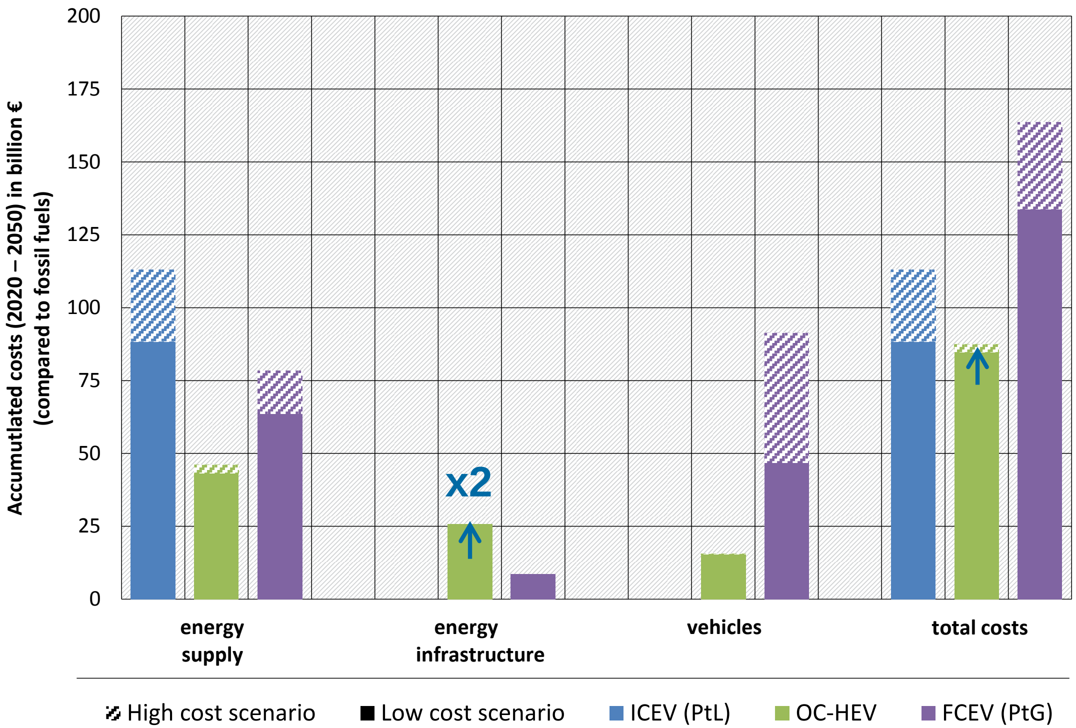
Source: Öko-Institut et al. (2016/2019): Erarbeitung einer fachlichen Strategie zur Energieversorgung des Verkehrs bis zum Jahr 2050. Study commissioned by the Federal Environment Agency (UBA)

Overall costs of carbon neutral road freight transport until 2050: energy costs of particular importance

Case study:
Decarbonisation of German long-haul freight transport

Sensitivity:

High investment costs for overhead catenary network

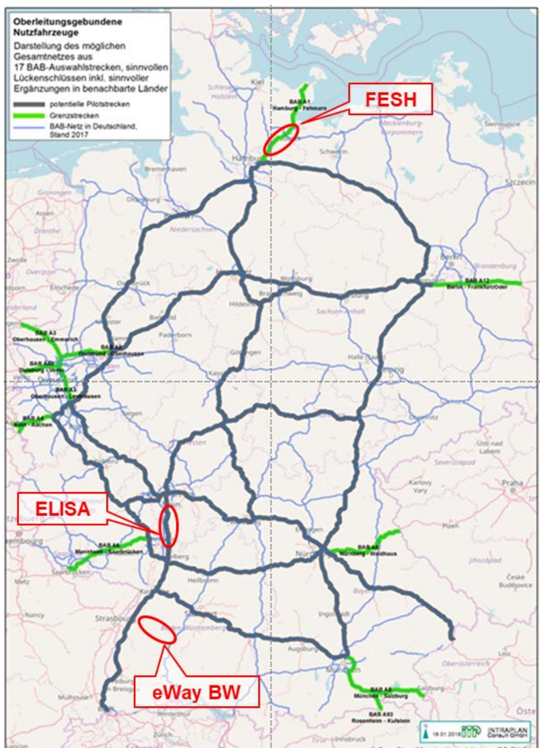


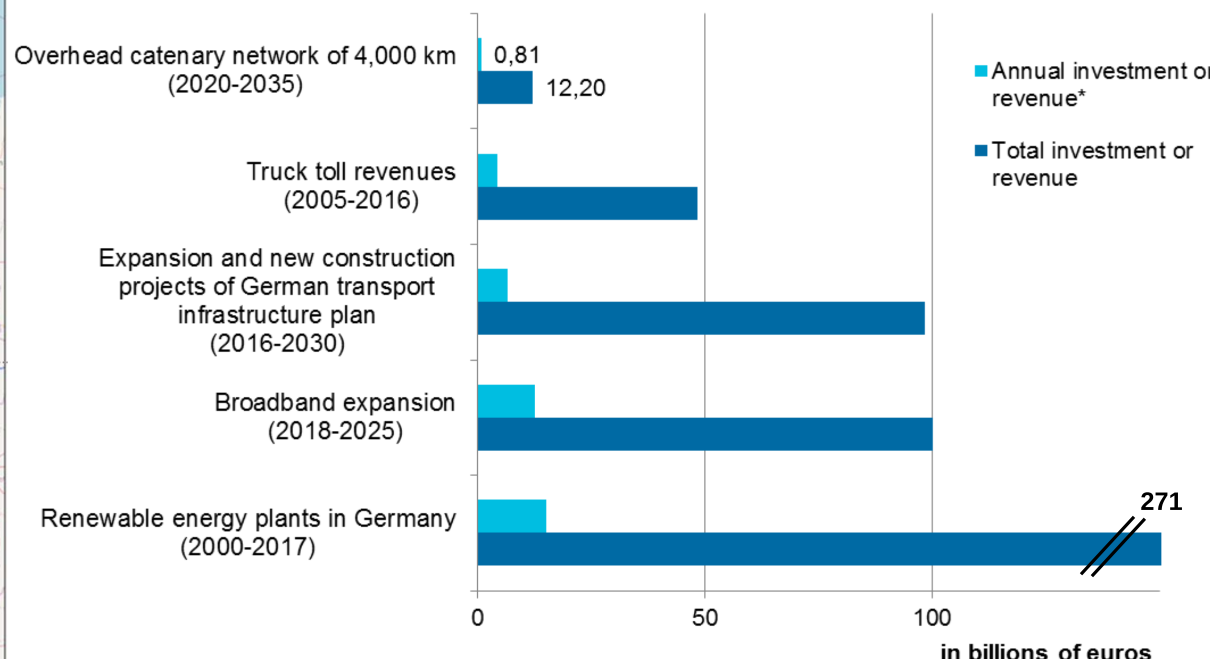
- Decarbonisation of freight transport is related to considerable economic costs
- Total costs are determined by the energy costs
- Costs of infrastructure and vehicles are less important from this perspective
- Direct use of electricity shows **robust** economic cost advantages

Source: Öko-Institut et al. (2016/2019): Erarbeitung einer fachlichen Strategie zur Energieversorgung des Verkehrs bis zum Jahr 2050. Study commissioned by the Federal Environment Agency (UBA)

Example of overhead catenary core network (4.000 km) in Germany: relatively low investment required

- All alternative propulsion systems require a reliable energy supply infrastructure
- In road freight transport, a relatively low network density along corridors could already be attractive for a variety of applications
- Investment needed is moderate compared to other expenditures for future technologies



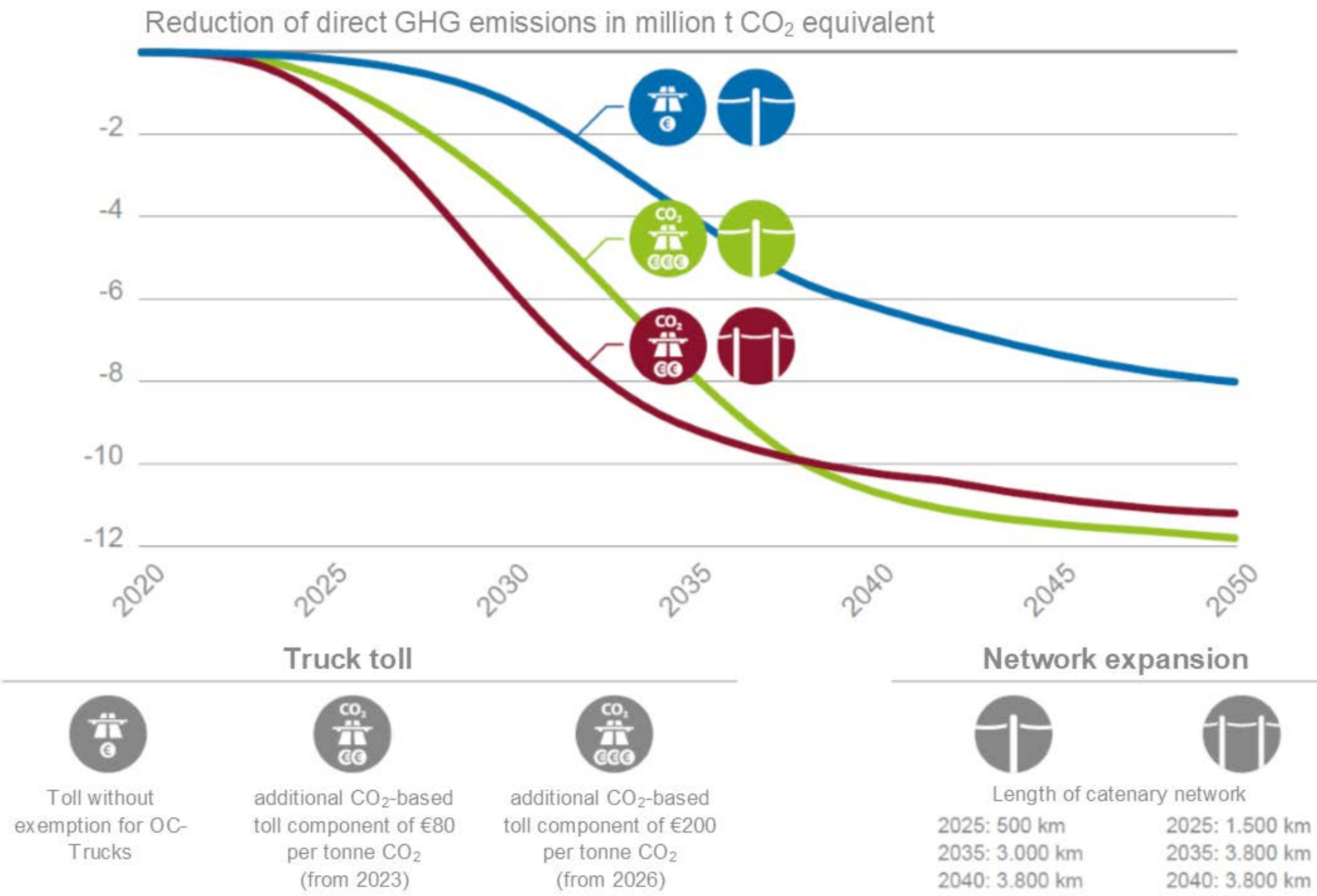


*Average annual toll revenues or infrastructure investments during the indicated period

Source: Öko-Institut (2018): Oberleitungs-Lkw im Kontext weiterer Antriebs- und Energieversorgungsoptionen für den Straßengüterfernverkehr. Ein Technologie- und Wirtschaftlichkeitsvergleich. Subreport of StratON project

Speed of infrastructure development and CO_2 pricing decisive for GHG reduction of ZE trucks – the example of OC-HDV

Three scenarios with different toll designs and network expansion rates



- Rapid infrastructure development is a key requirement for relevant GHG reduction
- CO_2-based truck toll system: establishes a **polluter pays relationship**, creates a **robust user cost advantage,** enables **infrastructure financing**

Quelle: own illustration based on Öko-Institut et al. (2020): StratON final report

Electrification of long-haul road transport: Conclusions

- **Electrification enables climate neutrality** of road freight transport
- Electric trucks **can already be operated economically** in the near future
- The **direct use of electricity is the most efficient** and requires the least expansion of renewable energies
- **Infrastructure costs** are particularly relevant in the start-up phase, but are **of secondary importance in the long term**
- The **GHG mitigation** potential is highly **dependent on** the speed of **infrastructure development**

What should happen now?
Plan of action

- **Planning security for market players:** Align freight transport policies with GHG emissions
- **Guarantee infrastructure expansion:** Develop a reliable infrastructure expansion plan and public financing of infrastructure
- **Framework conditions for the supply side:** Set minimum quota for new electric truck registrations
- **Framework conditions for the demand side:** Base truck tolls on CO_2 emissions
- **Practical experience:** Enable and promote larger implementation projects in public road space
- **International cooperation:** Initiate cross-border technology development and start standardization at an early stage

A challenging journey from today's situation to the set targets – decisive action is required!

Targets set in the German government's climate package (09/2019) for the year 2030:

One third of road freight transport performance **on the basis of electricity**

Number of electric trucks (>12 t payload) registered in Germany in 2019:

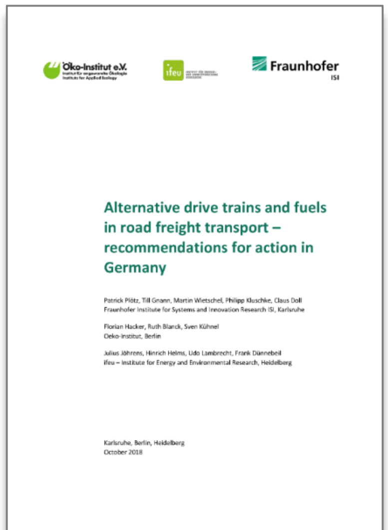
8 out of 120.000

Source: KBA (2019): Fahrzeugzulassungen (FZ) Bestand an Kraftfahrzeugen nach Umwelt-Merkmalen, 1. Januar 2019

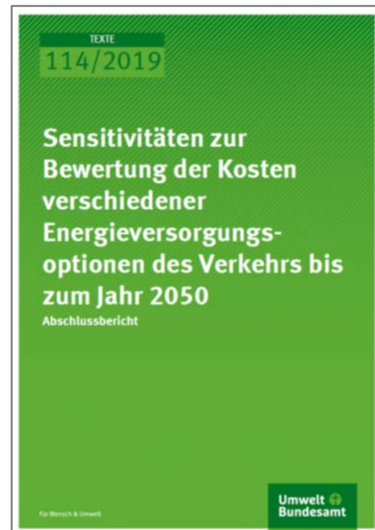
Further reading:
Recent publications of Oeko-Institut

StratON project report (09/2018)
on overhead catenary heavy-duty vehicles

Policy paper (10/2018)
on alternative drive trains and fuels for HDV



Final report (02/2019)
energy supply options of the transport sector



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Further reading:
Recent publications of Oeko-Institut

StratON final report (02/2020)
assessment of overhead catenary trucks

Final report (05/2020)
assessment of LNG trucks

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Thank you for your attention!

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