TRANSITION PATHWAYS TO DEFOSSILISE GERMANY'S ROAD SECTOR WITH A FOCUS ON THE ROLE OF TECHNOLOGIES

35th International Electric Vehicle Symposium and Exhibition (EVS35)
Oslo, Norway, June 11-15, 2022

Ines Österle, Samuel Hasselwander; DLR Institute of Vehicle Concepts
Dennis Seibert, Florian Koller, Tudor Mocanu; Institute of Transport Research

GEFÖRDERT VOM

KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie

Bundesministerium für Bildung und Forschung

DLR

AGENDA

1. Introduction
2. An introduction of the German car market
3. Analysis: Scenario modelling of the fleet development to investigate the role of technologies to de-fossilize the transport sector
4. Conclusions
5. Q&A

1. Introduction

STUDY BACKGROUND

KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

DLR

STUDY BACKGROUND

- This study was part of a comprehensive **Scenario Study**, aimed to investigate **transition pathways** to achieve climate neutrality in 2045
- It covered all sectors and deployed multiple energy, transport and integrated assessment models from different research organisations
- As part of the Scenario Study, DLR focused on the vehicle sector and investigated **major technological options** to defossilize the **car sector** in Germany

→ Focus of this presentation

- The works were undertaken as part of Ariadne – Kopernikus Projekt, **a major research project** funded by Federal Ministry for Education and Research to accompany the energy transition (“Energiewende”)
- The study is in good company; the **major scenario studies in 2021** were: BCG (2021); Consentec et al. (2021), EWI et al. (2021) and Prognos et al. (2021)

https://ariadneprojekt.de/publikation/deutschland-auf-dem-weg-zur-klimaneutralitat-2045-szenarienreport/

GEFÖRDERT VOM
KOPERNIKUS Ariadne PROJEKTE Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung

Boston Consulting Group, 2021. “Klimapfade 2.0 - Ein Wirtschaftsprogramm für Klima und Zukunft,” Study prepared for BDI;
Consentec, Fraunhofer ISI, TU Berlin, ifeu, 2021. “Langfristszenarien für die Transformation des Energiesystems in Deutschland 3,” Study prepared for the Federal Ministry for Economic Affairs and Climate Action.
EWI, FIW, ITG, Uni Bremen, Stiftung Umweltrecht, Wuppertal-Institut, 2021. “Aufbruch Klimaneutralität. Dena-Leitstudie,” Study prepared for Dena,
Prognos, Öko-Institut, Wuppertal-Institut, “Klimaneutrales Deutschland 2045,” Study prepared for Stiftung Klimaneutralität, Agora Energiewende, Agora Verkehrswende,

2. Background

THE GERMAN CAR MARKET AND OEMS' PLANS TO INTRODUCE ELECTRIC VEHICLES

KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie

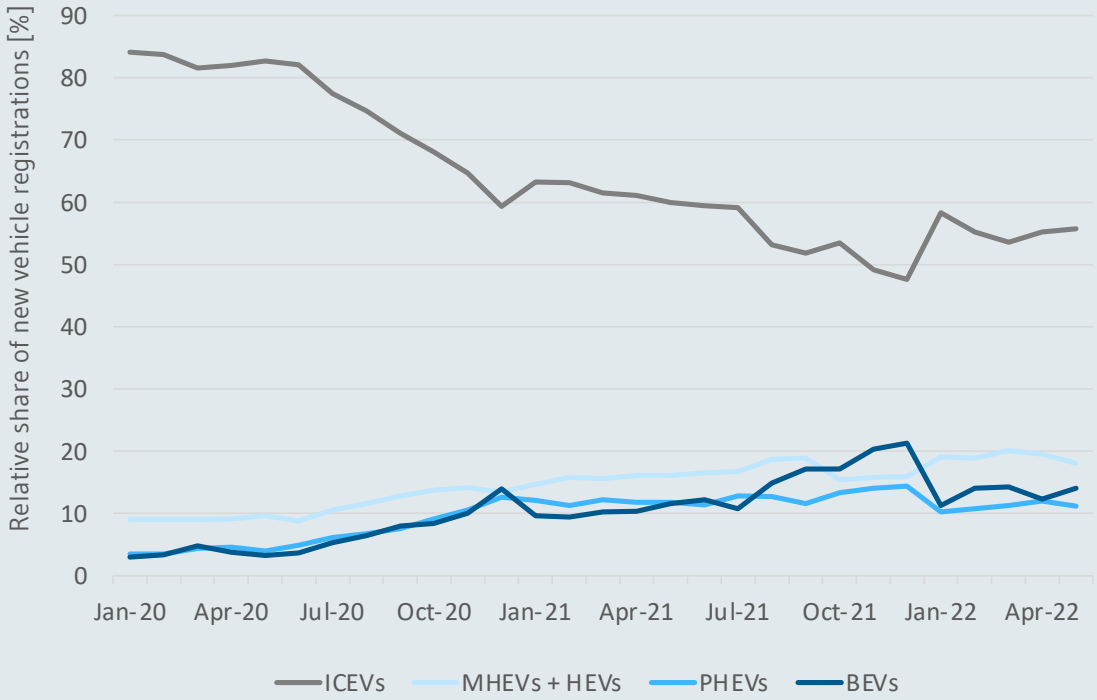
GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

DLR

CURRENT MARKET SITUATION

- EVs are rapidly gaining market shares in Germany
  - Battery-electric and plug-in hybrid vehicles have rapidly gained market share
  - At the expense of conventional vehicles
  - Sales of full hybrids and gas vehicles have stagnated
  - Fuel cell vehicles play no role in the passenger car market

Development of new vehicle registrations in Germany focussing on electrified vehicles

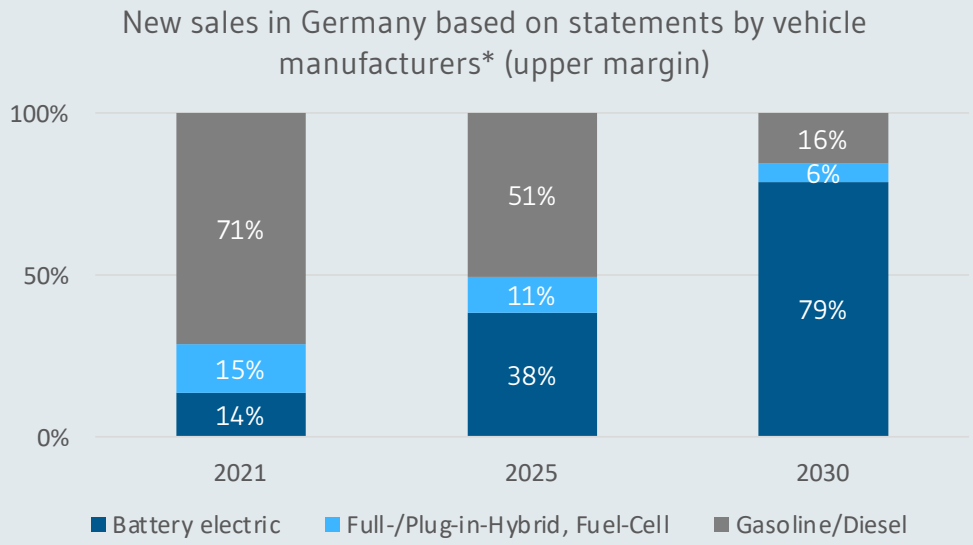


MHEV = Mild-Hybrid Electric Vehicle
HEV = Hybrid Electric Vehicle
PHEV = Plug-In-Hybrid Electric Vehicle
BEV = Battery Electric Vehicle
FCEV = Fuel-Cell Electric Vehicle

xEVs = electrified vehicles

GEFÖRDERT VOM
KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung

MARKET RAMP-UP OF ELECTRIC VEHICLES ACCORDING TO OEM PLANS



** Approx. 80% of the market covered*

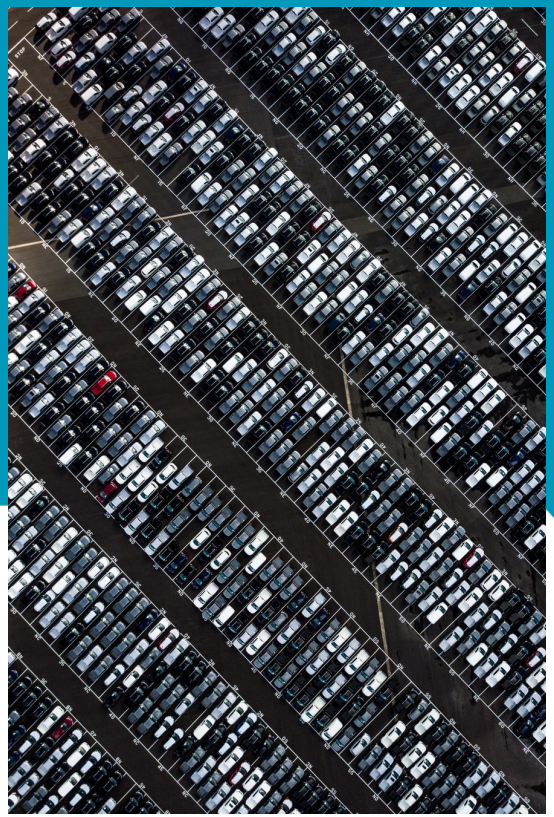
Strong focus on battery electric vehicles (BEVs). Opel, Daimler, Ford, Volvo announced to be all-electric by 2030 at the latest. FCEVs not substantially part of the product portfolio

Source: Own evaluation according to OEM announcements

MHEV = Mild-Hybrid Electric Vehicle
HEV = Hybrid Electric Vehicle
PHEV = Plug-In-Hybrid Electric Vehicle
BEV = Battery Electric Vehicle
FCEV = Fuel-Cell Electric Vehicle

xEVs = electrified vehicles

GEFÖRDERT VOM
KOPERNIKUS Ariadne PROJEKTE Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung



3. Analysis

SCENARIO MODELLING OF THE GERMAN CAR MARKET

KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

DLR

SCENARIO MODELLING
TOOL: VEHICLE TECHNOLOGY SCENARIO MODEL (VECTOR21)

VECTOR21
Scenario analysis software

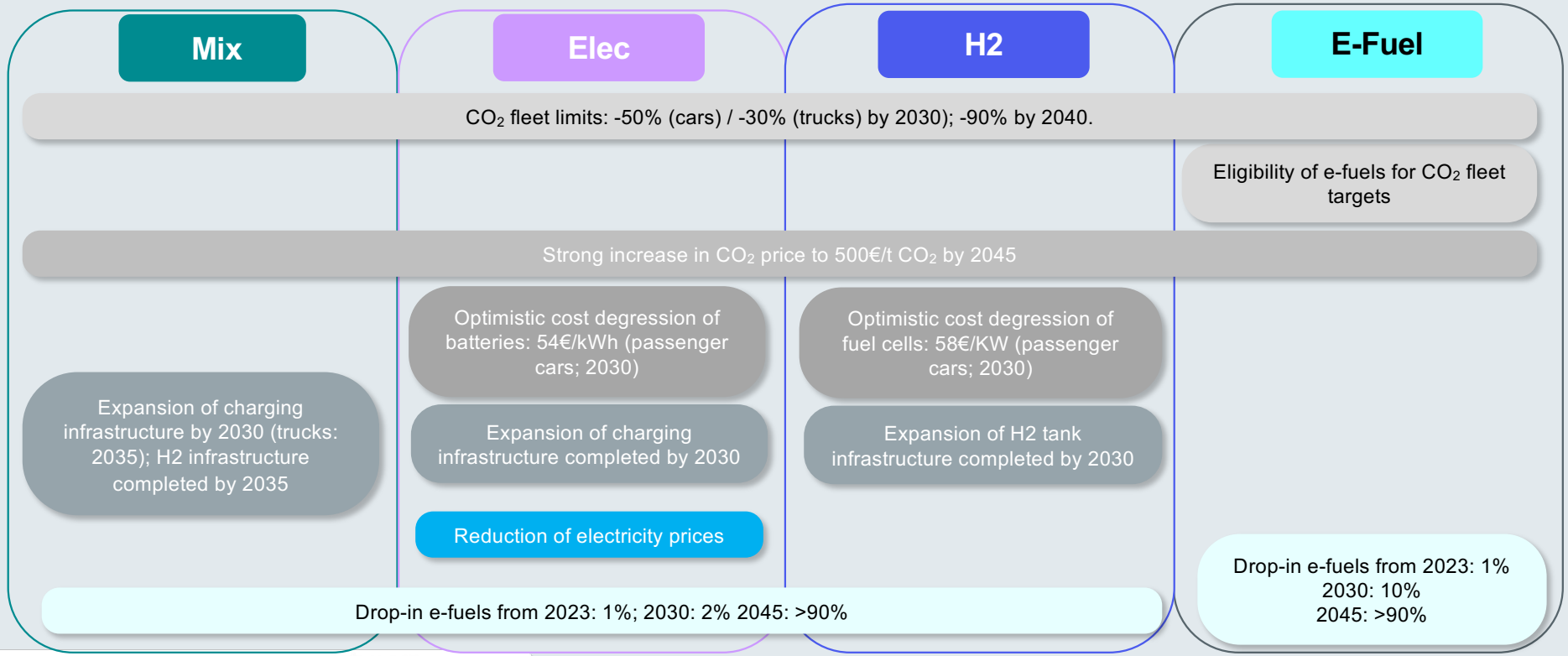
- Technology transition: important factors
  - CO_2 fleet regulation and CO_2 price
  - Purchase incentive („environmental bonus", vehicle tax exemption for e-cars, toll exemption for e-trucks)
  - Build up of refueling/charging infrastructure
  - Reduction of technology costs: vehicles
  - Transformation of fuels: e-fuels

- Technology transition: Modeling with VECTOR21 (June 2021; update April 2022)

KOPERNIKUS PROJEKTE
Ariadne
Die Zukunft unserer Energie

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

SCENARIO MODELLING
ASSUMPTIONS (JUNE 2021 RUN)

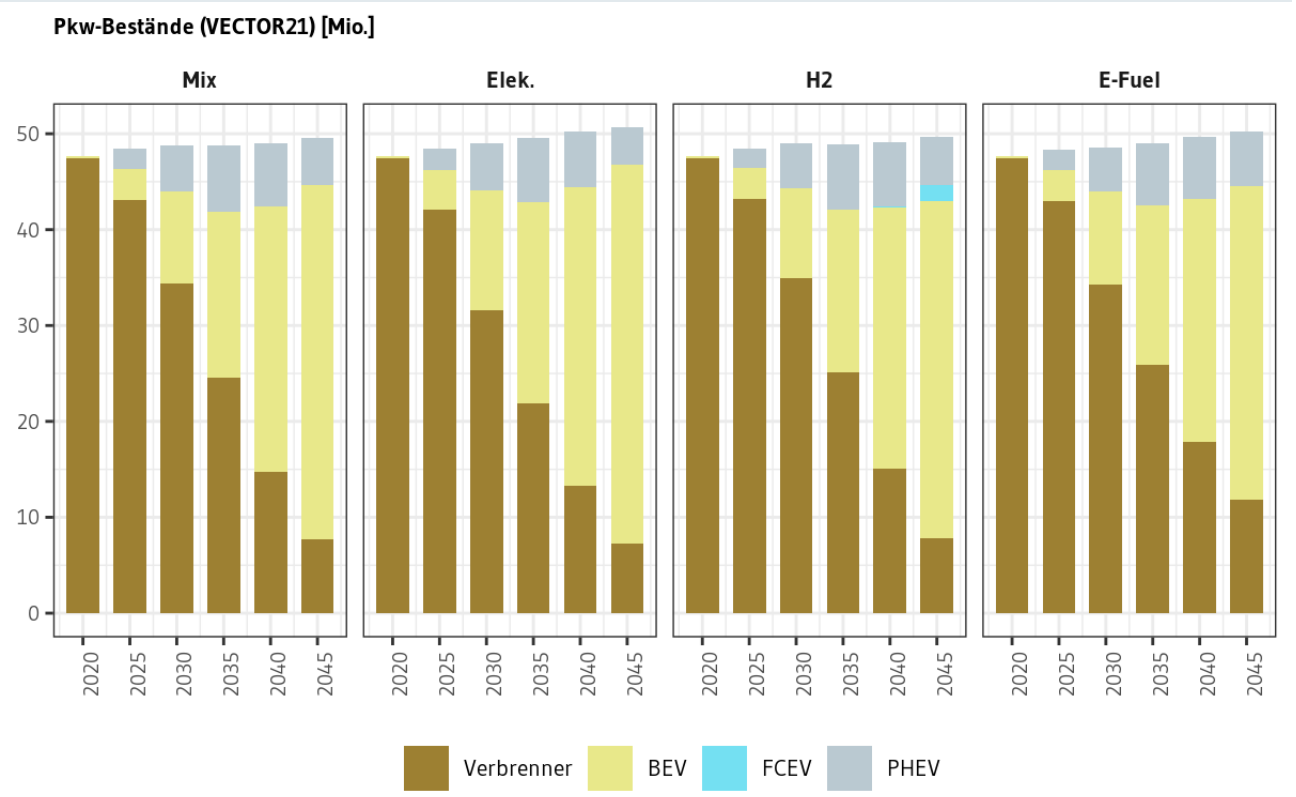


Car purchase incentives until 2025 according to scheme in place in 2021
Vehicle tax exemption for e-cars until 2025/2030
Toll exemption e-truck

GEFÖRDERT VOM
KOPERNIKUS PROJEKTE Ariadne
Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung

SCENARIO MODELLING *RESULTS*

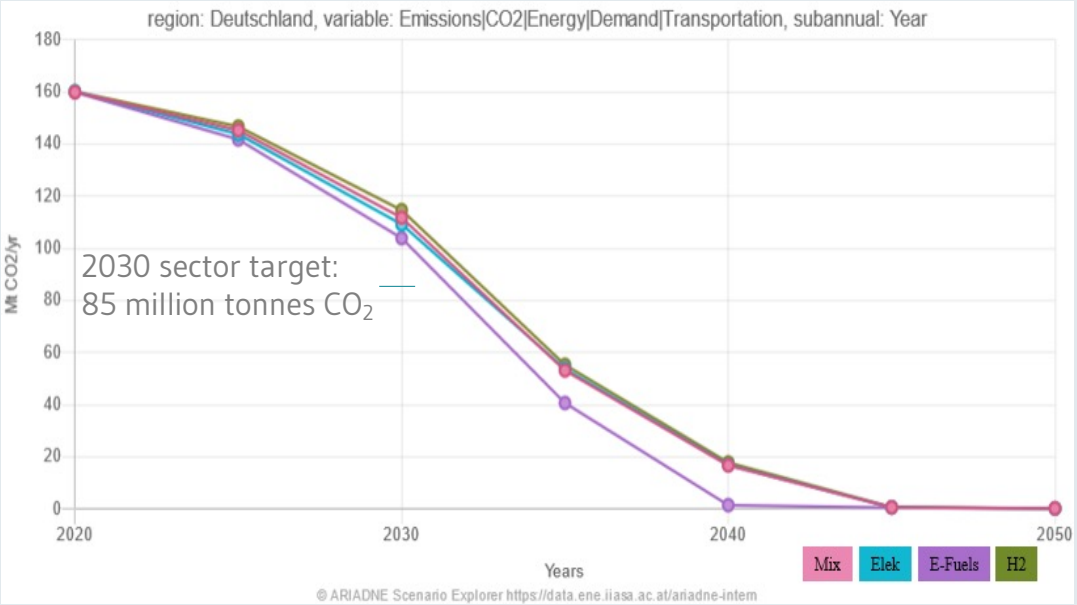
- BEVs:
  - Dominant technology in the future
  - Fastest ramp-up in electric scenario due to optimistic cost assumptions for batteries and rapid expansion of charging stations
- PHEVs: rapid ramp-up in the 20s, stagnating partly because BEVs are becoming more attractive
- FCEVs: Technology of the future. Competitive from 2040 onwards under optimistic assumptions
- E-fuels will be needed for between 11 and 17.5 million passenger cars with internal combustion engines in the fleet in 2045



GEFÖRDERT VOM
KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung

THE SCENARIOS FAIL TO MEET THE SECTOR TARGET OF THE FEDERAL CLIMATE PROTECTION ACT IN 2030

- By assumption, all scenarios achieve full decarbonization in 2045 through a combination of advanced fleet electrification and the provision of CO_2 - neutral fuels.
- The sector target of the Federal Climate Protection Act (KSG) for 2030 is not achieved
- In all scenarios, passenger road transport is forecast to decrease slightly up until 2030 and to increase moderately thereafter. Road freight is assumed to increase by 20 percent until 2045.



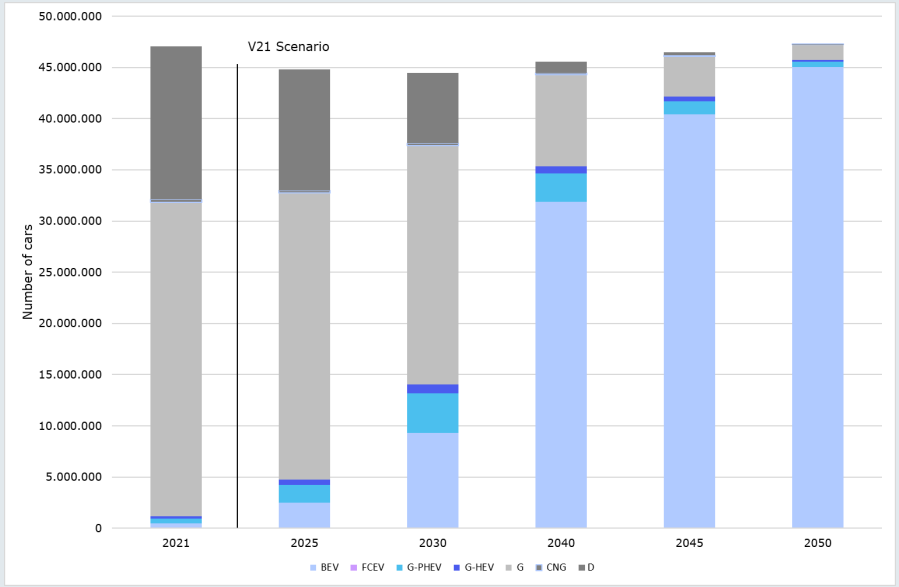
2030 CO_2 target is not met in the scenarios considered. A sole focus on new powertrains is not sufficient.

GEFÖRDERT VOM
KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung

2022 UPDATE

- In July 2021, the European Commission proposed to phase out vehicles with ICEs by 2035. This was confirmed by the Parliament on May, 8 2022
- In September the newly elected coalition government has set the target to reach 15 million BEVs (and PHEVs?*) by 2030
- In April 2022, the Federal Ministry for Economic Affairs proposed to cancel purchase subsidies for PHEVs from January 2023 and a reduction in subsidies for BEVs/FCEVs

→ New VECTOR21 simulation in April 2022 of the MIX scenario shows much accelerated replacement of diesel/petrol vehicles with BEVs starting from 2030, resulting in only 4,2 mio vehicles with ICE in 2045



MHEV = Mild-Hybrid Electric Vehicle
HEV = Hybrid Electric Vehicle
PHEV = Plug-In-Hybrid Electric Vehicle
BEV = Battery Electric Vehicle
FCEV = Fuel-Cell Electric Vehicle

** The coalition parties do not agree if PHEVs are be part of the 15 million or not (Status: 12 June 2022)*

GEFÖRDERT VOM
KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung

4. Conclusions

KOPERNIKUS Ariadne PROJEKTE
Die Zukunft unserer Energie

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

DLR

MAIN RESULTS AND CONCLUSIONS

- In the passenger car sector, BEVs are the dominant drive technology in the future
- FCEV technology is not mature and is currently lagging behind BEVs in terms of technology development. Future market potentials depend on the expansion of H2 infrastructure, cost degression of vehicles/H2, but also development of batteries
- E-fuels are necessary for defossilizing the vehicle stock; these still play a role in all scenarios
- 2030 CO_2 transport target (85 mio. tonnes CO_2) is not met in the scenarios considered. A sole focus on new powertrains is not sufficient to reduce emissions

GEFÖRDERT VOM
KOPERNIKUS Ariadne PROJEKTE Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung
DLR

Thank you for your attention

Q&A

GEFÖRDERT VOM

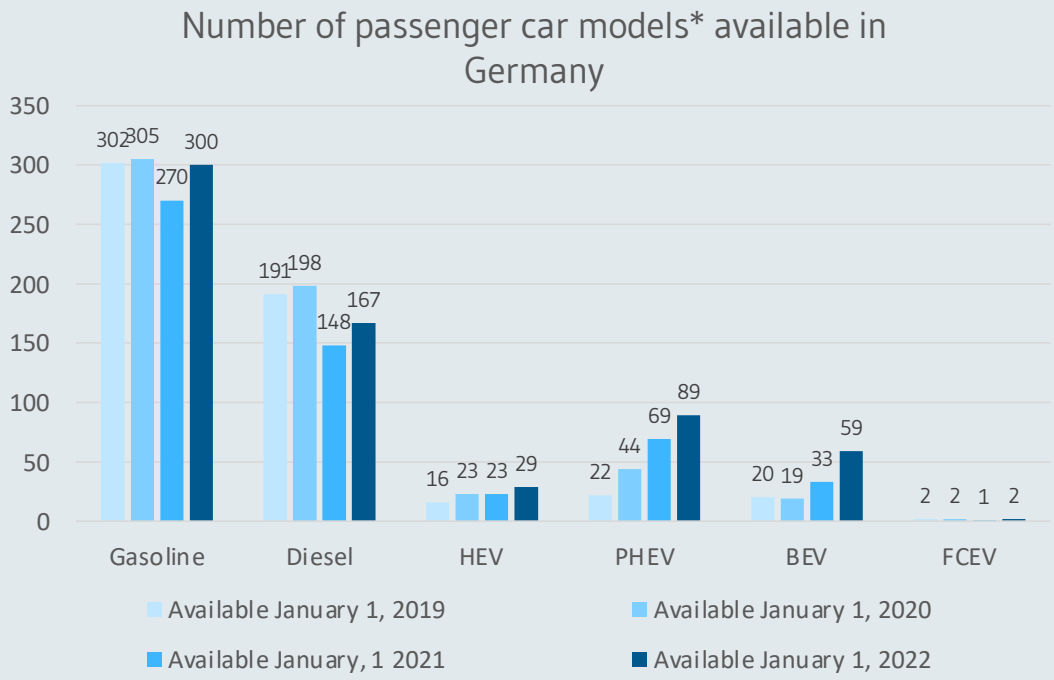
KOPERNIKUS PROJEKTE
Ariadne
Die Zukunft unserer Energie

Bundesministerium
für Bildung
und Forschung

DLR

DEVELOPMENT OF AVAILABLE PASSENGER CAR VEHICLE MODELS IN GERMANY 2019 - 2022

- Substantial improvement in model choice of xEVs at the expense of diesel/gasoline vehicles
  - **PHEV** model selection increased by more than 300%
  - **BEV** model selection increased by nearly 200%
  - Diesel model selection fell by 13%
  - Currently only two FCEV models on the market



* Sales designation by which a vehicle model is designated in the trade. It usually corresponds to the lettering on the vehicle (e.g.: VW Golf, Opel Corsa, Mercedes EQC, etc.). The available drive type is only taken into account once for each vehicle model.

Source: Own evaluation based on ADAC vehicle data

MHEV = Mild-Hybrid Electric Vehicle
HEV = Hybrid Electric Vehicle
PHEV = Plug-In-Hybrid Electric Vehicle
BEV = Battery Electric Vehicle
FCEV = Fuel-Cell Electric Vehicle

xEVs = electrified vehicles

GEFÖRDERT VOM
KOPERNIKUS Ariadne PROJEKTE Die Zukunft unserer Energie
Bundesministerium für Bildung und Forschung