Development of a scenario model for the simulation of the technology diffusion in the commercial vehicle market in Germany

Özcan Deniz (German Aerospace Center)

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

EVS35 OSL2022

Development of the German road freight transport

Development between 1995 and 2020

-33%
spec. CO2/tkm

+100%
Mileage tkm

+48%
Vehicles in stock

(+25% until 2030)

+17%
abs. CO2/tkm

Climate Policy

Paris Climate Agreement (UN)

Green Deal (EU Commission)

Federal Climate Protection Act

Energy Efficiency Strategy 2050 (2045)

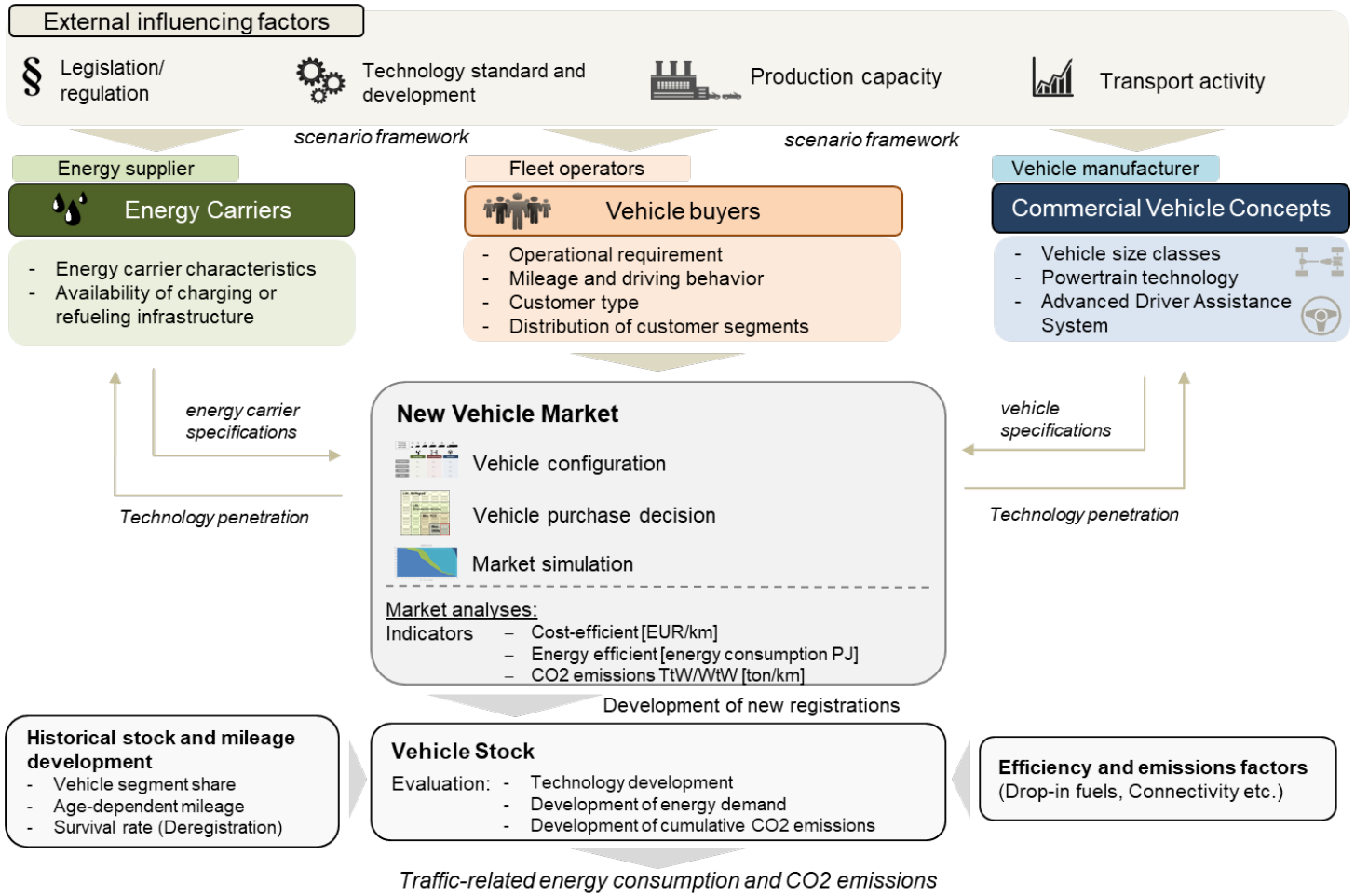
→ scenario analyse of different technology set-ups to achieve climate neutrality in German Road freight Transport until 2045

Outline

- Methodology
- Scenario definition and assumption
- Scenario results
- conclusion

Methodology: scenario model structure

- The overall model is divided into two market models:
  - New vehicle market - simulation of the market potentials of alternative powertrains and energy sources.
  - Stock vehicle market - mapping of technology adoption and calculation of mileage-related CO2 emissions
- Technical implementation of the overall model in the vehicle technology scenario software VECTOR21 by DLR

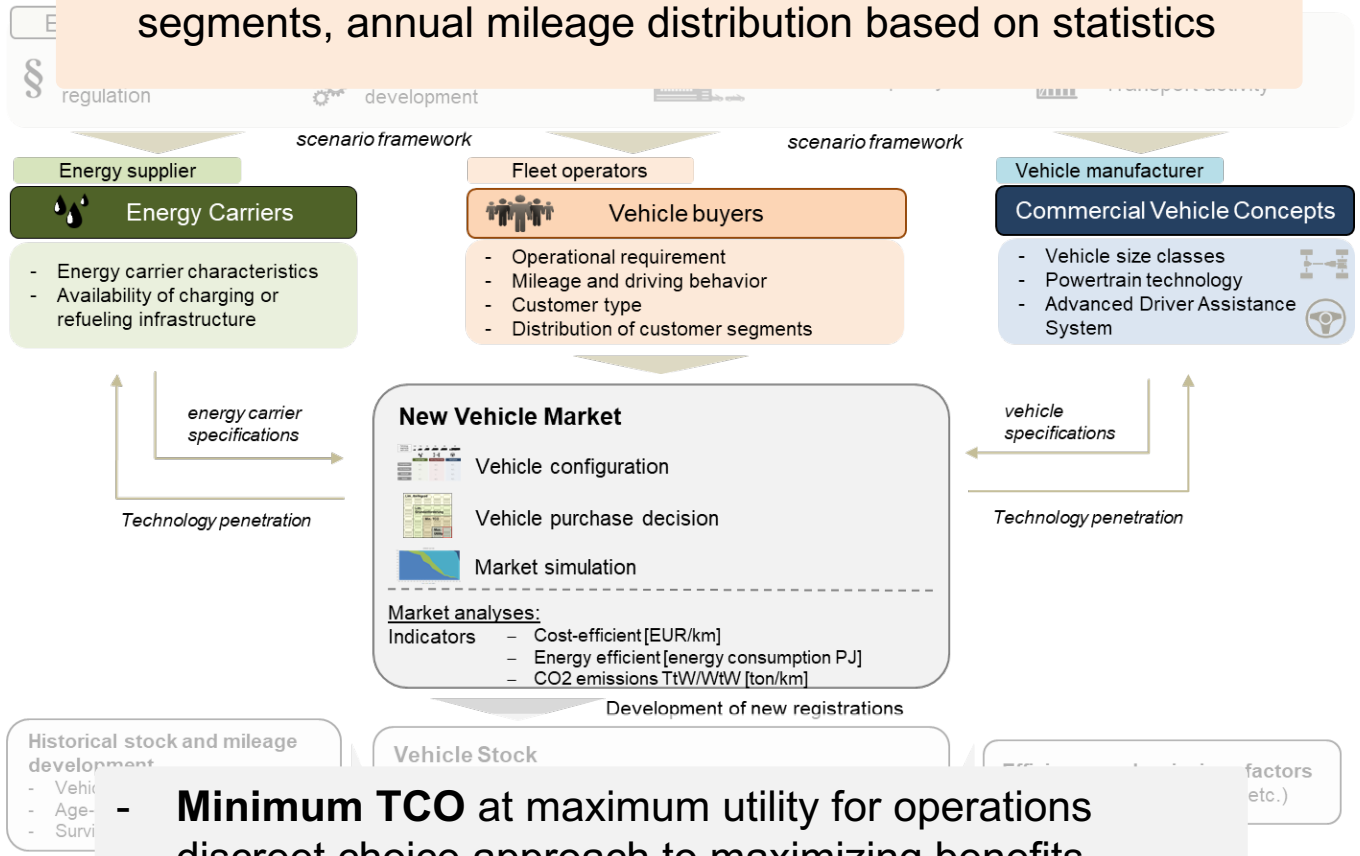


VECTOR21 scenario analysis software

Methodology: Modeling of Supply and Demand

- **Agent-based** simulation approach
- Application to the **German market**: market share of vehicle segments, annual mileage distribution based on statistics

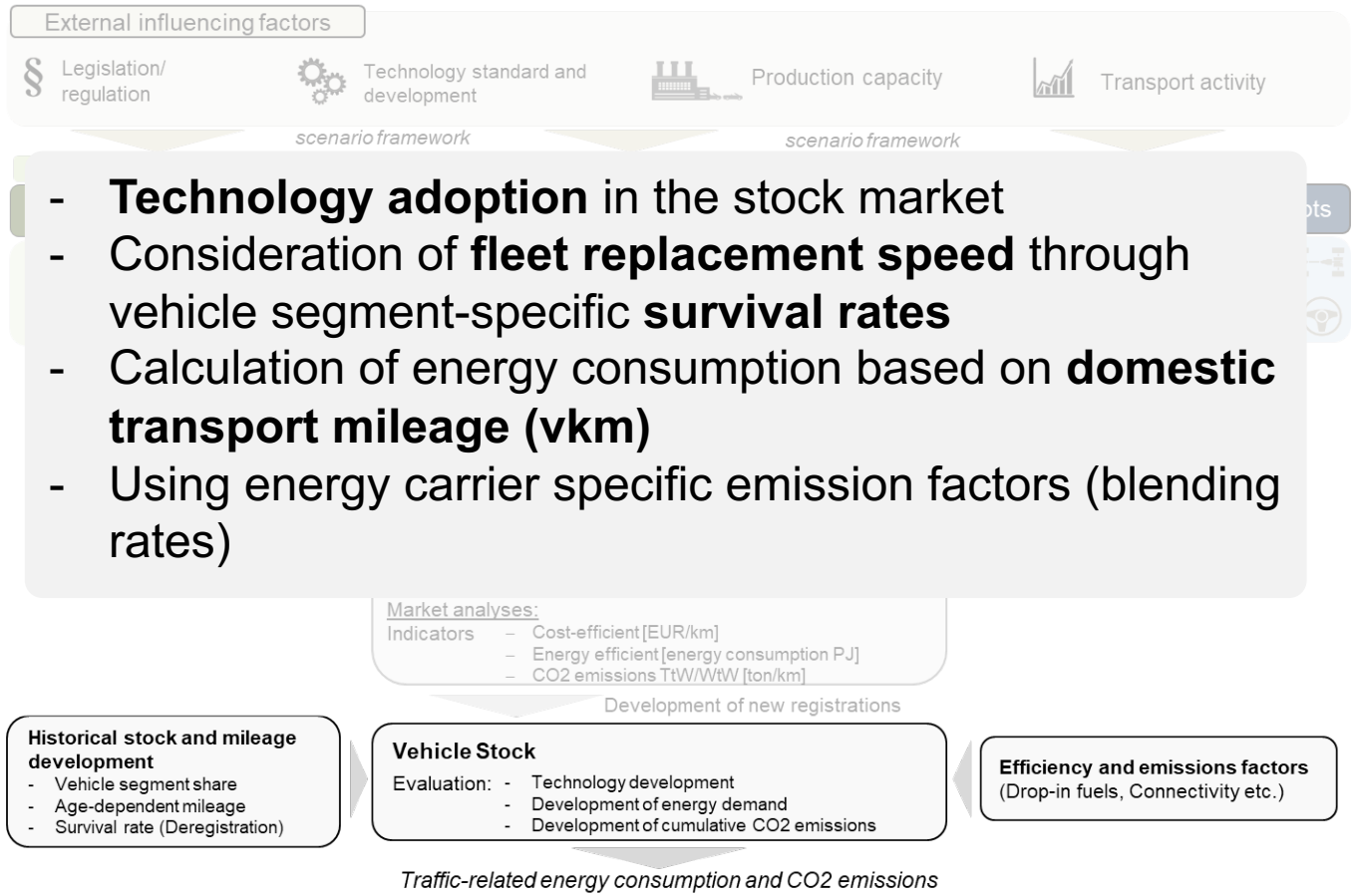
- Nine **reference energy carriers**: diesel, syn-diesel, CNG, syn-CNG, syn-LNG, electricity, comp. H2, Liquid H2
- Bottom-up **calculation of the energy price** at the station



- Six **vehicle segments** (up to 40 tons gross vehicle weight)
- Seven **powertrain concepts**: ICE, MHEV, FHEV, PHEV, REEV, BEV, FCEV
- **Bottom-up vehicle specification** based on key component attributes

- **Minimum TCO** at maximum utility for operations
- discreet choice approach to maximizing benefits
- Checking the technology availability

Methodology: Technology adoption and transport development



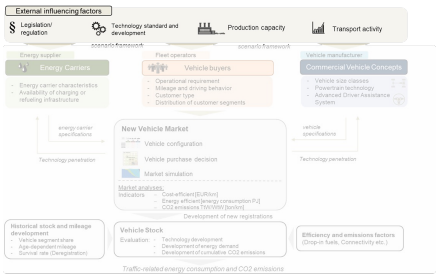
Scenario definition

- Scenarios focusing on different technology options for the transport sector to meet climate targets.
- Considered scenarios:

Technology Scenarios (GHG -100% until 2045)

E-Fuels	Hydrogen	Eletcric Mobility

Scenario assumptions



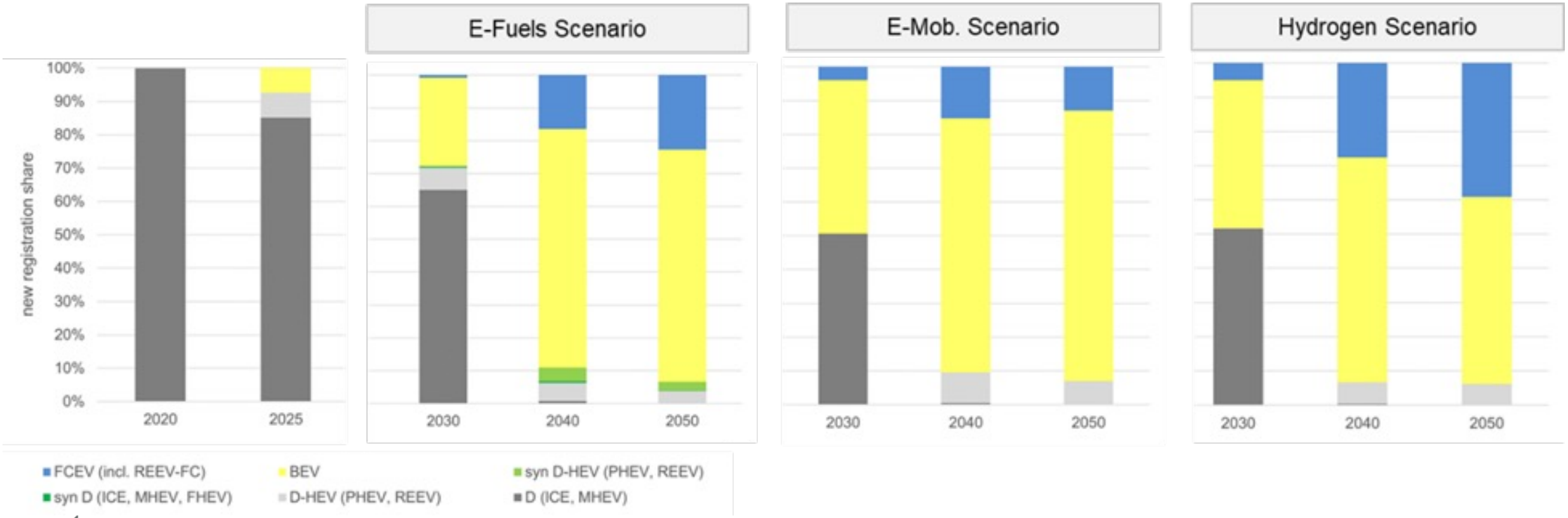
Relevant scenario measeare for a „climate protection – GHG-neutrality in 2045“scenario:

- EU average CO2 emission targets for LDV and HDV: 0 g/km /tkm in 2040
- (domestic) CO2 price: 2030: 100 €/ton CO2; 2045: 300 €/ton CO2
- Forecast vehicle mileage: 2020: 83.5 billion veh-km; until 2030: +10%; until 2050 +20% compared to 2020
- Crudie oil price: 2020: 36€/bbl; 2030: 69€/bbl; 2050: 85€/bbl

	E-Fuels	**E-Mob**	**H2-Mobility**
EU Fleet CO2 Emission regulation	Crediting of E-Fuel Blends in EU CO2 fleet emission regulation	-	-
Toll	-	Toll exemption for BEV and FCEV until 2035	
Vehicle tax	-	Tax exemption for BEV and FCEV until 2035	
Energy tax	Tax exemption for E-Fuels until 2035	-	Tax exemption for H2 until 2035
Energy carrier price	Syn Diesel: 3,09 €/l (2030)	Electricity: 0,30 €/kWh (2030)	Hydrogen: 5,67 €/kg (2030)
Technology development	ICE (BTE 55% in 2030)	Lithium-Ion Bat system min price: 91€/kWh	Min. prices: Fuel Cell System 121€/kW, H2-Tank-System 322€/kg
Infrastructure availability	-	Roll-out Megawatt-Charger (800kW) until 2030	Roll-out public H2-Station (CH2) until 2030

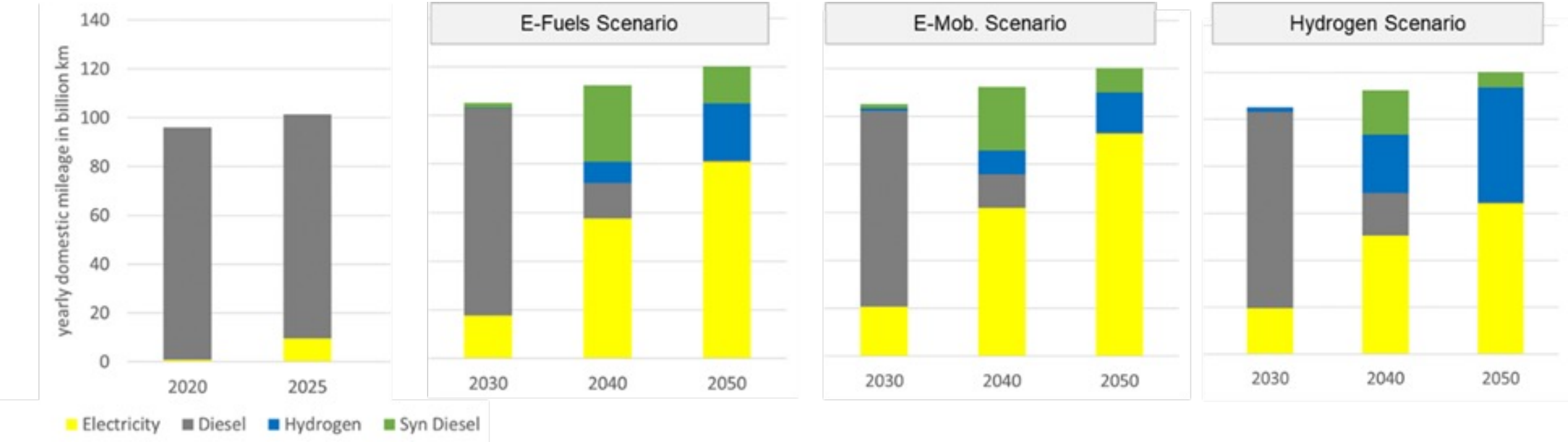
Results: Market potential of alternative powertrains

- BEV as dominate powertrain post-2030 – especially for Light Duty Vehicles
- Market potential of Fuel Cell Electric Heavy Duty Vehicles in long haul operation
- Imitated adoption of E-fuels based ICEV



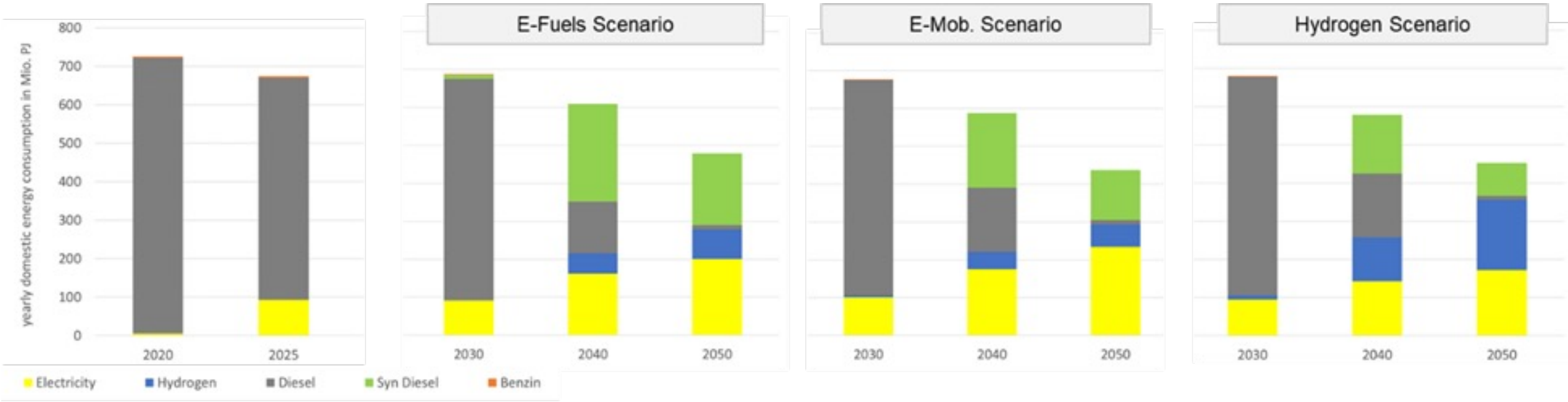
Results: Development of the vehicle mileage per energy type

- Increased share of electric mileage in all scenarios
- E-Fuel share in vehicle mileage mainly through blends for stock vehicles
- The target of 1/3 of the mileage being driven electric in 2030 will not be met in any of the scenarios



Results: Development of the end energy demand

- Increasing share of BEVs while total mileage increases, reduce final energy demand in all scenarios
- The “Energy Efficiency Target for 2050” is met at closest by the Electric Mobility scenario



Conclusion

Methodology

- This paper presents a scenario model to simulate the diffusion of alternative powertrains and energy carriers in the German road freight vehicle market
- Three technology scenarios are described to achieve climate neutrality in road freight transport until 2045
- The scenario model and analysis show a suitable approach to evaluate policy measures

Results

- The scenario comparison highlights that the direct electrification predominantly shows the greatest market potential
- However, the targets in 2030 for the road freight transport sector will not be met. A technology transformation alone will not be enough.

Outlook

- The attributes of specific synthetic energy carriers should be modeled and a discrete choice approach for measuring user preferences should be extended by a survey among logistics operators.

Thank you!

Özcan Deniz

German Aerospace Center
Institute of Vehicle Concepts
Wankelstraße 5
70563 Stuttgart, Germany

Telephone +49 711 6862-8637
Email oezcan.deniz@dlr.de