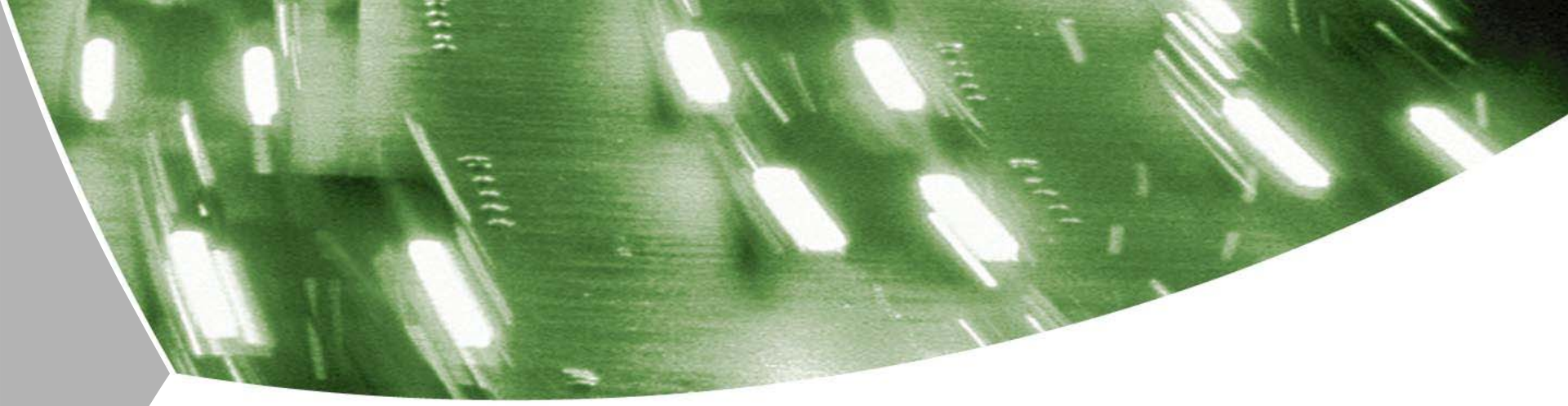

Market prospects of passenger vehicle technologies and their effect on CO_2-emissions up to the year 2030

A model based approach

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in der Helmholtz-Gemeinschaft

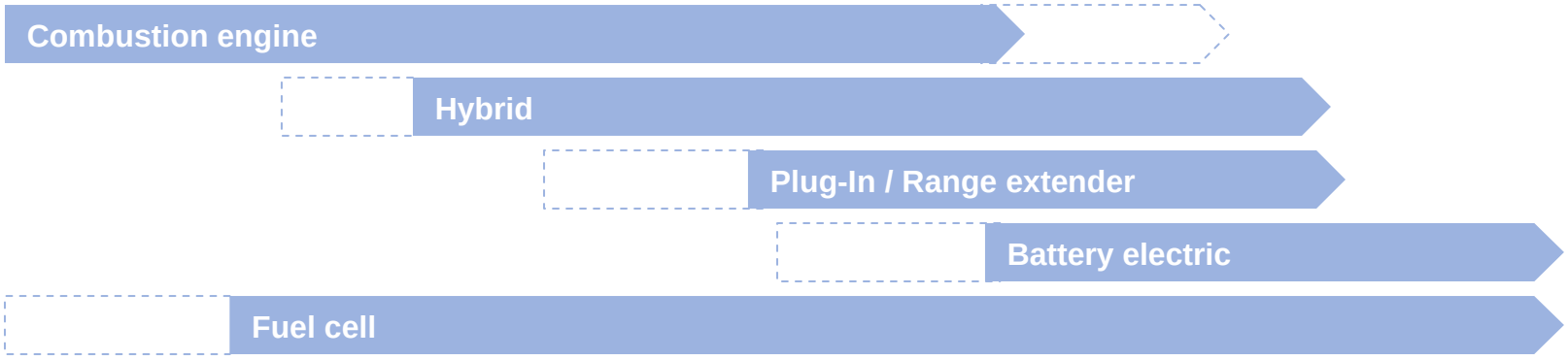
Topics of the Future

The main challenges for future automotive technology are the reduction of CO_2-emissions and hence the development of new propulsion technologies

Long-distance traffic

Country roads

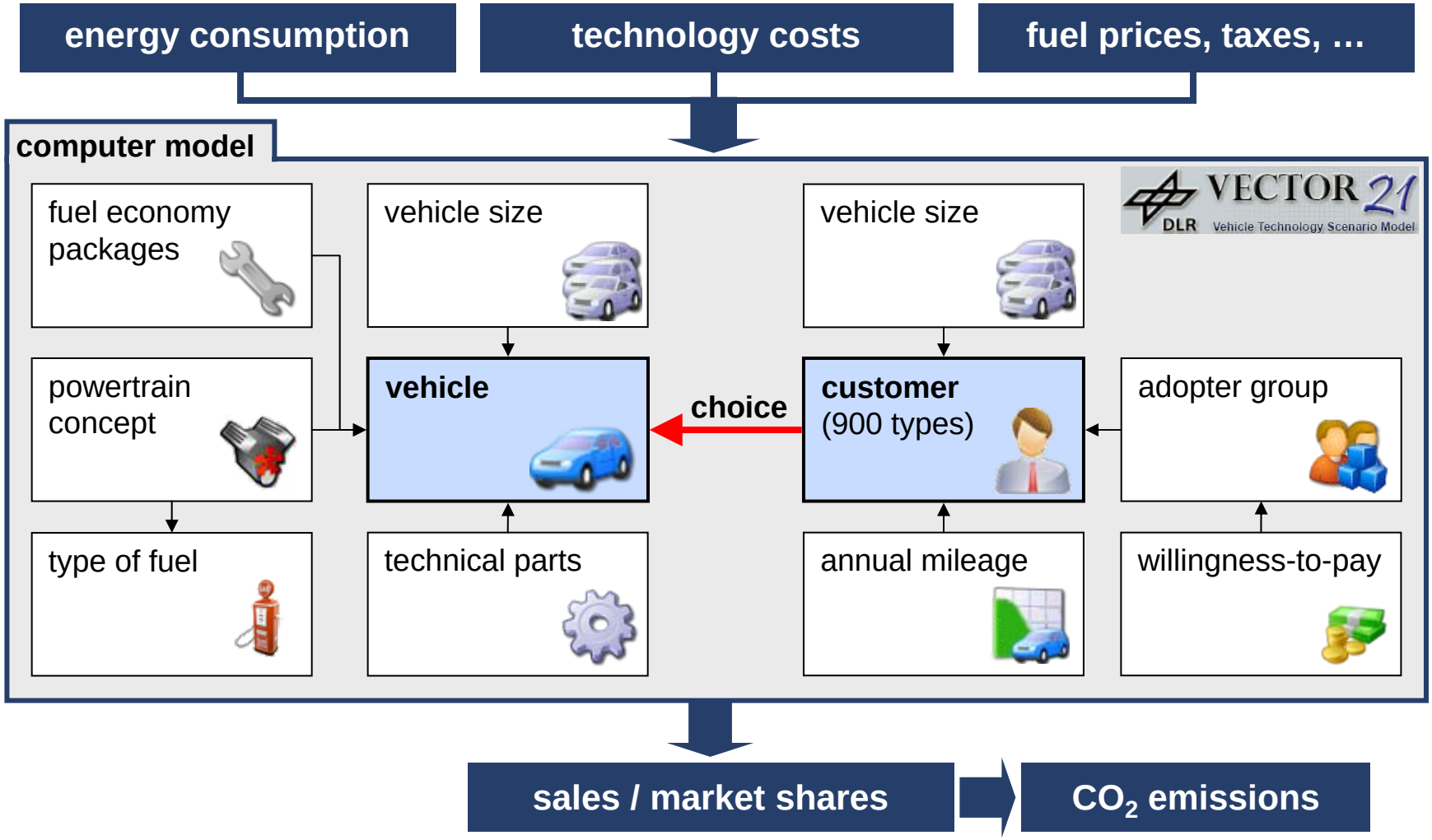
Urban traffic



Source: Rabe (2009), Fahrzeugbauweisen der Zukunft, 13. Dresdner Leichtbausymposium, Volkswagen / EUCAR

Scenario model *(VECTOR21)*

Modeling both technology supply and customer demand

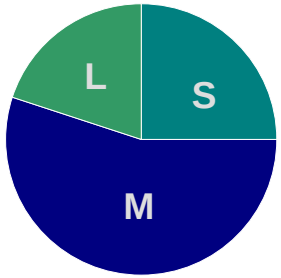


Source: DLR, *VECTOR21*

Scenario model *(VECTOR21)*

Within the model, 900 different types of customers are simulated

Vehicle segment

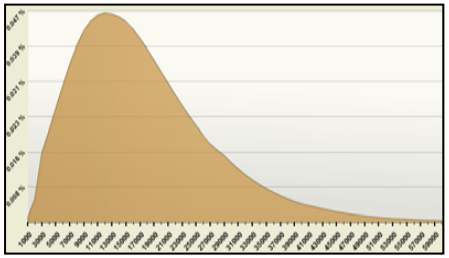


- 3 vehicle sizes: small, medium, large
- Input based on historical data of the German Federal Motor Transport Authority

3

x

Annual driving distance



- Different distributions for the driving distances, depending on the vehicle size
- Data based on the survey „Mobilität in Deutschland 2008 (MiD)“

60

x

Adopter group

- Five different attitudes towards innovations
- Based on theory from Rogers
- Crucial for willlingness-to-pay of customers

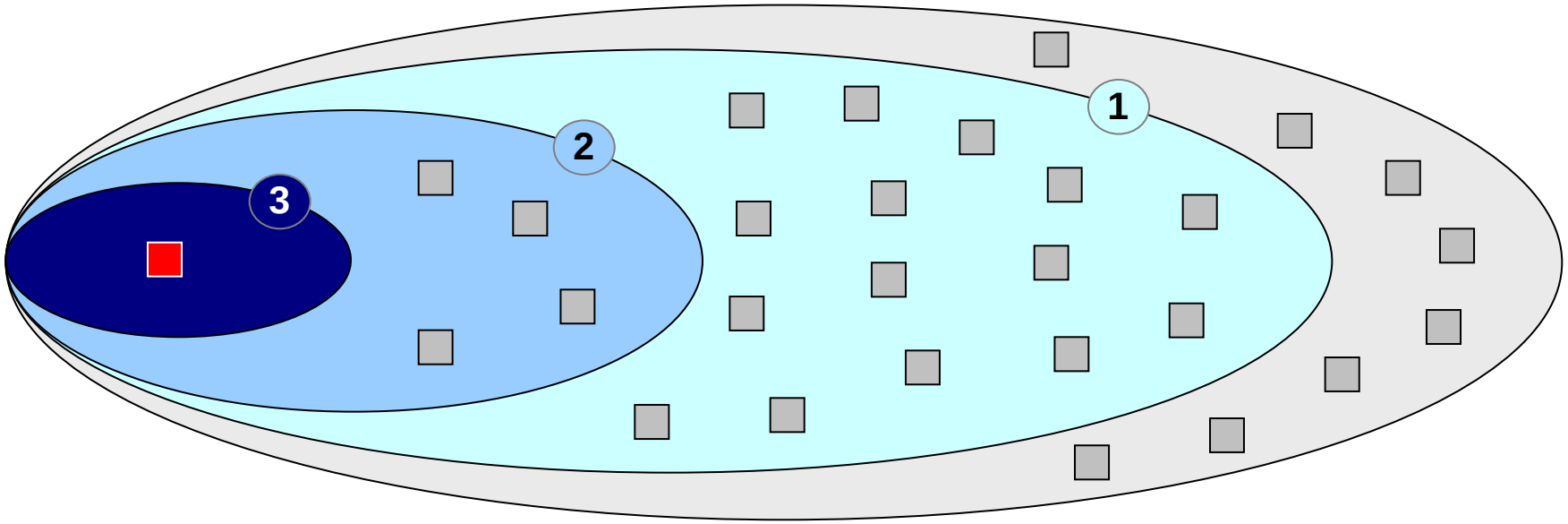
5

900

Source: DLR; Mobilität in Deutschland 2008 (MiD); Kraftfartbundesamt

Scenario model *(VECTOR21)*

The buying-decision is implemented in a three step approach



vehicle variants (combination of vehicle technology and fuel)

1 **step 1: filter for vehicle size category and general compulsory requirements**

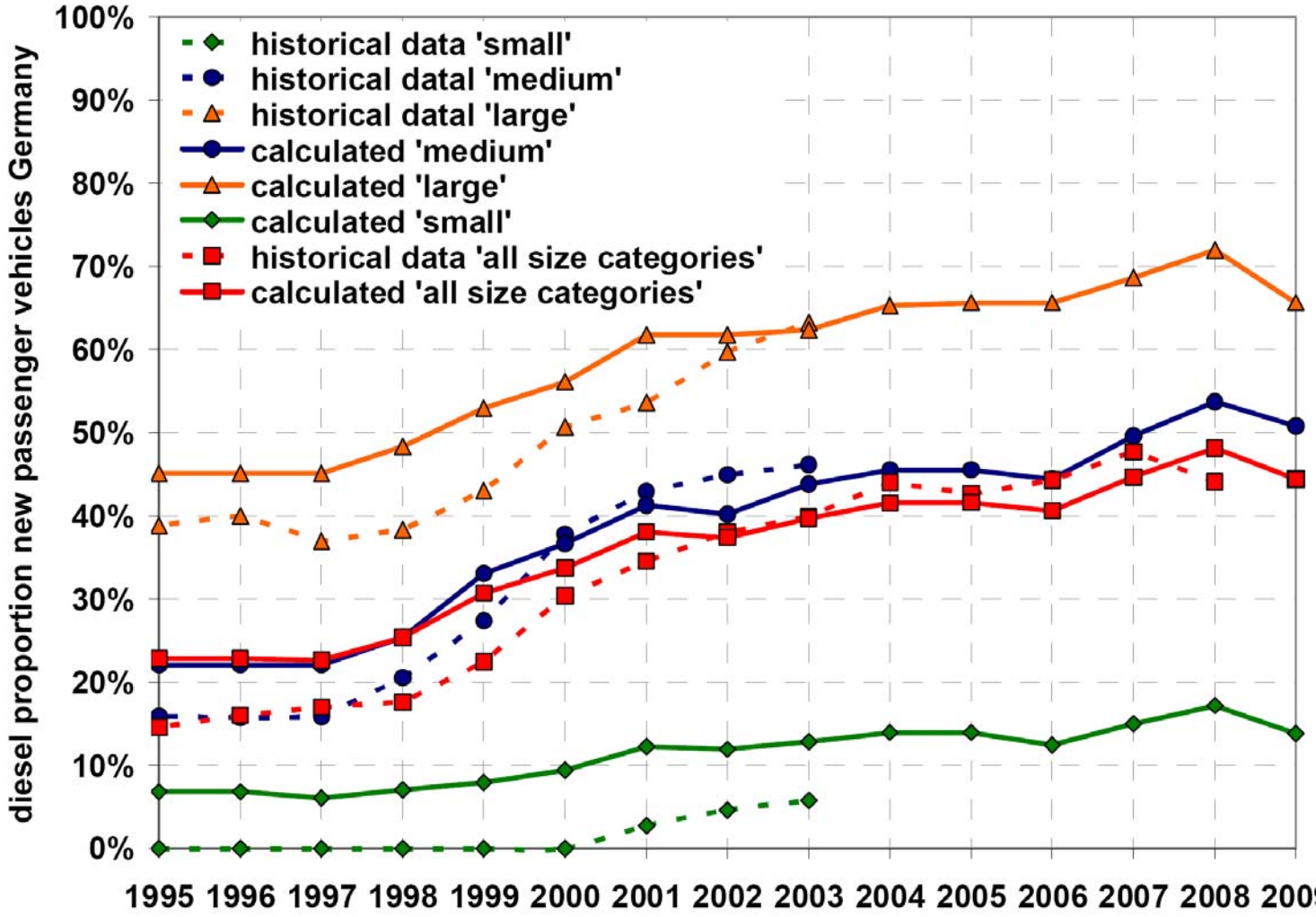
2 **step 2: choose lowest relevant cost of ownership (RCO)**

3 **step 3: choose lowest well-to-wheel CO_2 emissions**

Source: DLR, *VECTOR21*

Scenario model (*VECTOR21*)

The model has been validated using historical data for market penetrations of Diesel-vehicles on the German market



Scenario 1 - Business-as-usual

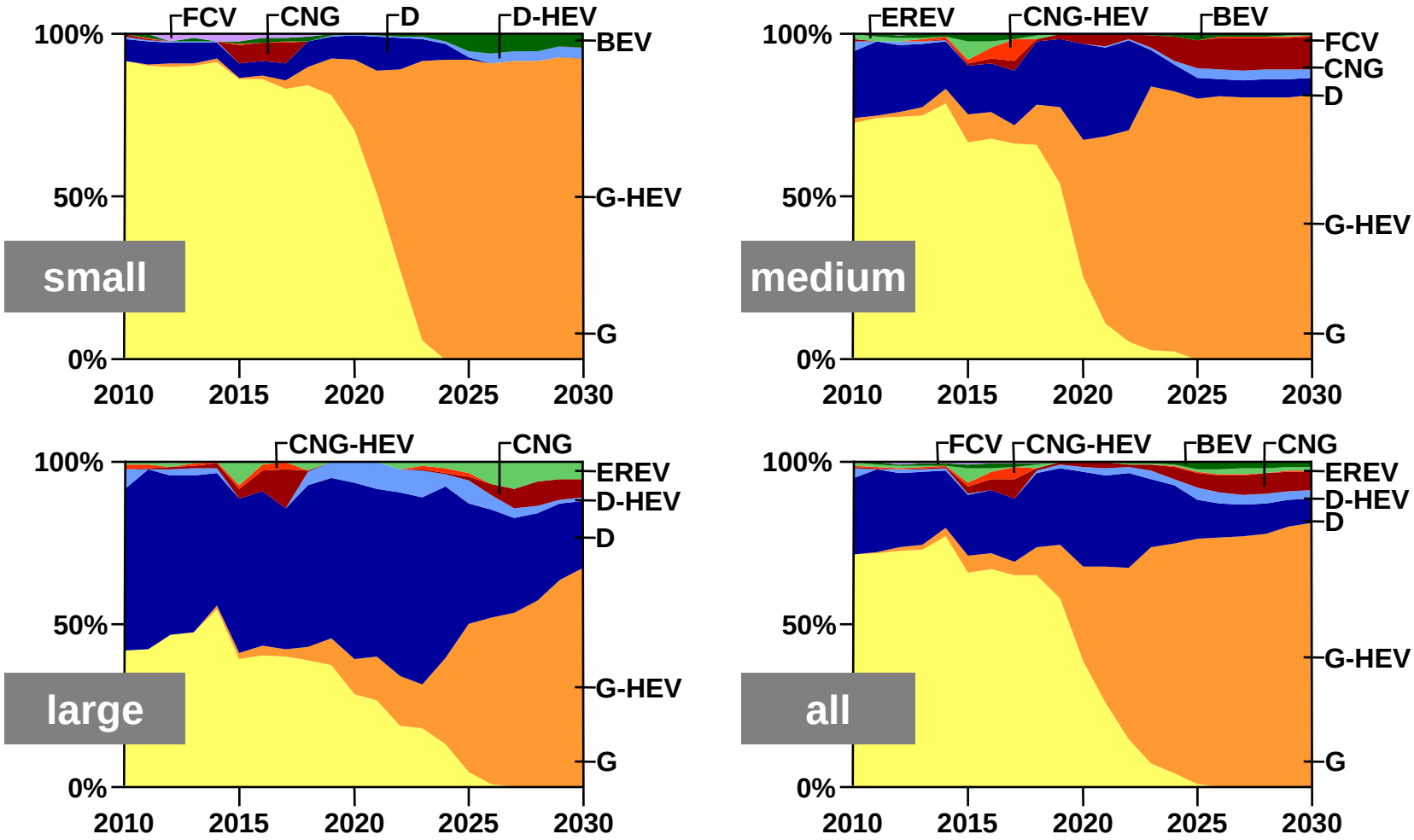
The first scenario represents a rather conservative development incorporating only evolutionary changes

	2010	2015	2020	2025	2030
Oil price [€/bbl]	54	52	50	58	65
Share of biofuels [%]	0-8	4-11	8-13	11-14	15
Electricity – Source	German mix				
Electricity – CO_2 intensity [g/kWh]	600	610	620	590	550
Electricity – price [€/kWh]	0.18	0.18	0.35	0.35	0.35
Hydrogen – source	natural gas			electricity	
Hydrogen – CO_2 intensity [g/kWh]	350	350	740	700	650
Hydrogen – price [€/kWh]	0.16	0.16	0.35	0.35	0.35
CO_2 – target value new vehicles [g/km]	---	140	125	113	113
CO_2 – penalty for exceeding target [€/(g/km)]	---	95	95	95	95
Customers – willingess to pay for fuel economy [%]	0-10	0-10	0-10	0-10	0-10
Vehicle size categories (small / medium / large) [%]	25/55/20	26/52/21	28/50/23	29/47/24	30/45/25

Source: DLR, *VECTOR21*

Scenario 1 - Business-as-usual

Alternative propulsion concepts will not be able to gain significant market shares



Source: DLR, *VECTOR21*

Scenario 2 - Climate Protection

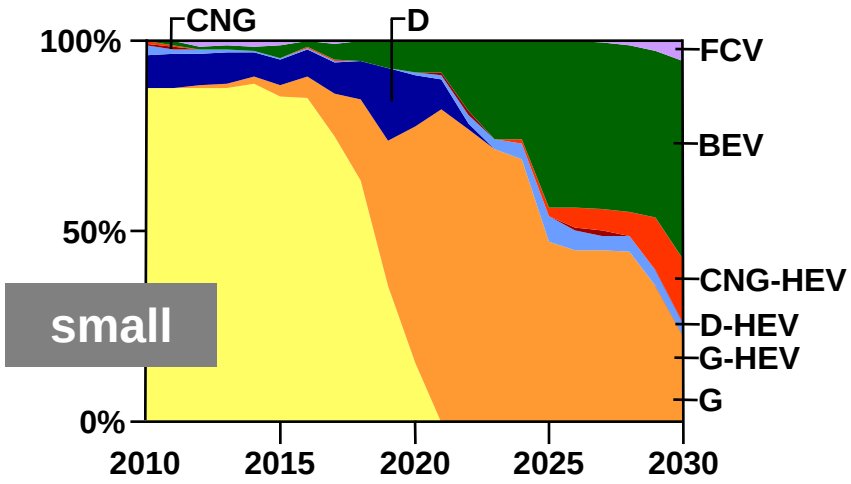
An alternative scenario assumes a rather eco-friendly-future development

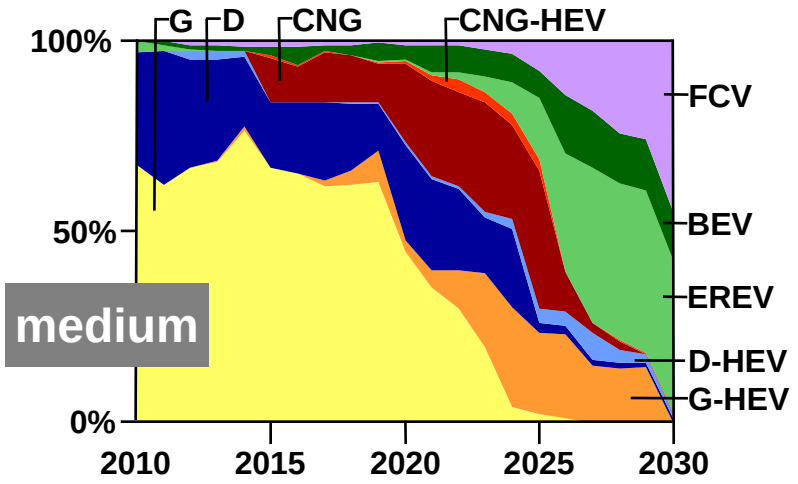
	2010	2015	2020	2025	2030
Oil price [€/bbl]	54	52	50	58	65
Share of biofuels [%]	0-8	**6-14**	**13-18**	**19-21**	**25**
Electricity – Source	**renewables**				
Electricity – CO_2 intensity [g/kWh]	**20**	**20**	**20**	**20**	**20**
Electricity – price [€/kWh]	**0,21**	**0,21**	**0,37**	**0,37**	**0,37**
Hydrogen – source	**electricity**				
Hydrogen – CO_2 intensity [g/kWh]	**25**	**25**	**25**	**25**	**25**
Hydrogen – price [€/kWh]	**0,21**	**0,21**	**0,38**	**0,38**	**0,38**
CO_2 – target value new vehicles [g/km]	---	140	**113**	**95**	**76**
CO_2 – penalty for exceeding target [€/(g/km)]	---	95	**105**	**113**	**120**
Customers – willingess to pay for fuel economy [%]	**0-20**	**0-20**	**0-20**	**0-20**	**0-20**
Vehicle size categories (small / medium / large) [%]	25/55/20	26/52/21	28/50/23	29/47/24	30/45/25

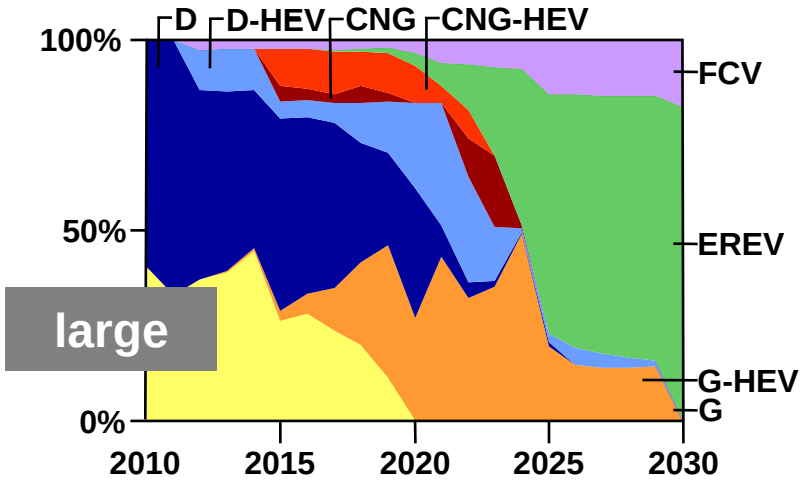
Source: DLR, *VECTOR21*

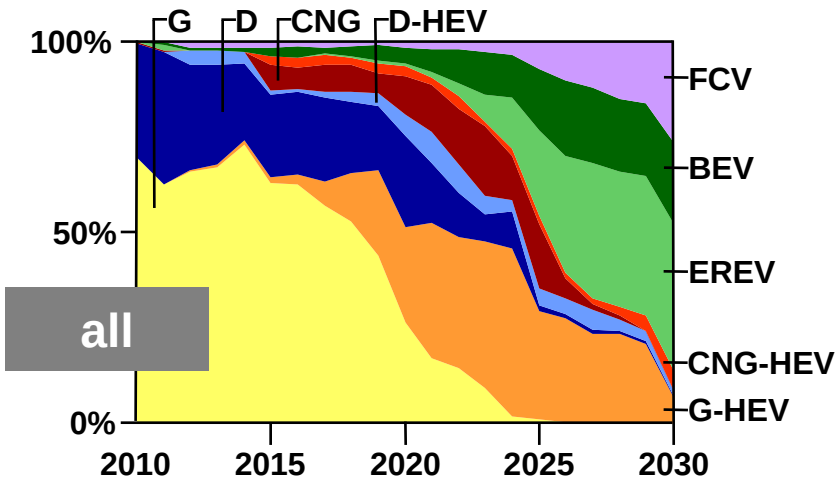
Scenario 2 - Climate Protection

Starting around 2020, alternative propulsion concepts will be able to gain significant market shares throughout all vehicle segments





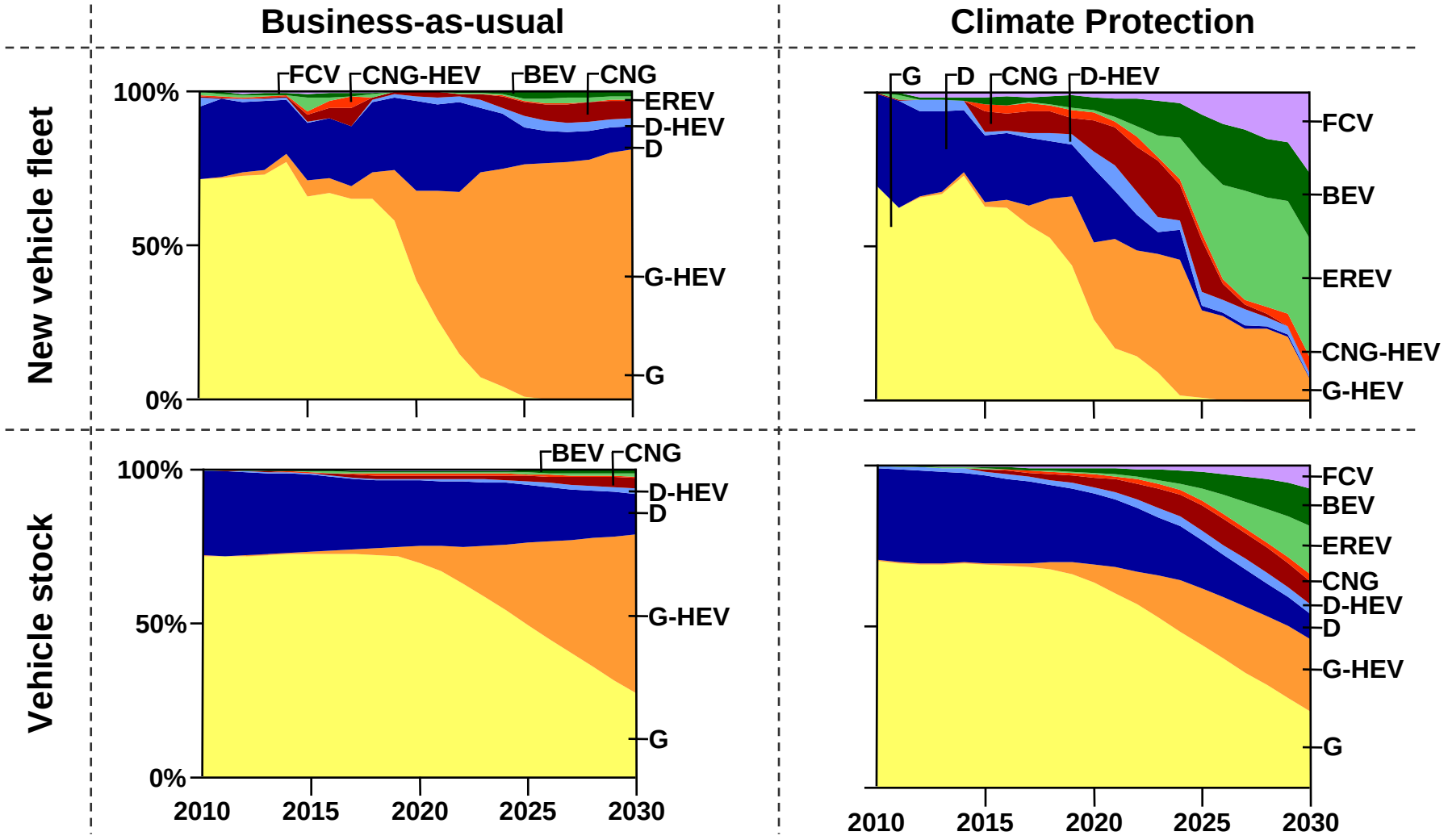




Source: DLR, *VECTOR21*

Business-as-usual vs. Climate Protection

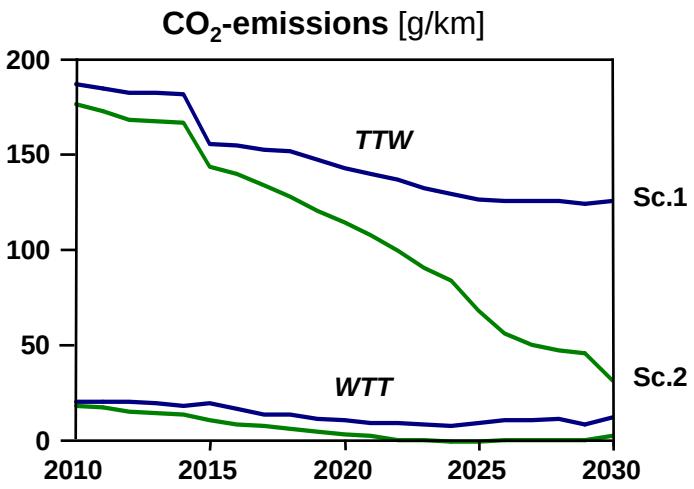
Nevertheless, the entire vehicle stock will only adapt slowly to the changes

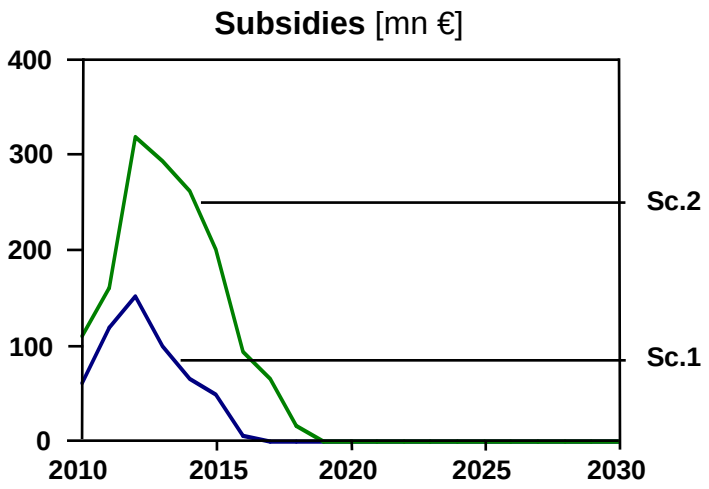


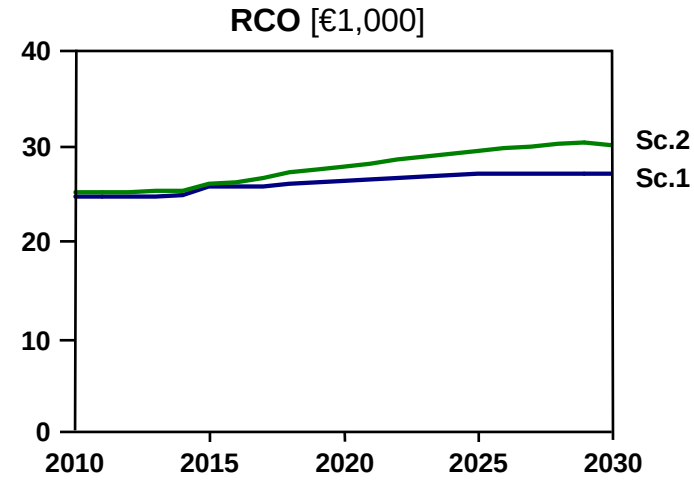
Source: DLR, *VECTOR21*

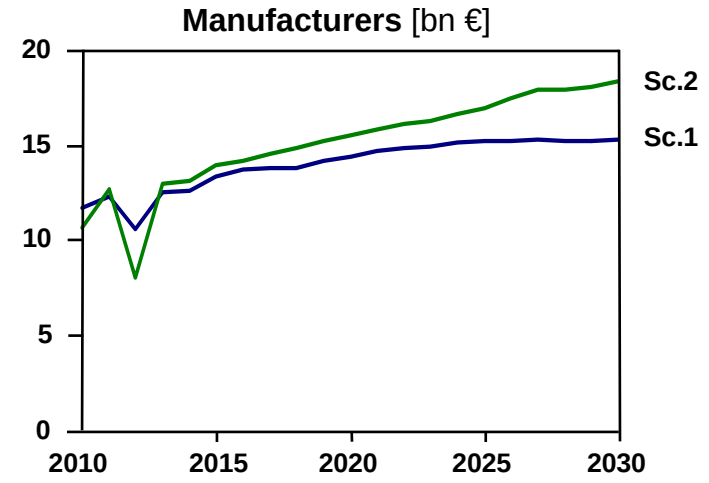
Economical effects

The second scenario shows that significant reductions of CO_2-emissions are feasible, but come at high costs









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