Well-to-wheel emission factors for future cars in Germany with a focus on fleet composition, new technologies and emissions from energy supplies

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1. Qualitative Scenarios

Society

Technology

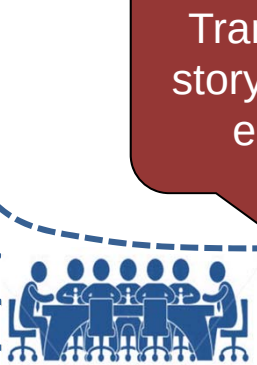
Economy & Energy

Environment

Politics

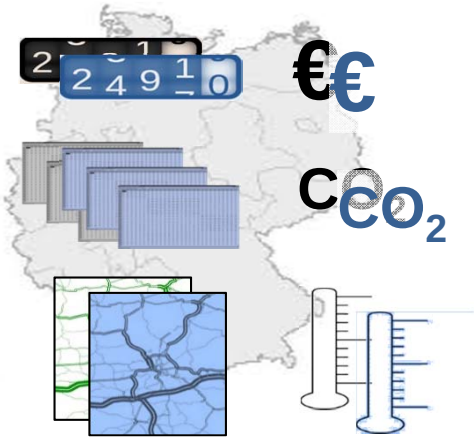
2. Quantitative Modeling

Translating scenario-storylines in consistent emission factors



Model-Network

3. Potential futures of transport (2040)



The aim is to develop scenario-specific emission factors for cars and fleets, including interdependencies of technology and fleet developments

Context:

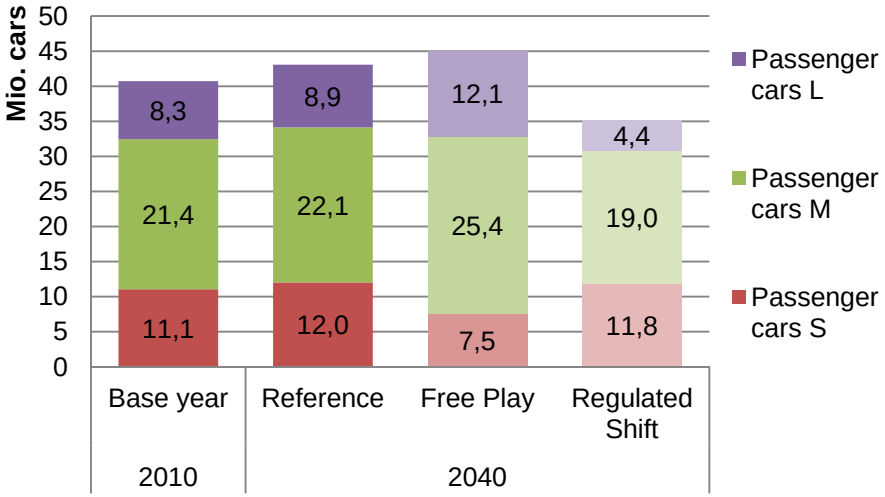
- **Transport and the Environment Project**

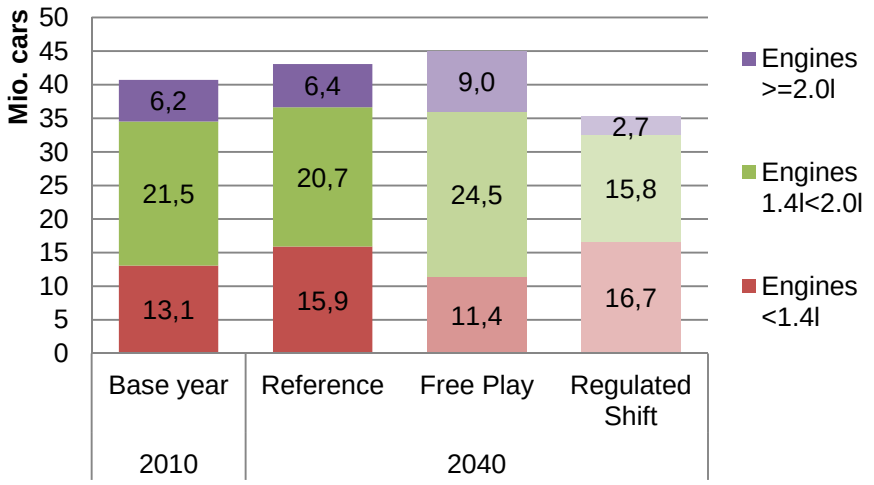
➢Three explorative scenarios
➢Mobility in Germany in 2040
➢Development pathways that are deemed realistic
➢Include well to tank emissions because of shift to electricity

Regulated Shift	Reference-Scenario	Free Play
The „Energie-wende“ winner	*Business as usual*	*Economic well-being through market forces*

Modifying the car and engine sizes according to scenario storylines

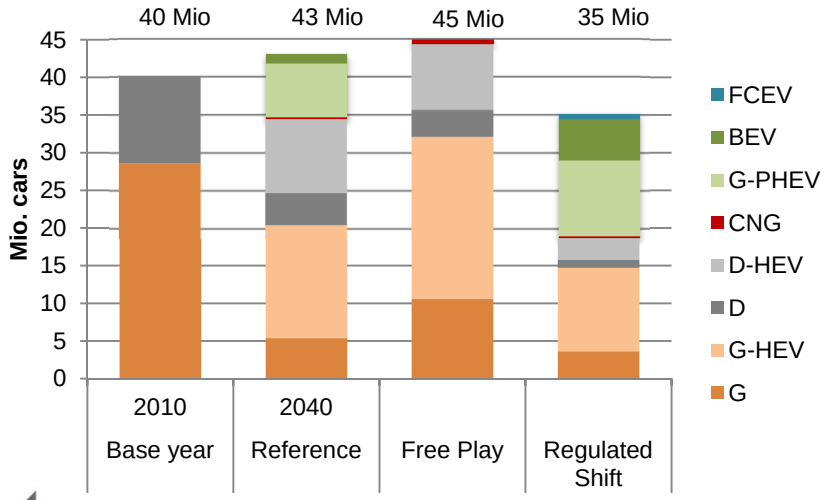
- The Reference scenario was calibrated on data from HBEFA 3.3 for 2010 and 2030
- Engine size allocation used the motorization of prominent car models in their class
- Adjustments to trends were made according to the storylines
- Resulting in different car and engine size of the future car fleet in Germany





Modifying and expanding HBEFA emission factors, to be able to develop scenario-related future passenger car fleets

- Emission factors for hybrid vehicles: literature review plus DLR measurement and data
- Fleet composition and energy consumption were simulated with the VECTOR21 tool
- Energy demand and emissions factors developed for each type of drive-train and vehicle size for 2030 and 2040 (2010: HBEFA)



Multiple assumptions influence technology development, e.g.:

- Cost of battery
- Charging infrastructure
- CO_2 limit values
- Electricity price
- Etc.

G	gasoline vehicle
D	diesel vehicle
G-HEV	gasoline full hybrid electric vehicle
D-HEV	diesel full hybrid electric vehicle
PHEV	gasoline plug-in hybrid electric vehicles
BEV	battery electric vehicles
FCEV	fuel cell electric vehicles

To complement, creating scenario consistent well to tank emission factors

- Methodology: bottom-up energy scenario building, integration of transport analyses

National scenario background
Reference: Energy reference forecast BMWi 2014.
Free Play: REF with stagnation 2020
Regulated Shift: Long-term scenarios 2012 for BMU

Socio-economic context
consistent to VEU storylines and developments

Narratives & assumptions
development of demand drivers, efficiency, technologies, installed capacities depending on potentials, costs, barriers, targets

Scenario data base
trajectories for all sectors of the energy system under stable market conditions

Scenario assessment
role of energy for transport, emissions of CO_2 & air pollutants, energy costs…

electricity costs
CO_2 intensities

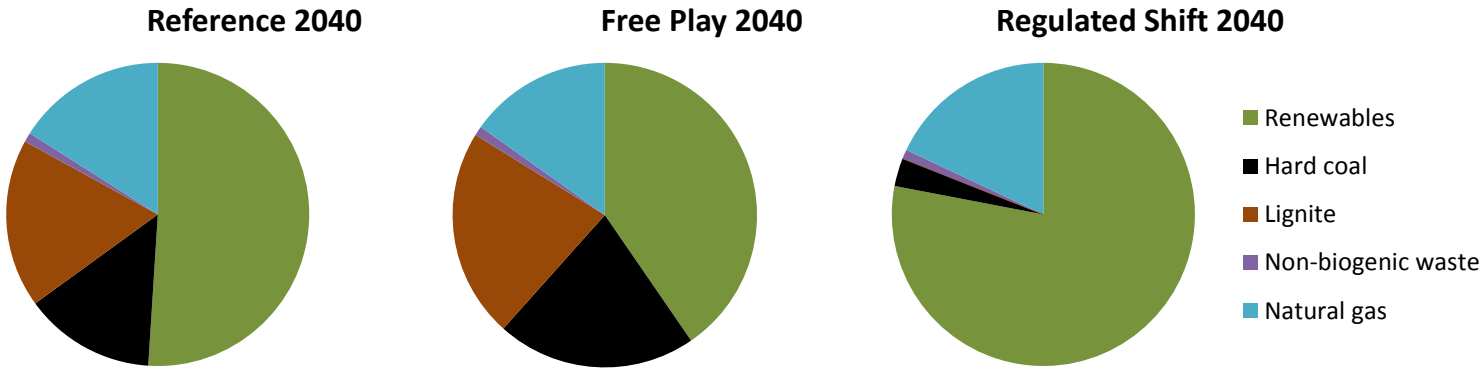
energy demand development

Current situation, statistics
energy balances, power plant park, infrastructure planning…

Transport analyses
mileage and vehicle fleet development, role of electricity and synthetic fuels, emissions

Emissions from energy supply differ greatly in the three scenarios

- Power generation structure and emissions from energy supply:



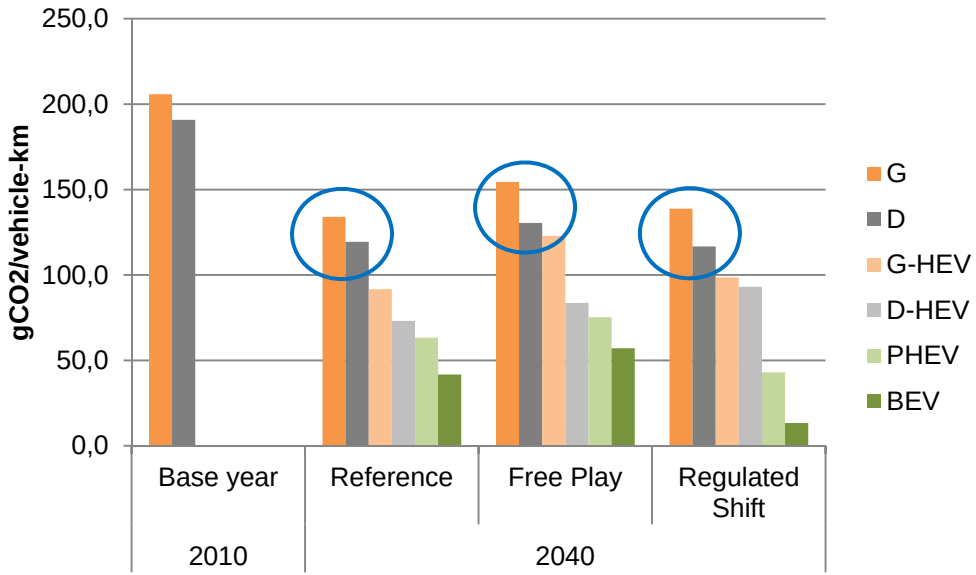
Specific emission	2010	Reference 2040	Free Play 2040	Regulated Shift 2040
CO_2				
electricity (g/kWh)	498	313	411	87
transport fuels (g/MJ)	4.6	3.7	3.6	3.8
NO_x				
electricity (mg/kWh)	423	279	332	158
transport fuels (mg/MJ)	4.1	3.6	3.5	2.9
CO				
electricity (mg/kWh)	188	137	158	95
transport fuels (mg/MJ)	0.4	0.4	0.3	0.3
PM_{10}				
electricity (mg/kWh)	13	9.6	11.5	4.4
transport fuels (mg/MJ)	0.7	0.5	0.5	0.4

Scenario-related differences in technology and size developments result in different tailpipe and upstream emissions

- According to the scenario storylines, different effects can be observed:

➔ Effects from differences in car and engine sizes

[well to wheel CO_2 emissions]



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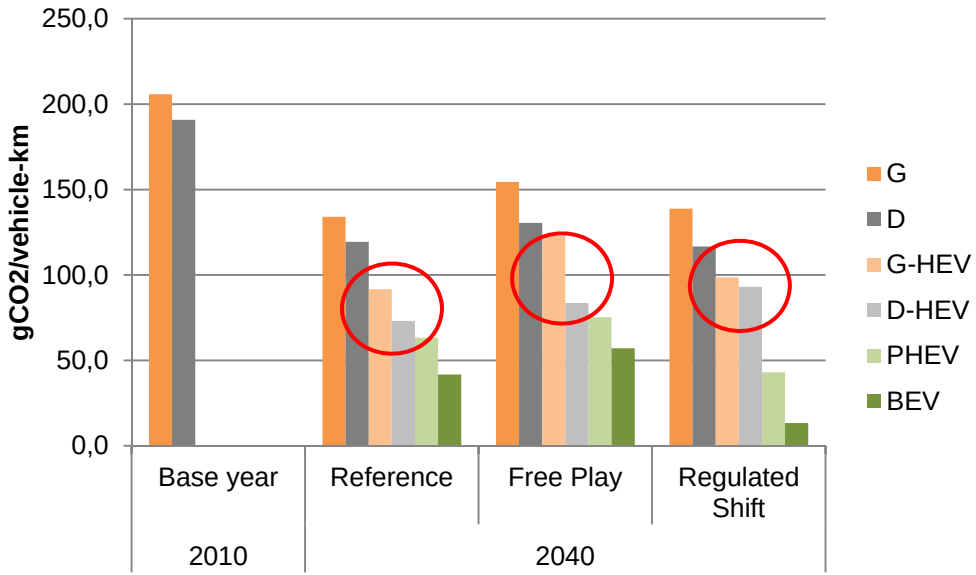
➔ Effects from differences in technological focus

[well to wheel CO_2 emissions]



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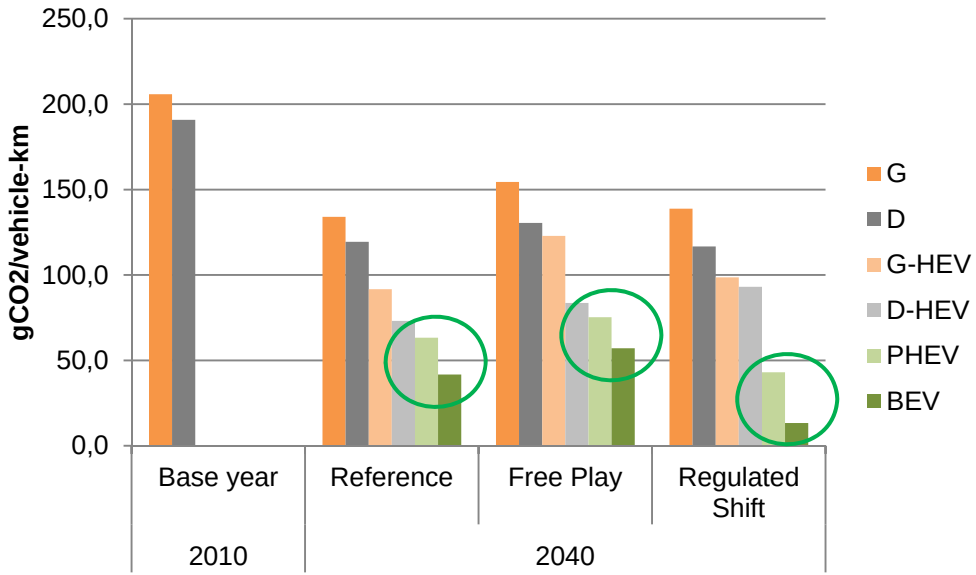
[well to wheel CO_2 emissions]

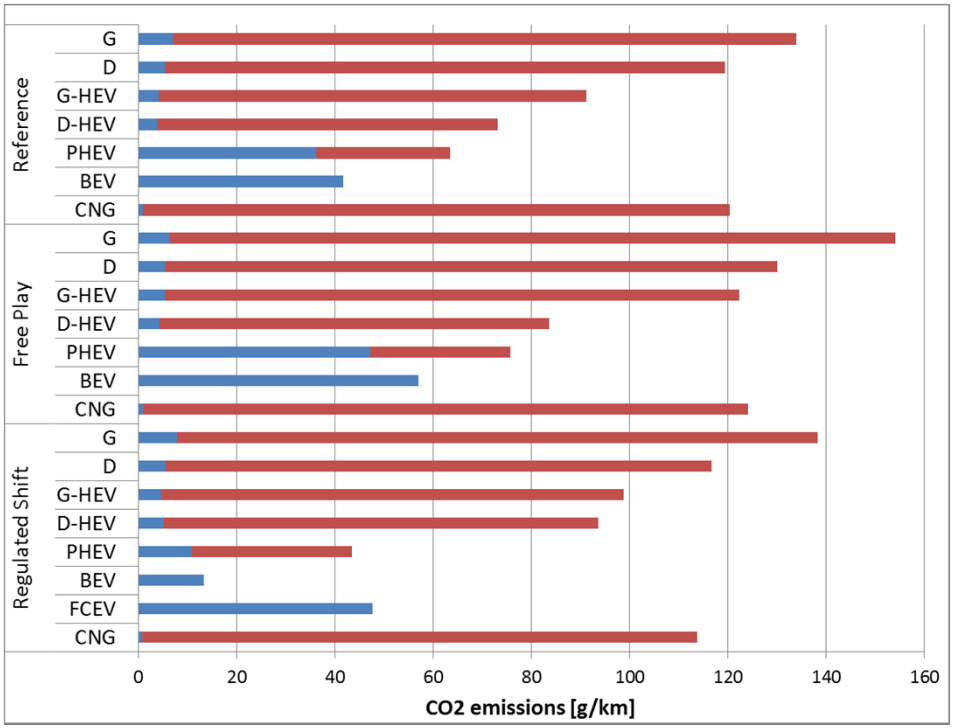


The differences in emissions from individual technologies is visible when taking different scenario developments into account

Examples:

- Due to technology improvements, CO_2 and pollutant emissions of conventional vehicles will decrease in all scenarios

- In the *Free Play scenario*, all vehicles with internal combustion engines have higher CO_2 emissions compared to the *Reference scenario*, i.e. mostly due to size. E.g. G-HEV + >30%



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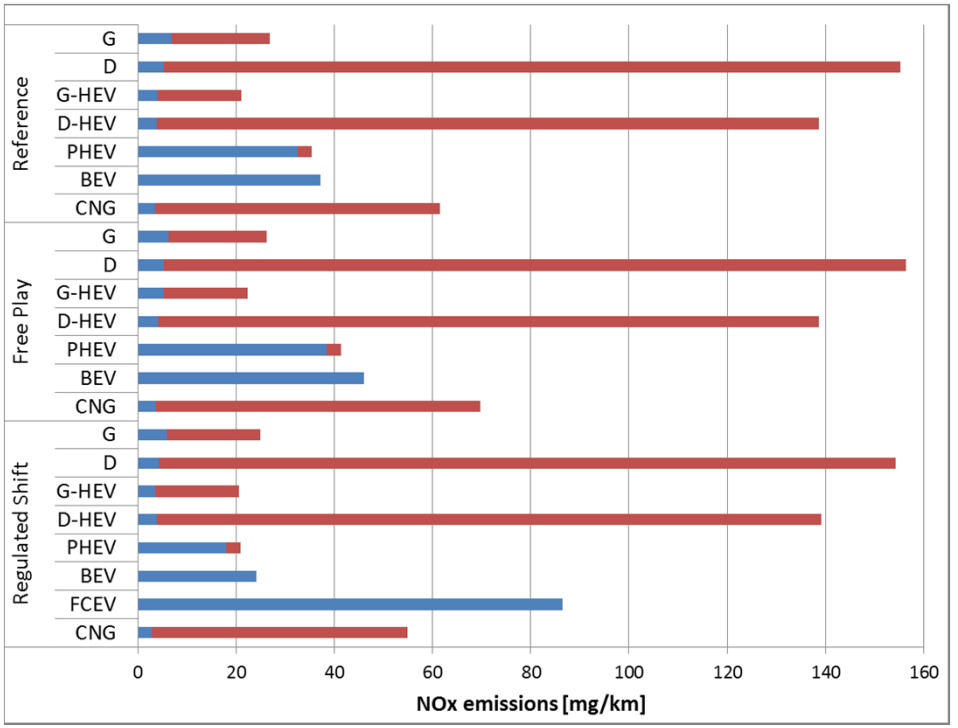
- Differences in direct NOx and PM emissions are small; However, *Free Play scenario* has up to 30% higher indirect NOx and PM emissions, while the *Regulated Shift* has up to 50% lower indirect emissions.



Conclusion

- Emissions for future fleets should not only take different fleet compositions into account, but also systematically address differences in size and technology developments.
- Emissions within one technology will differ for example according to vehicle sizes.
  - e.g. Free Play Scenario = 17% higher CO_2 emissions gasoline cars
- Furthermore, the market penetration of particular technologies will impact the speed and cost of technology developments and thus the final performance of those technologies.
- The development of vehicle technologies will progress in society in parallel with developments in the energy system.
- A differentiated projection of future emissions from transport best utilizes systematic scenario analysis to capture the interdependencies of developments.
- Future emissions from vehicles should also include well to tank emissions for electricity generation and fuel production in order to assess overall societal benefits.
  - e.g. Free Play electricity production = 30% higher CO_2-emissions than Reference; Regulated Shift = >70% lower than Reference

Thank you for your attention. More information in the paper:

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