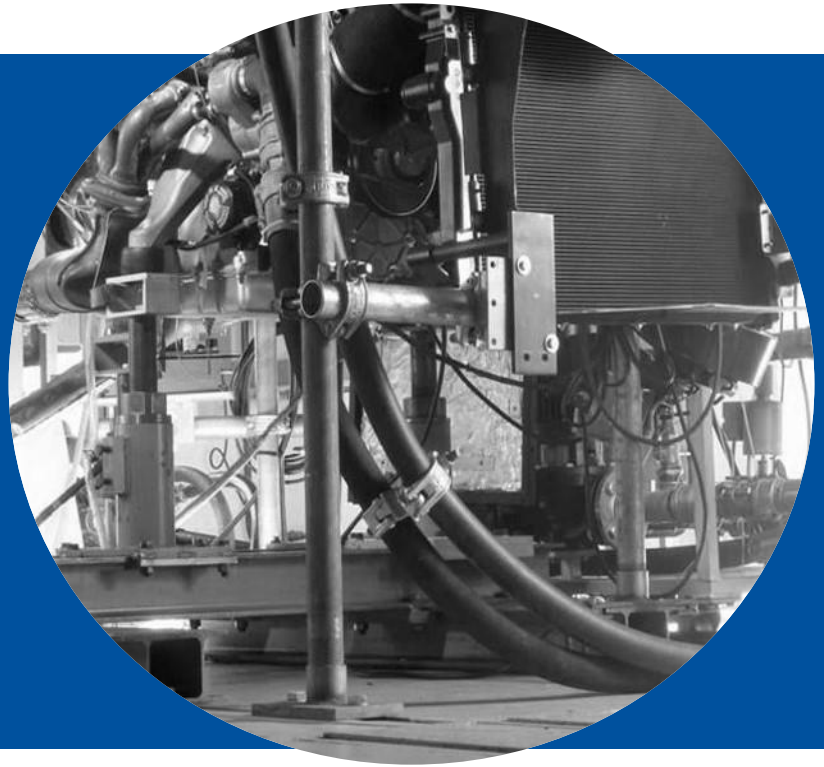
Universität Stuttgart
Institute for Acoustics and Building Physics
Life Cycle Engineering GaBi

LCM 2021

POWERTRAIN 2040

POTENTIAL POWERTRAIN CONFIGURATIONS TO OBTAIN FUTURE CO_2-GOALS



Dipl.-Ing. Aleksandar Lozanovski
Andreas Geß, M.Sc.

AGENDA

1. Introduction
2. Scenarios of Future Development
3. Results of vehicle production
4. Results of production and use
5. Conclusion and Outlook

Introduction

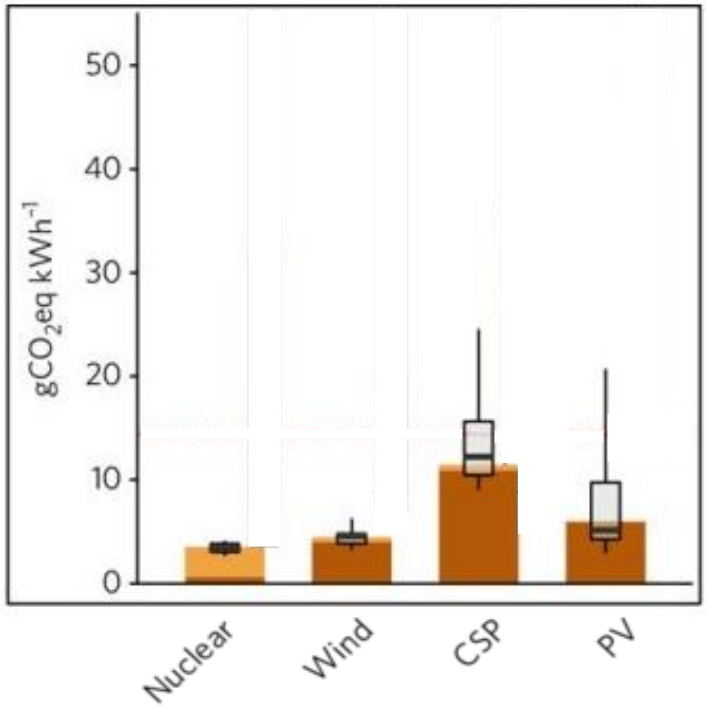
Vehicle Definitions and Study Scope

	SEDAN CAR	SUV	LIGHT TRUCK
			
EMPTY WEIGHT [KG]	1,400	1,800	2,200
PAYLOAD [KG]	400	500	5,290
GROSS WEIGHT [KG]	1,800	2,300	7,490
SYSTEM POWER [KW]	~100	~200	~150
LIFETIME MILEAGE [KM]	200,000	200,000	300,000

- Focus: **year 2040** including technology development of the powertrains
- Included powertrain concepts: **HEV, PHEV, BEV & FCEV** with various gearboxes and powertrain configurations
- Assessed fuels: **syn. gasoline, syn. Diesel, SNG, Hydrogen, Electricity**
- **57 variants in total**

Scenarios of Future Development

Future Electricity



- Especially for synthetic fuels and electric drives the GWP of the electricity is important
- Future (newly built in 2050) renewables might reach 5 (wind) to 7 (PV) g CO_2e/kWh [1)]
- But conservative scenarios without additional efforts on environmental friendly technologies expect 213 g CO_2e/kWh grid mix for the year 2040 [2)]

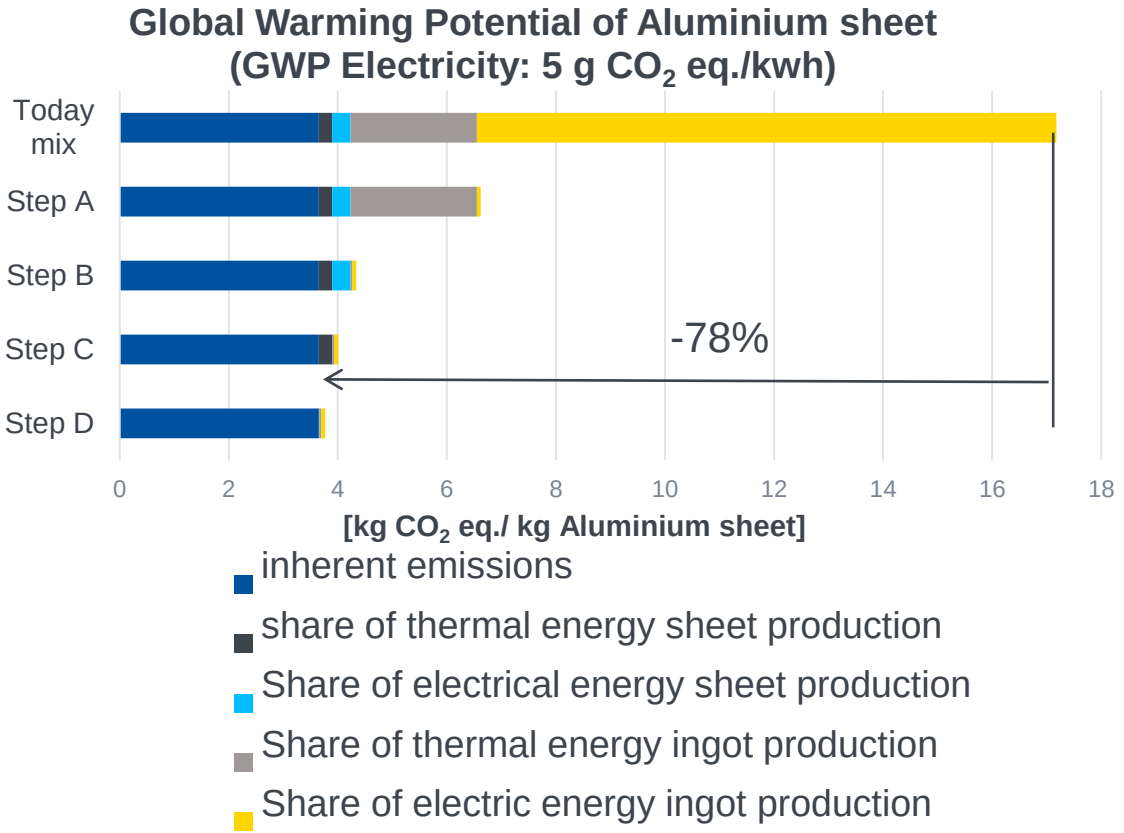
→ **GWP Electricity range of 5 – 213 g CO_2e/kWh**

Source: 1) Pehl et al. 2017 Understanding future emissions from low-carbon power systems by integration of life-cycle assessment and integrated energy modelling

2) EU (2016): EU reference scenario

Scenarios of Future Development

Future Material Production e.g. Aluminium



- Reduction of future production impact → Electric and thermal energy replaced
- Conducted for:
  - Aluminium
  - Steel
  - Lithium
  - Nickel
  - Manganese
  - Platinum
- Depending on the material and electricity, savings are 20% to 90% compared to today

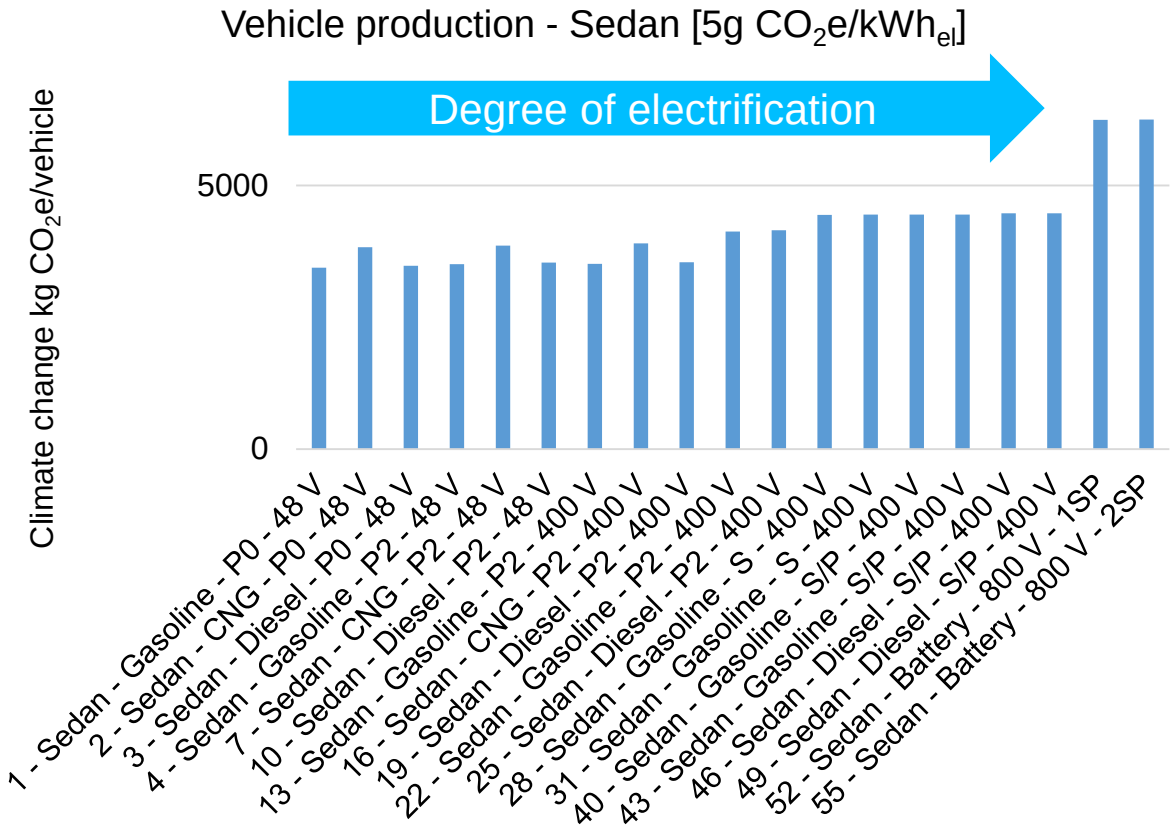
Life Cycle Assessment - Results

Status Quo

- The results of the production and use of the vehicles are only partly final
- Calculation of battery size is done after consumption calculation, when the range is fixed
- Calculation of tank size is done after consumption calculation, when the range is fixed

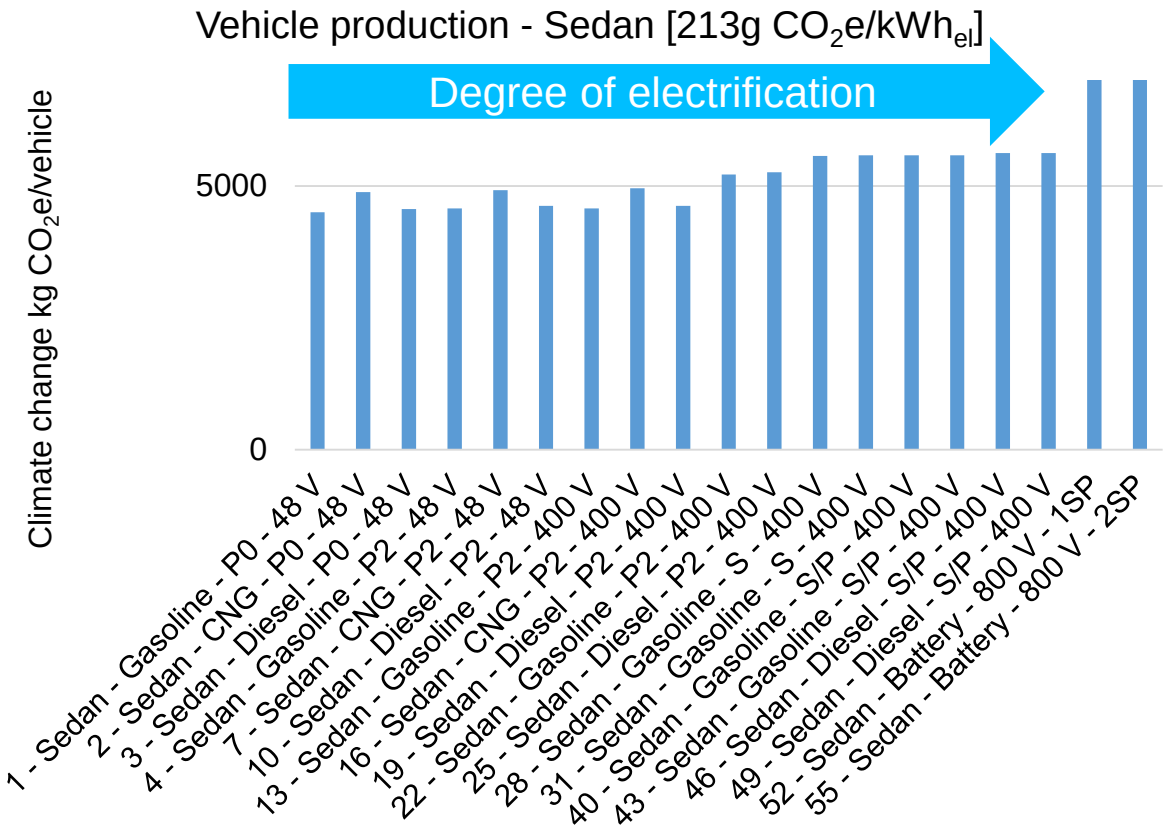
- Results on the next pages show order of magnitude with partly estimated battery and tank size

Life Cycle Assessment - Results



- The higher the degree of electrification and hence battery size, the higher the results
- CNG tanks also make an difference (type 4 carbon tanks)
- Results are good for a order of magnitude but not final

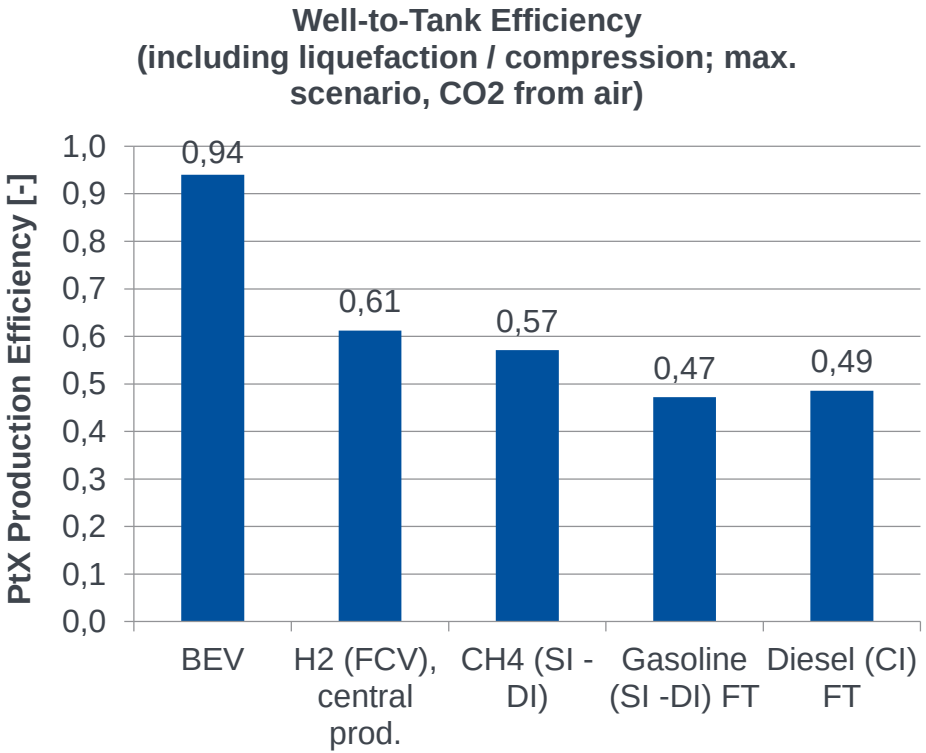
Life Cycle Assessment - Results



- The higher the degree of electrification and hence battery size, the higher the results
- CNG tanks also make an difference (type 4 carbon tanks)
- Results are good for a order of magnitude but not final

Life Cycle Assessment - Results

Fuel Production

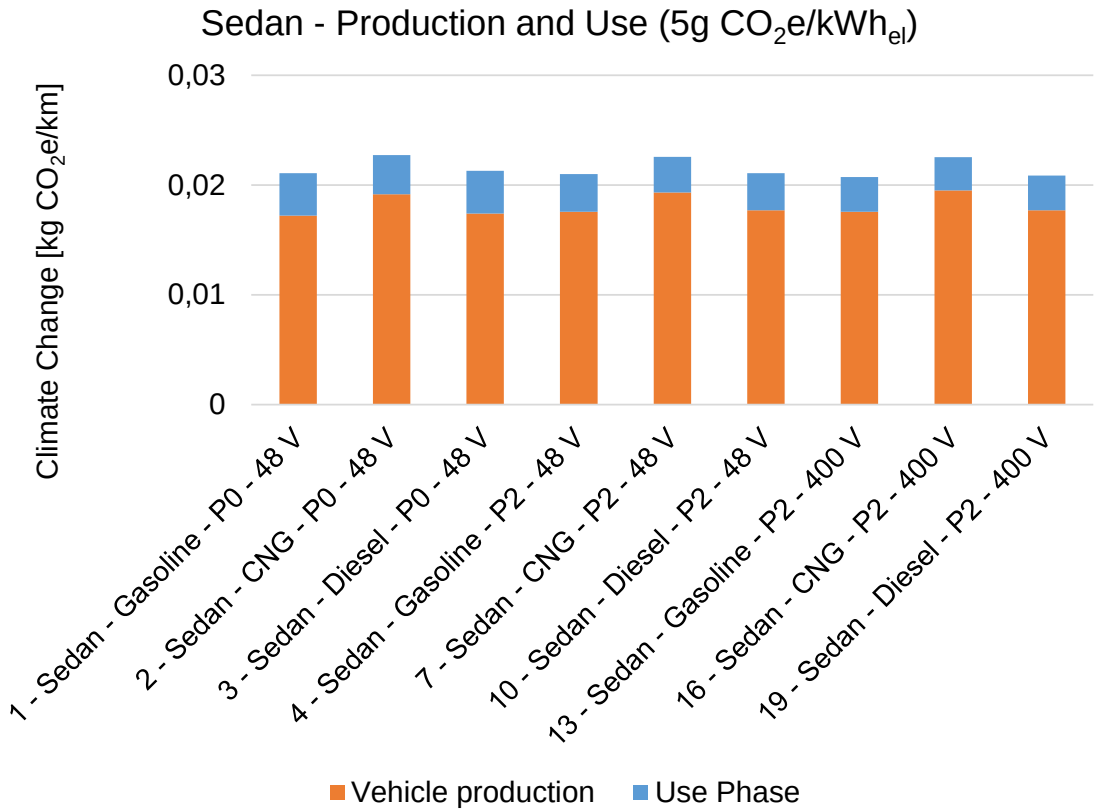


- Fuel production efficiency values for the future used from Fuel Study III (FVV 2018)
- Then fuel production efficiency is combined with 5 g CO_2e/kWh_{el} and 213 g CO_2e/kWh_{el}
- Charging losses for BEV shown here
- Electricity storage for intermittent renewables considered for BEV
- H_2 central production also considers energy storage

Source: Research Association for Combustion Engines eV (FVV) 2018: FVV Fuel Study Energy paths for road transport in the future

Life Cycle Assessment - Results

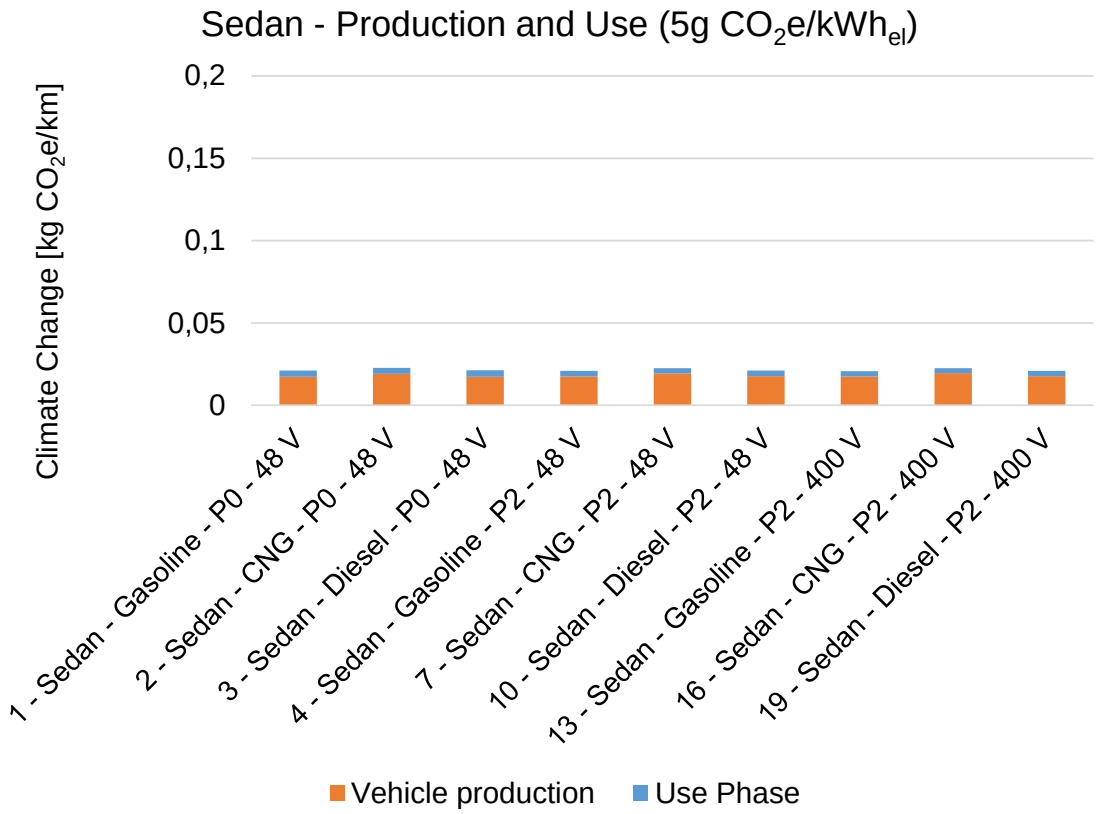
Sedan Production and Use @ 5 g CO_2e/kWh$_{el}$ (PDC)



- At 5 g CO_2e/kWh$_{el}$ the production of the vehicle has the higher impact
- Impact of CNG tank production is visible
- There are slight effects of the fuel economy and fuel production efficiency

Life Cycle Assessment - Results

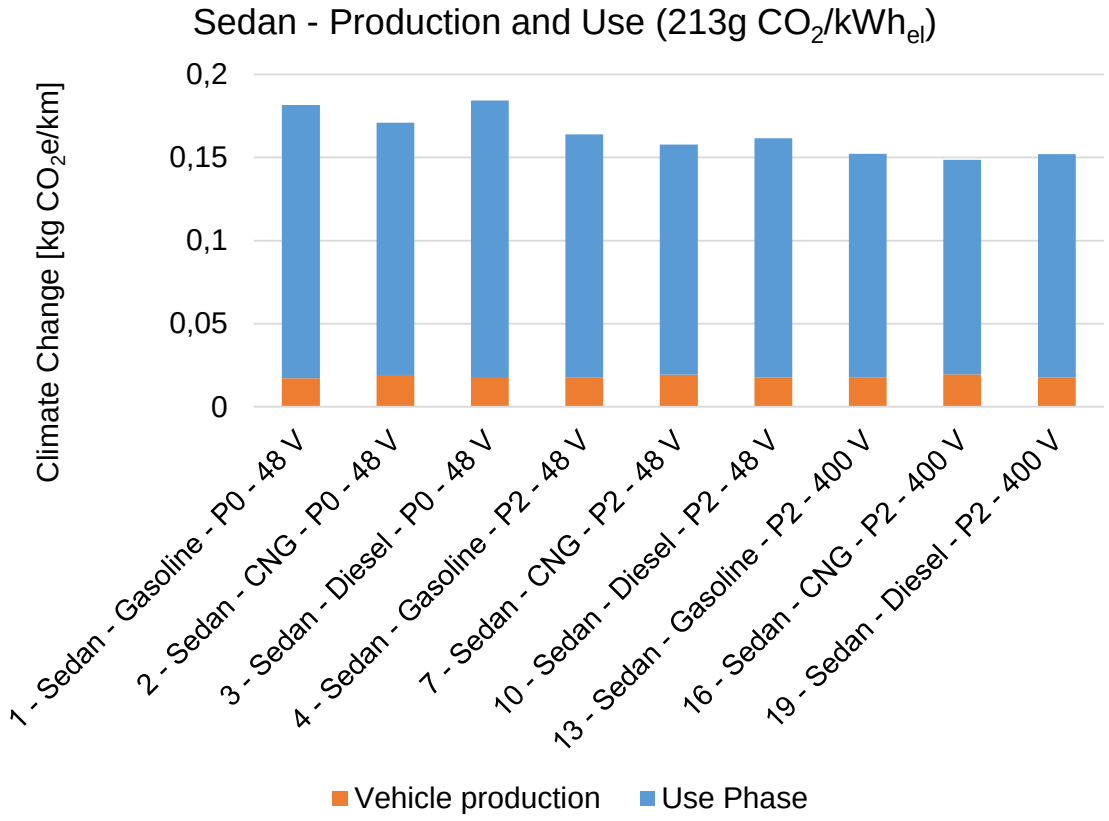
Sedan Production and Use @ 5 g CO_2e/kWh$_{el}$ (PDC)



- Values are the same like in the last slide
- The y-Axis is altered to set the scene for the next slide (213 g CO_2e/kWh)

Life Cycle Assessment - Results

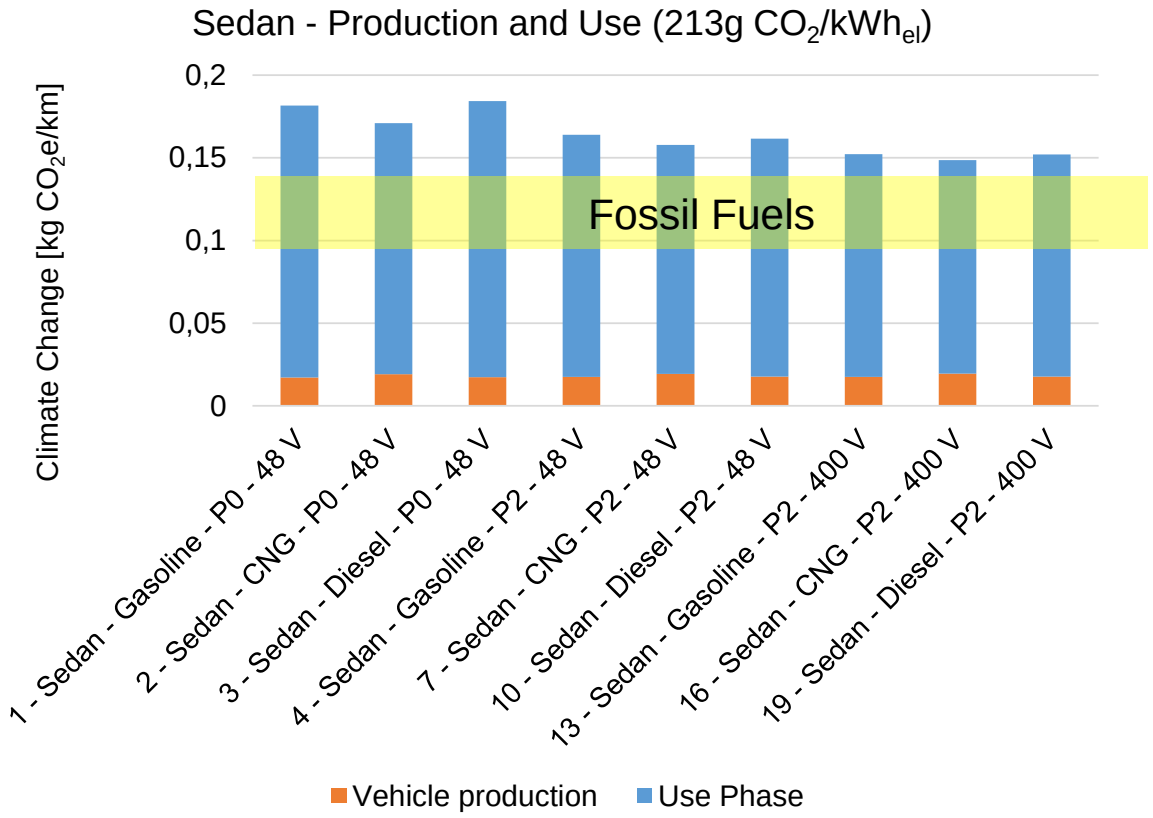
Sedan Production and Use @ 213 g CO_2e/kWh$_{el}$ (PDC)



- At 213 g CO_2e/kWh$_{el}$ the use phase if dominant
- Use phase is determined by fuel production and fuel efficiency

Life Cycle Assessment - Results

Sedan Production and Use @ 213 g CO_2e/kWh_{el} (PDC)



- The yellow bar indicates the range fossil fuels would be at
- Using this conservative electricity provision scenario, more CO_2e is emitted than with fossil fuels

Life Cycle Assessment - Results

Conclusion and Outlook

- First results give an overview of the general trends
- Depending on the scenario either production of the vehicle or the use phase is dominant
- At 213 g CO_2e/kWh_{el} more CO_2e is emitted compared to fossil fuels
  → For synthetic fuels a higher share of energy from renewables is vital

- More powertrain concepts will be evaluated soon
- Comparison of classical and alternative powertrain concepts and fuels
- Results will be published in an open-access report in 2022 via the FVV

Dipl.-Ing. Aleksandar Lozanovski

University of Stuttgart

Institute for Acoustics and
Building Physics (IABP)
Life Cycle Engineering GaBi

Aleksandar.lozanovski@iabp.uni-

Andreas Geß

University of Stuttgart

Institute for Acoustics and
Building Physics (IABP)
Life Cycle Engineering GaBi

Andreas.Gess@iabp.uni-