COMPARISON BETWEEN DIESEL AND GASOLINE ENGINES AS PROPULSION SYSTEMS FOR HEV

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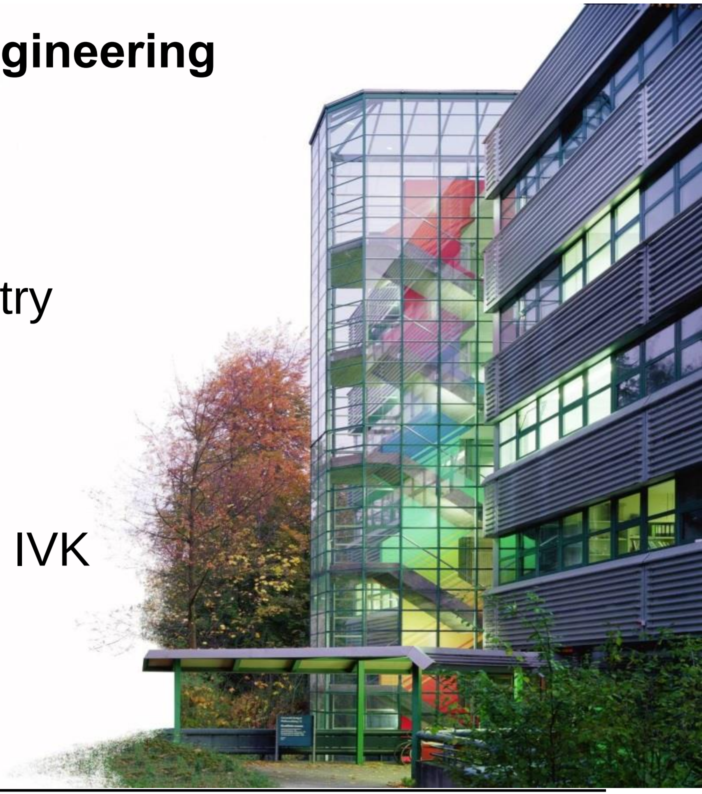
Agenda

- FKFS
- Motivation
- Vehicle and Powertrain
- ICE Optimization
- Driving Cycle and Optimization Tool
- Concept Comparison
- Conclusions

FKFS …

- means **„Research Institute for Automotive Engineering and Vehicle Engines Stuttgart“**
- is a non-profit making foundation under civil law
- has no basic funding
- operates as an engineering partner for the industry
- has more than 160 employees
- turn around > 18 M €

- works in cooperation with the University Institute IVK
- was founded in 1930 by Wunnibald Kamm to overcome restrictions of public administration
- … which is still a good reason



FKFS

Prof. Wiedemann

Automotive Engineering

Prof. Reuss

Automotive Mechatronics

Prof. Bargende

Automotive Powertains

Systems Expertise for the Automobile of the Future!

Motivation

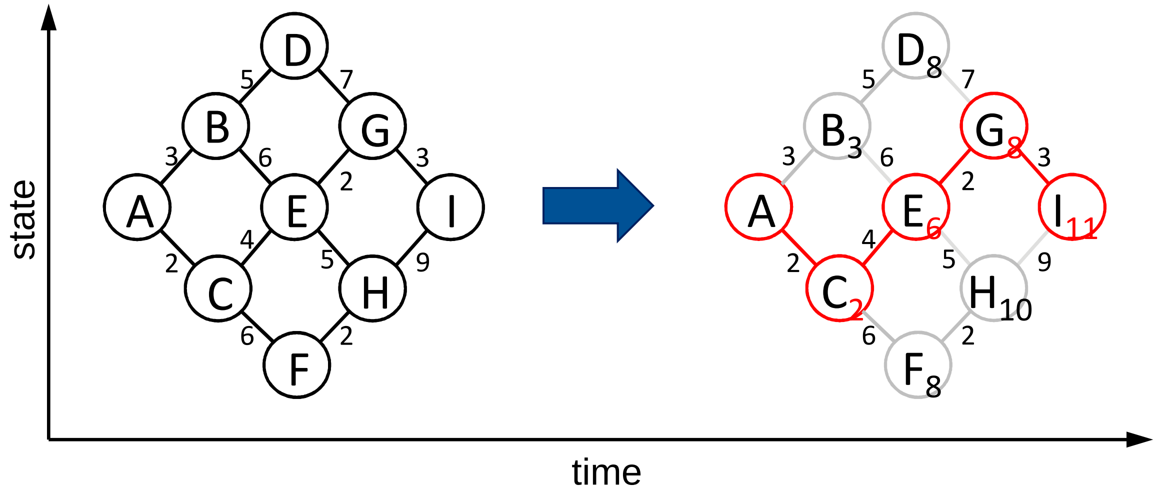
- Optimization of conventional drivetrains will play a significant role in reducing fuel consumption in the short and medium term, as the roads are still dominated by ICE powered cars
- ICE Optimization is also a key factor for HEV

  Very often, engine optimization technologies and Hybridization are investigated and evaluated independently, which is not always feasible (in some cases 1 + 1 does not equal 2…)
- Driving Cycle Simulations offer a great possibility to investigate different concepts and combinations of components

Simulation Model
method: dynamic programming

Bellman‘s Principle of Optimality (1957)

„An optimal policy has the property that whatever the initial state and initial decision are, the remaining decisions must constitute an optimal policy with regard to the state resulting from the first decision“

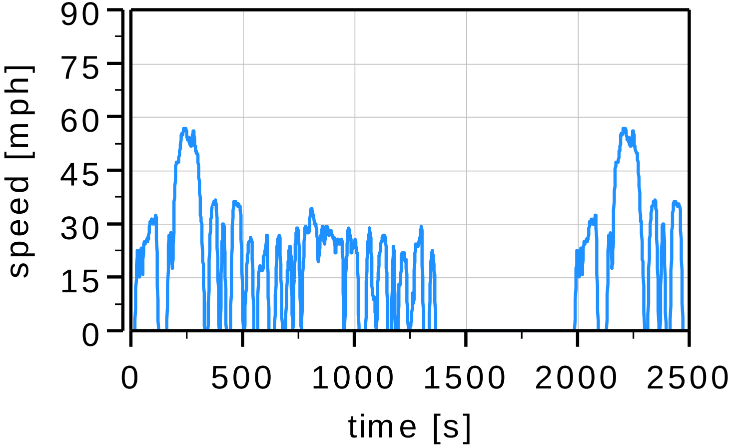


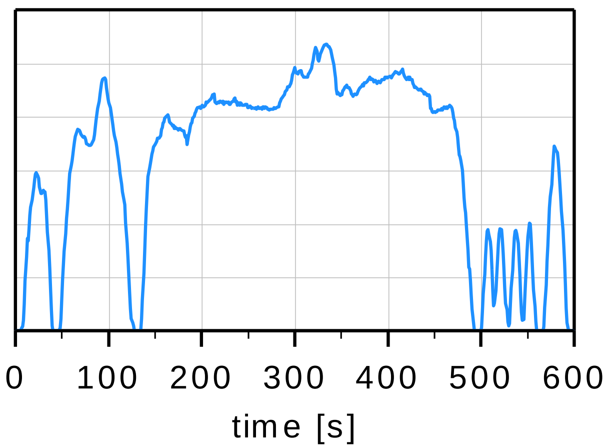
- Knots represent the system states (e.g. SOC)
- Transition costs between time steps (e.g. CO_2 / NO_X)
- Goal: way with minimal total costs

Driving Cycle and Optimization Tool

- Dynamic Programming Matlab Function
  - Determines optimal control of vehicle: Torque Split and Gear
  - Calculates optimal fuel consumption for given vehicle setup
  - All results SoC-balanced and without cold start

- FTP-75 / US06





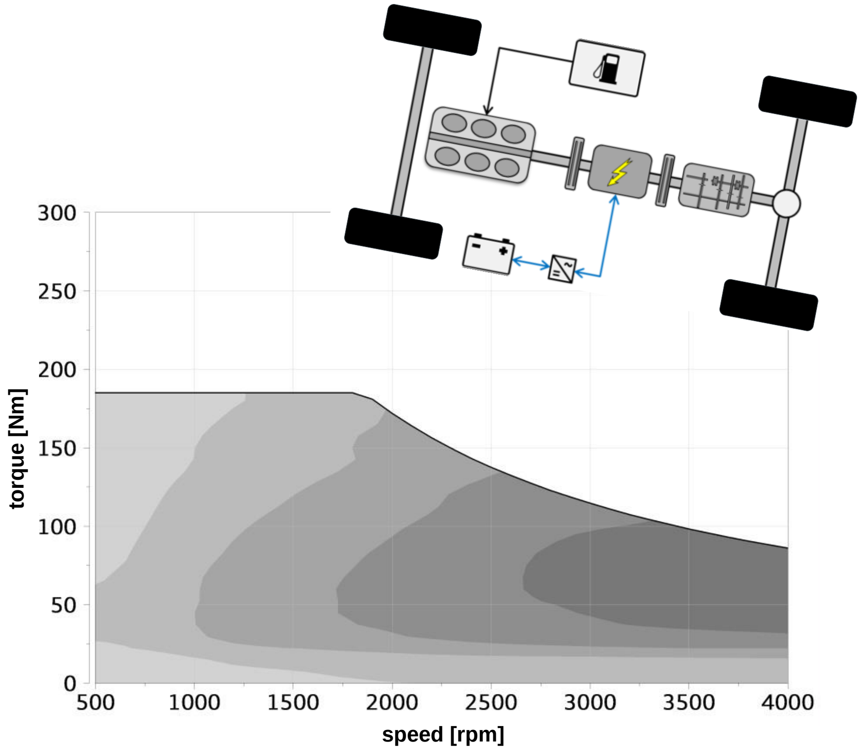
Simulation Model
Vehicle and ICE specifications

	Diesel	Gasoline
Vehicle mass (conv | HEV) [kg]	1900 | 2000	1800 | 1900
Frontal area [m^2]	2.3	
Drag coefficient	0.3	
Rolling resistance coeff.	0.008	
Brake drag torque per wheel [Nm]	1.5	
Displacement	3.0 l turbocharged	2.0 l turbocharged
Maximum Rated Power [kW]	180	185
Exhaust after treatment	NSC | SCR	TWC

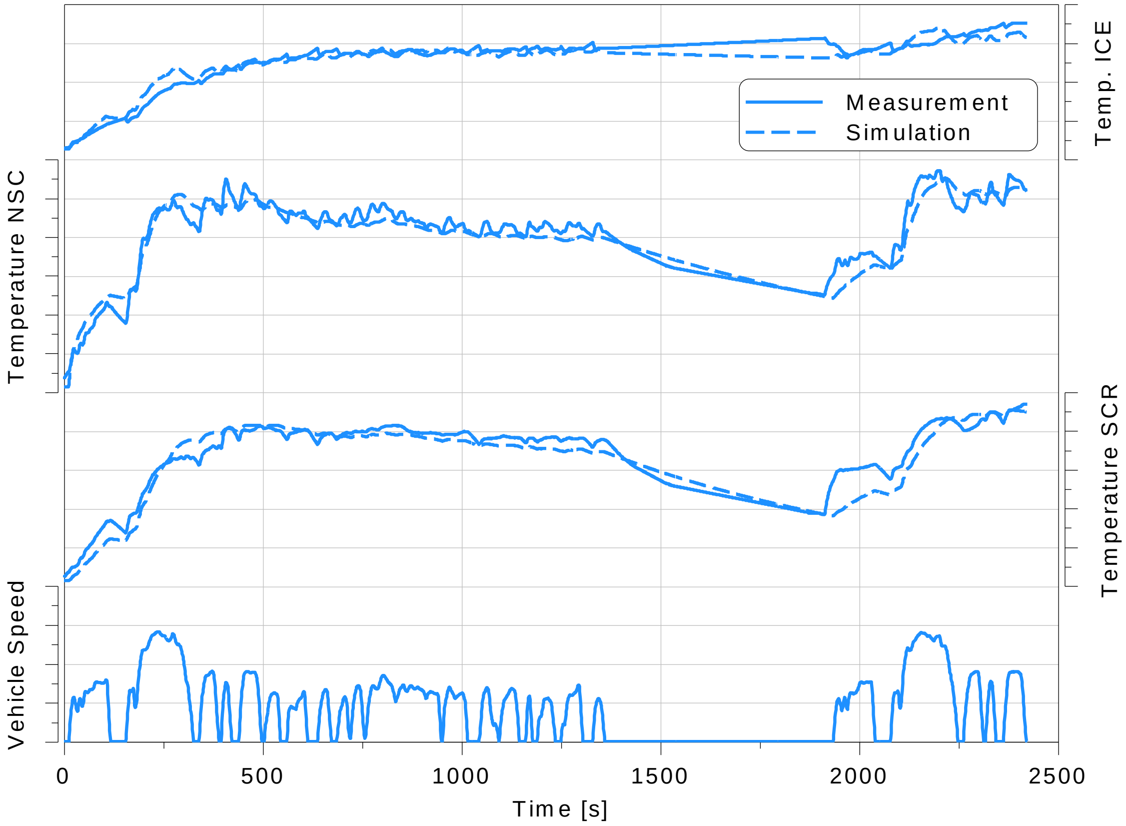
Simulation Model
Specification of hybrid powertrain

- Optimized components
  - 7shift-DCT with dry clutches for better efficiencies
  - Electric machine with diesel-optimized efficiencies (down speeding)

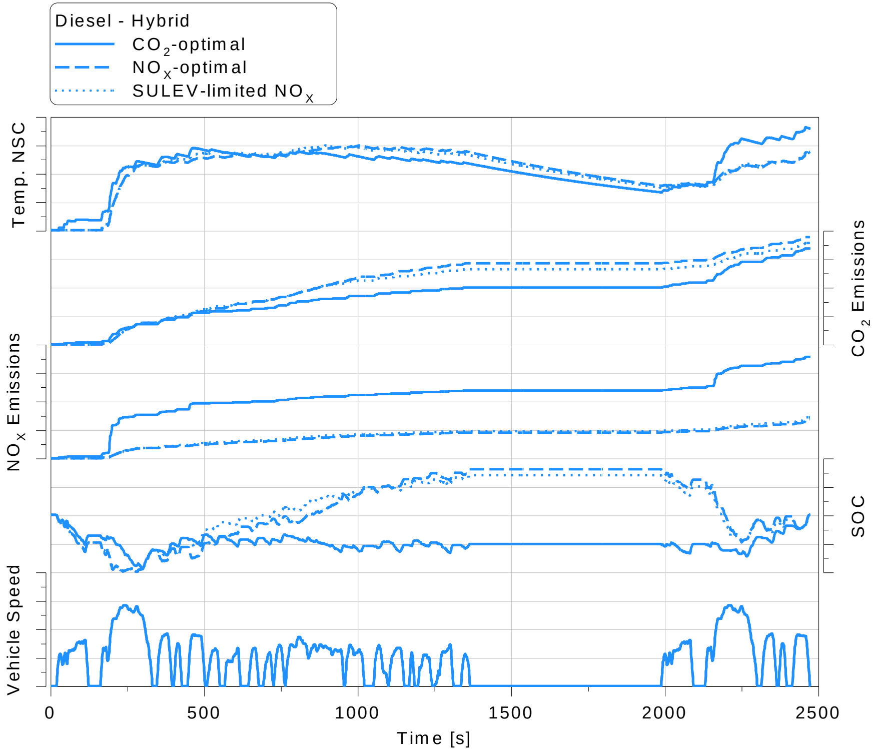
Assumptions HEV powertrain		
Electric Machine	25 kW permanent excited	
Battery	2.4 kWh	
SOC range	35 - 75	
Transmission	8-shift-automated	
Final drive ratio	2.519 (diesel)	3.033 (gas.)

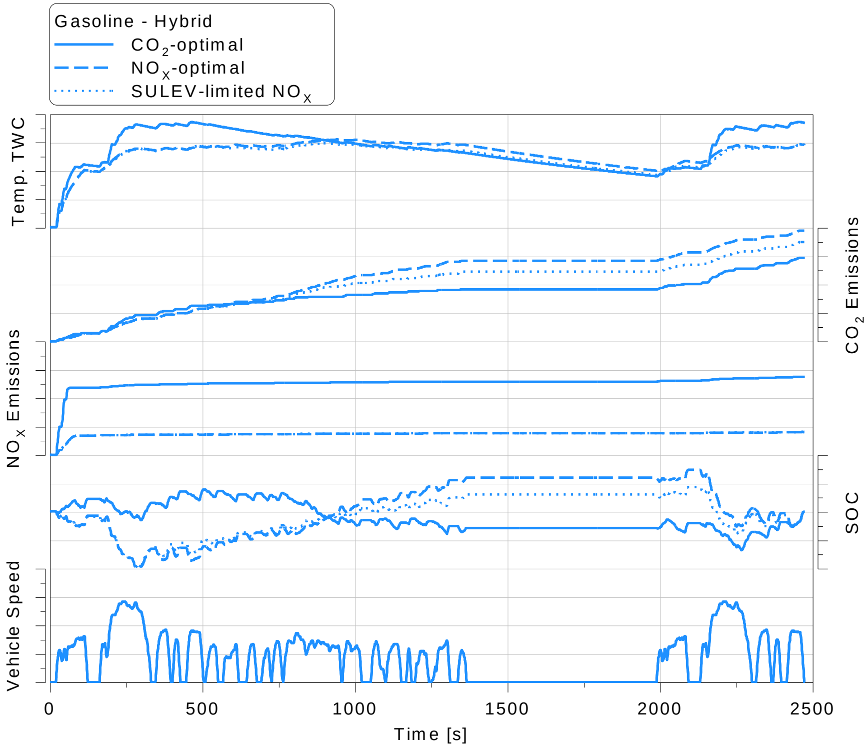


Simulation results
Validation

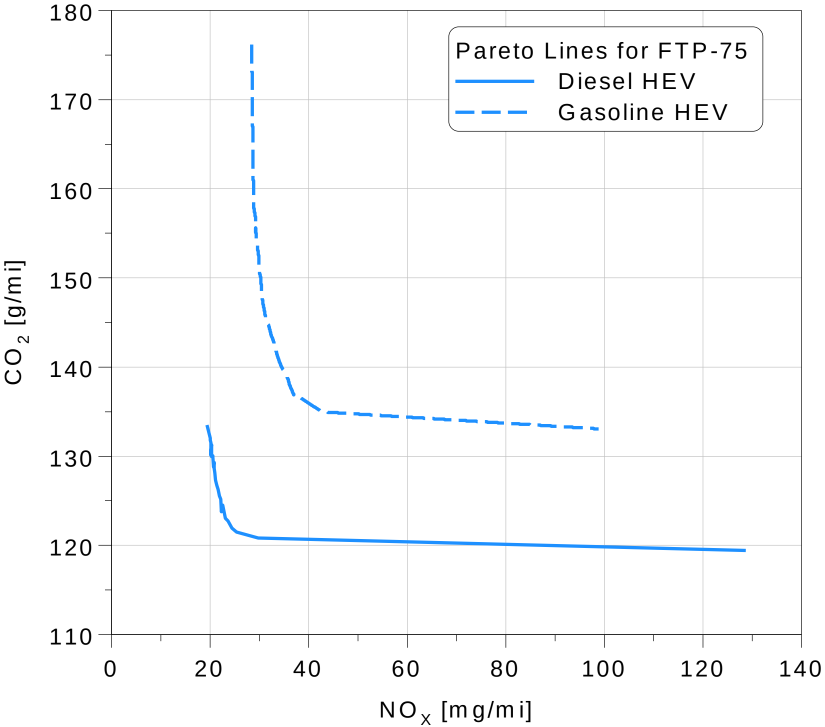


Simulation results
Hybrid Operation Strategies for Diesel vs. Gasoline HEVs





Simulation results

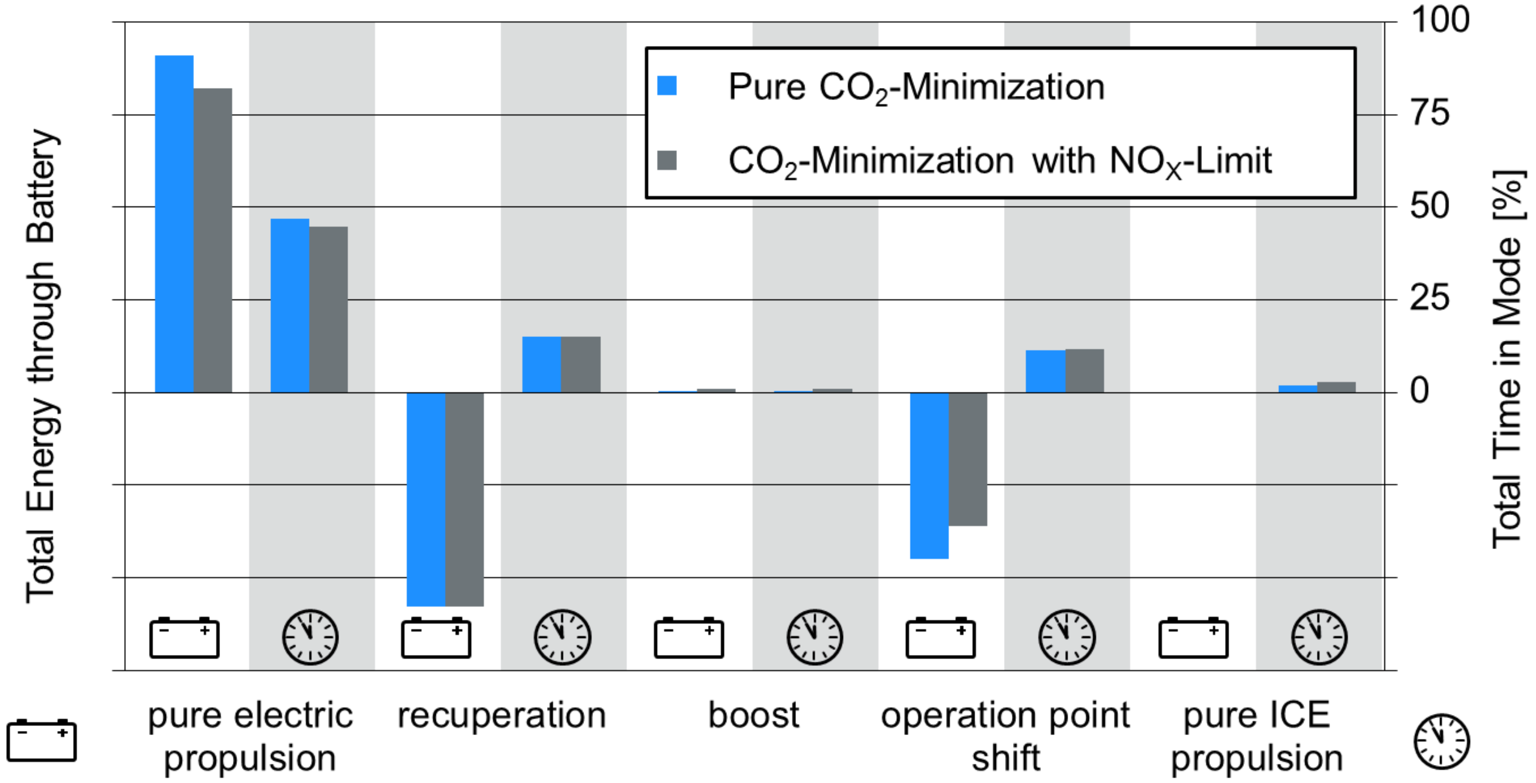


		FTP75		US06	
		Diesel	Gas.	Diesel	Gas.
Standard Powertrain	CO_2	188	215	232	265
	NO_X	116	114	48	31
CO_2-optimized	CO_2	119	133	192	213
	NO_X	129	99	65	27
NO_X-optimized	CO_2	133	176	203	-
	NO_X	20	28	23	-
SULEV-limited NO_X	CO_2	121	152	193	-
	NO_X	30	30	30	-

CO2 in [g/mi] | NOX in [mg/mi]

Simulation results

Impacts of NO_X-limitation on operation modes (Diesel HEV)



Conclusions

- The Benefits of Engine Part-Load Optimization can only to a small extend be transferred to Full HEV, as these concepts eliminate most of the part load Operation Points
- For efficiency gains in Full HEV, an improvement in the high load areas is required

  - ➢ Engine optimization depending on the boundary conditions

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