



ISEA RWTH Aachen Electric Bus Simulation

Finding the Optimal Technical Configuration

05.04.2017

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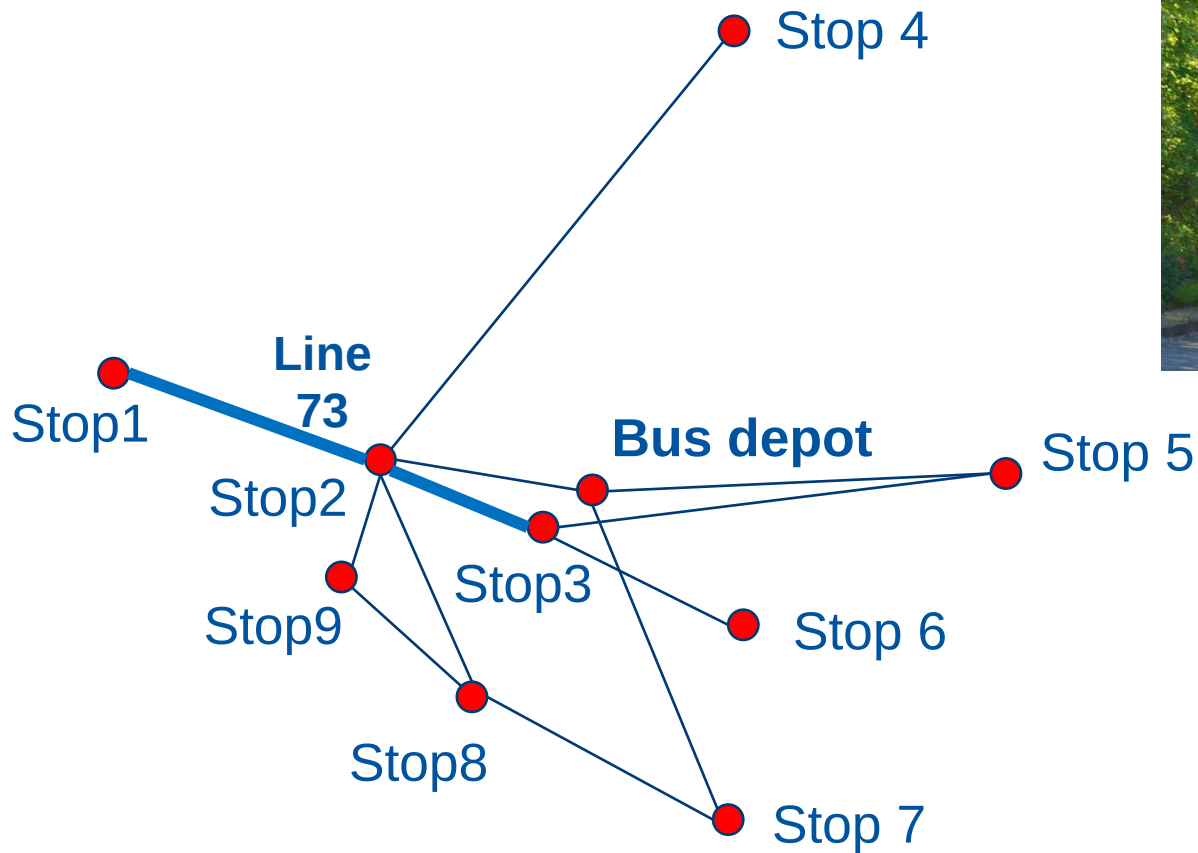
Lehrstuhl für Elektrochemische Energiewandlung
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Electric Bus Simulation - Motivation

- Theoretical evaluation of technical feasibility
 - Charging times & power, Battery energy capacity
- Evaluation of different technological concepts before implementation / demonstration
 - Overnight/Opportunity-Charging, different Battery technologies
- Fast & valuable results, if input data is as realistic as possible
 - Check robustness against Worst-Case conditions
- Estimation of resulting (technical) Project costs
- Optimization of technical configuration in order to decrease costs

Example – 3 new Electric Buses on Line 73 in Aachen



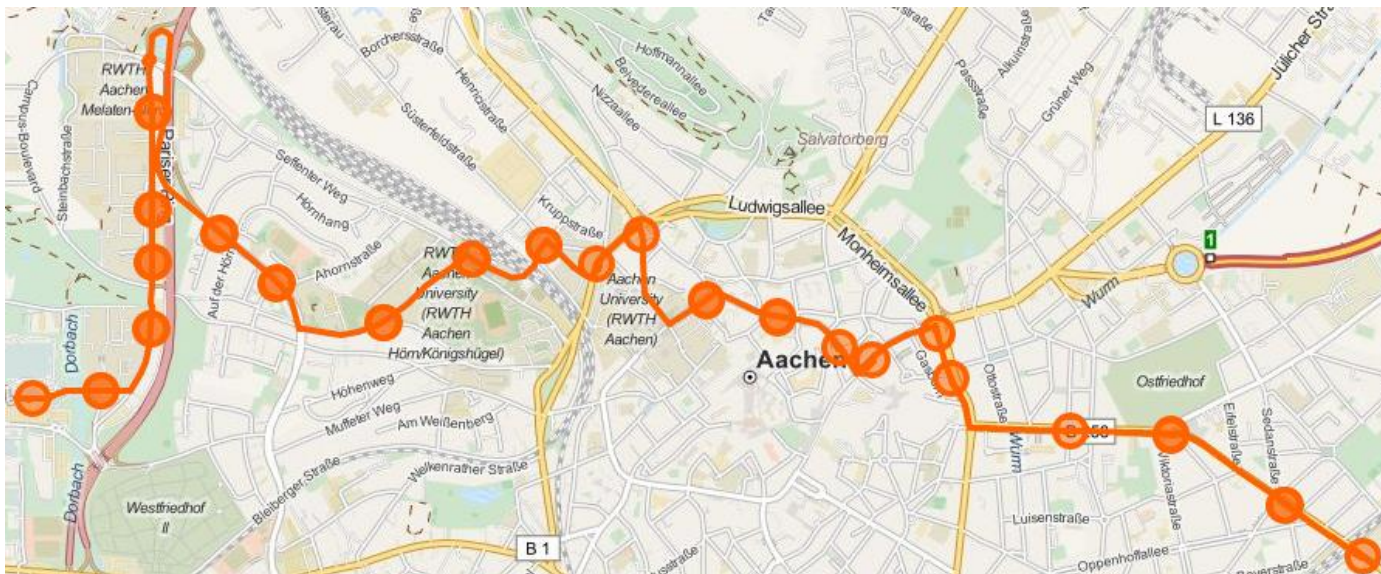
● Final stop

Driving Profiles from vehicle schedules

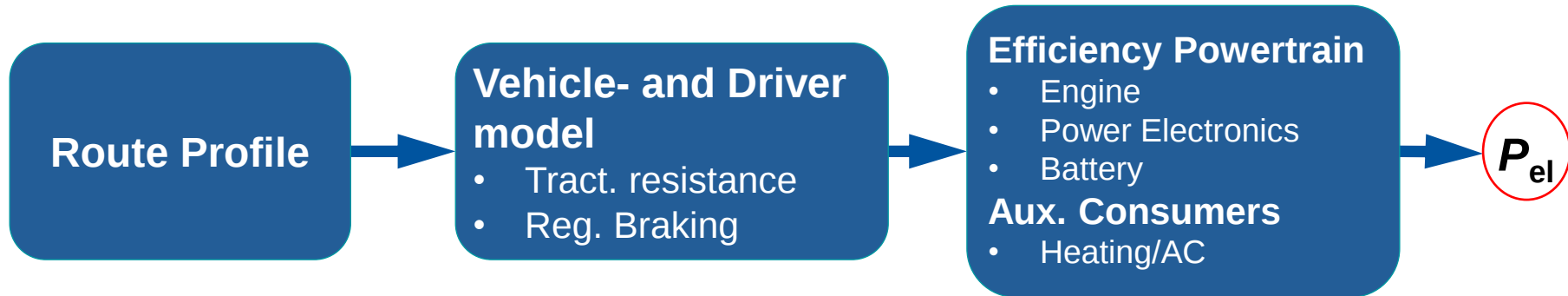
Line	Schedule	Veh. type	7	30	8	30	9
8	926	NCC	Profil_000 ZBH 38 BF14* BF14 52	Profil_0002 73 KL12* KL12* KL12 11 18	Profil_0003 73 BFRO1* BFRO1 50	Profil_0004 73 KL12* KL12* KL12 26 27 48	Profil_0005 73
40	925 S	NCC	Profil_0007 ZBH 35 SCSC1* SCSC1 2	Profil_0008 S{A} ROWE1* ELI2* ELI2 36 47	Profil_0009 33 KL12* KL12* KL12 9 18	Profil_0010 73 BFRO1* BFRO1 50	Profil_0011 73

■ Detailed route is taken as a basis including:

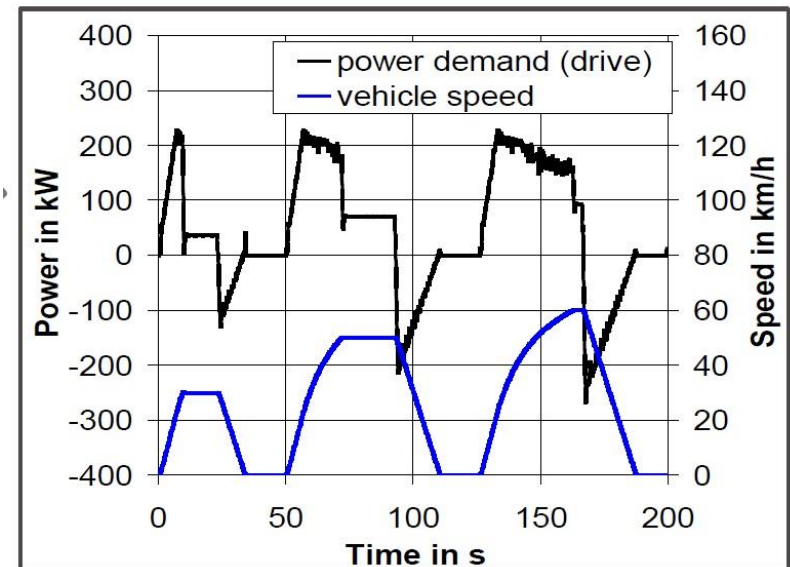
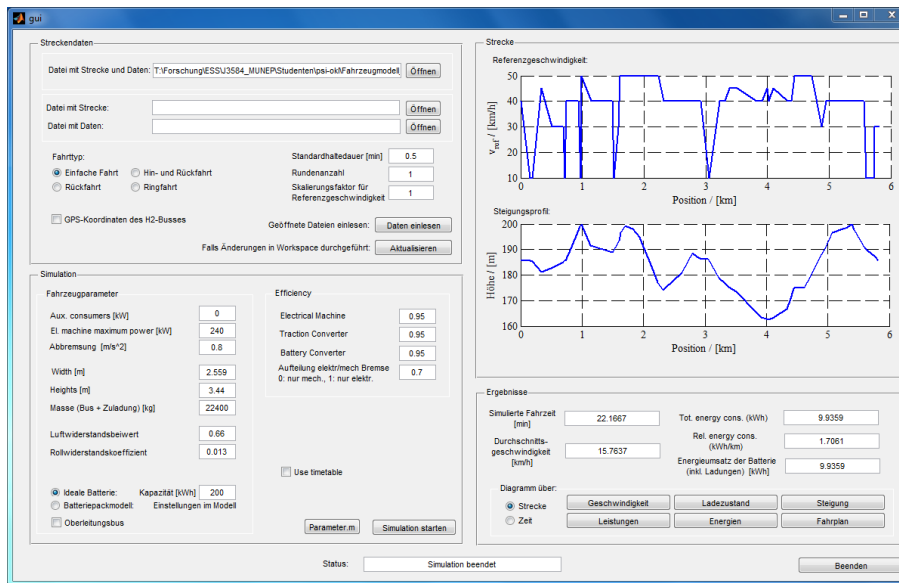
- Traffic lights
- speed zones
- height profile
- curves



From Route to Load Profiles

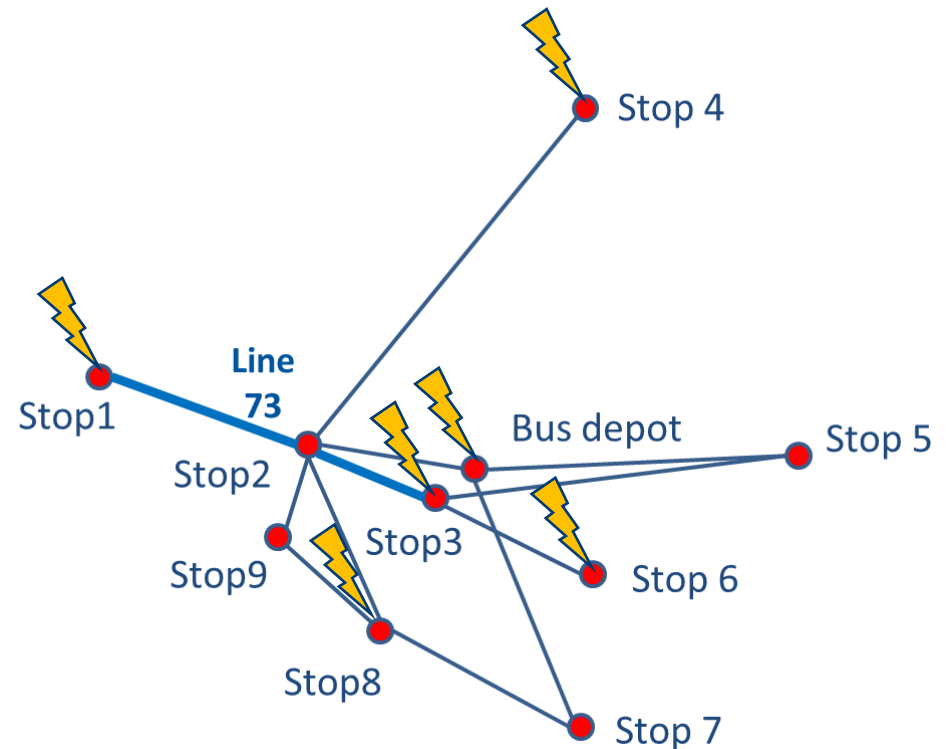


- With help of a vehicle model, the power requirement at each time point is calculated from the route profile



Finding the configuration with lowest TCO

Optimization variable	
Battery capacity	? kWh
Charging station Stop1	? kW
Charging station Stop3	? kW
Charging station Stop4	? kW
Charging station Stop6	? kW
Charging station Stop8	? kW
Bus Depot	? kW
Other parameter	
Investigation timeframe	12 years
Interest rate	4 %



System Model

Power-Supply

Charging station

Vehicle

- Building cost subsidy,
- Connection charge, *
- Network charge

Constructional measures

Aux. consumers

El. Machine

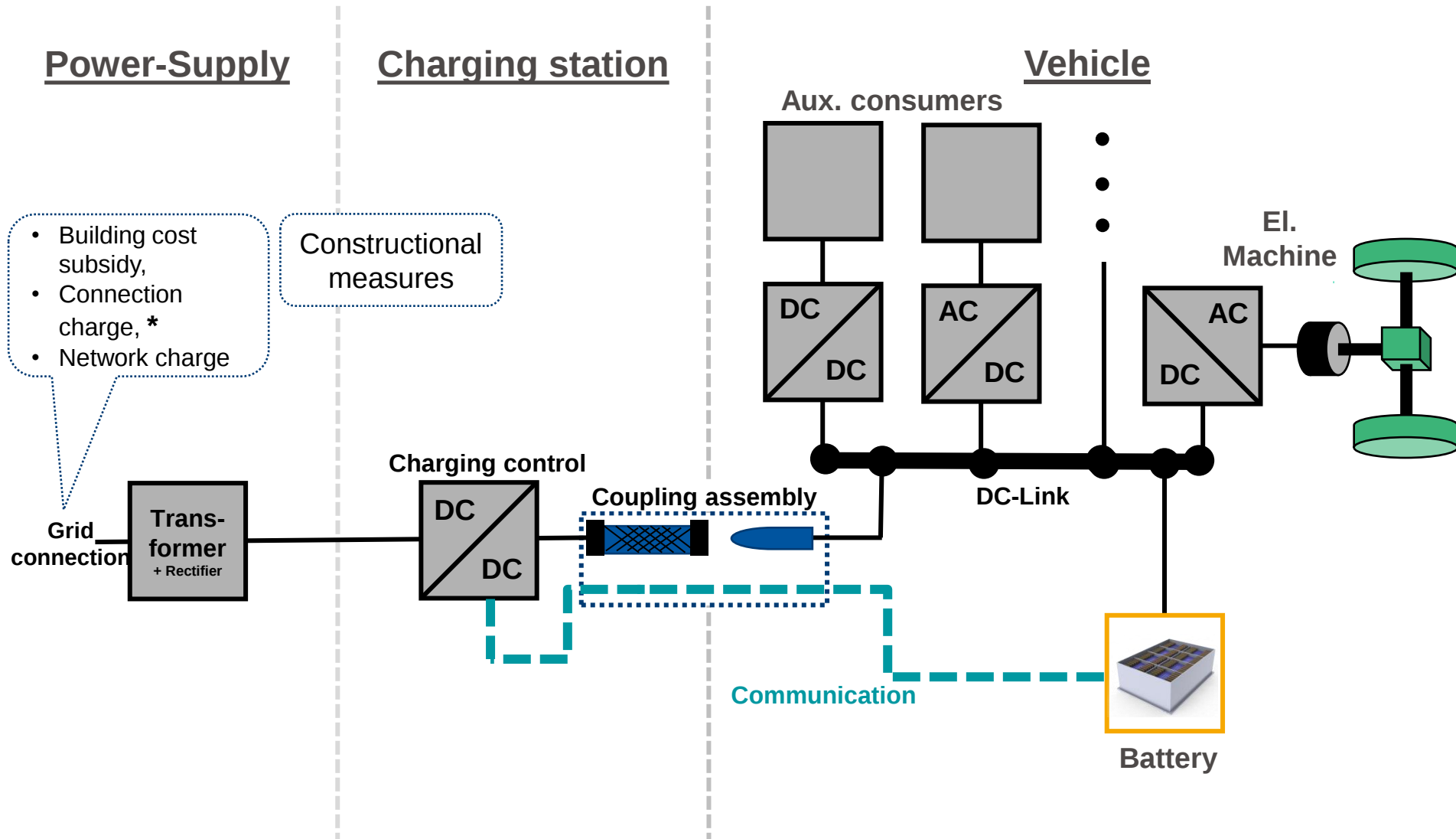
Charging control

Coupling assembly

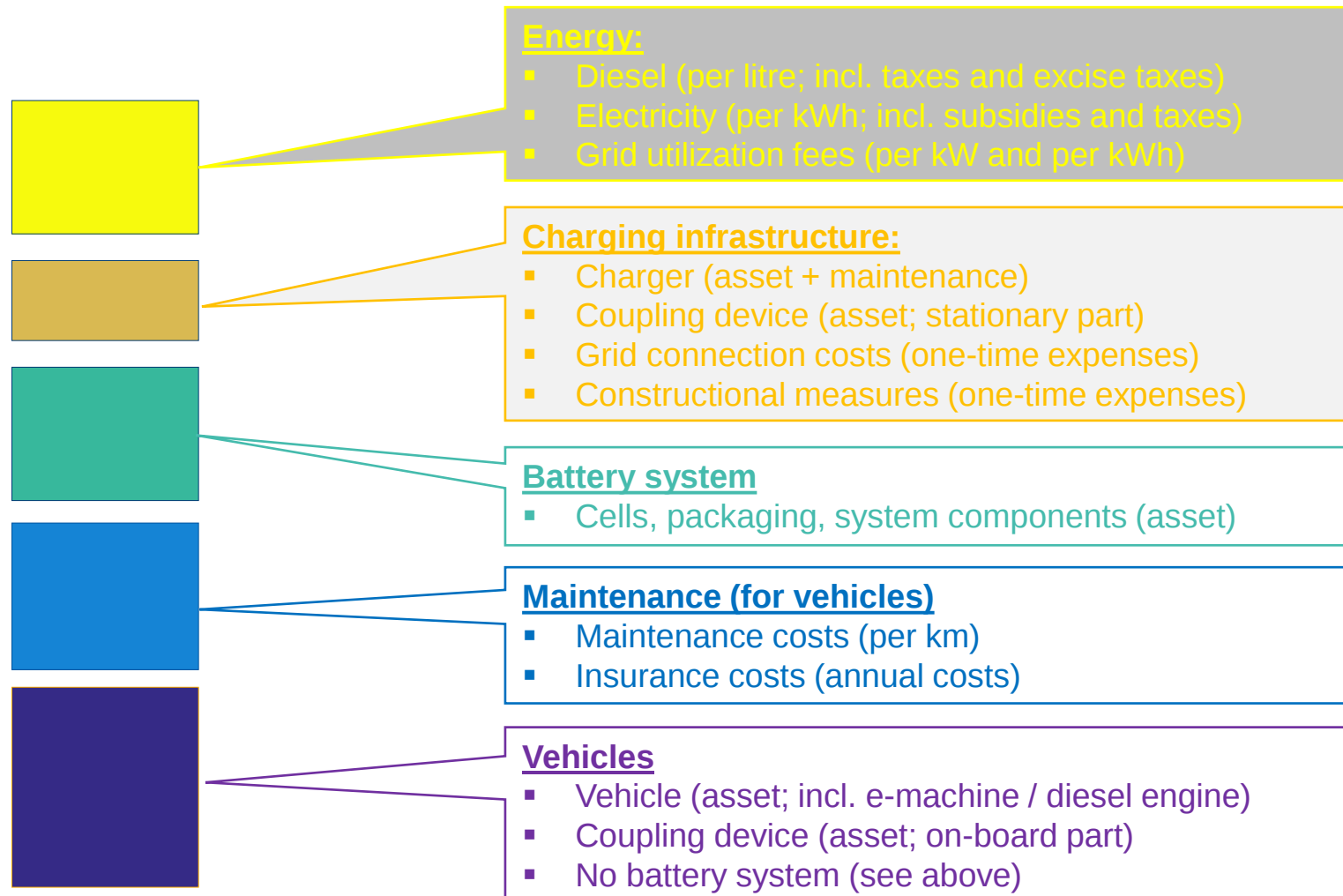
DC-Link

Communication

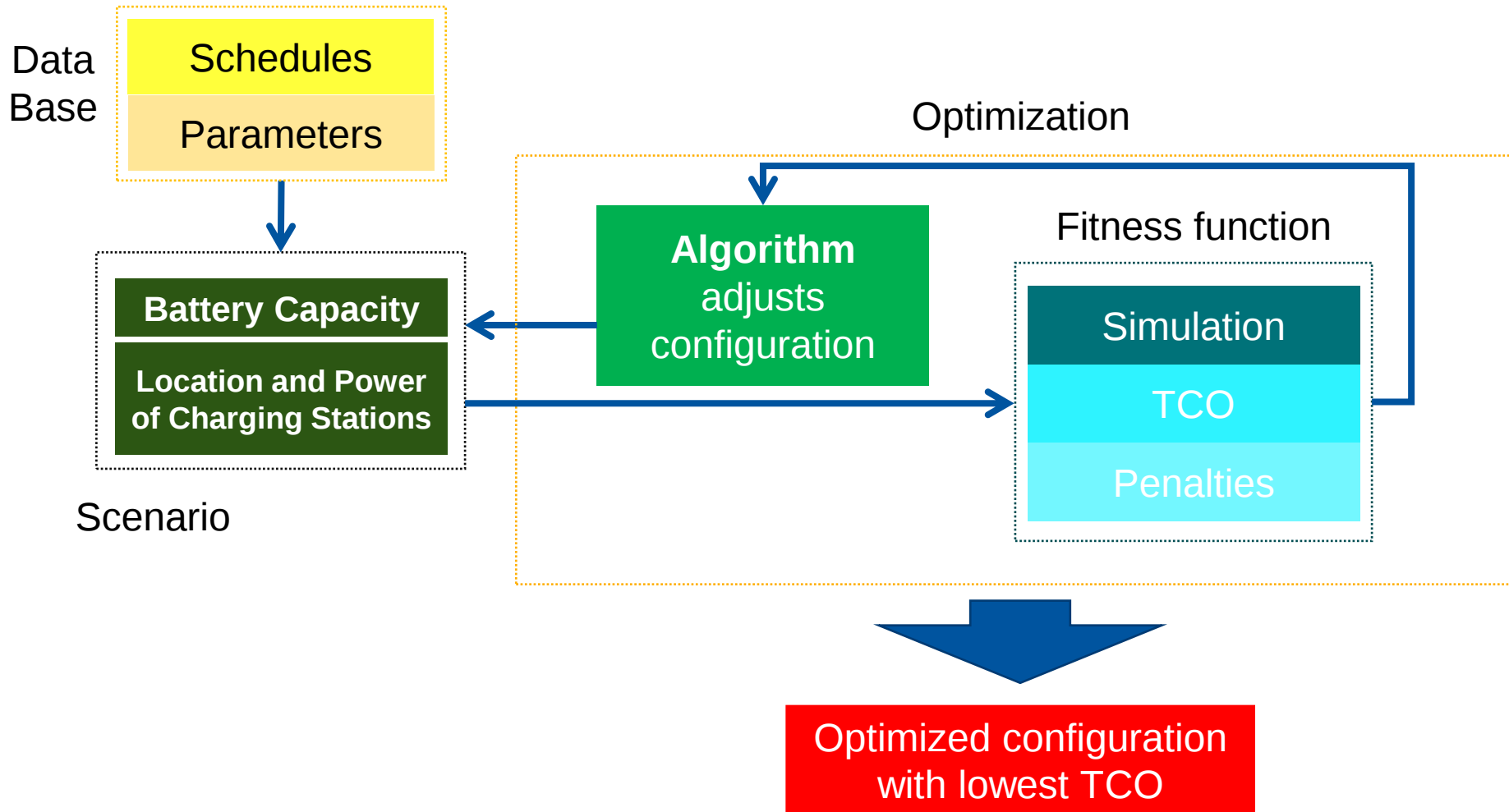
Battery



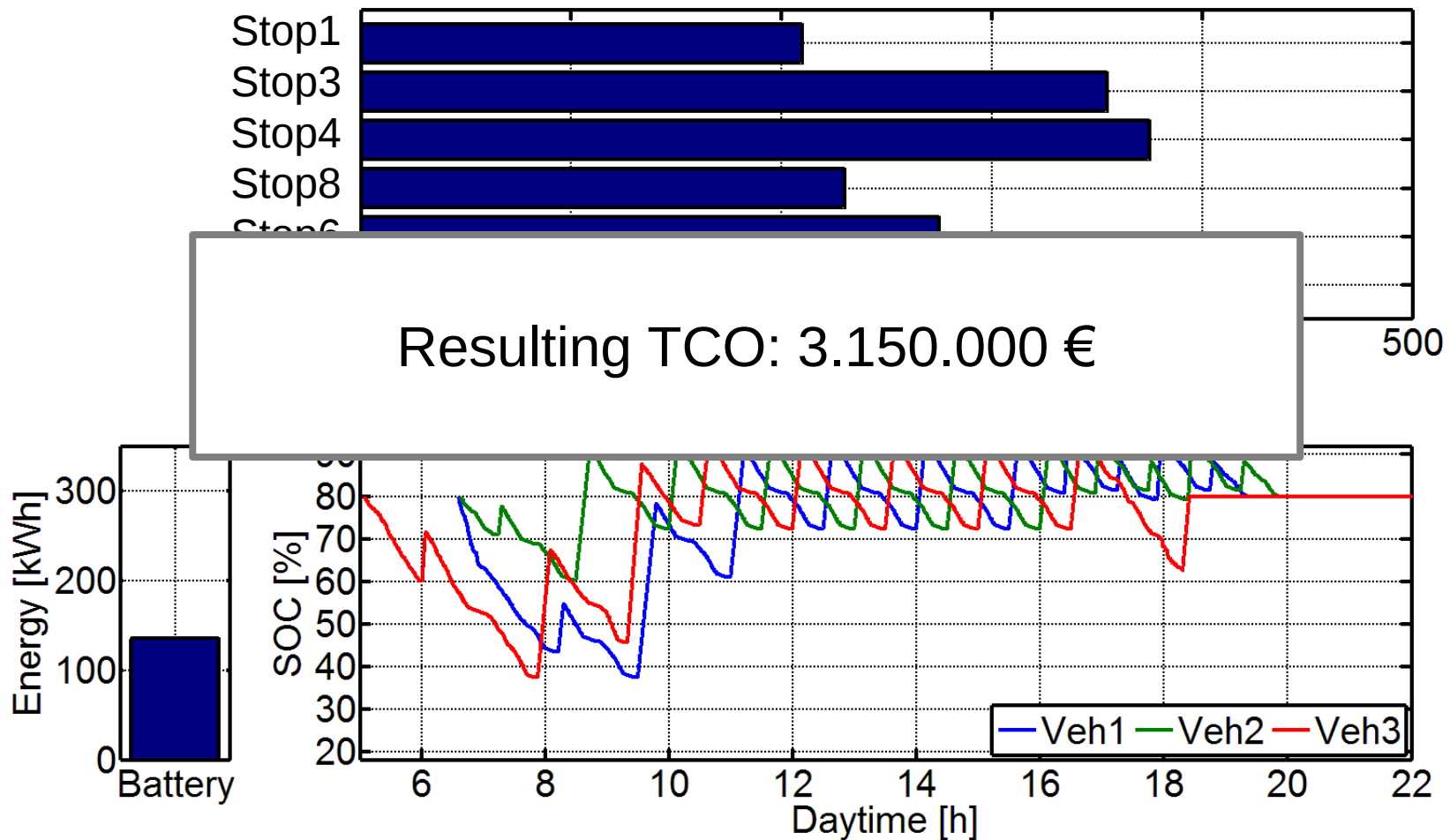
TCO composition



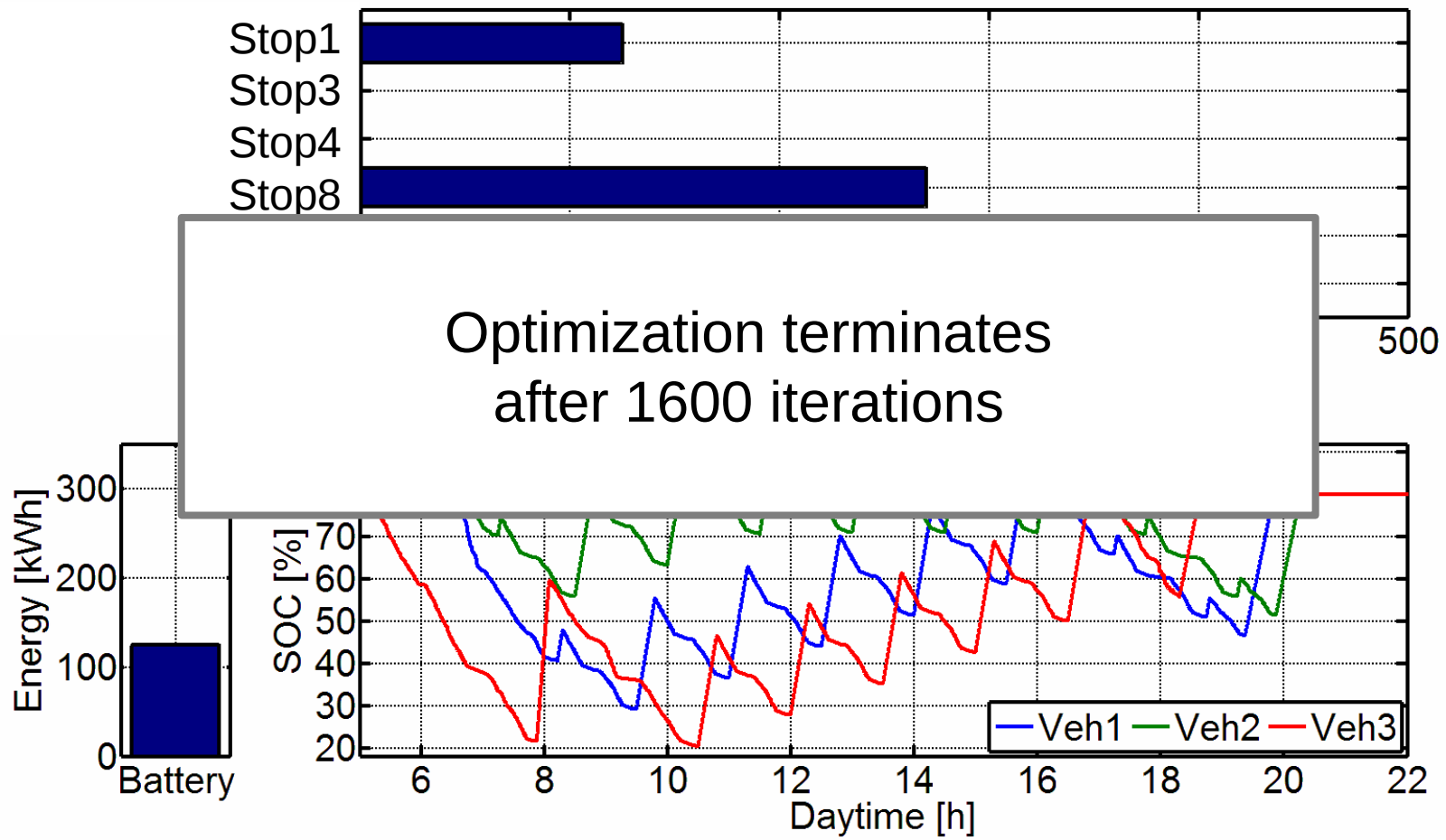
Optimization Loop



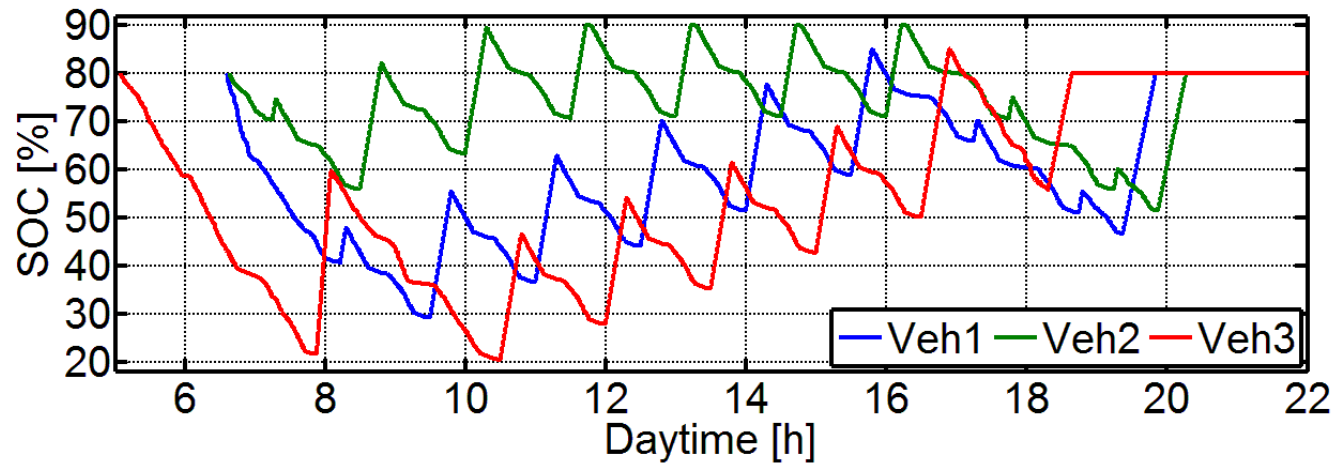
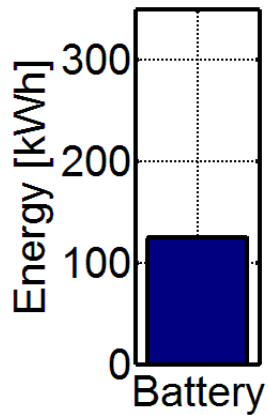
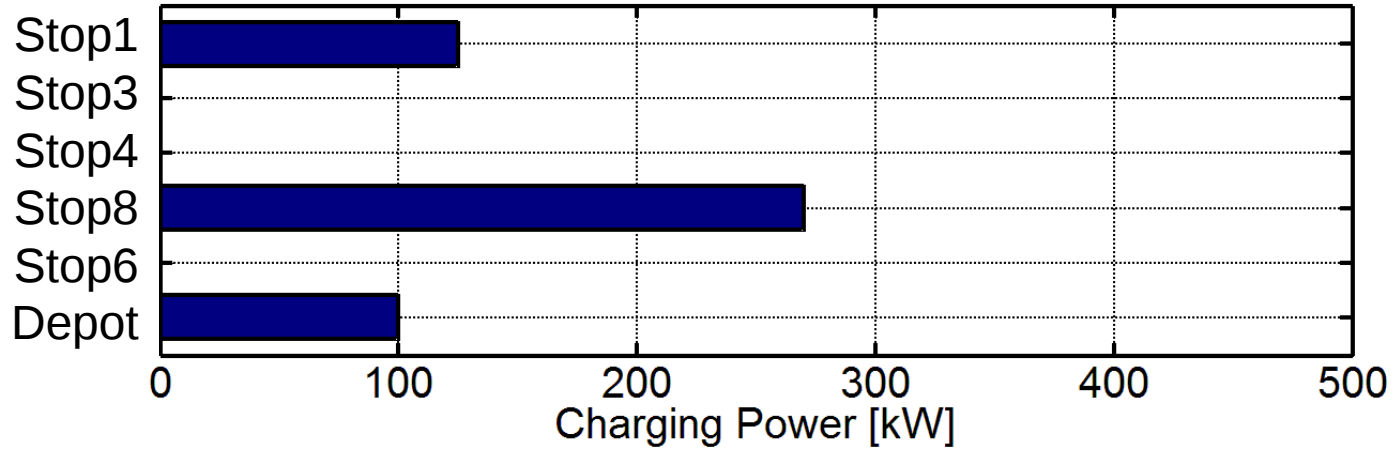
TCO Calculation (1)



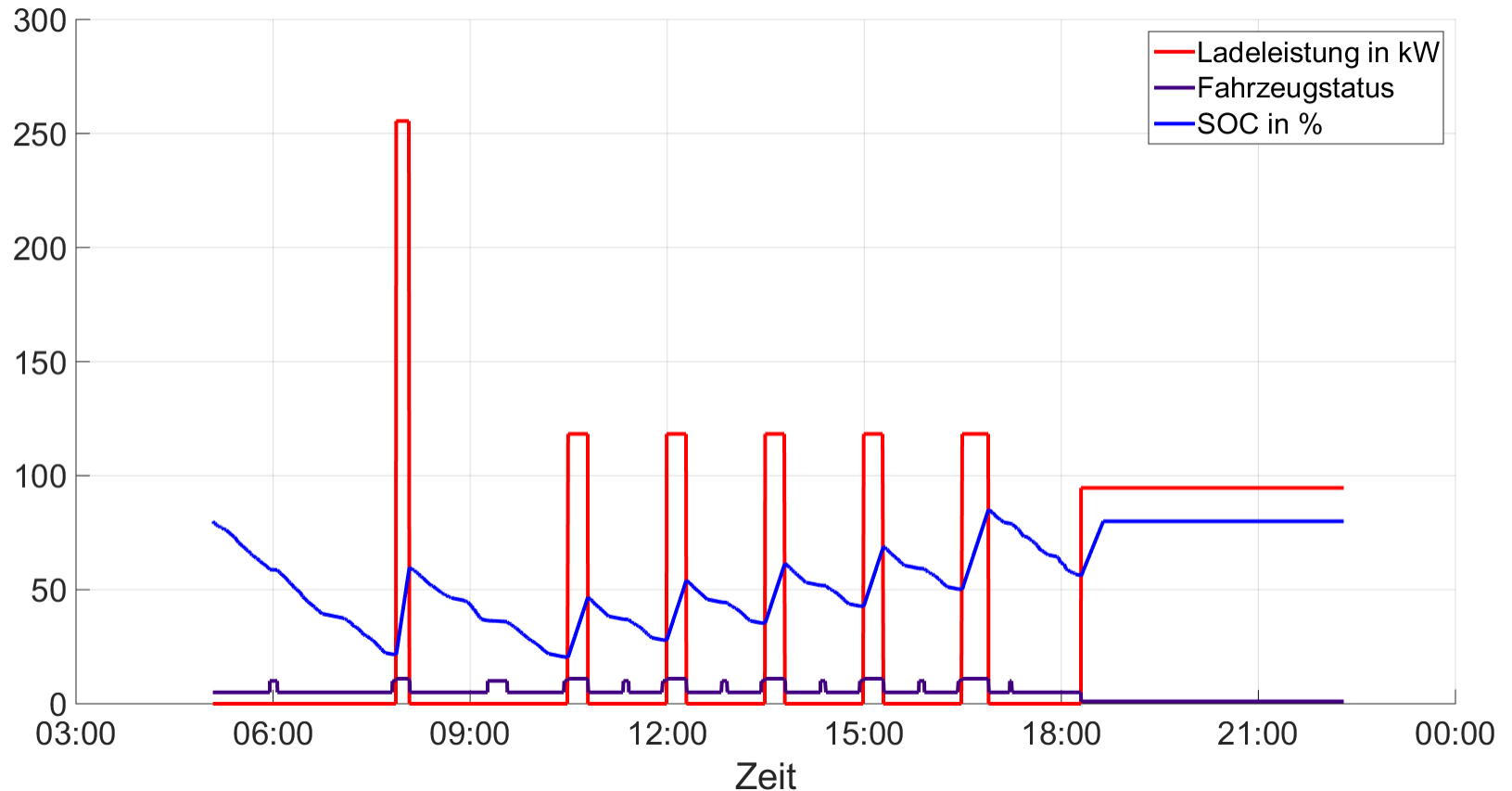
Optimization Loop



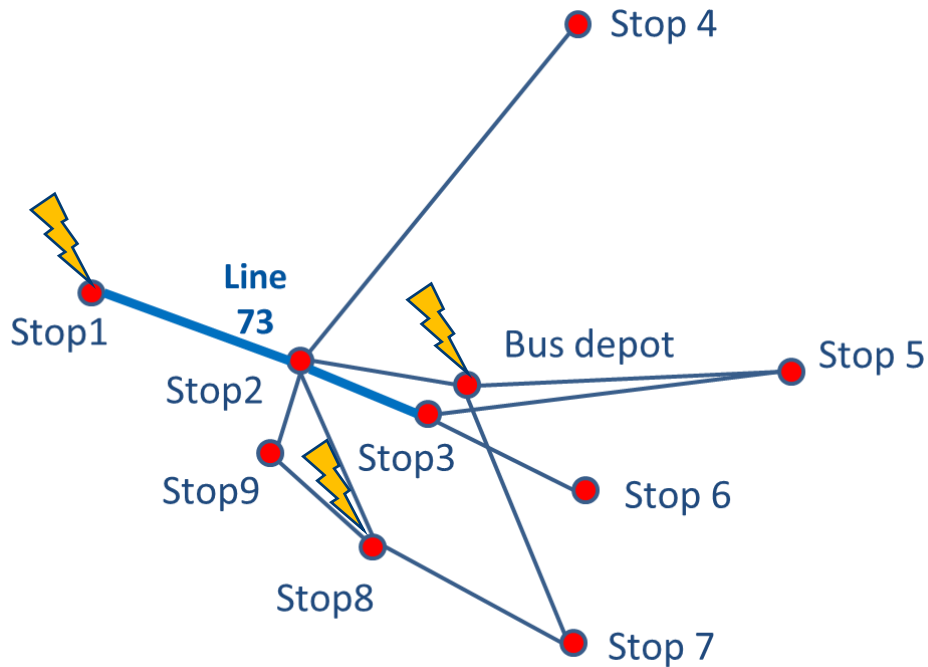
Result



Exemplary: Daily load of vehicle 3



Final Result



Optimization variable	
Battery capacity	125 kWh
Charging station Stop1	125 kW
Charging station Stop3	0 kW
Charging station Stop4	0 kW
Charging station Stop6	0 kW
Charging station Stop8	270 kW
Bus Depot	100 kW

Cash value of resulting total costs: **2,38 Mio. €**



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