EVS 27

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UNIVERSITEIT GENT

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Drivetrain design for an ultra light electric vehicle with high efficiency

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Introduction

Increasing interest in electric vehicles (EVs):
- Ecological awareness
- Increasing oil prices
- **Ultra light EV with high efficiency: named ELBEV (Ecologic Low Budget Electric Vehicle)**
  For the same driving range less batteries are needed
    - Cost ↓
    - Weight ↓

We want to develop a transportation method with less energy consumption than a conventional EV, but yet much faster, more comfortable and safer than a bike.

Ecologic Low Budget EV

Single-person battery EV
- City and suburbs
- Commuting purposes

Tri-cycle:
- Two driven and steering front wheels
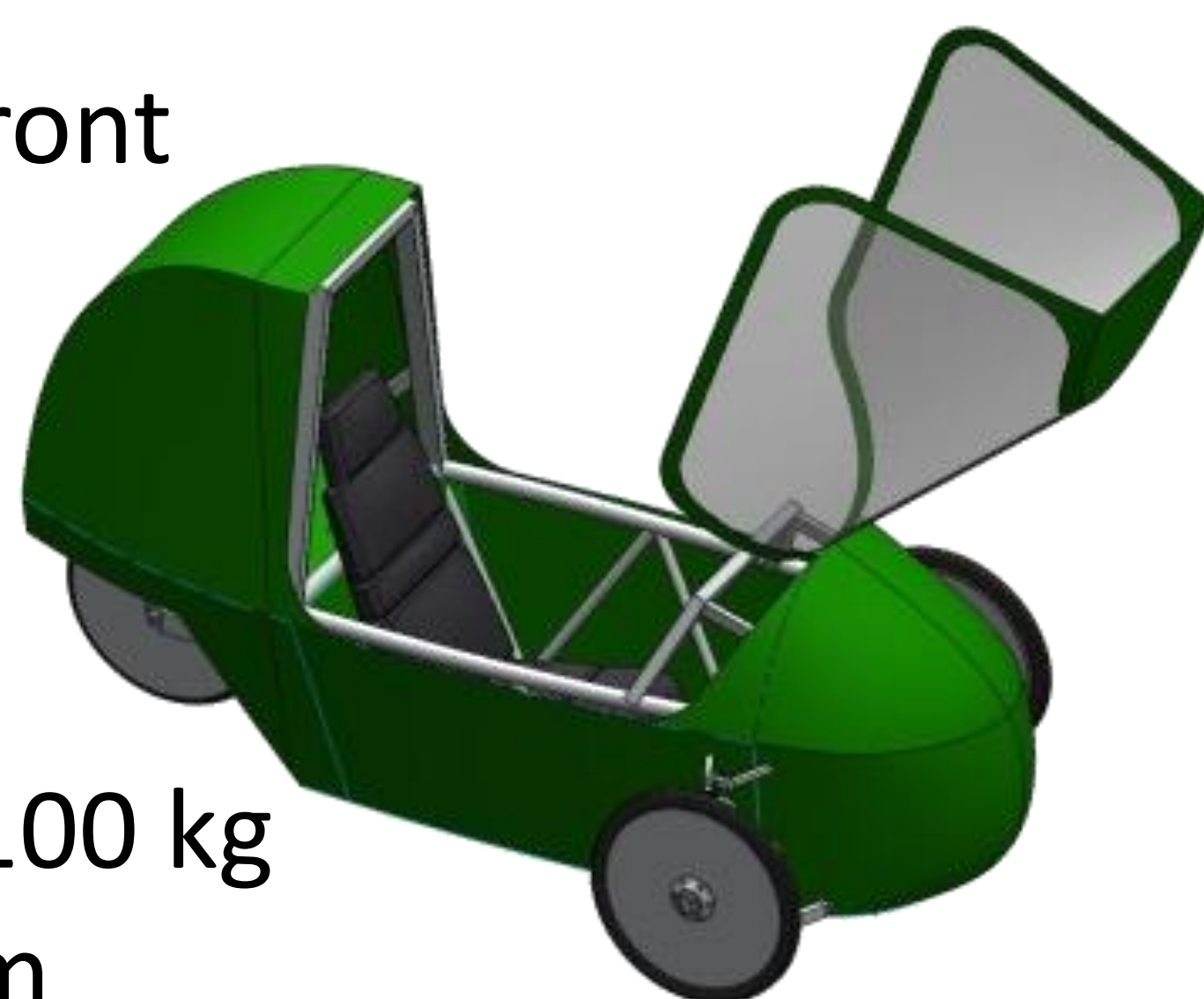- One rear wheel

Driving range: ± 100 km
Maximum speed: ± 70 km/h
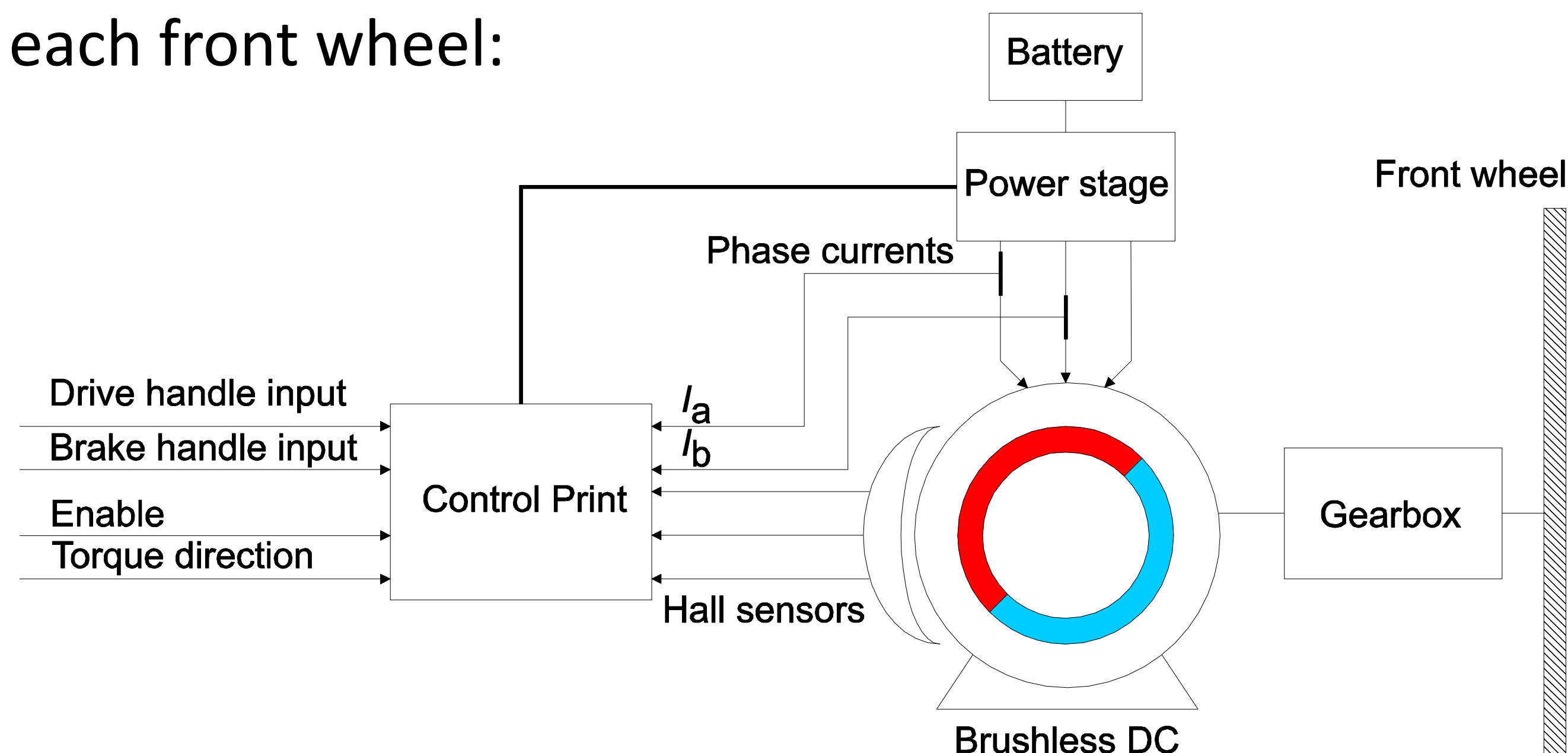Curb weight (batteries incl.): 100 kg
Dimensions: Length 2200 mm
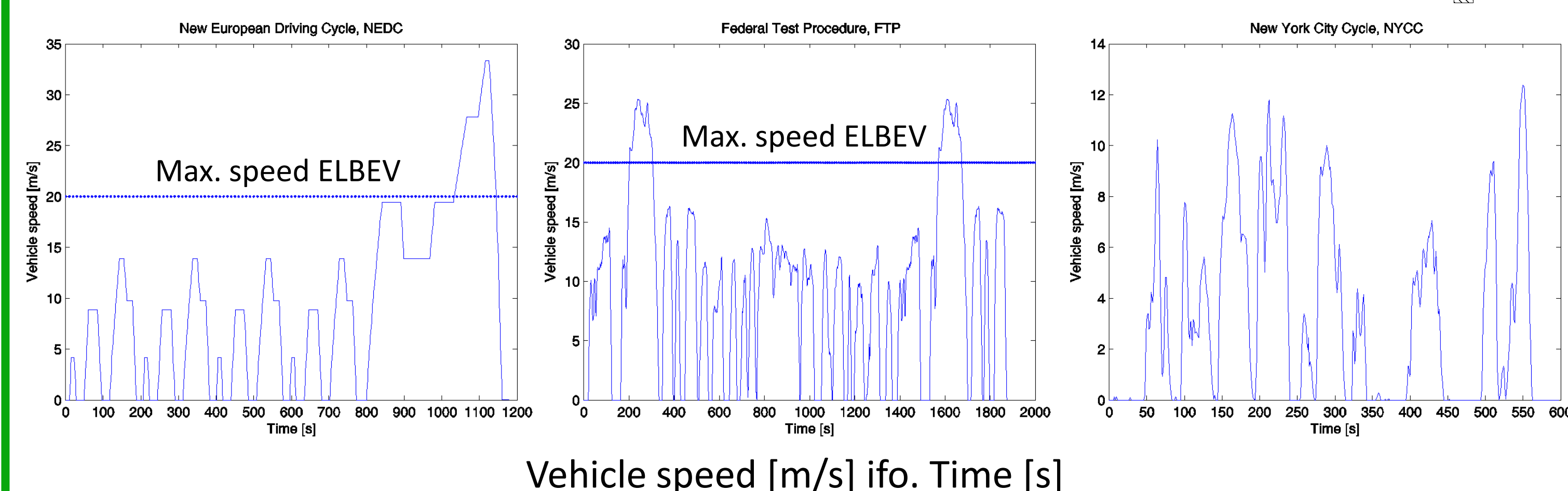   Width 1200 mm
              Height 1300 mm

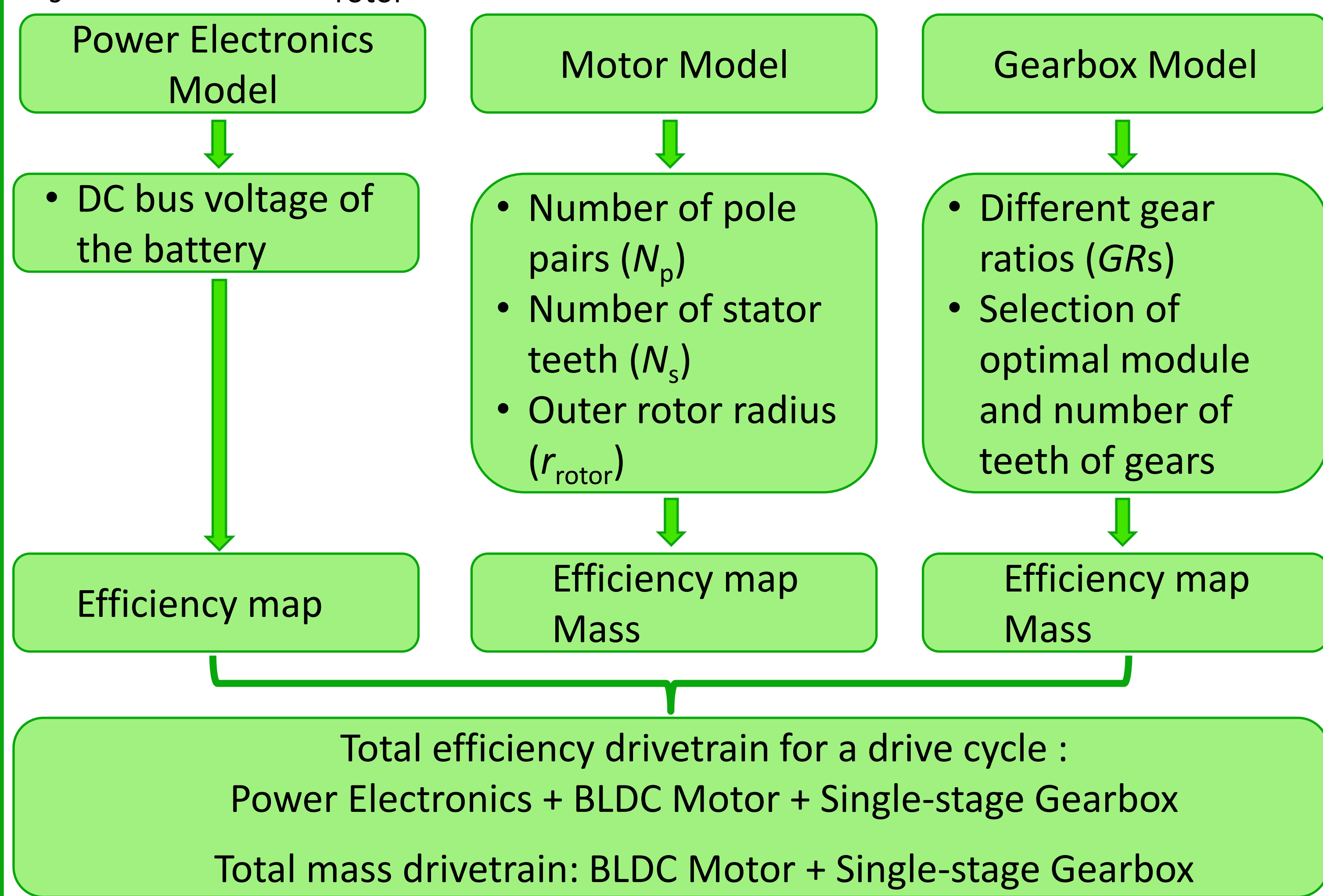## Drivetrain ultra light EV

For each front wheel:

Battery, Power stage, Phase currents, Drive handle input, Brake handle input, Enable, Torque direction, Control Print, I_a, I_b, Hall sensors, Brushless DC, Gearbox, Front wheel

Drivetrain is optimized for:

New European Driving Cycle, NEDC — Max. speed ELBEV
Federal Test Procedure, FTP — Max. speed ELBEV
New York City Cycle, NYCC

Vehicle speed [m/s] ifo. Time [s]

Integrated design

Objective function executed for gear ratios: $\frac{1}{2}$ - $\frac{1}{7}$, N_p: $3-8$, N_s: $9-18$ and r_{rotor}: $0.04-0.1$ m

Power Electronics Model
- DC bus voltage of the battery
→ Efficiency map

Motor Model
- Number of pole pairs (N_p)
- Number of stator teeth (N_s)
- Outer rotor radius (r_{rotor})
→ Efficiency map Mass

Gearbox Model
- Different gear ratios (GRs)
- Selection of optimal module and number of teeth of gears
→ Efficiency map Mass

Total efficiency drivetrain for a drive cycle :
Power Electronics + BLDC Motor + Single-stage Gearbox

Total mass drivetrain: BLDC Motor + Single-stage Gearbox

Results

GR: 1/3, N_p: 7, N_s: 12, r_{rotor}: 0.055 m			
Property	NEDC	NYCC	FTP
Av. Total Eff.	85.72 %	71.15 %	85.37 %
Dr. range (km)	112.98	325.77	125.61
Total mass	8.99 kg		

GR: 1/7, N_p: 7, N_s: 12, r_{rotor}: 0.04 m			
Property	NEDC	NYCC	FTP
Av. Total Eff.	85.56 %	76.18 %	85.57 %
Dr. range (km)	112.77	348.80	125.91
Total mass	12.58 kg		

Possible to choose a good combination of Motor + Gearbox with ↑ efficiency and ↓ mass

Av. Efficiency: Outer rotor radius [m] ifo. Gear ratio
Total mass: Outer rotor radius [m] ifo. Gear ratio
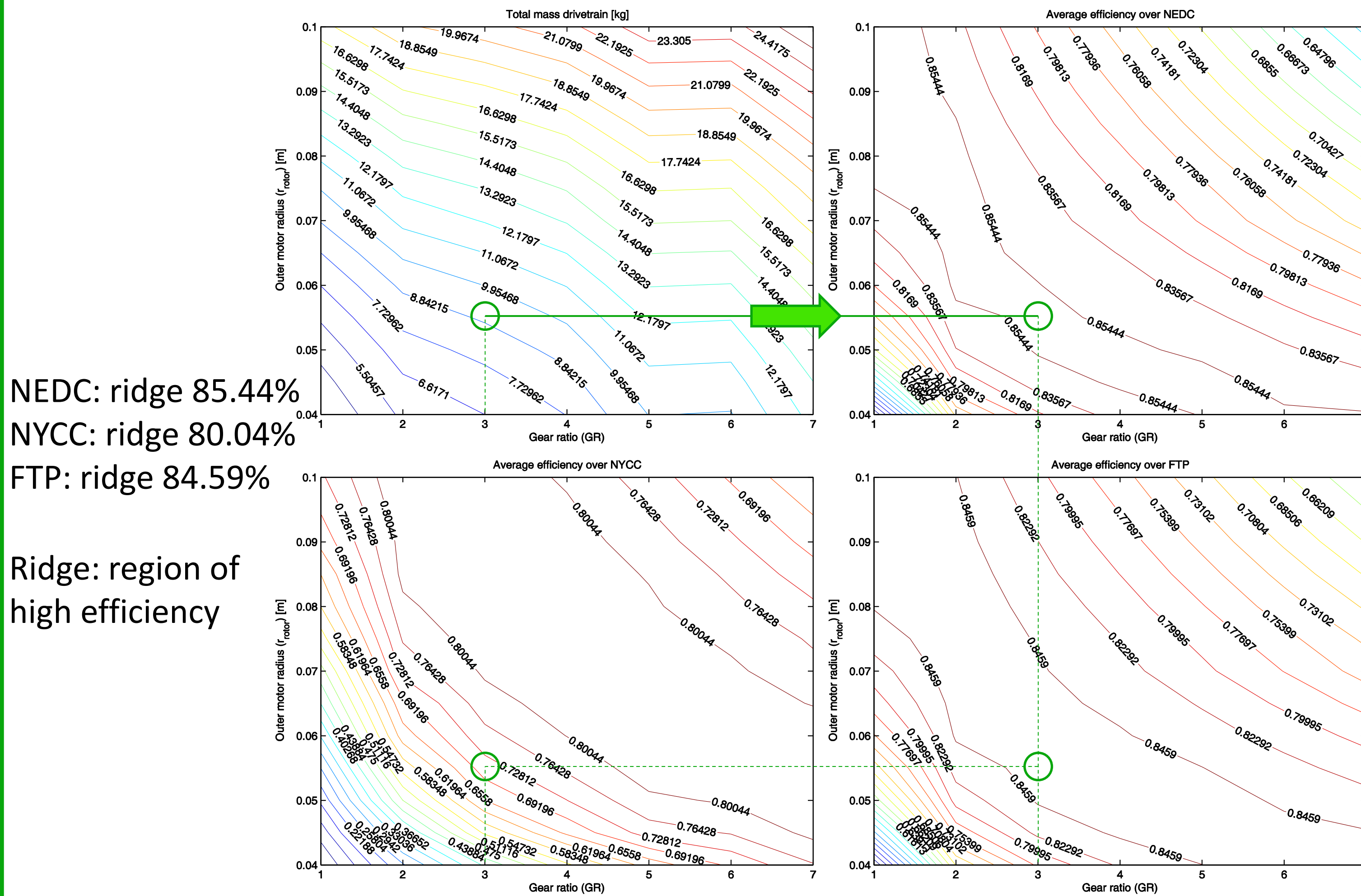
NEDC: ridge 85.44%
NYCC: ridge 80.04%
FTP: ridge 84.59%

Ridge: region of high efficiency

Conclusions

- Optimization of the complete drivetrain is always a compromise between average efficiency and total mass.
- Optimization for different driving cycles will result in an optimal combination of Motor and Gearbox for that driving cycle.