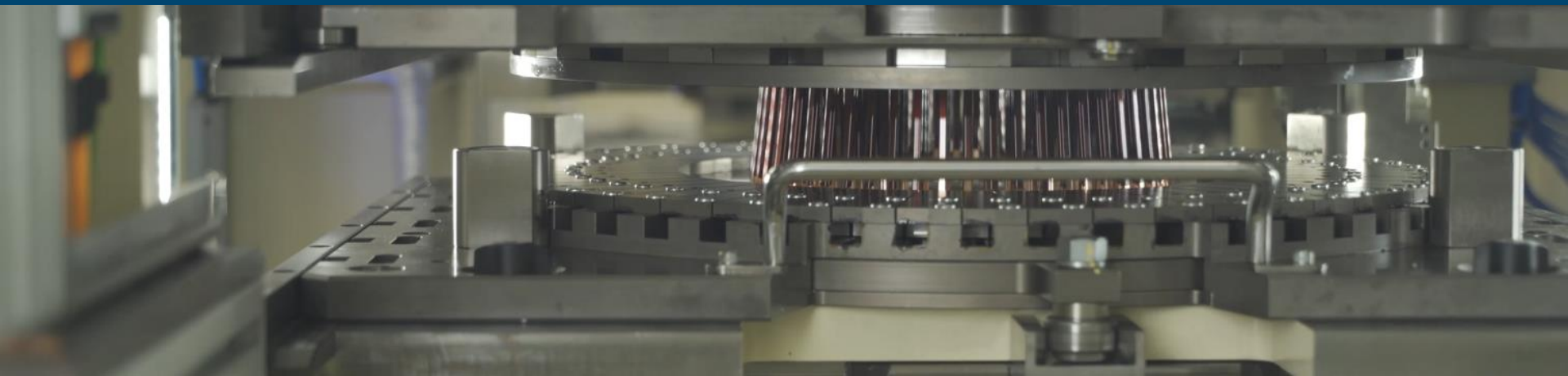




ZF eMotors - From Market Needs to Product Portfolio

Dr. Gerd Hillenbrand | Director Strategy and Performance Electric Motors



ZF at a Glance



150.000
Employees



270 Locations
42 Countries



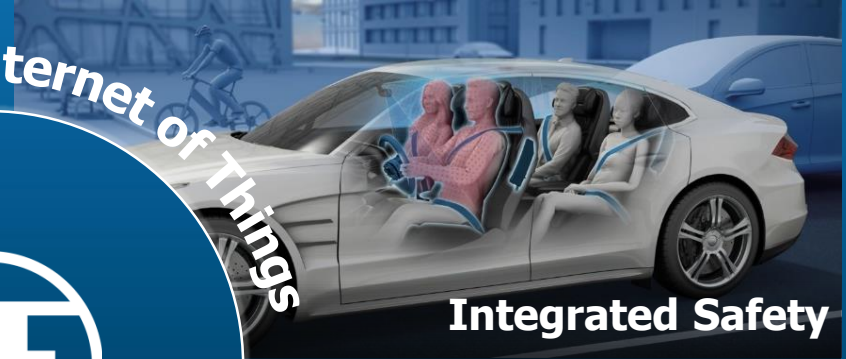
32,6 Billion €
Turnover



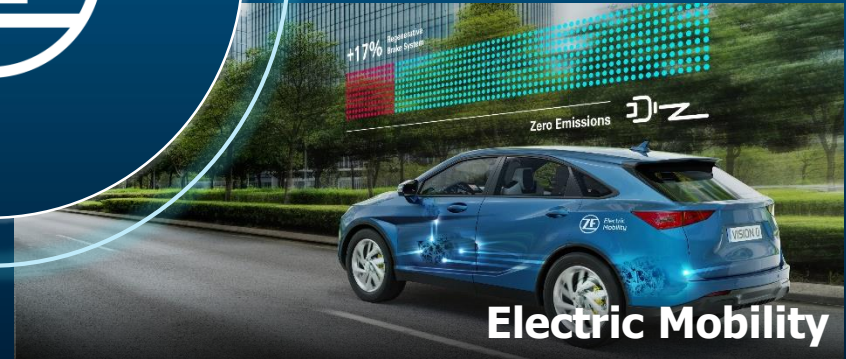
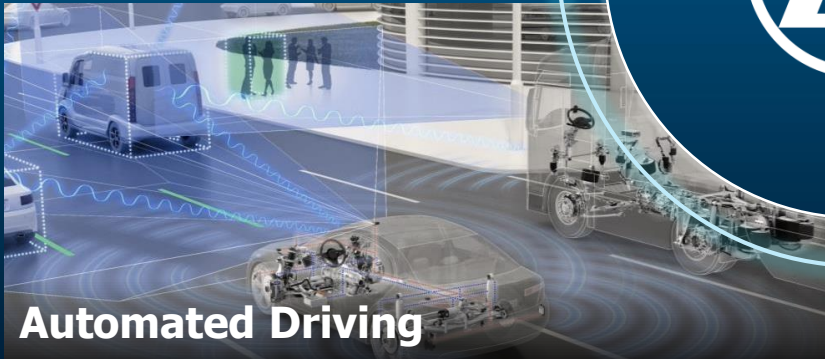
2,5 Billion €
Research & Development



Next Generation Mobility: ZF Shapes the Future in Four Technology Domains



Internet of Things
Digitalization





Until 2030

-80%

CO₂ emissions
from ZF plants
vs. 2019

-40%

CO₂ emissions
from supply chain &
product use
vs. 2019

2040

Emission free



ZF Electrifies Everything



2020 was the tipping point in the e-mobility transformation

EU green deal & global more restrictive emission targets or bans accelerated e-mobility adoption

xEVs outperform traditional vehicles in sales recovery post COVID driven by incentives

Significant invest increase in charging infrastructure & acc. battery price erosion

EV platforms on the rise: Number of EV models offered to customers to double until 2022

2016

2017

2018

2019

2020



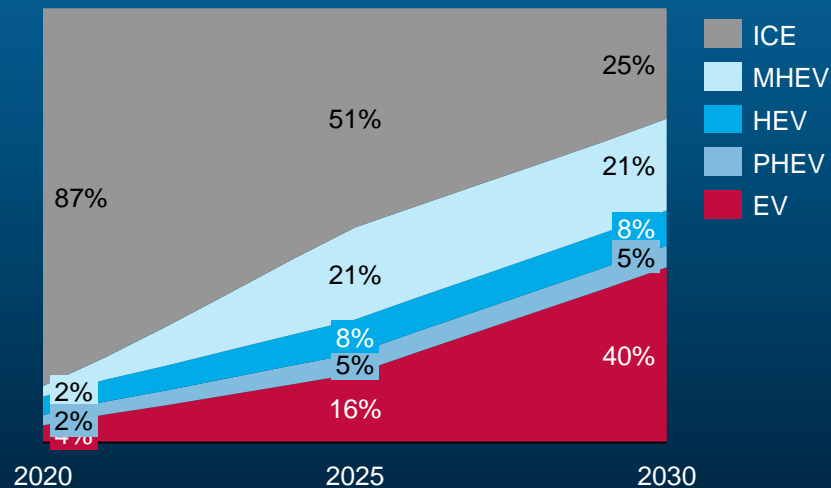
Regulatory action results in faster transformation to e-mobility in the Passenger Car Sector

Drivers & Trends

- Government initiatives **favour electrification of PassCars**
- OEMs have to **reduce fleet emissions**
- To meet emission targets an **OEM-specific fleet mix** is decisive.



Global Vehicle Production by Type (in %)



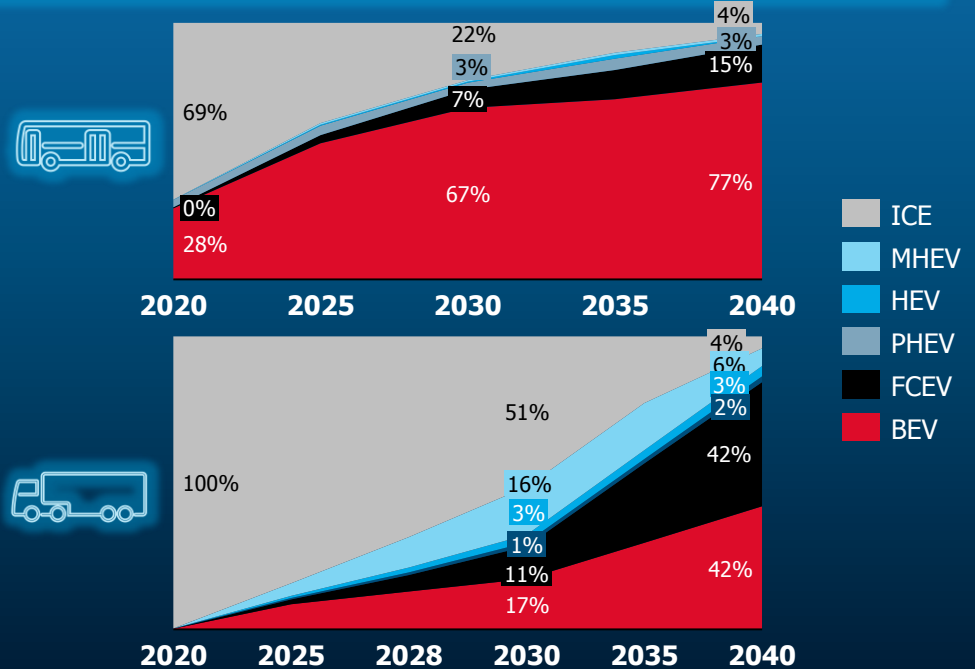
Accelerated Change to E-mobility is also seen in the Commercial Vehicle Market

Drivers & Trends

- **Stricter emission legislation** globally
- **Incentives** for EVs
- International & national **hydrogen strategies**
- Introduction of **zero emission fleet targets**



Global Vehicle Production by Type (in %)

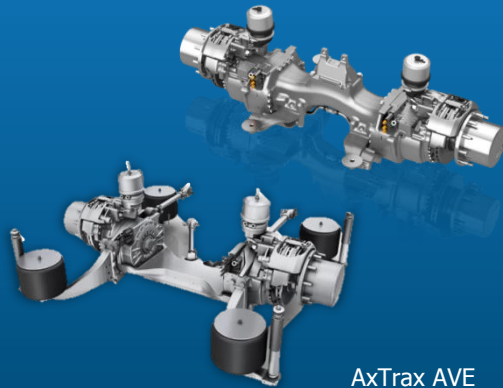
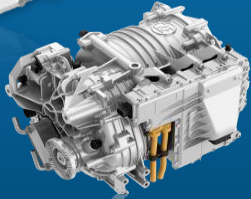


The future is electric – in all areas

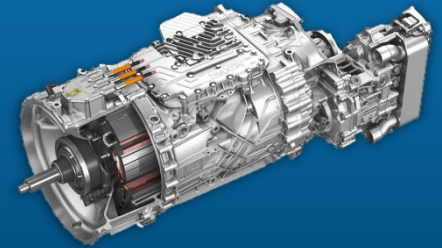


CeTrax

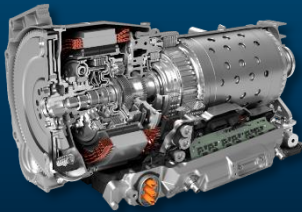
CeTrax lite
Central Drive



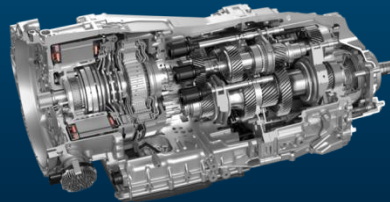
AxTrax AVE



TraXon Hybrid



8-speed Plug-in Hybrid Transmission



8-speed Dual Clutch Transmission
Plug-in Hybrid



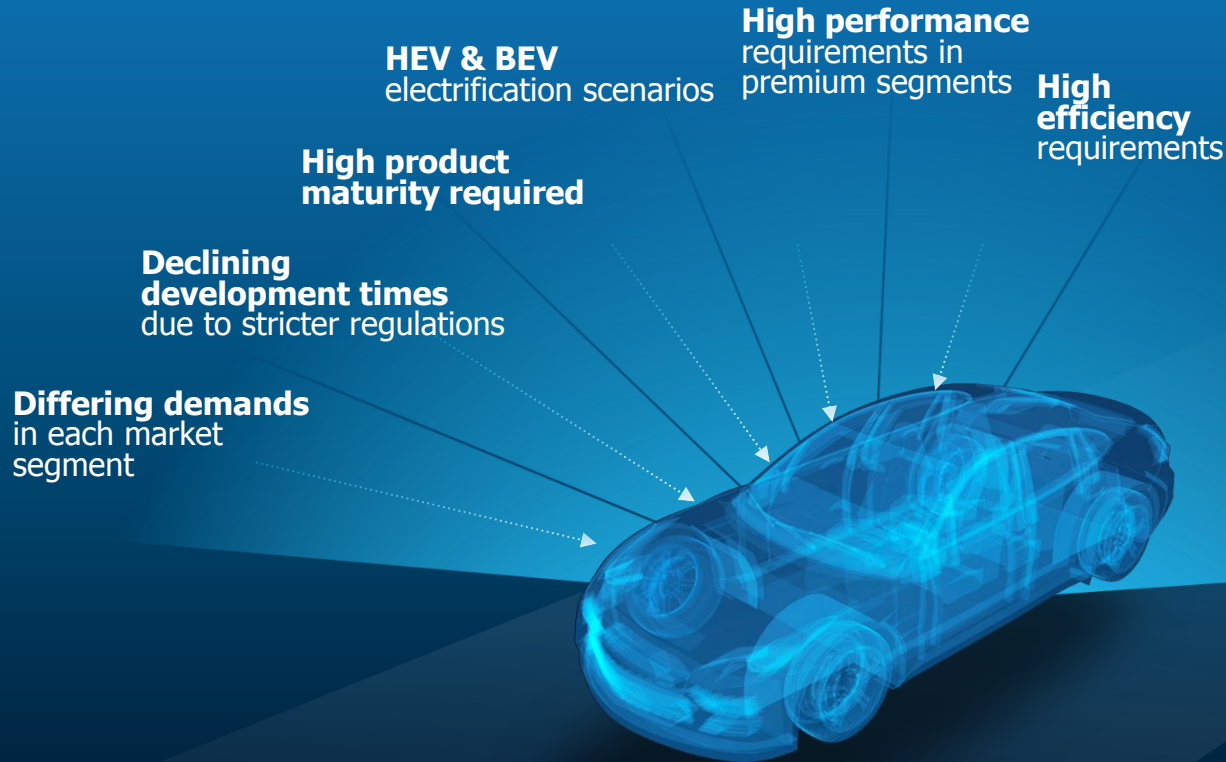
Electric Axle Drive System



eTRAC



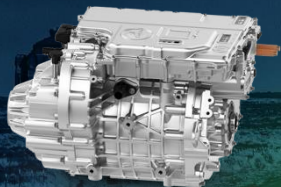
Challenges for Electric Drives



» We need an approach that combines efficient working with innovation



Holistic Electrification Strategy



ZF electric Vehicle Drive

Series Production since 2019

400V & 800V Applications

BEV



ZF 8HP Portfolio

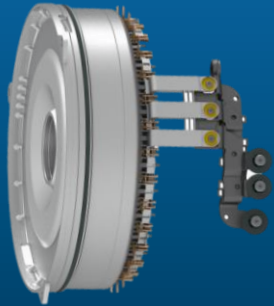
Series Production since 2009

4th Generation SOP in 2022

PHEV

E-Motors for Hybrid Solutions

MHEV 4th GEN



- Performance 22KW/ 220 Nm
- PSM technology
- Single tooth winding
- Oil cooling

PHEV 4th GEN



- Performance 160KW/ 450 Nm
- PSM technology
- Hairpin winding
- Oil Cooling

Key Characteristics:

- Large Outer Diameter
- Short active length
- Fit in the same packaging.

Hybrid Modular Drive Train Architecture

Hybrid Transmission

8HP 4th Generation

Hybrid components

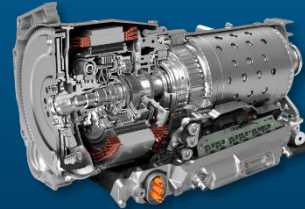


Electric Machine

**+ Power Electronics
+ Functions**



**+ Clutches
+ Torsional Damper
+ Functions**



**+ Transmissions
+ Transmission Controls
+ Sensor Cluster
+ Functions**



PHEV Solution

MHEV Solution
P1 & P2 systems

Modularity enables packaging neutrality with conventional variant

Vision EVplus – the new definition of Plug-In Hybrids

Up to 150 km
fully electric drive

Berlin

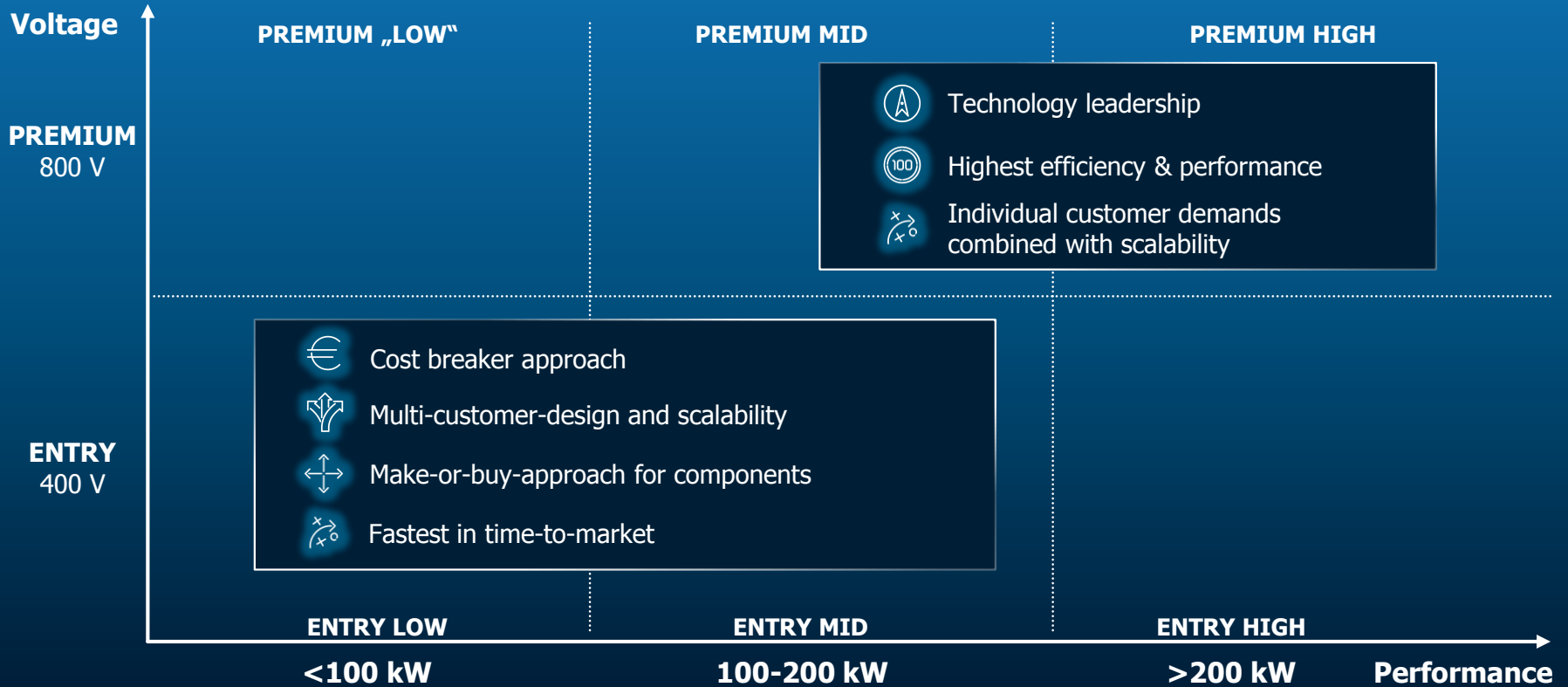


Advantages in terms of
CO₂ reduction and costs

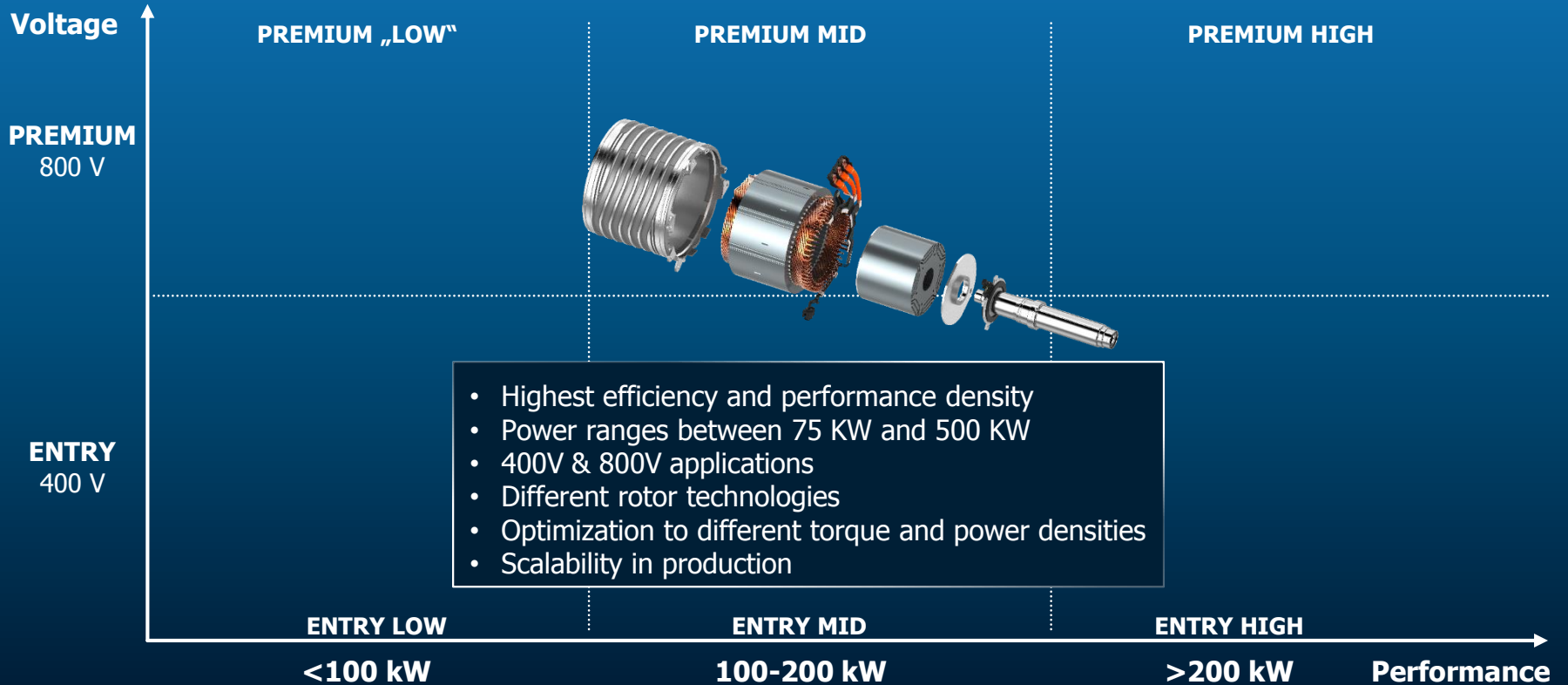
Covers a family's basic
mobility needs

No more fear of limited range

Each EV Market Segment Shows Specific Demands

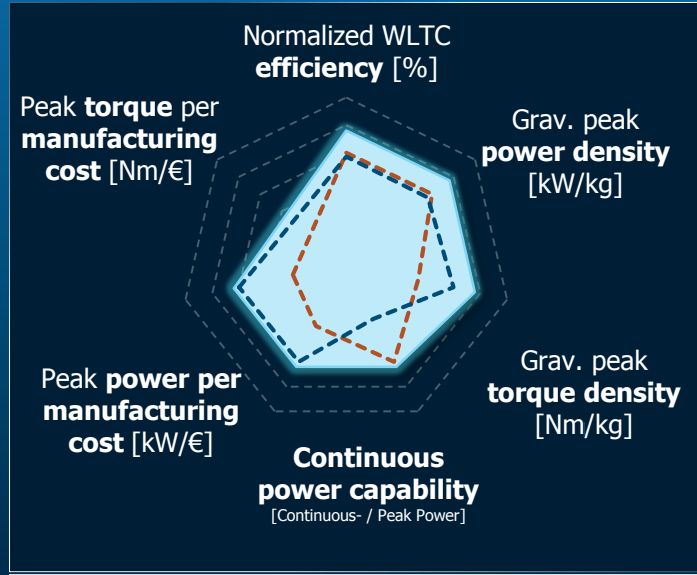


Electric Machines have to cover a wide range of requirements



EV Modular Kit Approach from Component to System Level

Benchmark-analysis



ZF Modular kit variants

EM Modular Kit
ASM-/ PSM-options

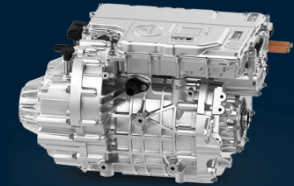
3
inverter platforms

2
gearbox layouts

Future
Software Kit

01011010
11
01

Customized solution with optimization on system level



Premium high e-axle (example)

- Peak-power 200 kW
- Peak-performance 3200 Nm
- 800 V SiC technology



Modular kit approach ensures fast time-to-market, high product maturity and economies of scale



ZF Modular E-Motor Kit

Efficient Configuration of Different Customer Specific Solutions



Stator design	Common electromagnetic design	
Rotor design	Common design PSM	Common design ASM
Electro sheet	Focus performance & efficiency	Focus cost efficiency
Cooling	Oil Cooling	Water Cooling
Voltage [V]	800 V	400 V
Active length	Various active lengths possible from 80-200mm	
Performance data	75 kW – 500 kW 250Nm - 800 Nm	
Sensor	Depending on axle design: ax-parallel or co-axial One Sensor per design	

Summary

Stricter emission legislation is accelerating the transformation towards e-mobility

Market needs vary based on electrification type and segment

ZF uses a modular kit approach to achieve shorter development times and economies of scale



Thank You for Your Attention

Next
Generation
Mobility.

NOW.