



Manufacturing Technologies and Prototype  
Shop Electric Machine, 02/19/2013

# CHALLENGES OF THE PRODUCTION OF E-DRIVE COMPONENTS.

IQPC, ADVANCED E-MOTOR TECHNOLOGY 2013 , NUERMBERG

**BMW  
GROUP**



# **CONTENTS.**

- History of electrification at BMW**
- The BMW ActiveE**
- Challenges for the production**
  - The electric motor for the BMW ActiveE**
  - Production steps of the electric motor and its challenges**
- Summary**

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# ICONIC CHANGE IN THE AUTOMOBILE INDUSTRY.

## Megacities

- Increasing population in megacities.
- Changing infrastructure.
- Local emissions.



## Environment

- Global warming.
- Climate change is observable.



## Economy

- Shortage of resources.
- Price increase of fossil fuels.



## Culture

- Sustainable mobility part of modern lifestyle.
- Social responsibility.
- Industrial policies.



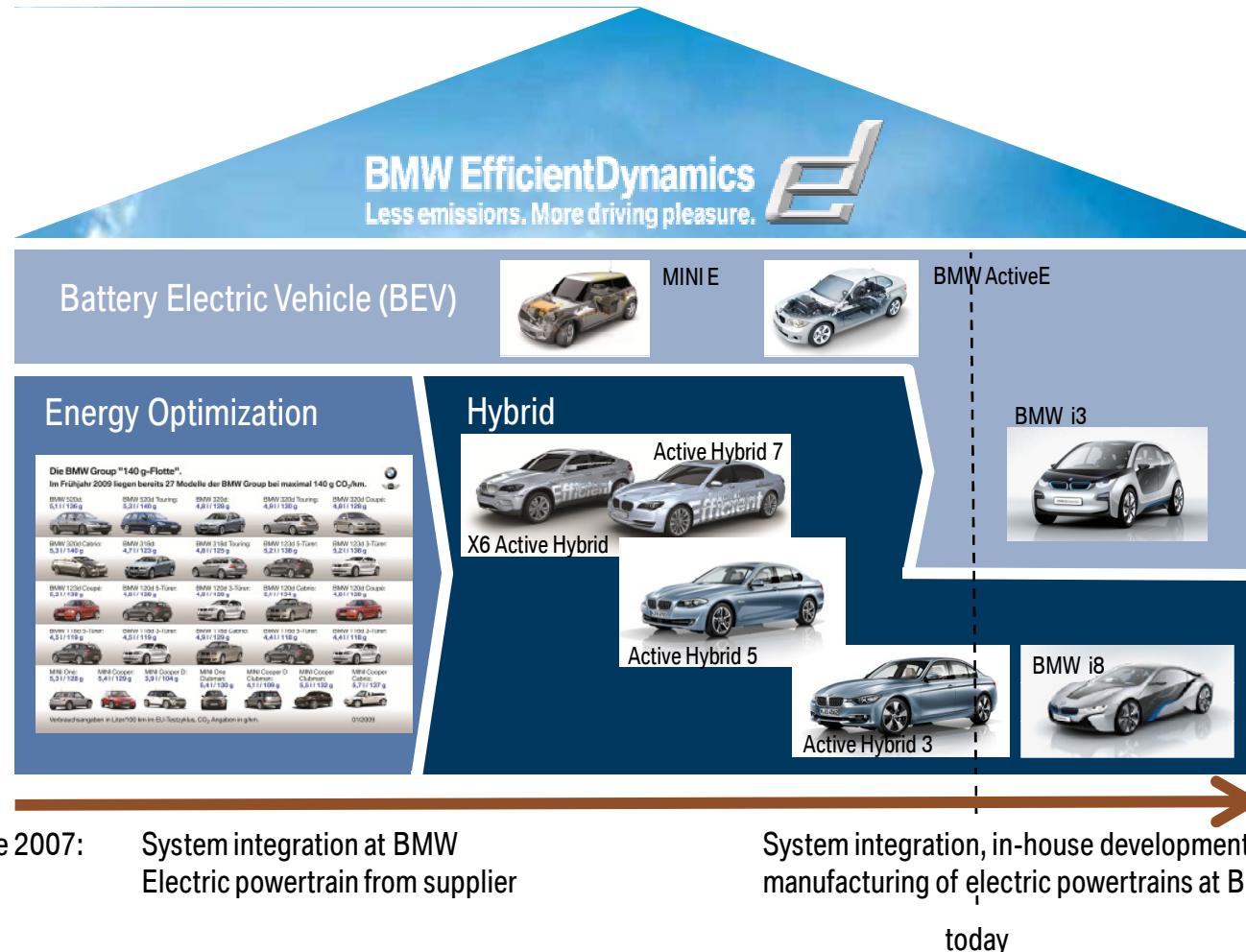
## Emissions

## CO<sub>2</sub>-Reduction

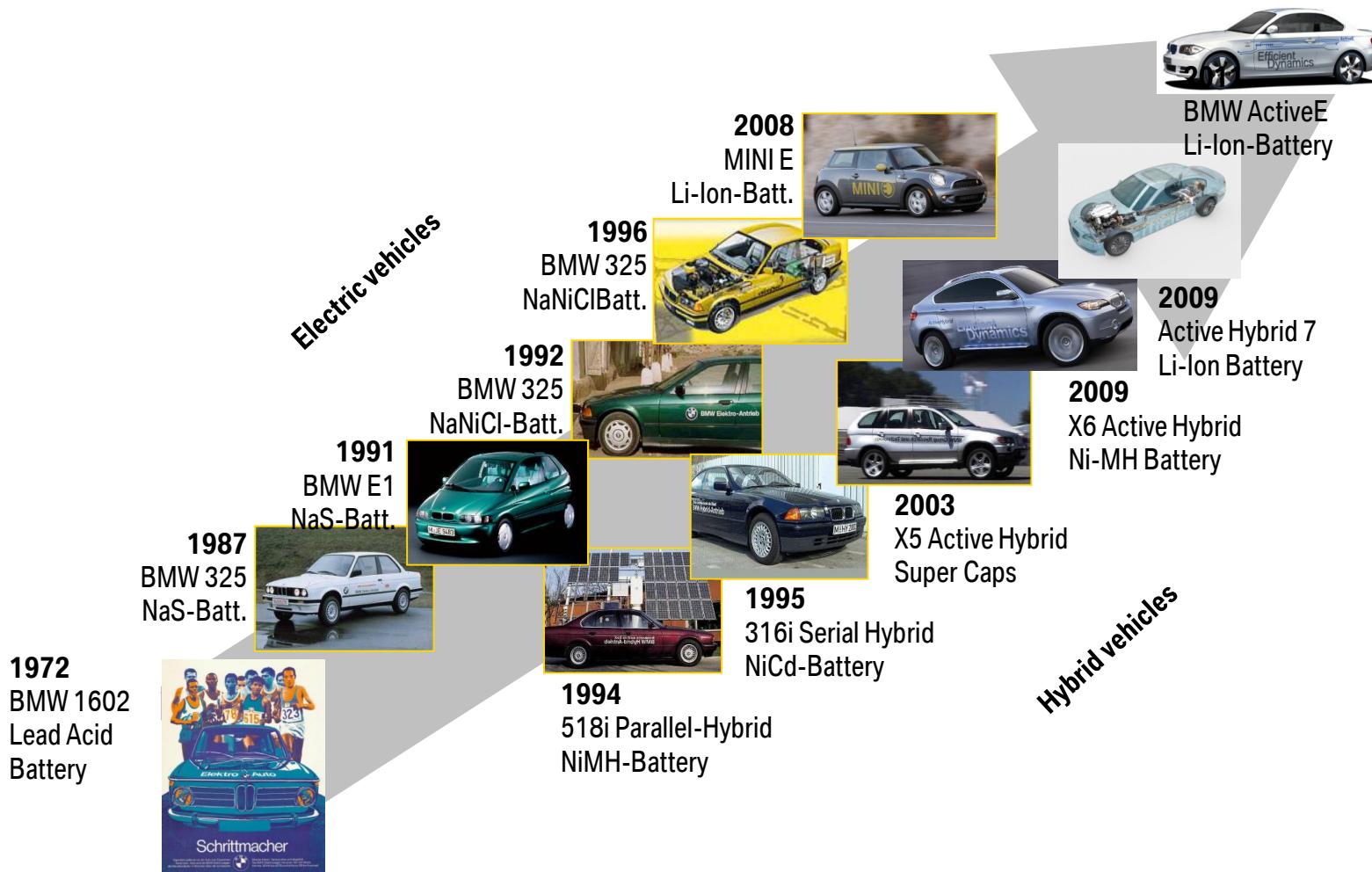
## Efficiency

## Sustainability

# THE ELECTRIC POWERTRAIN IS PART OF THE BMW EFFICIENTDYNAMICS STRATEGY.



# HISTORY OF ELECTRIFICATION AT BMW.



# ELECTRIFICATION AT BMW - FROM THE MINI E TO THE MEGA CITY VEHICLE.



Use of re-newable energies

Market potential

Change scenarios

User behavior

Social acceptance

Infra-structure

Strengths and weaknesses

2009



MINI E

2011



BMW ActiveE

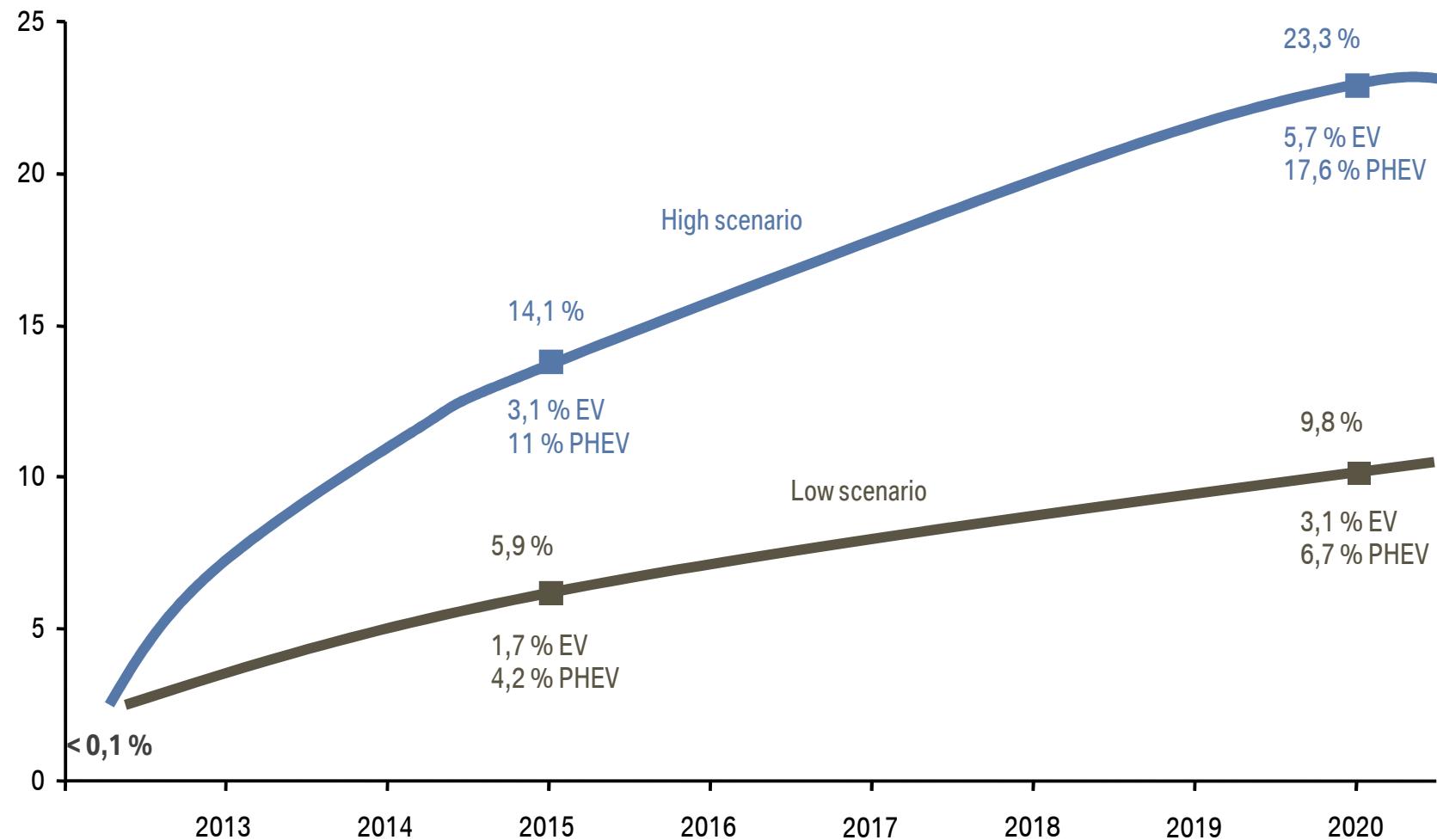
2013



BMW i3



# SHARE OF PHEV/EV POWERTRAIN TECHNOLOGIES EUROPE IN 2020 [%].



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# THE BMW ACTIVE E FITS PERFECTLY THE REQUIREMENTS OF A MEGACITY.

The diagram illustrates the BMW Active E's layout, highlighting the 'Maximum Use of Installation Space' in the front, the 'E-Motor and Power Electronic Unit on the Rear Drive', and the 'In-house Development and Production of Key Components' located under the car.

Vehicle	
Length	4,36 m
Weight	1815 kg
<b>Driving Performance</b>	✓
Acceleration 0-60 km/h	4,5 s
Acceleration 0-100 km/h	9,0 s
Maximum Speed	145 km/h
Range (NEDC*)	205 km
Range (Customer)	160 km
<b>Consumption</b>	✓
Incl. Recharging (NEDC*)	0,16 kWh/km
CO <sub>2</sub>	0 g/km*

\* NEDC: New European Driving Cycle

# THE BMW ACTIVE E: THE NEW BMW ELECTRIC DRIVE MECHANISM IN ACTIVE E.

## Electric storage:

- Energy content: 32 kWh.
- Lithium ion technology.
- 40 Ah-cells by SBLimotive.



## Vehicle:

- 4 seats, 200 l luggage compartment.
- Maximum speed 90 mph.
- Range (customer) > 100 mls.

## Power electronic:

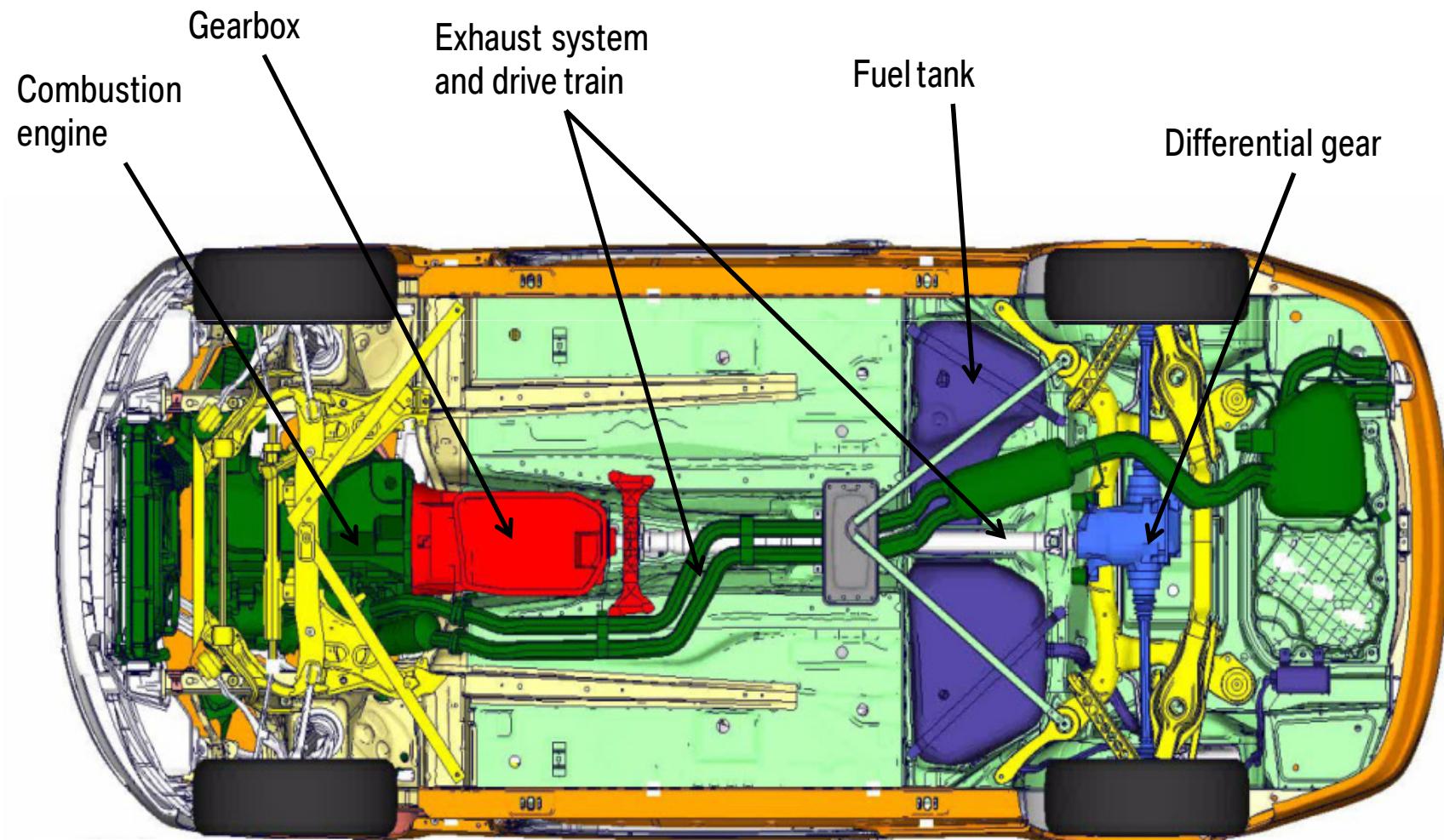
- Inverter 350V DC / 350V AC
- DC/DC 350V DC => 12V DC
- Charger 32A (SAE1772)



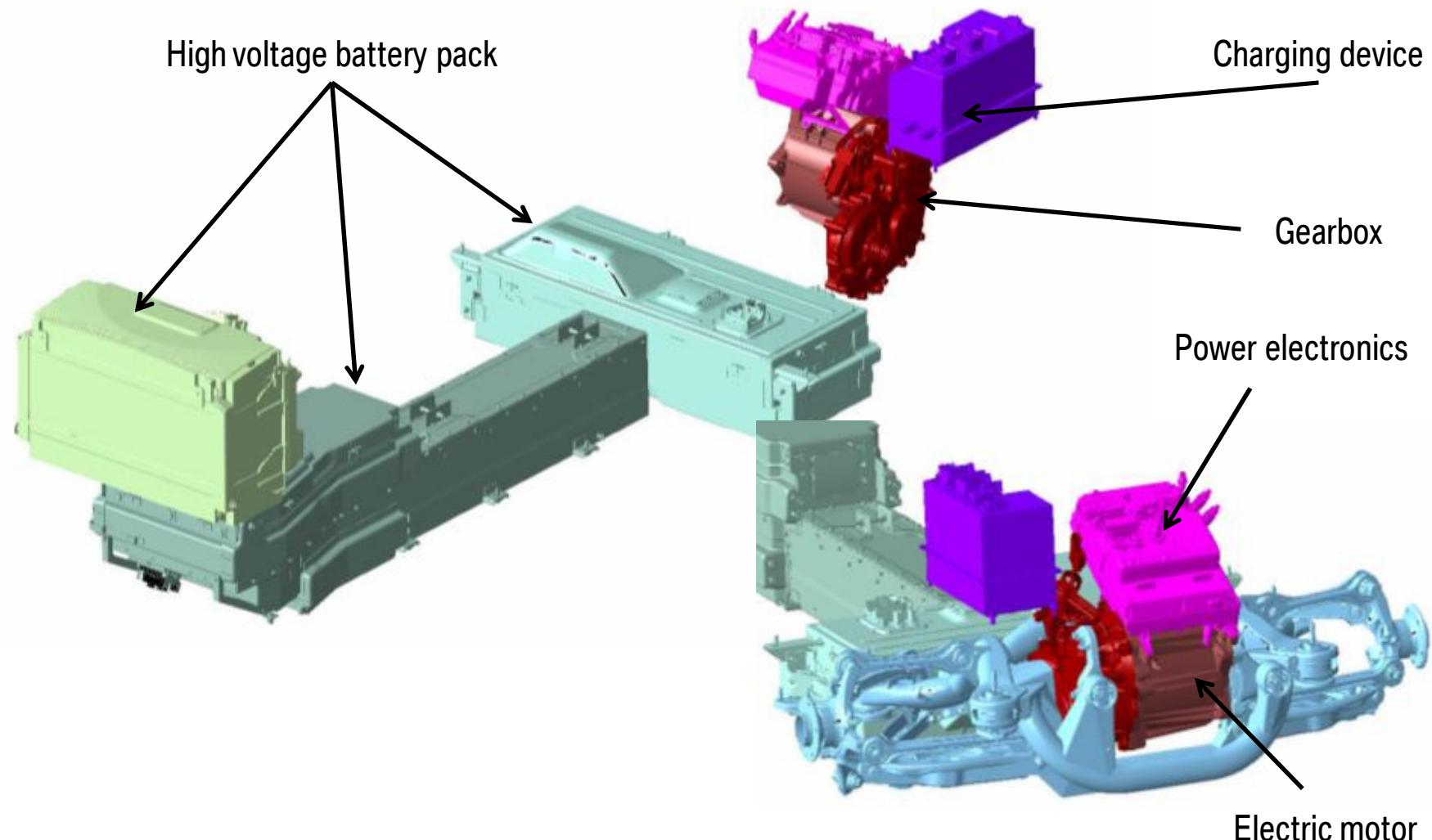
## Electric motor:

- Hybrid synchronous motor (HSM).
- Pmax= 125 kW, Mmax = 250 Nm.
- nmax = 12.000 1/min.

# THE BMW ACTIVE E: MISSING PARTS COMPARED TO COMBUSTION ENGINE DRIVEN CAR.



# THE ELECTRIC POWERTRAIN OF THE BMW ACTIVE E.



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# THE ELECTRIC MOTOR OF THE BMW ACTIVE E.



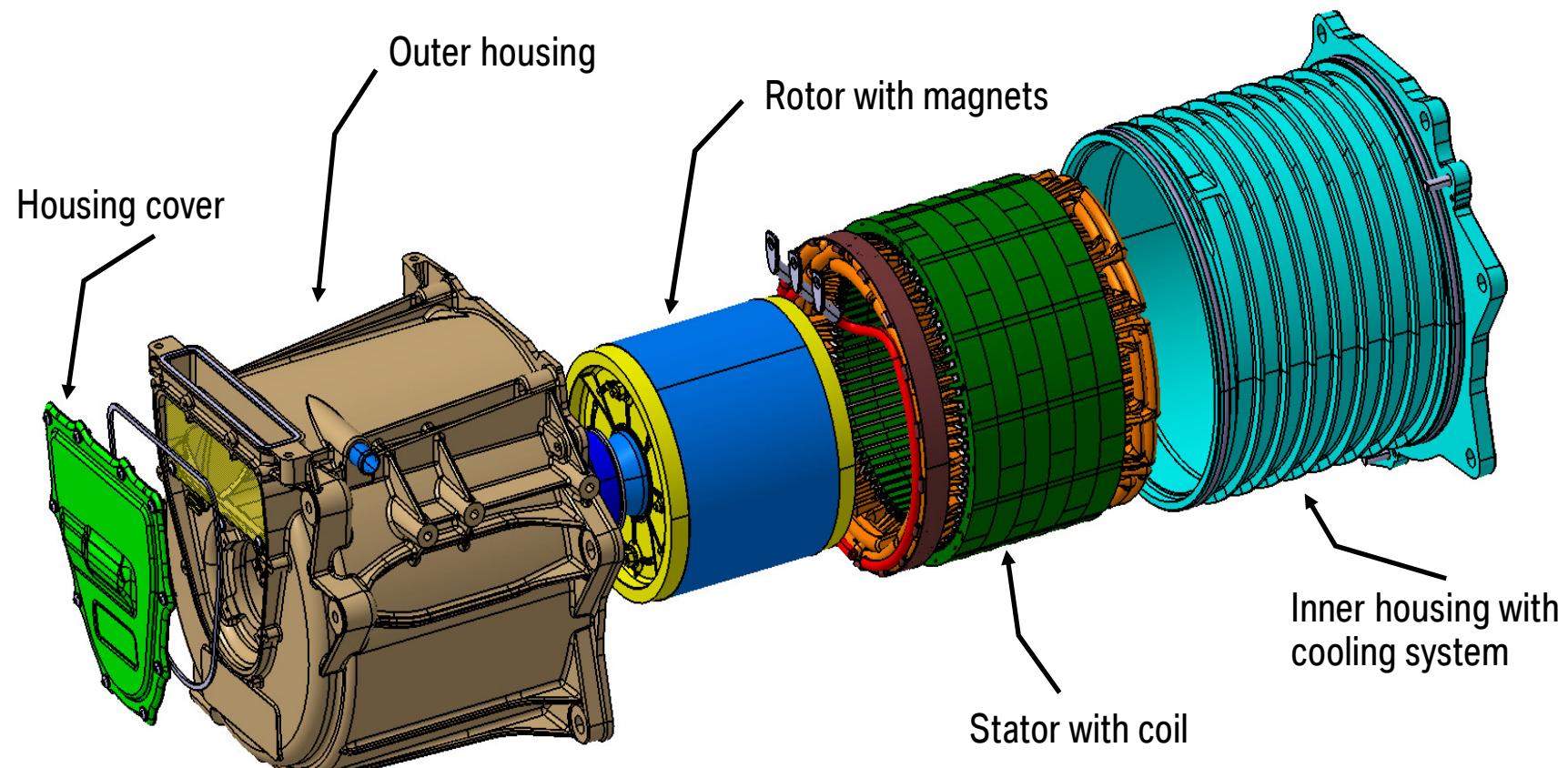
## Specifications:

Max. power	125 kW
Max. torque	250 Nm
Power (30 min.)	60 kW
Max. revolution	12.000 1/min
Efficiency	> 90%
Voltage range	250 – 400 V
Electric current	400 A
DC-DC power	2,8 kW max.
Weight	ca. 65 kg

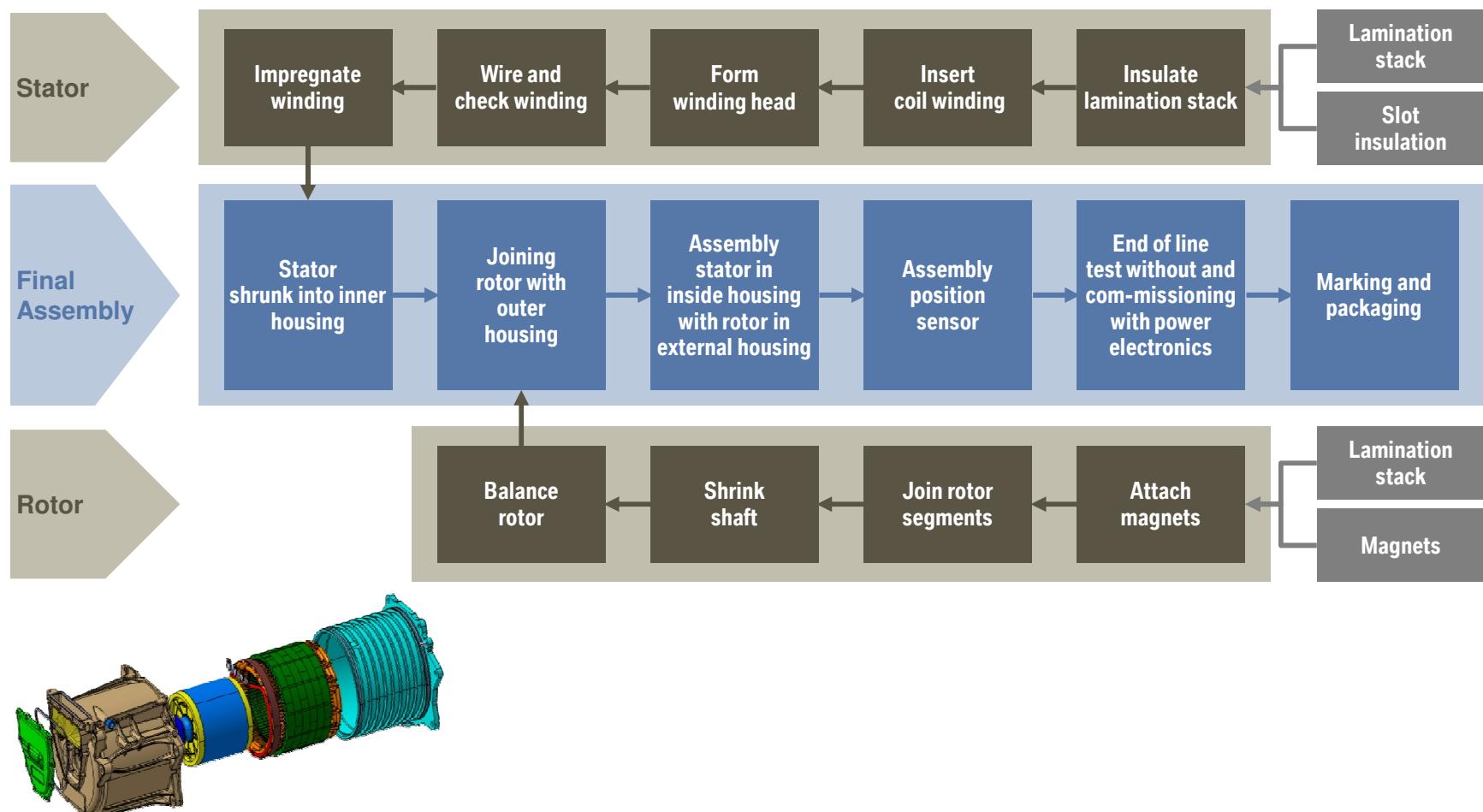
- Optimum ratio of power vs. weight
- Maximum torque during start-up
- High degree of efficiency over a wide operating range.



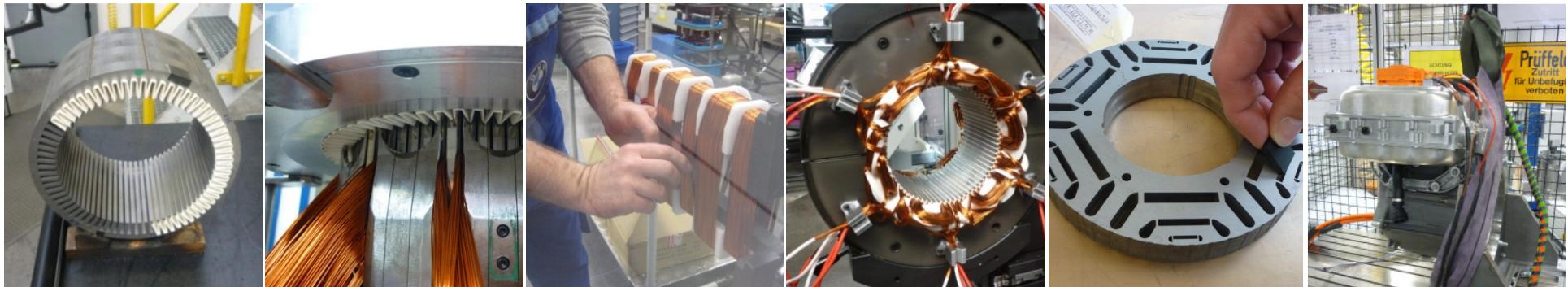
# BASIC ASSEMBLY OF THE ELECTRIC MOTOR FOR THE BMW ACTIVE E.



# PRODUCTION STEPS OF THE ELECTRIC MOTOR.



# CHALLENGES IN PRODUCTION OF ELECTRIC MOTORS FOR THE AUTOMOTIVE INDUSTRY.



- High output **flexibility** of the production system required in case of rapid variations in demand.
- Optimized **manufacturing processes** to improve efficiency and power/weight ratio:
  - Winding → Slot filling factor.
  - Forming and connecting the winding head
  - Minimize packaging space.
- Production-orientated design of **isolation concepts** in large series:
  - Material primary and secondary isolation, impregnation process,
  - concepts phase separation and –isolation.
- Reliable handling of **magnets**.
- **Measurement and testing** technologies: Standards and automation.

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# SUMMARY OF GENERAL CHALLENGES ON AUTOMOTIVE PRODUCTION FACING E-MOBILITY 1/3.



- Global **increase of production capacities** within all parts of the automotive industry expected (conventional and new drive technology)
- **Unpredictable volumes regarding e-mobility**, depending on lots of volatile parameters (legislation, markets, customer acceptance, ...)
- High **variety** and **change rate** of design, variants and derivatives expected
- **Flexibility**, modularity, scalability **of production** necessary
- Strong **competition between OEMs and suppliers** → “survival of the fittest”
- High **cost pressure**, especially on e-drive components and systems

# SUMMARY OF GENERAL CHALLENGES ON AUTOMOTIVE PRODUCTION FACING E-MOBILITY 2/3.



- High **speed of innovation** necessary (battery cells, ....) to optimize power, energy, durability, efficiency, size , weight, cost
- **New and rare qualifications** of engineers and workers required
- **Interdisciplinary work** required (mechanical, electrical, process, chemical , software engineering + economics + business administration)
- **Increase of automation** to reach high quality, safety and cost efficiency => depending on volumes!
- Manufacturing of **new and expensive materials**: high strength steel, light metals, fibre-reinforced plastics, ceramics, sandwich constructions, hybrid design, rare earth and complex material mixes

# SUMMARY OF GENERAL CHALLENGES ON AUTOMOTIVE PRODUCTION FACING E-MOBILITY 3/3.



- **New requirements on joining technologies** necessary (hv electric current conduction, ...)
- Assembly of **highly integrated components** (e-motor and power electronics...)
- Dealing with high voltage within the production => **work safety!**
- Demanding **measuring and testing** equipment
- High impact of **energy efficiency and environmental** restrictions
- **Standardization** of processes and tools (global versus local interests!)
- **Cooperation and joined forces** between OEMs, suppliers, engineering companies and research institutes needed

