Dr. Frank Möbius, Planning and Production of Electric Drivetrains –
Manufacturing Technologies and Prototype Shop.
AMAA 2013, Berlin, 17.06.2013

CHALLENGES OF THE PRODUCTION OF ELECTRIC POWERTRAINS FROM THE PERSPECTIVE OF A PREMIUM CARMAKER.

BMW GROUP

CONTENTS.

IN A CHANGING WORLD, E-MOBILITY IS AN INTERESTING APPROACH.

Environment

Climate change its knock-on effects

Urbanisation

By 2030, over 60% of the world's population will live in cities

Customer Expectations

Changing values

DRIVING FACTORS

Culture

Sustainable mobility as part of a modern urban lifestyle; taking social responsibility

Economics

Dwindling resources, rising fossil fuel prices

Politics and Regulations

CO_2 and fleet regulations, import restrictions

BMW GROUP EFFICIENT DYNAMICS.
THE ROAD TO EMISSION-FREE MOBILITY.

BMW EfficientDynamics

Optimizing:

- Efficiency
- Aerodynamics
- Lightweight
- Energy Management
- Road Resistance

ActiveHybrid

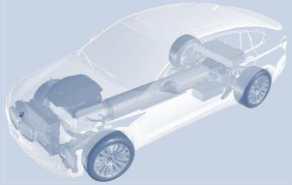
ActiveHybrid X6
ActiveHybrid 7
ActiveHybrid 5
Active Hybrid3

PEV / BMW i

Plug-in Vehicles / i3 & i8

Hydrogen

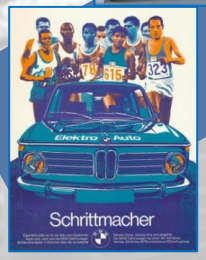
FCEV
Long Range ZEV Mobility



HISTORY OF ELECTRIFICATION AT BMW.

Electric vehicles (BEV)

1972
BMW 1602
Lead Acid
Battery



1987
BMW 325
NaS-Batt.

1991
BMW E1
NaS-Batt.

1992
BMW 325
NaNiCl-Batt.

1994
518i Parallel-Hybrid
NiMH-Battery

1995
316i Serial Hybrid
NiCd-Battery

1996
BMW 325
NaNiClBatt.

2003
X5 Active Hybrid
Super Caps

2008
MINI E
Li-Ion-Batt.

2009
X6 Active Hybrid
Ni-MH Battery

2009
Active Hybrid 7
Li-Ion Battery

2011
BMW ActiveE
Li-Ionen-Batterie

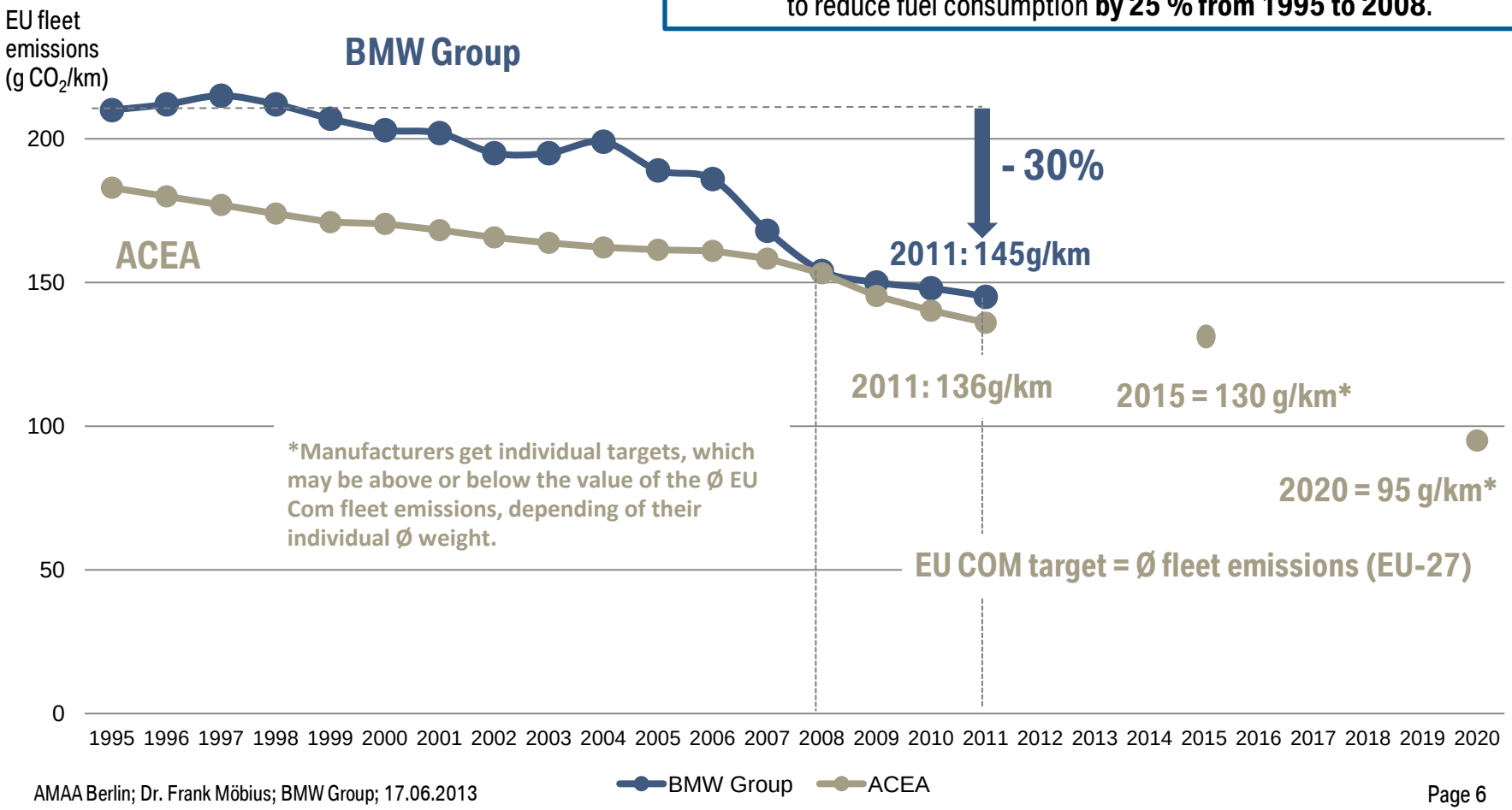
2013
BMW i3
Li-Ionen-
Batterie

2014
BMW i8
Li-Ionen-
Batterie

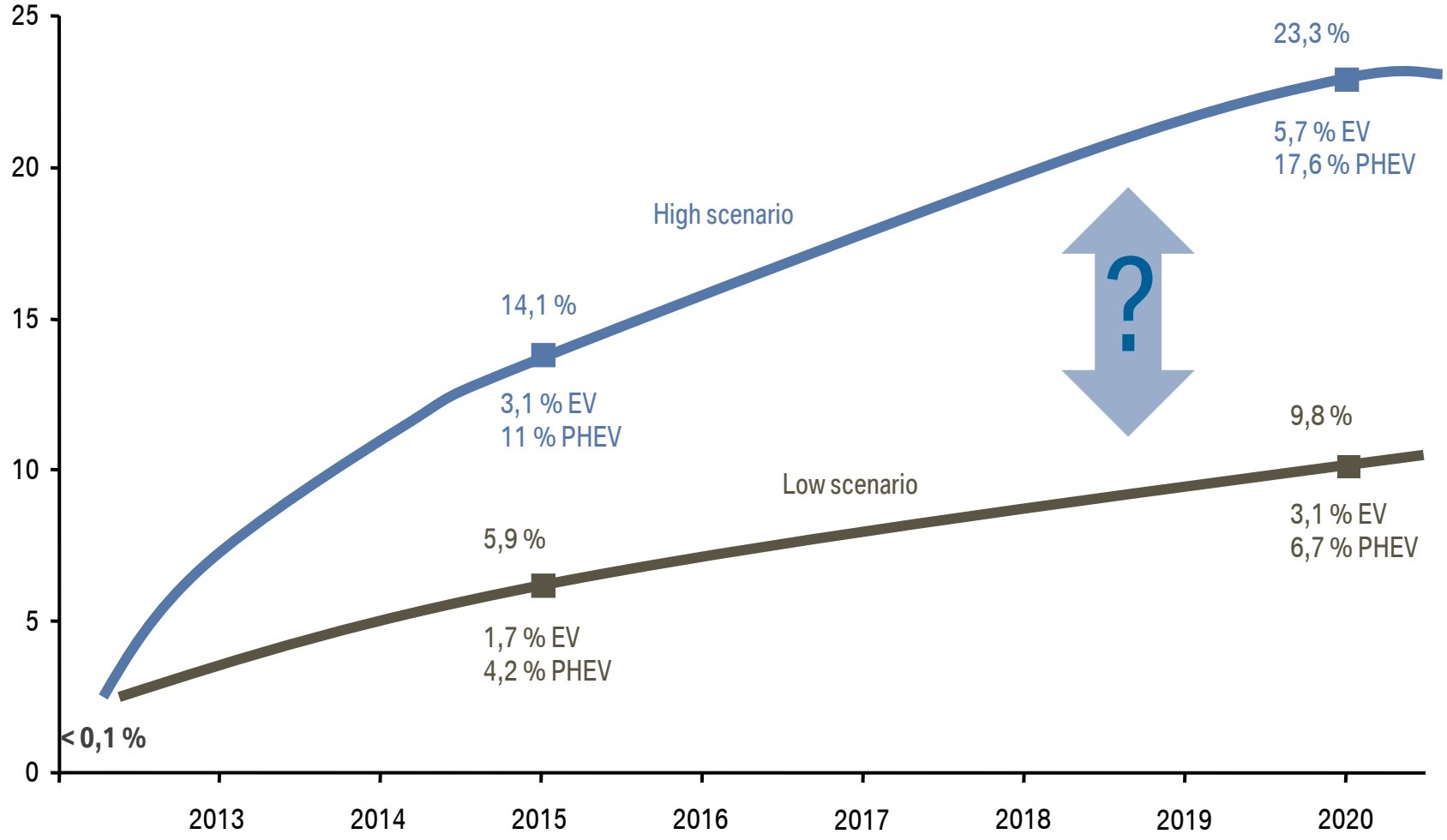
Hybrid vehicles (HEV/PHEV)

COMPARISON OF CO_2 FLEET REDUCTIONS IN EUROPE. BMW HAS ALREADY ACHIEVED A GREAT DEAL. TOUGH TARGETS TO COME.

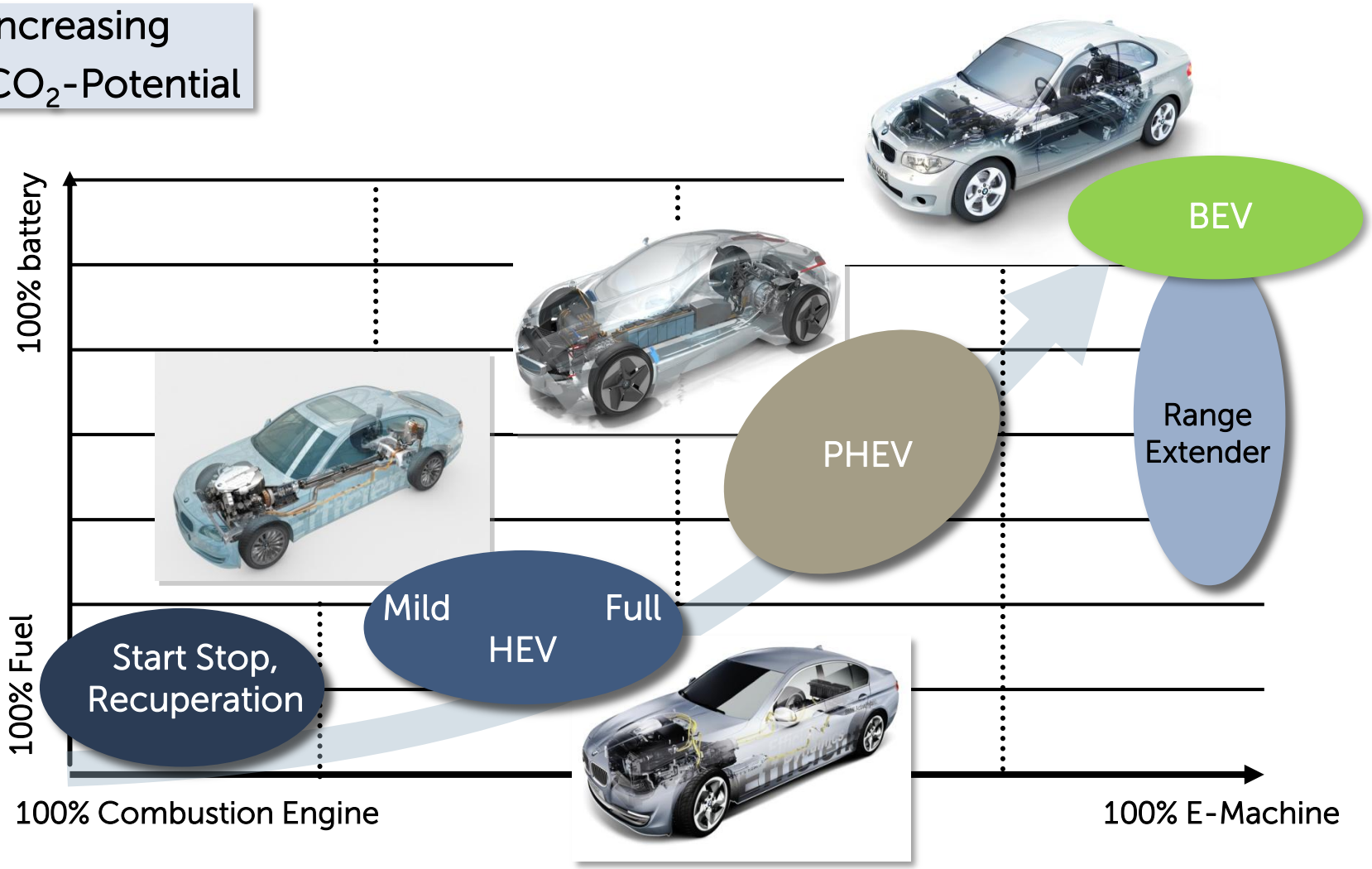
BMW Group has more than fulfilled its contribution to the **ACEA commitment** to reduce fuel consumption **by 25 % from 1995 to 2008**.



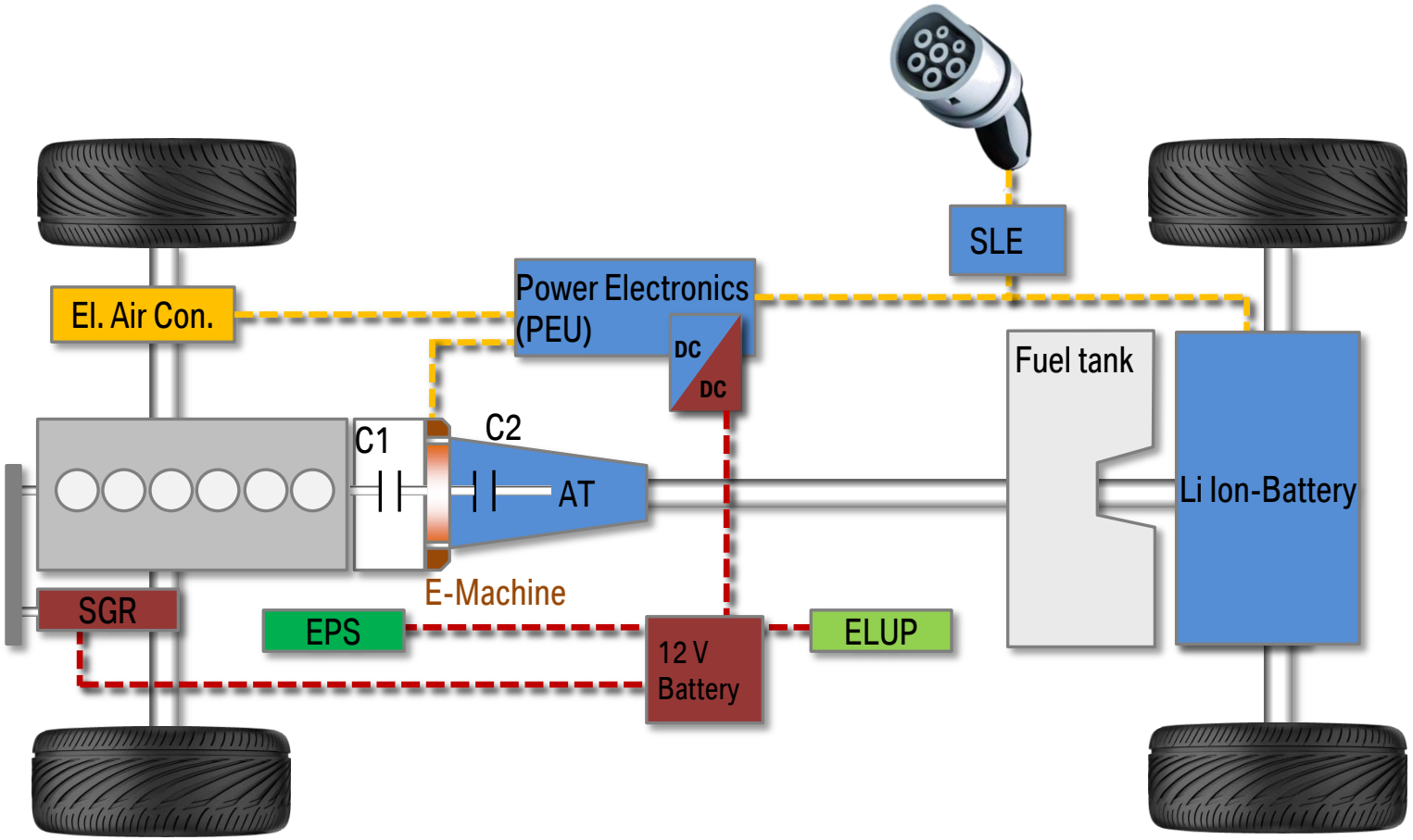
SHARE OF PHEV/BEV POWERTRAIN TECHNOLOGIES EUROPE IN 2020 – VERY DIFFERENT SCENARIOS.



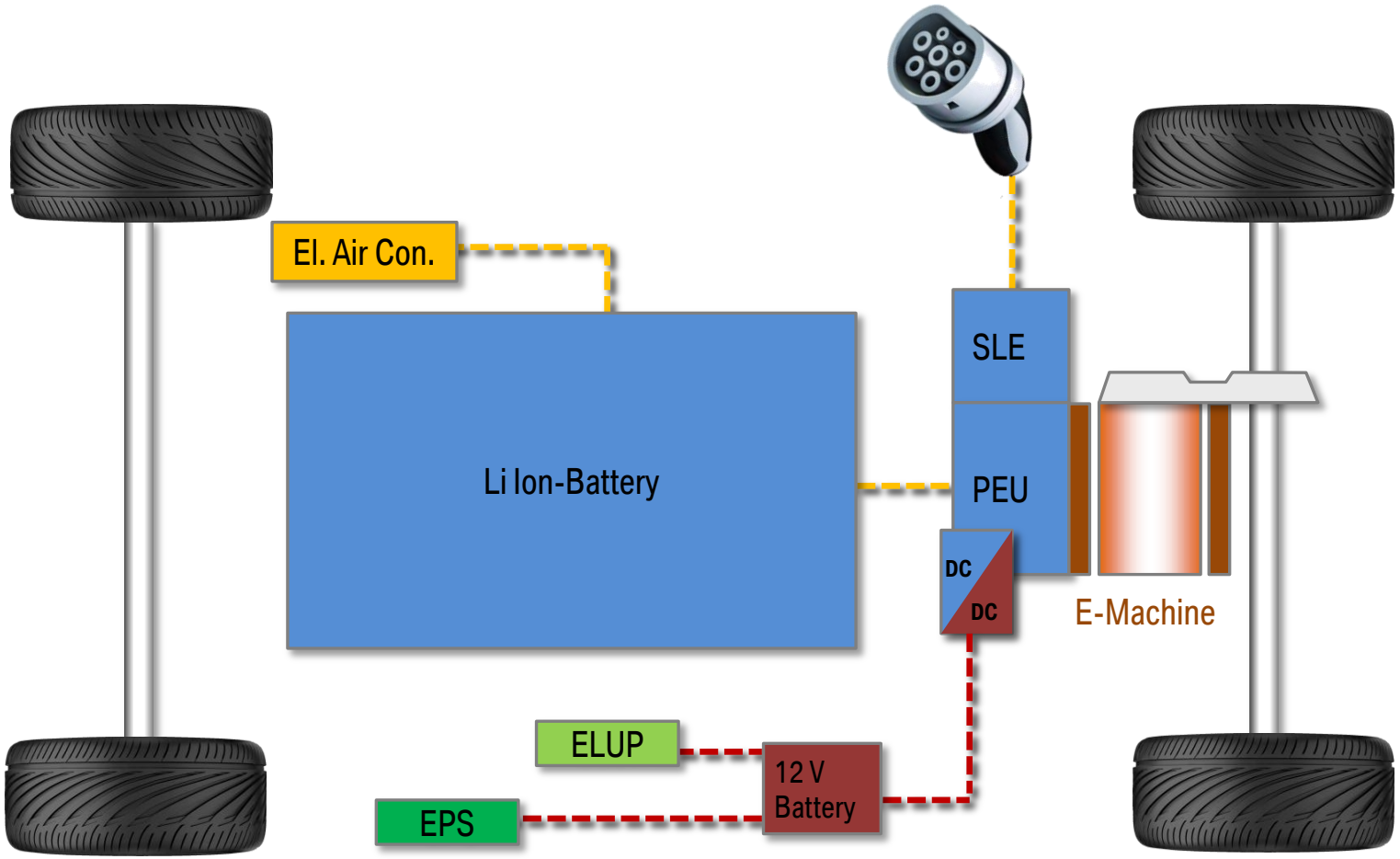
CLASSIFICATION OF ELECTRIFIED VEHICLES.



ARCHITECTURE OF A PLUG IN HYBRID (PHEV).



ARCHITECTURE OF A PURE ELECTRIC VEHICLE (BEV).



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BMW i IS A NEW VALUE PROPOSITION.

Thrilling Performance

Unrivaled Experience

Striking Technology

Dynamic Performance

Aesthetic Design

Innovative Technologies

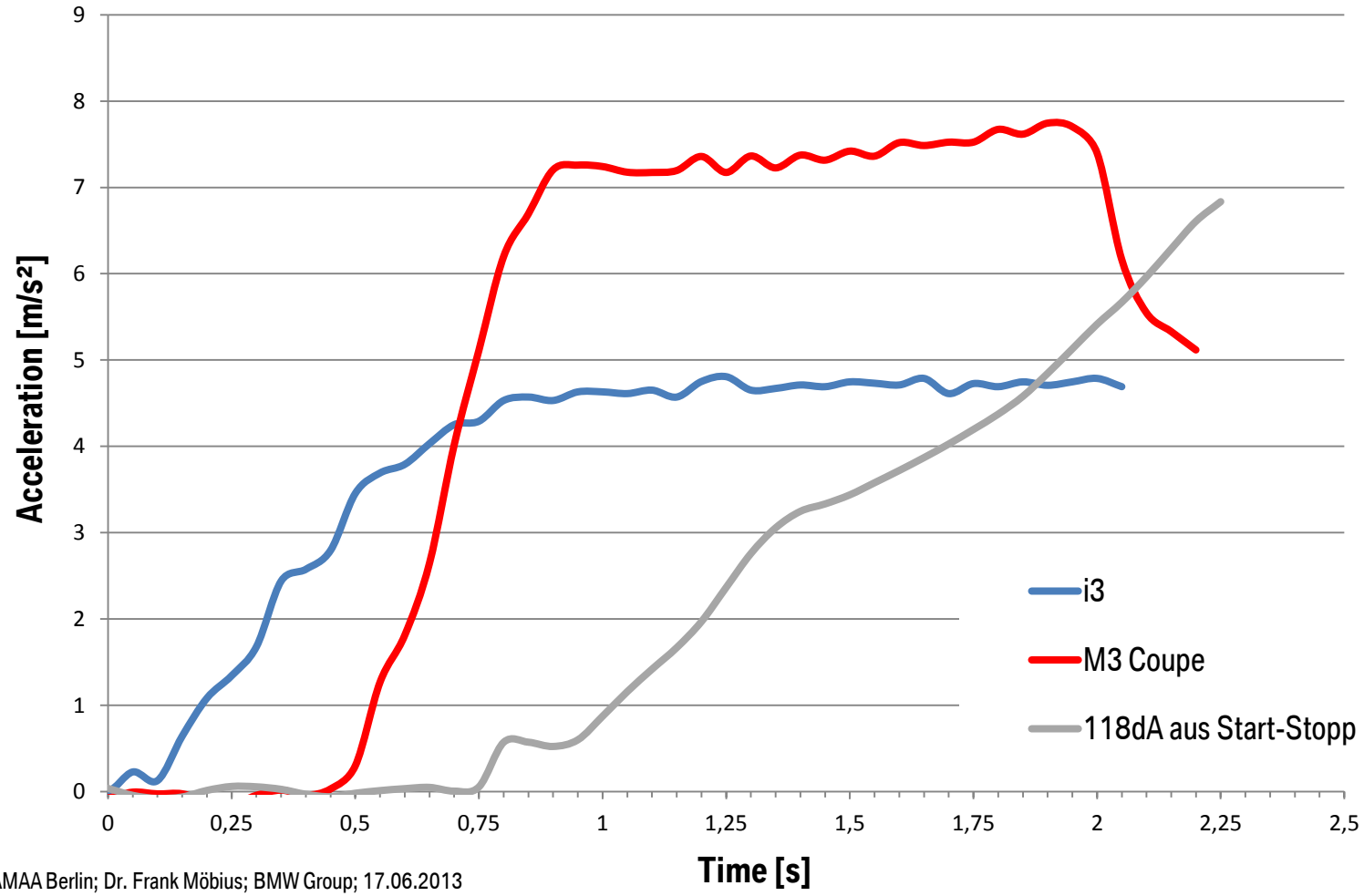
Visionary Mobility

Inspiring Design

Next Premium

RESPONSIVENESS FROM STANDSTILL.

Individual measurements for i3, M3 Coupé and 118dA compared.



PURE ELECTRIC DRIVING AT BMW: FROM THE MINI E TO THE BMW I3.







User behavior	Social acceptance	Infra-structure	Use of re-newable energies	Market potential	Mobility Services	Strengths and weak-nesses

2009

2011

2013


BMW i3 Concept

BMW i3 CONCEPT – SOME TECHNICAL DATA.

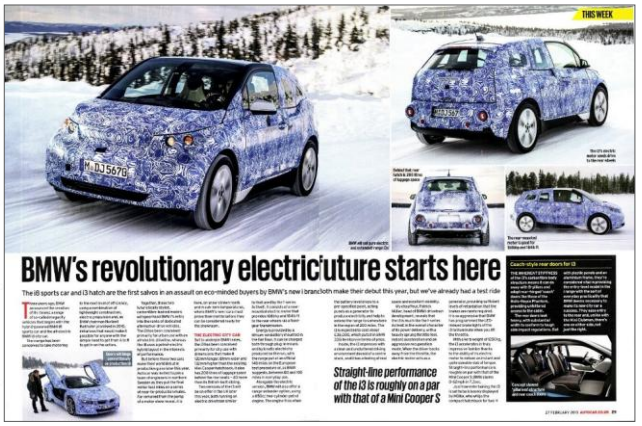
Vehicle	
Length	3,85m
Weight	1250kg
Driving Performance	
Performance	125kW/250Nm
Acceleration 0-100 km/h	7,9s
Maximum Speed	150 km/h
Range (NEDC)	225 km
Range (Costumer)	130 -160 km
Recharging	
Charging time (standard)	6h (100%)
Charging time (optional)	< 30 min (80%)

BMW i3: PRESS FEEDBACK.

„This car is a revolution“ (Auto Bild 1/3/2013).

Conclusion

The i3 does everything differently and much better. It is as quiet as a cat on the mantel, structurally strong as cast iron, tracks properly such as a rack railway and weighs without a battery even not 1000 kilograms. All this makes it an automotive revolution. "



Autocar, 27/2/2013

„The BMW i3 is a real BMW.“

Auto Bild, 1/3/2013

„Its (BMW i3) carbon fiber body is wrapped in layers of electronic services and smartphone apps designed to make life simpler and save time for the owner. ”

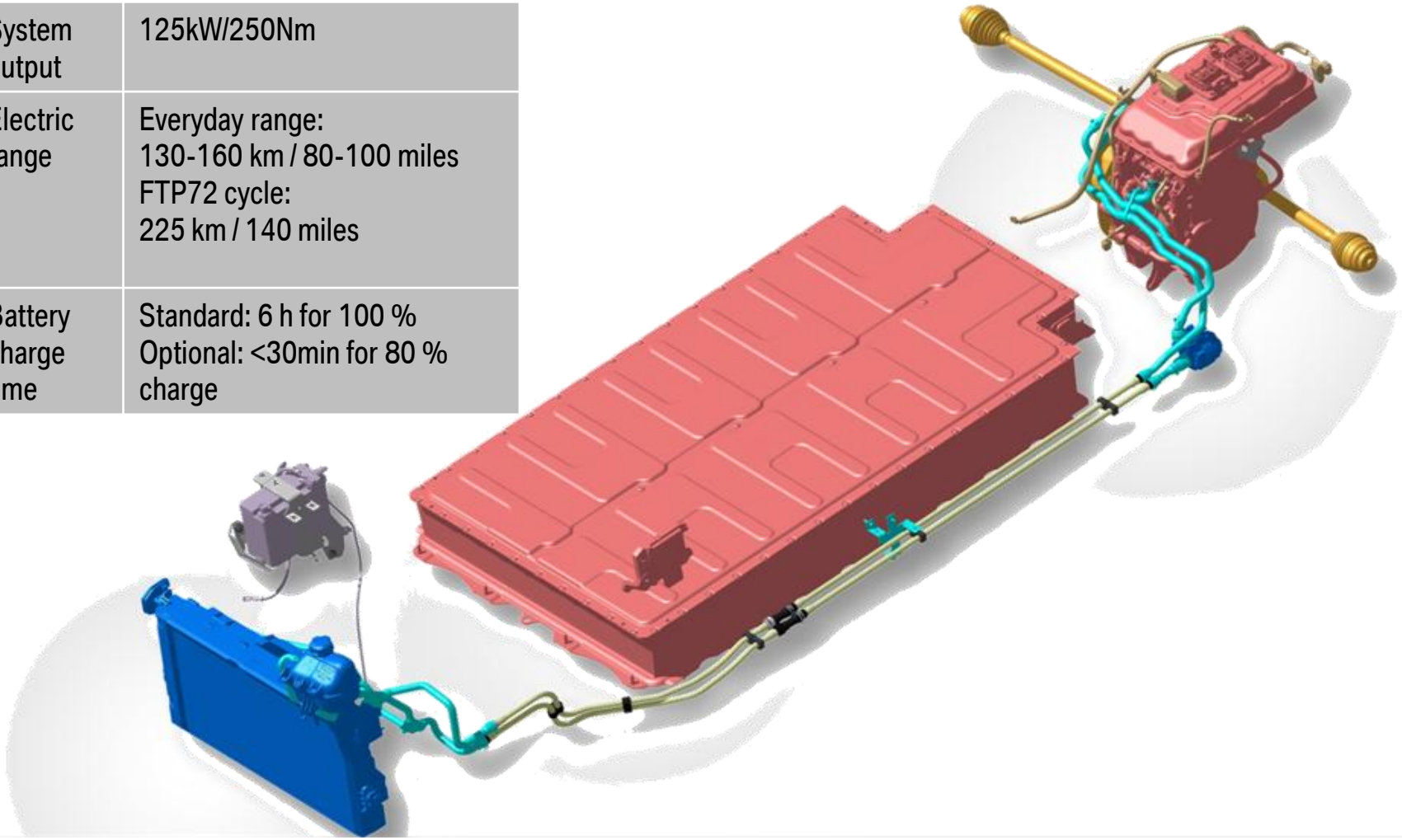
FORTUNE

„BMW’s pioneering i3 electric car is one of the most exciting cars of 2013.”

car
THE WORLD'S BEST CAR MAGAZINE

BMW i3 CONCEPT – POWERTRAIN.

System output	125kW/250Nm
Electric range	Everyday range: 130-160 km / 80-100 miles FTP72 cycle: 225 km / 140 miles
Battery charge time	Standard: 6 h for 100 % Optional: <30min for 80 % charge




BMW i8 Concept

BMW i8 CONCEPT – SOME TECHNICAL DATA.

Vehicle	
Length	4,63m
Weight	1480kg
Driving Performance	
Performance (System)	260kW/550Nm
Performance (Otto)	164 kW/ 300Nm
Performance (electric)	96kW/ 250Nm
Acceleration 0-100 km/h	4,6s
Consumption	2,7l, 66g CO_2
Range (electric)	35 km
Charging time	1:45h (100%)

BMW i8: PRESS FEEDBACK.

„Captain Future“ (Auto Zeitung 27/2/2013).

„… we now know that the BMW i8 is not only spectacularly futuristic in terms of appearance but also engagingly fast, eminently usable and comfortable enough to be used every day.”

AUTOCAR

„A mixture of Tesla Roadster and Porsche 911 - and yet so much more. The BMW i8 is a gamble, but it thrilles.”

Auto ZEITUNG

„The i8 with its performance of more than 350 hp can in icy curves be steered with four fingers. It drives manageable through the corners, with only slight oversteer. The track width, the favorable weight distribution by the two motors and the low center of gravity - thanks to the wide underlying battery - makes this possible.”

Auto ZEITUNG


Newsweek Exclusive BMW rides

Exclusive BMW rides New

BMW's new i8 and i3 are shaping up

Exclusive ride in revolutionary hybrid supercar and all-electric supermini

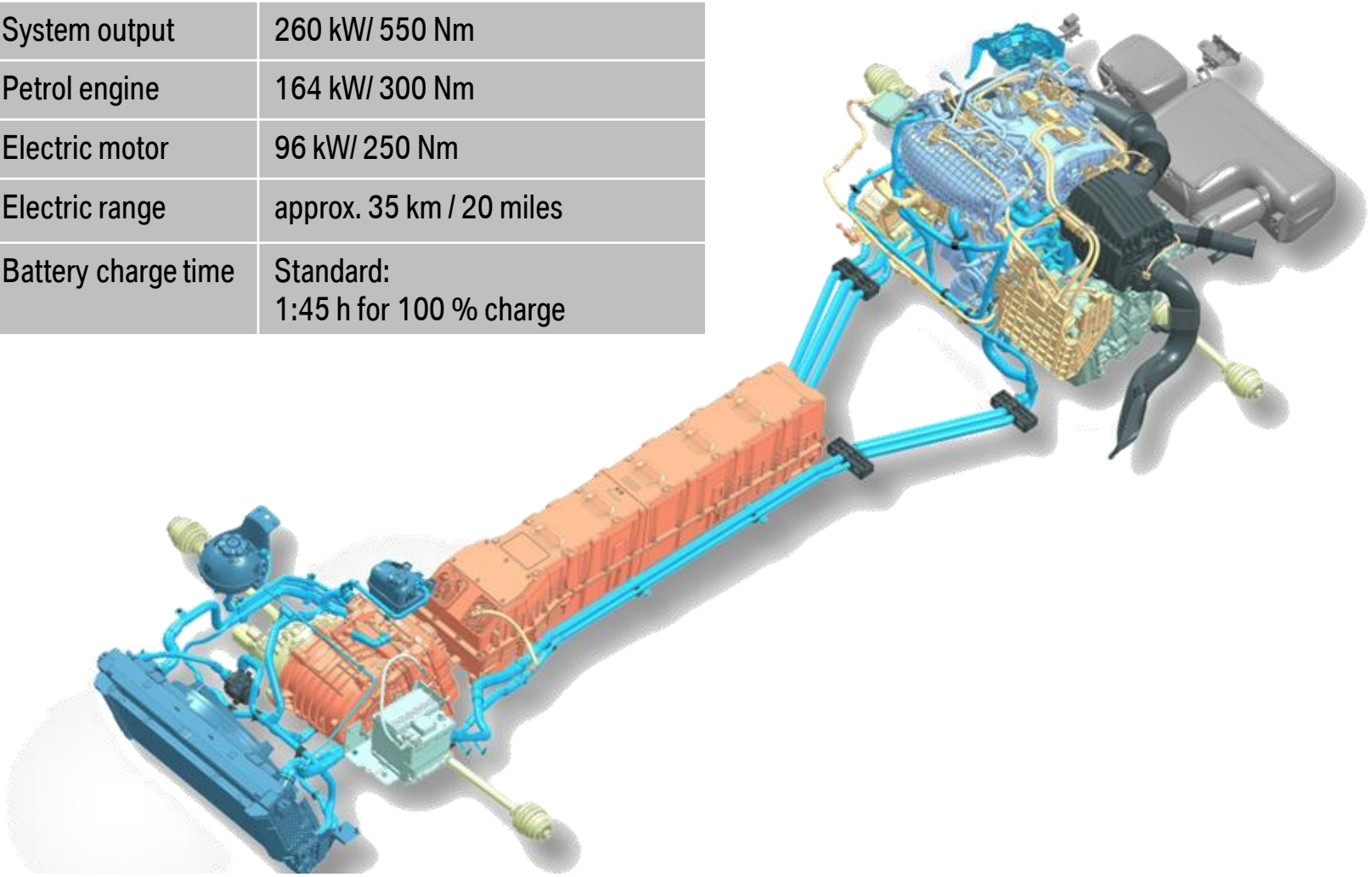
ON THE ROAD

"All-electric i3 feels like a hot hatch from the passenger seat"

Auto Express, 06Mar13

BMW i8 CONCEPT – POWERTRAIN.

System output	260 kW/ 550 Nm
Petrol engine	164 kW/ 300 Nm
Electric motor	96 kW/ 250 Nm
Electric range	approx. 35 km / 20 miles
Battery charge time	Standard: 1:45 h for 100 % charge



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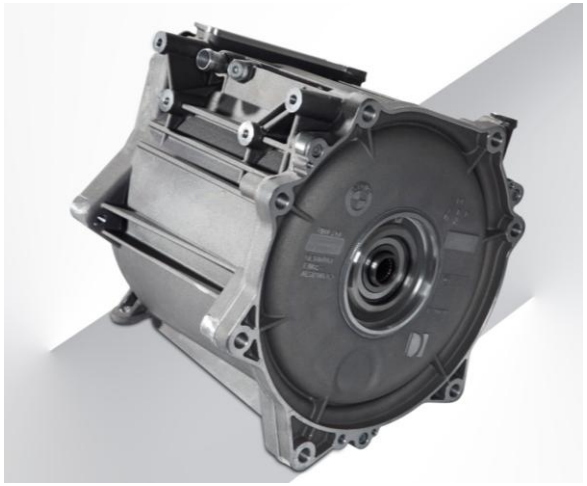
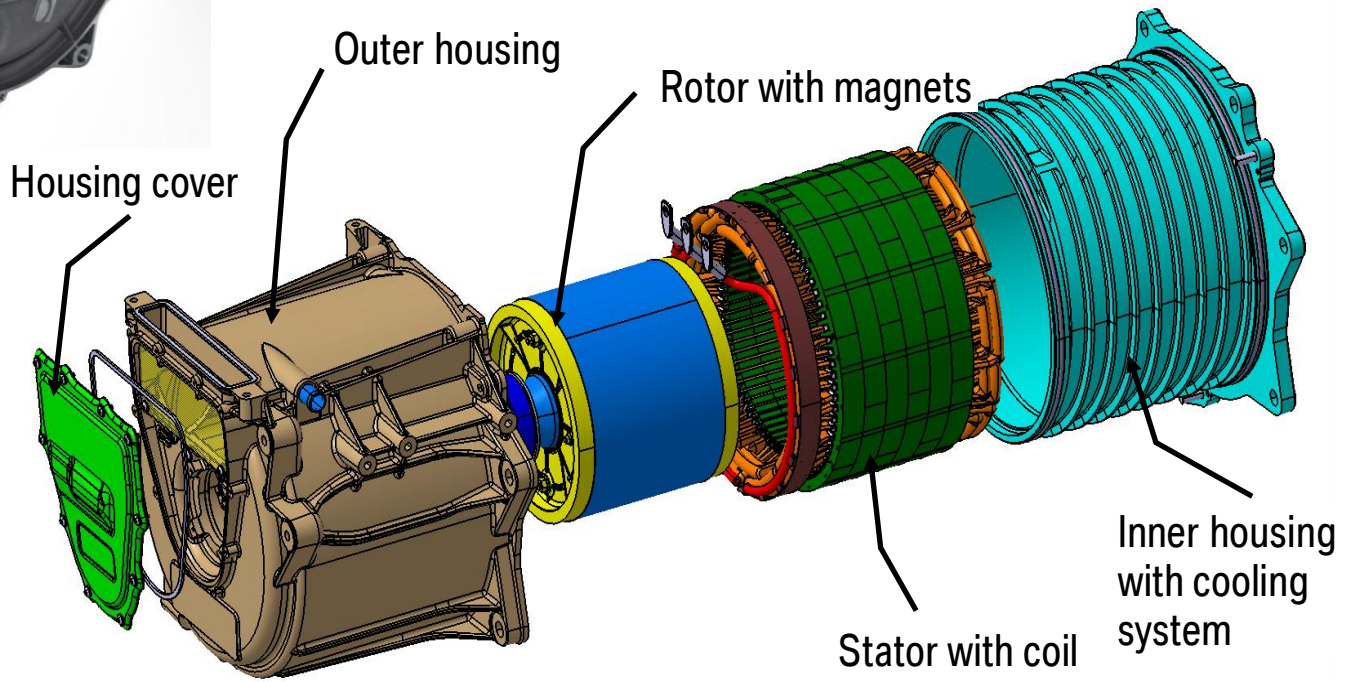
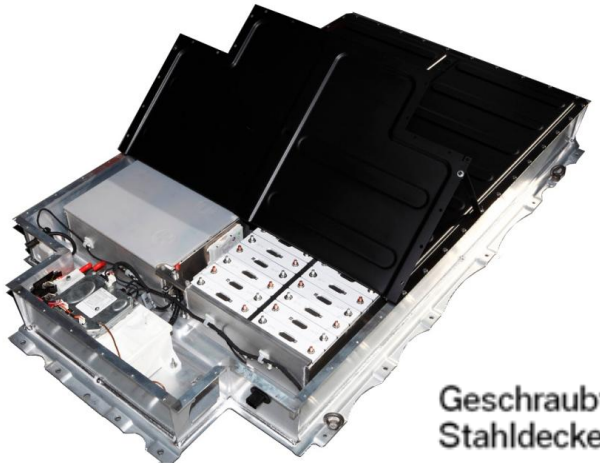
THE ELECTRIC MOTOR.



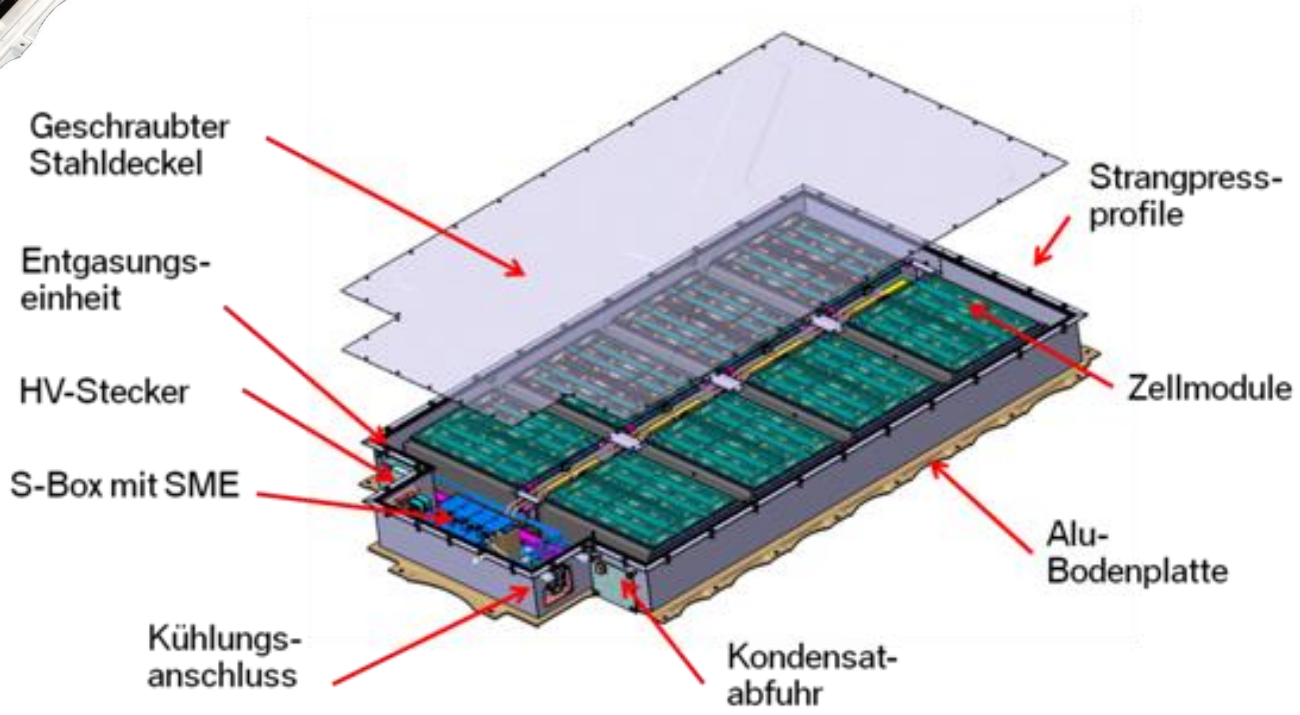
– Optimum ratio of power vs. weight
– Maximum torque during start-up
– High degree of efficiency over a wide operating range.



THE HIGH VOLTAGE BATTERY.



– Efficient and compact design
– High power and energy density
– High automotive life time robustness
– High level of automotive safety



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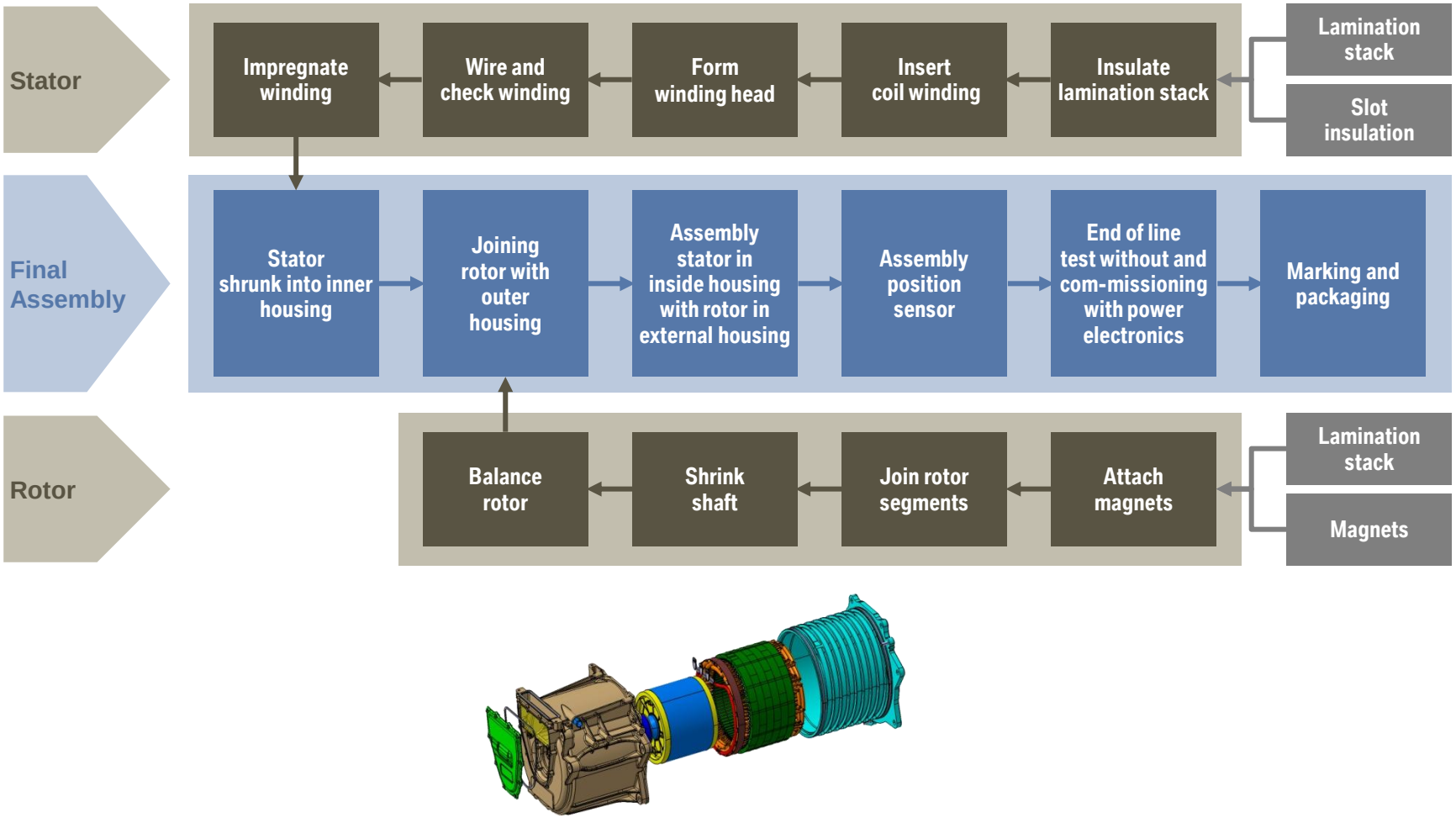
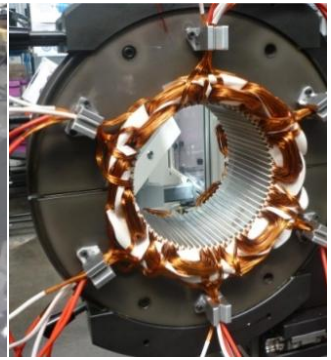
PRODUCTION STEPS OF THE ELECTRIC MOTOR.



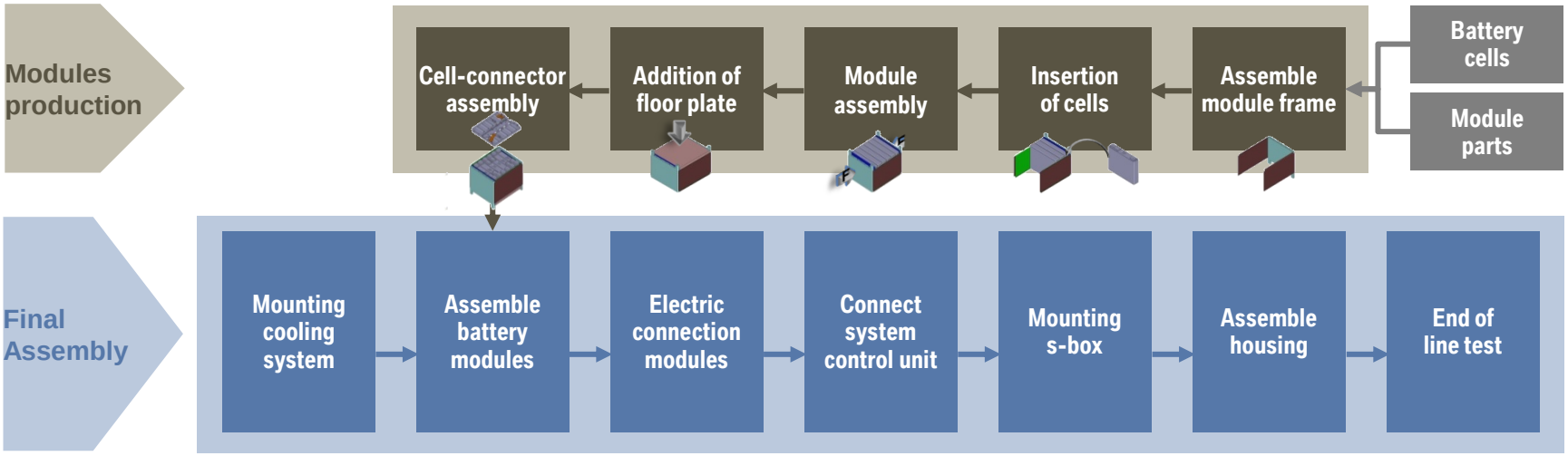
CHALLENGES IN PRODUCTION OF ELECTRIC MOTORS FOR THE AUTOMOTIVE INDUSTRY.

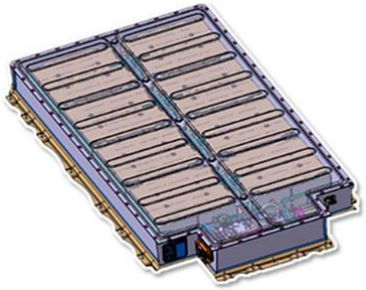


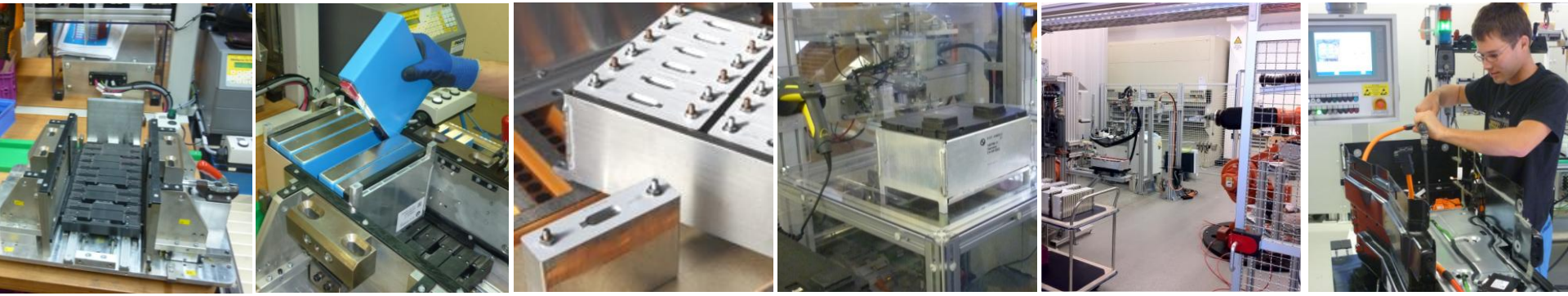
- High output **flexibility** of the production system required in case of rapid variations in demand.
- Optimized **manufacturing processes** to improve efficiency and power/weight ratio:
  - Winding →Slot filling factor.
  - Forming and connecting the winding head.
  - Minimize packaging space.
- Production-orientated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

PRODUCTION STEPS OF THE HIGH VOLTAGE BATTERY.





CHALLENGES IN PRODUCTION OF HIGH VOLTAGE BATTERIES FOR THE AUTOMOTIVE INDUSTRY.



- No manufacturing of **cells** in Europe leads to a high effort in **logistic and quality** inspection before assembly.
- High output **flexibility** of the production system required in case of rapid variations in demand.
- New requirements of **joining processes**: transmission of high currents in welded joints, heat transfer and electrical isolation in adhesive layers, …
- **Automation** of assembly procedures: screwing, mounting of contacts, handling of filigree cooling systems, …
- **Safety** when using high voltage and technical cleanliness of manual assembly.
- **Measurement and testing** technologies: Standards und automation.

CONTENTS.

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 technologies)
- **Unpredictable volumes regarding e-mobilty**, 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

THANK YOU FOR YOUR ATTENTION.