

TECHNOLOGY UPDATE.

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MEMBER OF THE BOARD OF MANAGEMENT OF BMW AG, DEVELOPMENT.

Munich
December 3rd 2018



Rolls-Royce
Motor Cars Limited

OUR AGENDA FOR THE DAY.

1

ENVIRONMENT AND STRATEGIC FRAMEWORK.

2

ELECTRIFICATION.

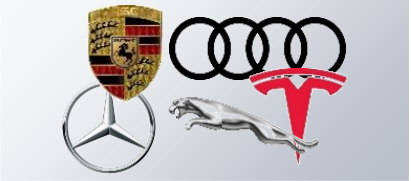


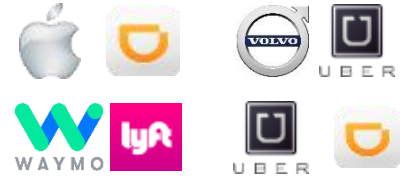
3

AUTONOMOUS DRIVING AND AI.

DYNAMIC CHANGES IN THE AUTOMOTIVE INDUSTRY AFFECT BOTH THE CORE BUSINESS AS WELL AS THE FUTURE ORIENTATION OF THE BMW GROUP .

	Significant image loss of the German automotive industry
	Diesel technology still heavily criticized
	Introduction of considerably stricter regulation
	Increasing regionalization of demands and requirements
	International increase in trade barriers



Significant expansion of the electric car offering	
Car as 'third space' besides the home and workplace associated with internet companies	
Creation of tech stacks to develop autonomous driving	
Increase in partnerships to implement car/ride sharing solutions	

OUTSTANDING TECHNOLOGICAL INNOVATIONS ARE A KEY STRATEGIC APPROACH.

We shape TOMORROW'S TECHNOLOGY.
We develop innovative technologies for
our prospective products and services.



WE ARE CURRENTLY DEVELOPING INNOVATIVE VEHICLE TECHNOLOGIES OF THE FUTURE VIA TWO FUTURE AREAS AND SIX KEY TOPICS.

Technology/Innovation Leadership

Future field: Powertrain technology



**Efficient
Dynamics
NEXT**



**Electro-
mobility**



Hydrogen



Connectivity

Future field: Digitalization



**Artificial
intelligence**



**Autonomous
driving**

Strategic Partnerships

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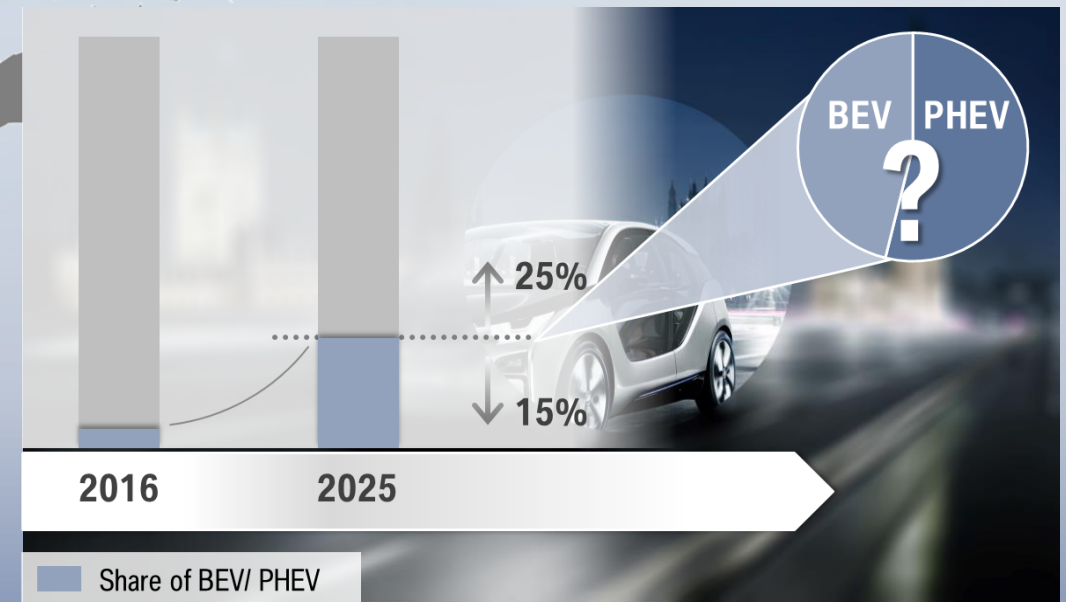
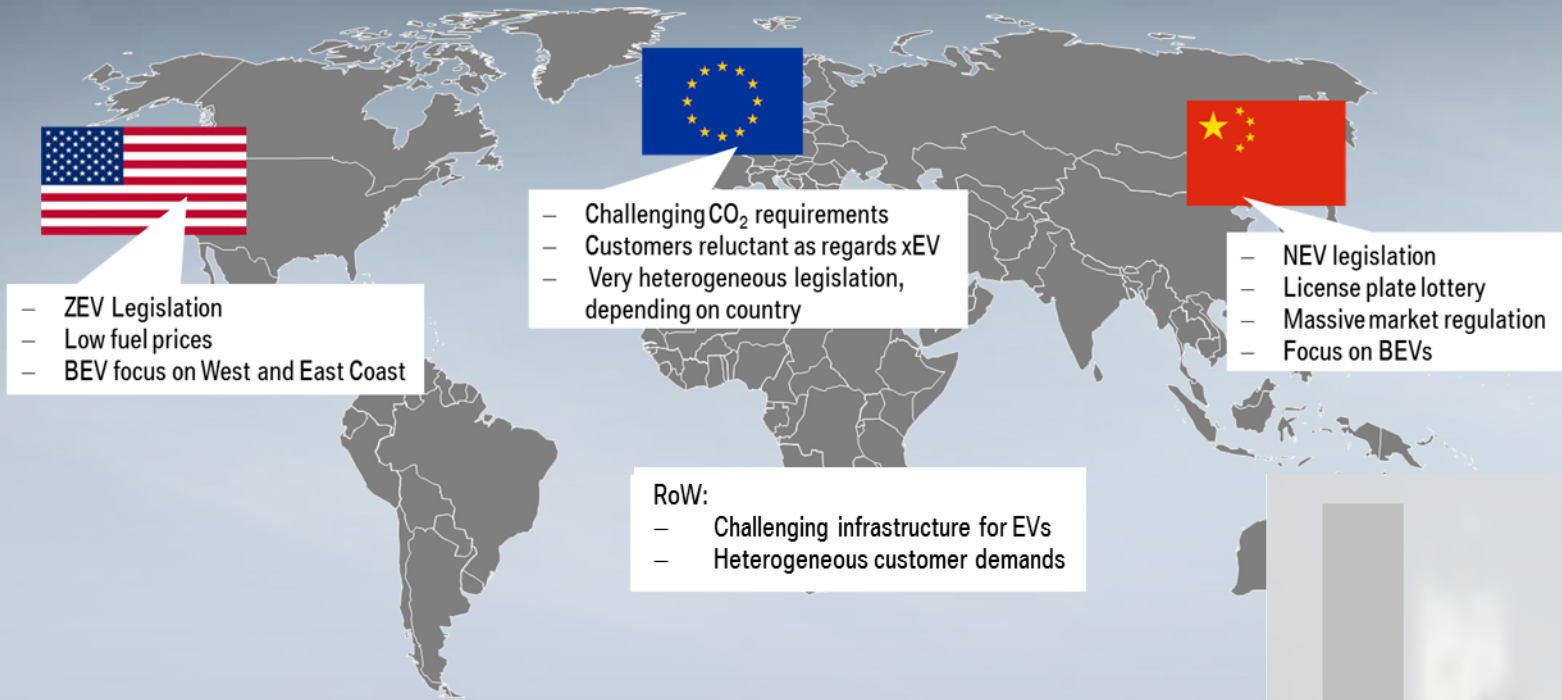
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ELECTRIFICATION.

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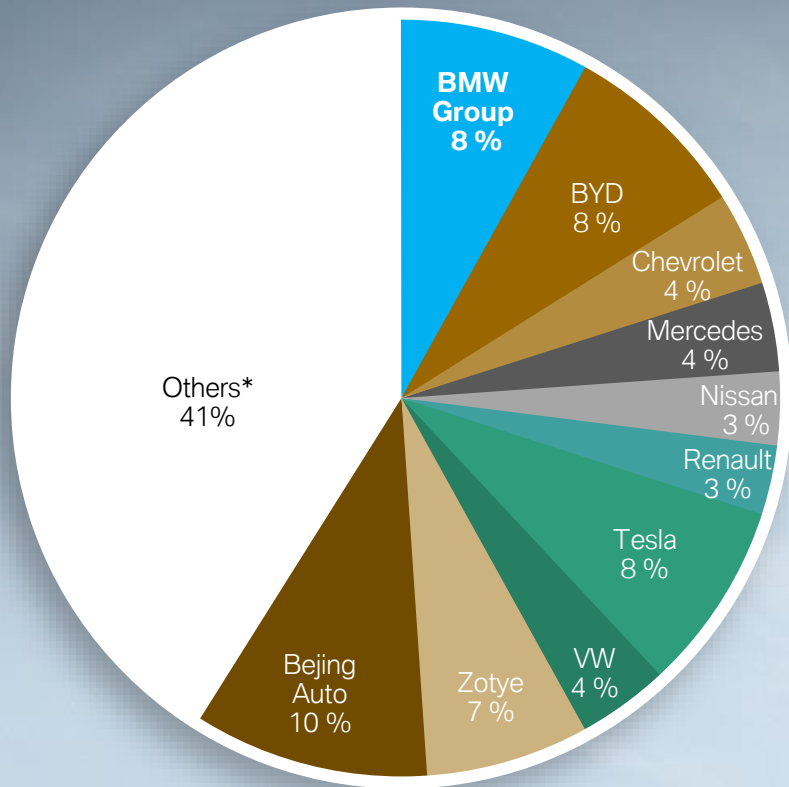
AUTONOMOUS DRIVING AND AI.

IN GLOBAL MARKETS WITH DIFFERING LEGISLATIVE, INFRASTRUCTURE AND CUSTOMER DEMANDS, FLEXIBILITY IS KEY.

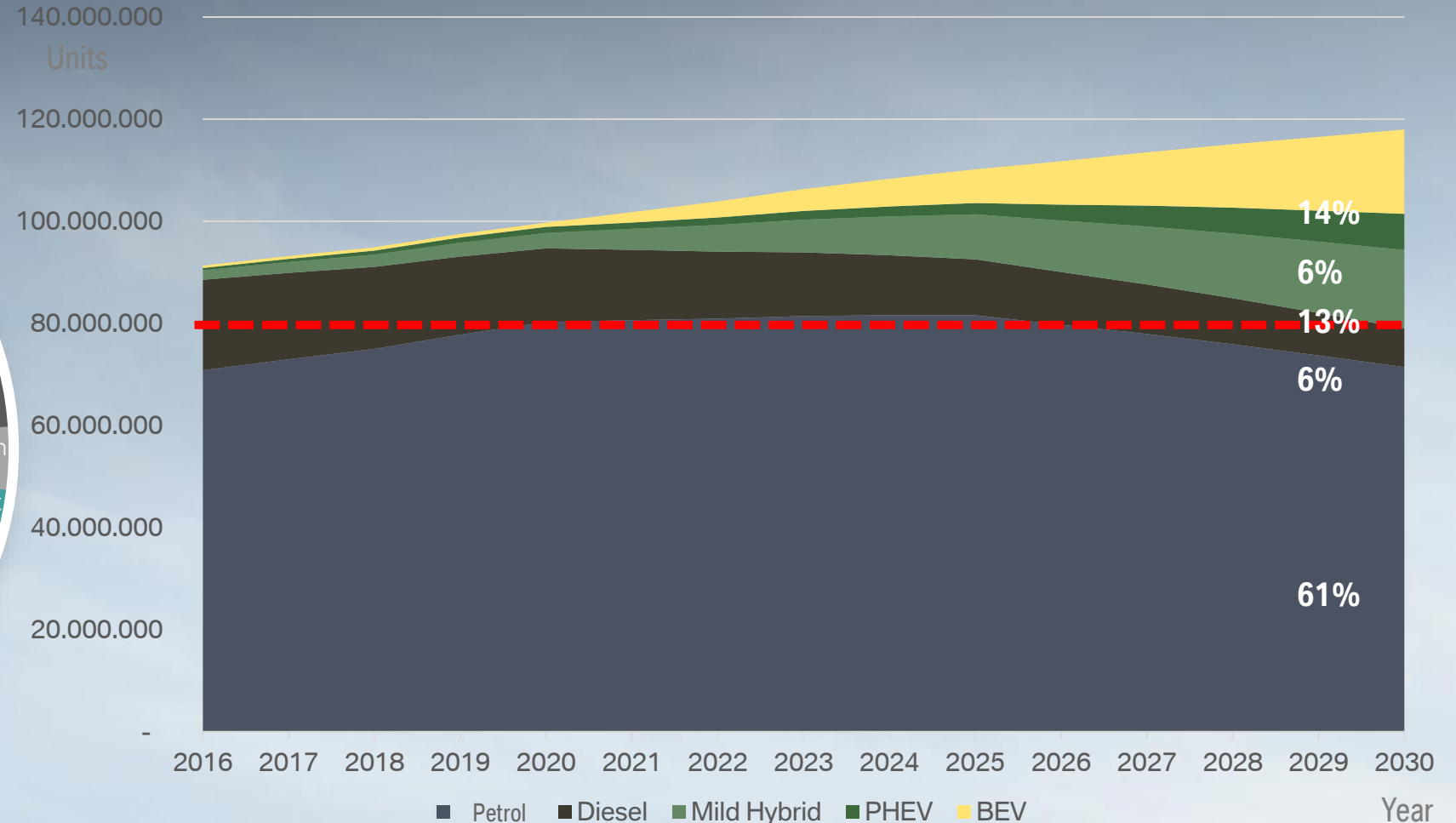


MARKET DEVELOPMENT OF ELECTRIFIED DRIVES.

Current status
Market share of
BEVs and PHEVs.



Forecast by type of drive



*Individual volume shares < 3 %.

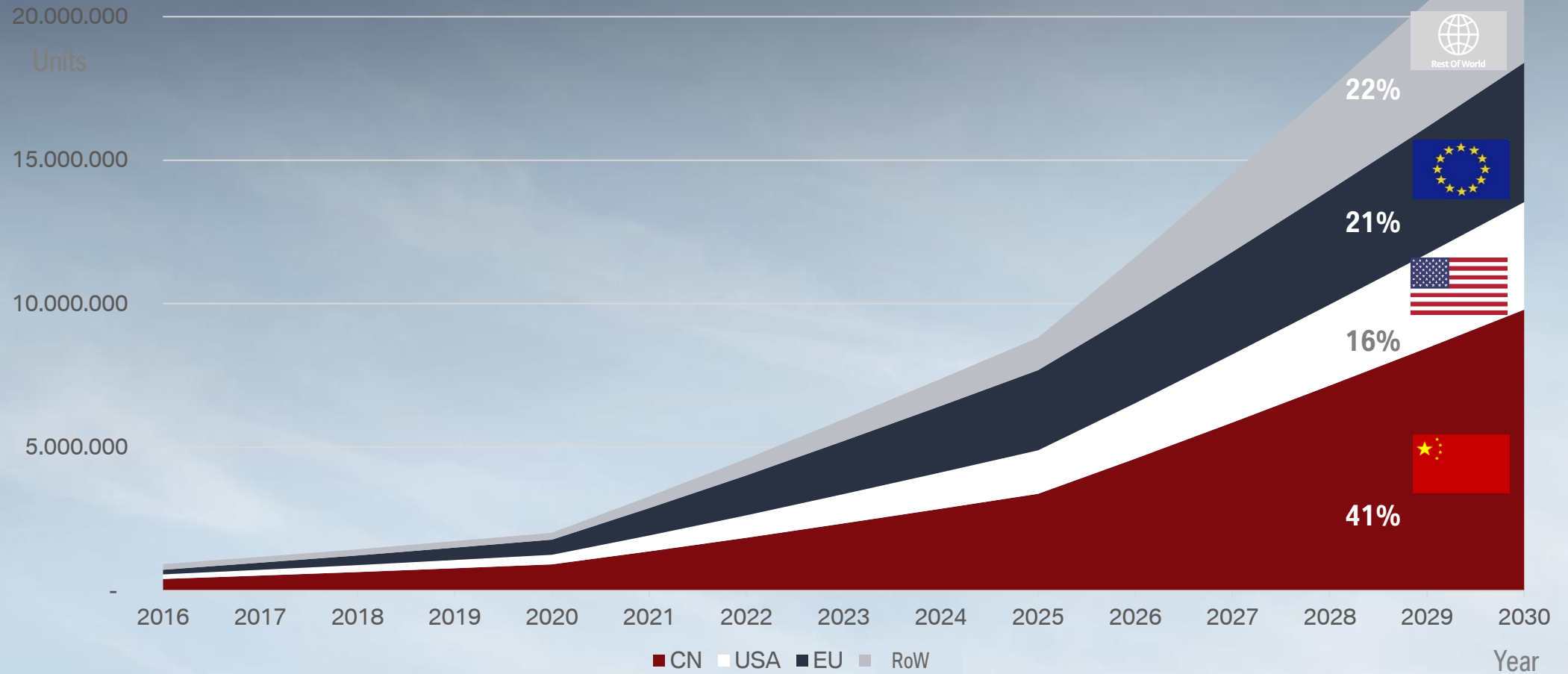


Volume of ICE products will not decline significantly but will remain very relevant for a long time to come.

We will see growth almost exclusively in xEV products.

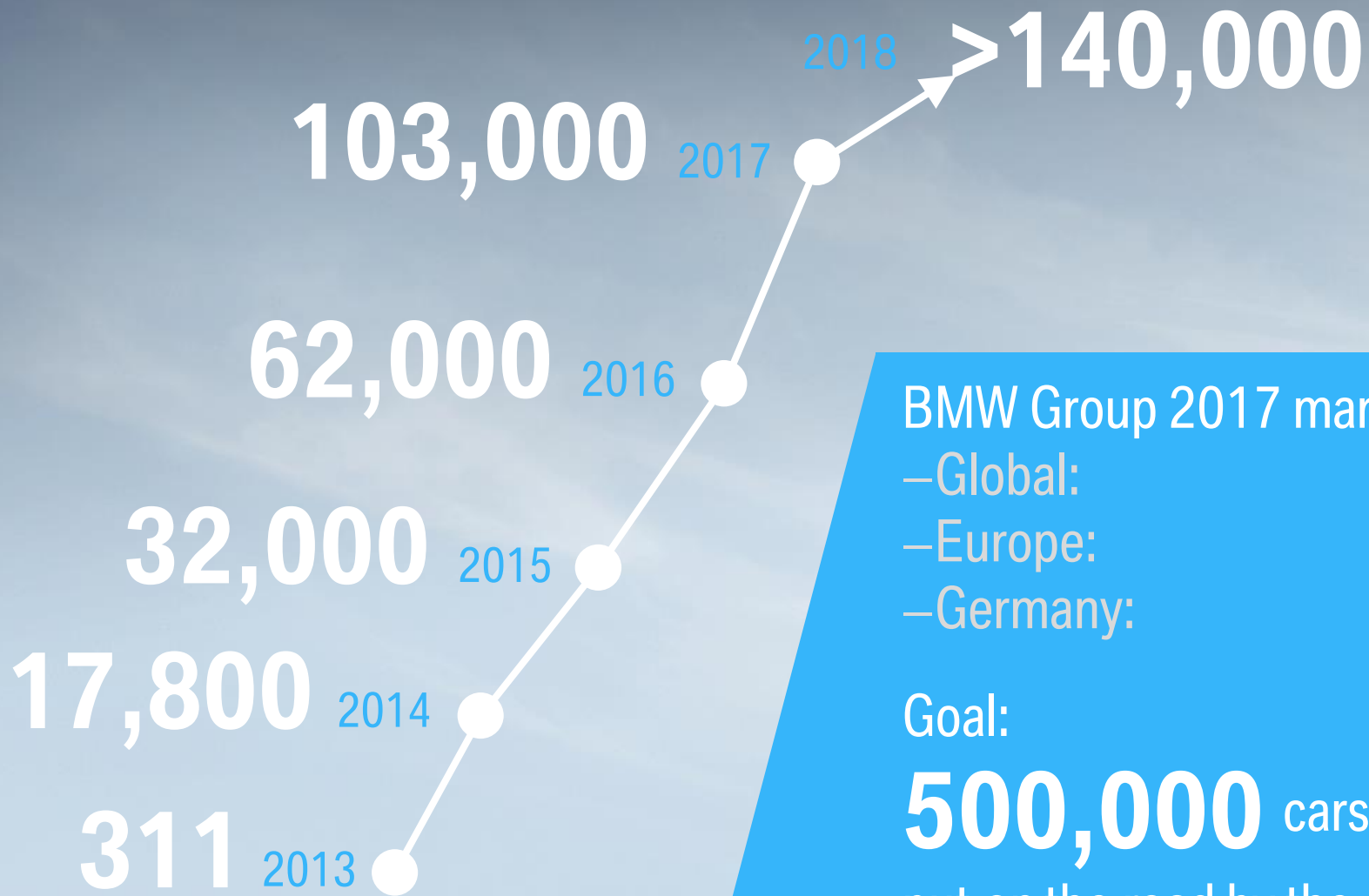
Sources: IHS / POLK 6 Feb 2018 report; global new car registrations 2017 (BEV and PHEV combined). BCG. The Electric Car Tipping Point. January 2018.

ELECTRIFICATION FORECAST BY WORLD REGION.



China is the lead market for electromobility.
The BMW Group adapts this development and offers special products there.
With our architectures and our modular electric powertrain kit, we can respond individually to every demand on ICEs, BEVs and PHEVs – worldwide.

THE BMW GROUP IS IN THE LEAD IN REGARD TO NEW ELECTRIC CAR REGISTRATIONS.



BMW Group 2017 market share:

- Global: 8.1%
- Europe: 26.1%
- Germany: 20.8%

Goal:

500,000 cars
put on the road by the end of 2019.



OUR CURRENT AND FUTURE SUCCESS IS BASED ON OUR ROADMAP FOR MEETING THE STRATEGIC ELECTRIFICATION TARGETS.

By 2025, we will launch **25 (BEV and PHEV) models**.

Our roadmap takes into consideration **regional customer needs and wishes**.

The offering of **emotional powertrains** and **high, customer-relevant ranges** will be expanded in all vehicle categories.

Based on architectures and components, we constantly work to reduce the high **manufacturing costs** and **one-time expenditure**.

End-to-end value creation: from securing all required raw materials to development and production expertise for all sub-systems and on to second life / recycling.



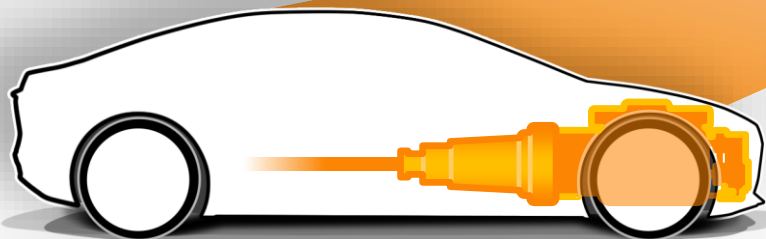
BMW i. FROM "BORN ELECTRIC" TO AN ARCHITECTURE FOR ALL DRIVES.

2013

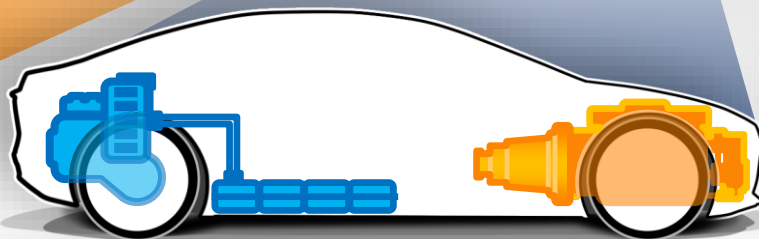
"Born electric"



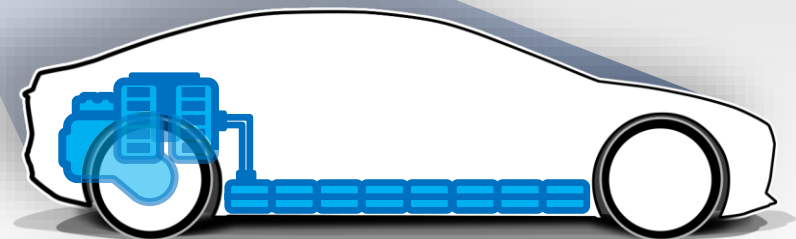
FROM 2021



➤ Combustion engine (ICE)



➤ Plug-in hybrid (PHEV)



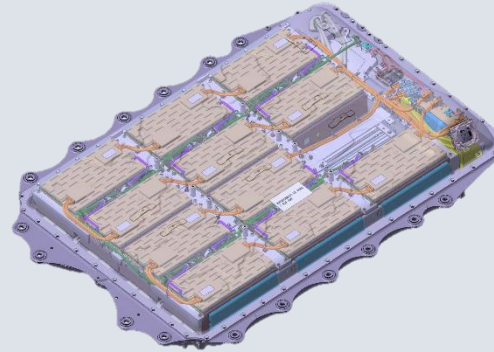
➤ All-electric (BEV)

BMW INHOUSE DEVELOPMENT AND PRODUCTION OF BATTERY MODULS AND PACKS SINCE 2008. FULL COMPETENCE IN CELL DESIGN.

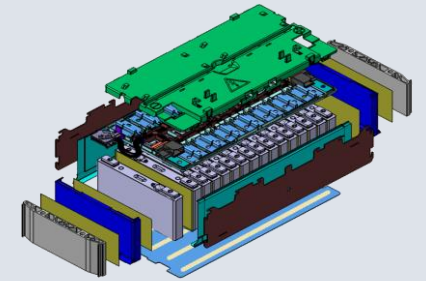
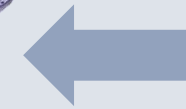
**Development
and Production
Inhouse**



xEV Vehicle



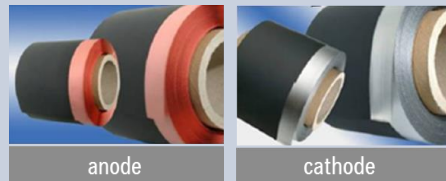
Battery Pack



Subsystem/Module



**Full Specification
and Design
Competence**



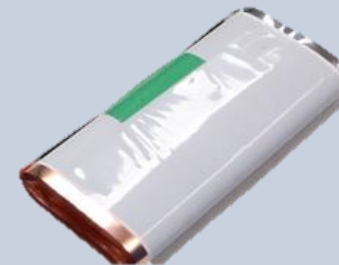
anode

cathode

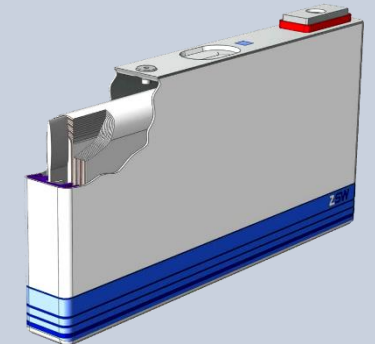


separator

Subcomponents / Electrodes



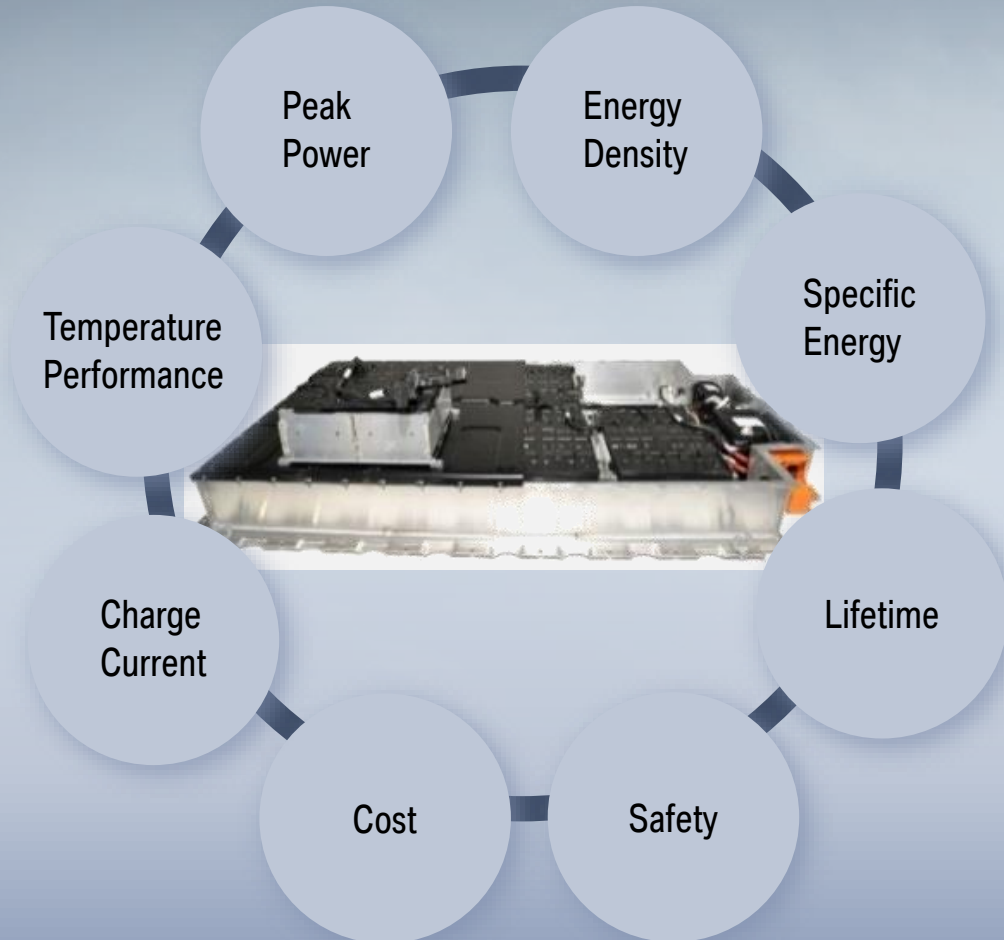
Jelly Roll



Cell

MAIN CHALLENGE: BATTERY CELL AND CELL MATERIALS AS KEY FACTORS IN PERFORMANCE AND COSTS.

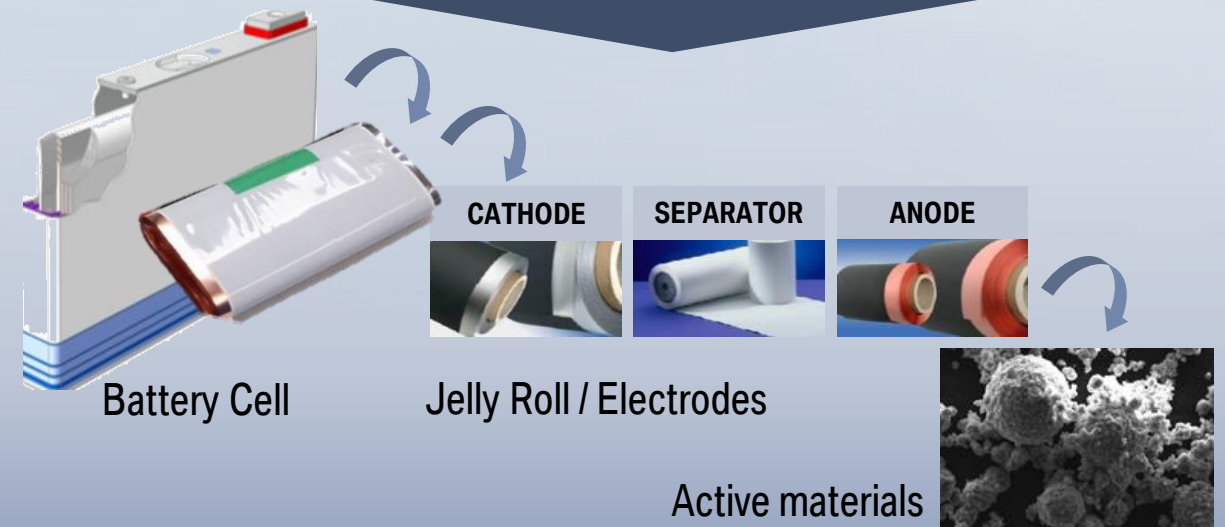
KEY PERFORMANCE INDICATORS



KEY COST REDUCTION OPPORTUNITIES

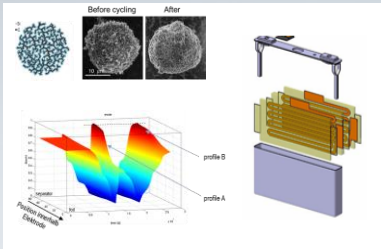
80% of battery cell costs are **material** costs

SIGNIFICANT LEVERS



BMW GROUP CONTINUOUSLY INCREASES CELL COMPETENCE TO ENHANCE THE LEVERAGE FOR REALIZATION OF CUSTOMER RELEVANT INNOVATIONS.

R&D



Materials & Analytics



BMW Competence Center Battery Cell

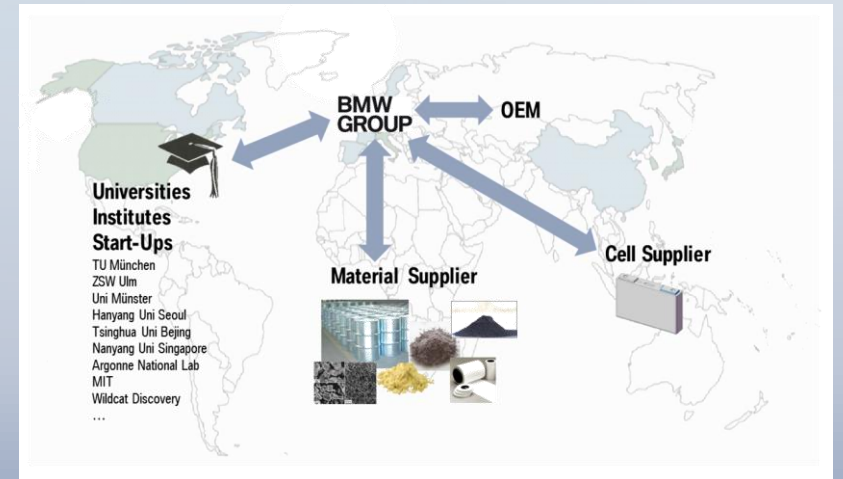


... in combination with a worldwide network

Securing Supply



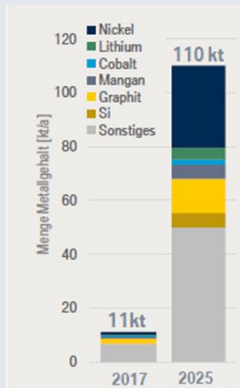
Prototypes & Testing



BMW GROUP CONSIDERS TOTAL VALUE CHAIN OF CELL – FROM CRADLE TO GRAVE.

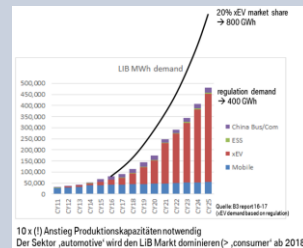
Raw Materials and Refining

- Environmental and social standards
- Raw material optimised for chemistry design
- Use of recycled raw materials
- Securing raw material supply



Cell Design and Production

- Optimised performance/costs based on BMW application
- Securing production capacity
- Reduction CO2 footprint



10x (!) Anstieg Produktionskapazitäten notwendig
Der Sektor „automotive“ wird den LIB Markt dominieren (> „consumer“ ab 2018)

Battery „2nd Life“

- Cell/module/pack design allows for secondary use
- Application on BMW sites
- Business models to secure markets



Recycling

- Cell/module/pack design to foster recyclability
- Development of recycling processes with ability to close material loops
- Securing recycling capacities



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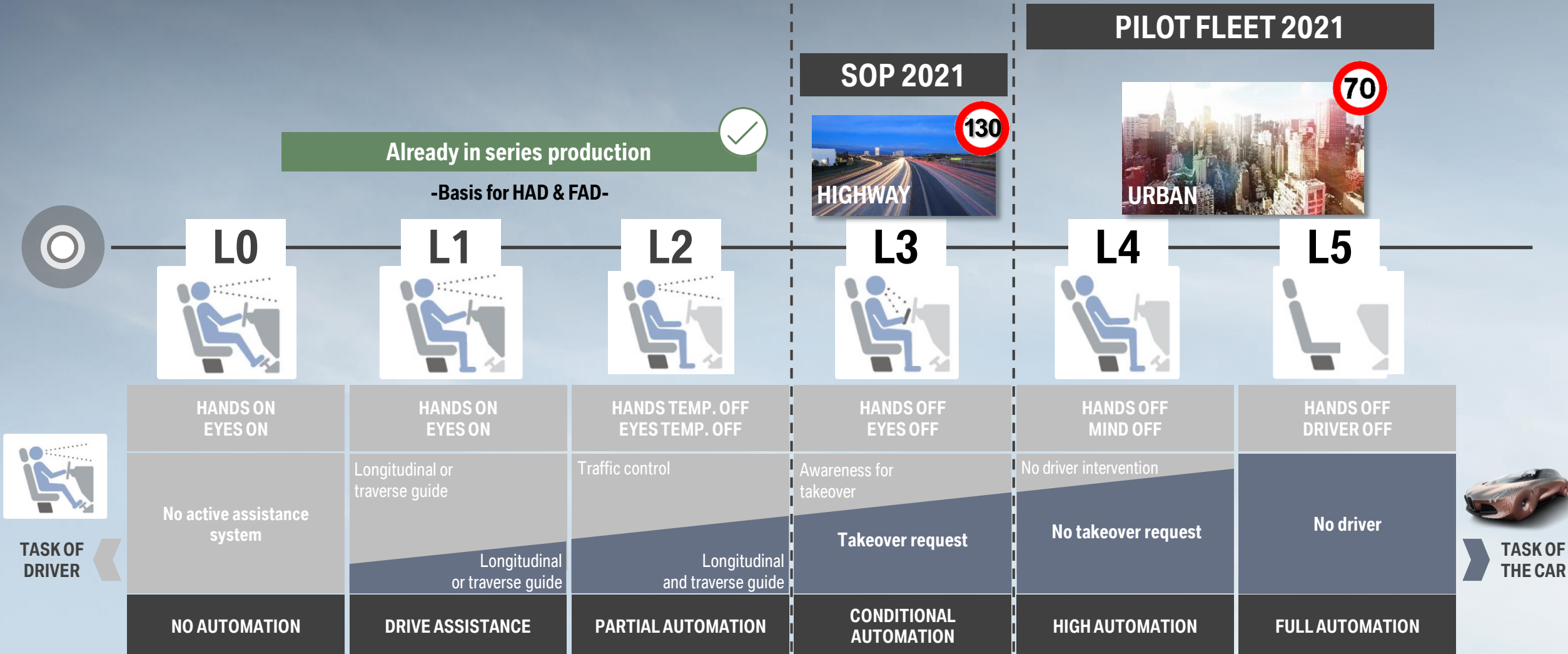
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AUTONOMOUS DRIVING AND AI.

THE DEVELOPMENT OF TODAY'S ASSISTED FUNCTIONS TO FULL AUTOMATION EQUALS A TECHNOLOGICAL QUANTUM LEAP.



Levels according to SAE (Society of Automotive Engineers) J3016

STATE OF THE ART AT BMW (LEVEL 2).

1 Increased Parking Automation.



2 Reversing Assistant.



3 ABK Concept of Assisted Driving Mode.



4 Steering and Lane Control Assistant (LSA).



5 Hands-off Option* (Assisted Driving Plus).



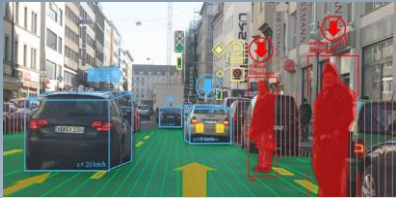
6 Speed Assistance.



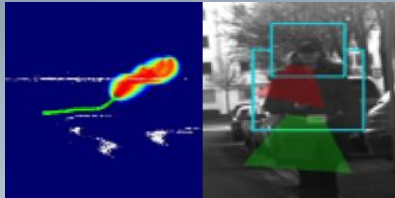
7 Emergency Stop Assistant (NHA).



NUMEROUS TECHNOLOGICAL CHALLENGES NEED TO BE ADDRESSED TO BE READY FOR CUSTOMERS AND MARKETS.



Environment Model



Prediction



Data Collection



AI Training and Algorithm Evaluation



Planning



Motion Control



AUTONOMOUS DRIVING



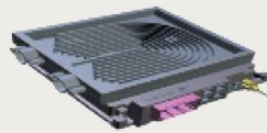
Data Center



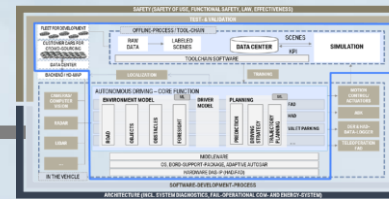
Urban HD Maps and Localization



Sensor Platform 360° perception



Middleware, OS uPAD



End-to-End Architecture



Security

AUTONOMOUS DRIVING REQUIRES TO COOPERATE WITH LEADING COMPANIES WITHIN THE TECH INDUSTRY.

COOPERATION



- Sensors: camera, radar, LIDAR
- Object fusion
- Road model
- Driving strategy/planning

AUTONOMOUS DRIVING



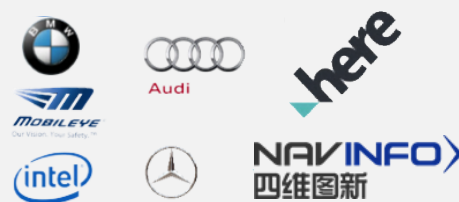
OEMs

HD-MAP



- Centimeter precision
- Real-time capable
- Highly available and reliable

OEM COOPERATION



INFRASTRUCTURE 5G

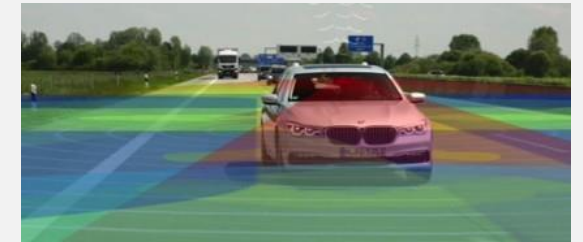


- Ultra low latency
- Ultra high reliability
- Ultra high data rates

5G AUTOMOTIVE ASSOCIATION



TEST FIELDS



- Worldwide regulation
- Unified homologation
- Safe and secure development

AUTHORITIES AND ASSOCIATIONS



**AGILE PRODUCT DEVELOPMENT ENSURES THE FAST RESPONSE TO CUSTOMER REQUIREMENTS.
OUR AUTONOMOUS DRIVING CAMPUS POOLS OUR AUTONOMOUS DRIVING EXPERTISE.**



Shared code basis.
Shared backlog.
Shared location.

LeSS

Customer-focused.
Adaptive & fast learning organization.
Continuous optimization.
End-to-end responsibility.

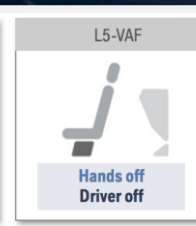


WITH THE LAUNCH OF THE iNEXT IN 2021, WE WILL OFFER THE NEXT GENERATION OF HIGHLY AUTOMATED DRIVING AND TEST AUTONOMOUS DRIVING WORLDWIDE.

HIGHWAY PILOT:
up to 130 km/h on highways.



URBAN PILOT:
pilot fleet in several cities worldwide.



2021: Our scalable AD Platform enables the Highway Pilot (L3) and the Urban Pilot (L4/5) in the BMW iNEXT.