TECHNOLOGY UPDATE.

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

Munich
December 3rd 2018
## OUR AGENDA FOR THE DAY.

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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
- Significant expansion of the electric car offering
- Diesel technology still heavily criticized
- Car as ‘third space’ besides the home and workplace associated with internet companies
- Introduction of considerably stricter regulation
- Creation of tech stacks to develop autonomous driving
- Increasing regionalization of demands and requirements
- Increase in partnerships to implement car/ride sharing solutions
- International increase in trade barriers
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
  - Electromobility
  - Hydrogen

- **Future field: Digitalization**
  - Connectivity
  - Artificial intelligence
  - Autonomous driving

Strategic Partnerships
OUR AGENDA FOR THE DAY.

1. Environment and Strategic Framework.
2. Electrification.
3. Autonomous Driving and AI.
IN GLOBAL MARKETS WITH DIFFERING LEGISLATIVE, INFRASTRUCTURE AND CUSTOMER DEMANDS, FLEXIBILITY IS KEY.

- ZEV Legislation
- Low fuel prices
- BEV focus on West and East Coast
- Challenging CO₂ requirements
- Customers reluctant as regards xEV
- Very heterogeneous legislation, depending on country

- NEV legislation
- License plate lottery
- Massive market regulation
- Focus on BEVs

RoW:
- Challenging infrastructure for EVs
- Heterogeneous customer demands

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Technology Update 3 Dec 2018
MARKET DEVELOPMENT OF ELECTRIFIED DRIVES.

Current status
Market share of BEVs and PHEVs.

Forecast by type of drive

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.

*Individual volume shares < 3 %.
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
One single architecture for all drives

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

KEY PERFORMANCE INDICATORS

- Peak Power
- Energy Density
- Specific Energy
- Temperature Performance
- Lifetime
- Charge Current
- Cost
- Safety

KEY COST REDUCTION OPPORTUNITIES

80% of battery cell costs are material costs

SIGNIFICANT LEVERS

Battery Cell
Jelly Roll / Electrodes
Active materials

CATHODE
SEPARATOR
ANODE
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

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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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).
6. Speed Assistance.
7. Emergency Stop Assistant (NHA).

* in the USA – not approved in GER/EU.
Numerous technological challenges need to be addressed to be ready for customers and markets.
AUTONOMOUS DRIVING REQUIRES TO COOPERATE WITH LEADING COMPANIES WITHIN THE TECH INDUSTRY.

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

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AUTONOMOUS DRIVING

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

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OEM COOPERATION

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

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5G AUTOMOTIVE ASSOCIATION

- Worldwide regulation
- Unified homologation
- Safe and secure development

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AUTHORITIES AND ASSOCIATIONS

- NHTSA
- VDA
- ACEA
AGILE PRODUCT DEVELOPMENT ENSURES THE FAST RESPONSE TO CUSTOMER REQUIREMENTS. OUR AUTONOMOUS DRIVING CAMPUS POOLS OUR AUTONOMOUS DRIVING EXPERTISE.

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

Shared code basis.
Shared backlog.
Shared location.
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.