Deep-dive E-Mobility

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President Business Division E-Mobility

January 8, 2019
CES - 17th Annual J.P. Morgan Auto Tech Conference
Las Vegas
Automotive OEM at a glance

Sales and EBIT margin

Sales by business division

Sales split by customer mix

1) FX-adjusted
2) Before special items
3) FY 2017
4) In % of Group Sales 2017
### Automotive OEM at a glance

#### Challenging environment – Dynamic Automotive Market

**Vehicle test cycle**
- Vehicle registration difficulties due to the new WLTP-cycle

**Trade environment**
- Risk of new trade wars rising

**China**
- Economic growth slow down

**Macroeconomic environment and risks**

**Electrification**
- Paradigm shift in technology leading to a transformation of the industry

**Autonomous driving**
- Evolution of new mobility solutions creates new market opportunities

**Price pressure**
- OEMs need to compensate increased investment costs

**Market has become more challenging**

**Industry-specific development**
Automotive OEM at a glance

Product portfolio – Broad drivetrain know-how

- **Engine systems** 31% of Automotive OEM sales in 2017
- **Transmission systems** 47% of Automotive OEM sales in 2017
- **E-Mobility** 5% of Automotive OEM sales in 2017
- **Chassis systems** 18% of Automotive OEM sales in 2017
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Mobility for Tomorrow – Our E-Mobility Strategy

Vision Powertrain
Global vehicle production [in mn units]

<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2020 e</th>
<th>2025 e</th>
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<td>ICE</td>
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Source: IHS and Schaeffler Assumptions / Values based on Light Vehicles < 6 tons only. ICE = Internal Combustion Engine; HEV = Hybrid Electric Vehicles ranging from 48V Mild Hybrid to PHEV, BEV = Battery Electric Vehicles (incl. Fuel Cell Electric Vehicles)

Electrified Drivetrain Portfolio
The average fuel efficiency of petrol cars has been constant in the last two years. Due to growing SUV mix and higher weight of the cars, the fuel-efficiency of diesel cars has worsened in 2017 (+1.1 g/km versus 2016).

Legislative fleet target: Target = 130 g/km

Position acc. Ø CO₂ emission

CO₂ emissions in g/km

Weight equals Fleet share

CO₂ Emissions EU 2017:

- Petrol: 117.9 g/km
- Diesel: 121.6 g/km
- Others: 96.7 g/km

1) Data Source: EAA (European Environment Agency): "Monitoring of CO₂ emissions from passenger cars - Data 2017 - Provisional data"
Balancing the scale – ICE optimization at its limit

**Key assumptions:**

- Fuel efficiency of petrol & diesel cars remains above target. Volumes to decrease due to PHEV/BEV uptake
- 48 V as the new standard: efficiency of this segment improves significantly with higher shares of P2 Hybrids
- Push of OEM’s towards BEV to achieve CO₂ target

**Carbon Dioxide Emissions EU 2025**

- ICE
- HEV
- EV

**Target** = 81 g/km

- **FHEV**
- **PHEV**
- **BEV**

**Deep-dive E-Mobility**

*Powertrain Scenario – Hybrid Technology will become key to achieve regulatory equilibrium*
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Powertrain Scenario – Cost per CO₂ reduction is key factor for successful business

Key aspects

- Hybrid share becomes major lever for OEM to balance CO₂ scale
- Strong future potential with 48 V P2 architectures at good cost-to-benefit ratio
- All of Schaeffler E-Mobility portfolio allows for CO₂ emission reductions below the penalty threshold (95 EUR/g)

1) Compared to C-Segment basic ICE vehicle. Battery price as per expectation 2020
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E-Mobility Pyramid

System Understanding

Mechatronic Systems

Mechanical Systems

Components

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E-Mobility Production Roadmap

- Hybrid Module Gen.2 and 2-speed E-Axle Transmissions for HEV applications in Series production
- Coaxial and parallel design 1-speed E-Axle Transmission for BEV application Europe SOP in process
- Hybrid Module Gen.3 with integrated Torque Converter to follow 12/2018
### Deep-dive E-Mobility

#### E-Axle Transmissions & Systems: Variants & Portfolio Roadmap

<table>
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<tr>
<th>2-Speed Axle Transmission</th>
<th>1-speed Axle Transmission</th>
<th>E-Axle Systems</th>
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<tr>
<td>for HEV applications, with integrated gear actuation and based on conventional bevel differential</td>
<td>based on Schaeffler Lightweight Differential with best in class Power Density, with optional parking lock actuation</td>
<td>based on high power density transmission design kits, with integrated E-Motor and Power Electronics</td>
</tr>
<tr>
<td>2-speed parallel design axle transmission</td>
<td>coaxial design</td>
<td>2-speed for (48 V) HEV</td>
</tr>
<tr>
<td>Gear Actuator (EAA)</td>
<td>parallel design with park lock</td>
<td>1-speed for BEV application</td>
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*In series production* | *In series production* | *Target SOP 2020/21*
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E-Axle Transmissions & Systems: Variants & Portfolio Roadmap

SCHAEFFLER
Deep-dive E-Mobility

E-Axle Modular Construction Kit

Modular design kit for different T/M ratios

2-speed solutions possible

Torque Vectoring units can be added

Basics:
- Schaeffler Light Weight Differential in combination with planetary gear set and spur gear stage
- Optional additional functions: parking lock, decoupling device
- Stand alone transmission or integrated gear set

...for coaxial & offset arrangements
Schaeffler is supplier for the new Audi eTron front & rear axle transmission!

- Weight related torque density of electric car transmissions

\[
D_{T,\text{hr}} = \frac{T_{\text{EM,max}} + \iota}{m_{\text{Gear}}}
\]

- Front Axle Transmission with integrated Parking Lock Actuator
- Rear Axle Transmission

Sources:
- Tesla Model S85 [https://www.teslarati.com/tesla-model-s-weight/]
- VW e-Up! SSP00052700-Nr_527__Der_e-up!
- BMW i3 – Benchmark FKA Aachen
- Tesla S90D Gewichtsbereich geschätzt 20 kg ... 30 kg
P2 Hybrid Modules: Variants & Portfolio Roadmap

**Generation 2**
- Highly integrated Hybrid Modules for Mild-, Full- and Plug-in Hybrid applications
- Integrated dry K0 clutch
- Integrated wet K0 clutch

**Generation 3**
- Integration of Start-up element to further reduce required design space and system costs
- Integrated Torque Converter
- Integrated Triple Clutch (3K)

**Generation 4**
- Integration of power electronics to further reduce packaging requirements and costs
- Integration of Power Electronics HV or 48 V

**Timeline**
- In series production
- SOP Q4/2018
- Target SOP 2020/21
Top facts of P2 HV Hybrid Module with integrated torque converter:

- High E-motor constant power up to 70 kW with active oil cooling at rotor and stator
- ICE torque up to 600 Nm; TC input to 700 Nm
- Compact design requires significantly less space than conventional P2 architecture
- Combined optimization of the damping system
- Available for the first time in 2020 in North America

Market specific solutions based on Schaeffler core Know-How in Transmission Systems
**Technology:**

- Highly simplified & innovative transmission concept for Full- & Plugin-Hybrid applications based on two electric machines combined with Schaeffler clutches, actuation and differential expertise.

- Outstanding driving comfort without any shifting (EVT = Electrically variable transmission) and good driving performance (2,500 Nm / 125 kW).

- Compact design allows for integration into existing vehicle platforms without any additional space requirements.

- High fuel efficiency & very good price potential (<2.000 EUR)
Schaeffler to acquire Elmotec Statomat

About Elmotec Statomat

- Elmotec is a pioneer in the production of stator manufacturing machines and world's largest supplier of machines for the production of stators for electric motors, alternators and generators.

- The headquarter of Elmotec Statomat GmbH is located in Karben near Frankfurt am Main (Germany) and has around 200 employees.

- Elmotec has been focusing on the round wire, flatwire and hairpin process technologies, and holds several over 50 patents for innovative winding technology (e.g. wave-winding).

Development, industrialization & mass production expertise for the Mobility for Tomorrow.
Schaeffler already covered the majority of the E-Motor production processes

With this acquisition we are closing now the last remaining production technology gap

Ready to produce by 2020
**E-Motor portfolio**

**Dedicated Hybrid Transmission**
- HV-Terminal for EM1/EM2

**P2 Hybrid Modul**
- Coil winding & joining machine
- Schaeffler P2 Hybrid E-Motor in single tooth winding technology
- Rotor and stator cooling with oil (supplied by transmission)
- E-Motor Peak Power up to 125 kW

**400V/800V E-motor**
- High traction power
- Reduced charging time
- Power 400 V class up to 250 kW
- Power 800 V class up to 500 kW

- Highly simplified & innovative transmission concept for Full- & Plugin-Hybrid applications based on two electric machines combined with Schaeffler clutches, actuation and differential expertise

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**Schaeffler AG**
Thank You!

E-Mobility - a Business Division of the Schaeffler Group

Dr. Jochen Schröder
08.01.2019