Trends impacting the Propulsion Technology

Evolution of Propulsion System Architectures

Resulting trends for AWD Systems

BorgWarner’s Answer for e-AWD

Outlook
Unique Propulsion Systems around the World
Trends Impacting Propulsion Technology

- Regulatory compliance continues to drive technology roadmaps until 2025
- Key markets US, EU, China require different technology solutions

- Efficiency/CO₂ emissions
- Autonomous driving
- Shared cars and rideshare
- Connected cars
The BorgWarner Alphabet

A → B

C, H, E

POINT A

Combustion

Hybrid

Electric

POINT B
EU CO₂ Targets for Pass Cars

Conversion factor NEDC – WLTC of 1.2 is considered
2021 WLTC value according to NEDC target is new base

95% of the fleet have to fulfil the 95 gCO₂/km target

2x

Super credits for vehicles with < 50 gCO₂/km 2020-2022
Impact for Representative EU Fleet

Type Approval CO$_2$ Emissions (fleet average) [g/km, NEDC]

Average Vehicle Mass [kg]

Source: ICCT
### Propulsion System Compliance in the EU

<table>
<thead>
<tr>
<th></th>
<th>2021</th>
<th>2025</th>
<th>2030</th>
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<tbody>
<tr>
<td><strong>C-Segment, 1300kg, e.g. VW Golf</strong></td>
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<td><strong>E-Segment, 1600kg, e.g. VW Passat</strong></td>
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*Target CO₂ number based on vehicle mass (conversion factor between NEDC and WLTC is considered to be 1.2)*
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<th>Year</th>
<th>Target CO₂/km (NEDC)*</th>
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*Target CO₂ number based on vehicle mass (conversion factor between NEDC and WLTC is considered to be 1.2)
Market Scenarios for 2025 and 2030

2025 (-15% vs, 2021, WLTP)

- **Scenario I**: 20% Plug In Vehicles
  - 23% GAS, 38% DIESEL, 13% MHEV, 3% HEV, 9% PHEV, 3% BEV
  - Lower CO₂ emissions

- **Scenario II (EV)**: High EV enables more MHEV and less PHEV
  - 22% GAS, 45% DIESEL, 10% MHEV, 3% HEV, 5% PHEV, 15% BEV
  - Lower CO₂ emissions

2030 (-37.5% vs, 2021, WLTP)

- **Scenario I**: 40% Plug In Vehicles
  - 7% GAS, 49% DIESEL, 4% MHEV, 4% HEV, 19% PHEV, 21% BEV
  - Lower CO₂ emissions

- **Scenario II (EV)**: High EV penetration limits HV HEV/PHEV
  - 11% GAS, 50% DIESEL, 4% MHEV, 4% HEV, 5% PHEV, 30% BEV
  - Lower CO₂ emissions

Significant share of PHEV/EV required in 2025+, higher EV share shrinks the total ICE market.
LV Propulsion Outlook – Europe

2017: Peak in Combustion engine volumes

Source: BW Apr. 2019 LV Market Outlook & IHS Markit
LV Propulsion Outlook – Global

2017: Peak in Combustion engine volumes

Will traditional AWD systems also peak in the near future?

Source: BW Apr. 2019 LV Market Outlook & IHS Markit
AWD Market Share for LV

Includes: T-Cases, Couplings, eAxles & Integrated Transmissions

Source: BW Apr. 2019 LV Market Outlook & IHS Markit
Impact of Electrical Power on Performance & CO₂

0 - 100 km/h Time [s]

Baseline

2.0L Miller engine
140 kW, 320 Nm
220 g/ kWh best BSFC

110kW HV DHT
110kW HV
25kW 48V
10kW 48V

Performance target

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Performance Levels of Electrified AWD

- CO₂ Salable Feature
- Enhanced Handling
- EV Drive

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<th>Power Level</th>
<th>Description</th>
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<tr>
<td>&gt;30kW</td>
<td>Typical SUV</td>
</tr>
<tr>
<td>15-30kW</td>
<td>Light Pass Car</td>
</tr>
<tr>
<td>&lt;15kW</td>
<td>48V</td>
</tr>
<tr>
<td></td>
<td>HV</td>
</tr>
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</table>

Performance testing at multiple Power/Torque levels
48V and High Voltage P4 Offerings

- 48V P4 Module
- High Voltage Integrated Drive Module
eAWD – P4

48V eAWD (P4)

**DESCRIPTION**
- Secondary electric drive axle capable of regeneration/boost and limited AWD (P4 HEV)
- Leverage lower cost 48V infrastructure
- 1 or 2-Speed function for enhanced AWD and regen
- Deliver improved FE/CO2 improvement

**BENEFITS**
- 7% FE gain in addition to 48V BAS equipped vehicle (simulated)
- Cost neutral to conventional mechanical AWD
- Launch assist (engine downsizing enabler) and creep capable for extended S/S
- Highway sailing sustained torque of 340 Nm

| 48V eAWD |  
|---|---|
| Continuous Power | 8 kW |
| Peak Power | 12.5 kW |
| Continuous Output Torque | 875 N-m |
| Peak Output Torque | 1,450 N-m |
| Status | POC |
Integrated Drive Module iDM

**Fully Integrated Drive Module**

**DESCRIPTION**
- Drive Module with fully integrated Electrical Machine and Power Electronics
- Operating Voltage: 250-450 V\text{DC}

**BENEFITS**
- Easy Vehicle Integration
- Scalable and Modular Architecture
- Optimized System Efficiency → World Class
  - Battery Energy Consumption
- State of the art Torque and Power Density
- High Speed Electrical Machine
- Water Cooled
- Optional e-Park Lock System

<table>
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<tr>
<th>Wheel Output</th>
<th>iDM 90</th>
<th>iDM 120</th>
<th>iDM 160</th>
</tr>
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<tbody>
<tr>
<td>Continuous Power</td>
<td>45 kW</td>
<td>65 kW</td>
<td>85 kW</td>
</tr>
<tr>
<td>Peak Power</td>
<td>90 kW</td>
<td>120 kW</td>
<td>160 kW</td>
</tr>
<tr>
<td>Continuous Torque</td>
<td>1,400 Nm</td>
<td>1,800 Nm</td>
<td>2,000 Nm</td>
</tr>
<tr>
<td>Peak Torque</td>
<td>2,500 Nm</td>
<td>3,000 Nm</td>
<td>3,800 Nm</td>
</tr>
<tr>
<td>Status, SOP</td>
<td>2022</td>
<td>Q4 2021</td>
<td>2022</td>
</tr>
<tr>
<td>Samples Available</td>
<td>2020</td>
<td>Q4 2019</td>
<td>2020</td>
</tr>
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Outlook

- AWD will continue to grow

- Increase in electrified AWD solutions but the peak for traditional AWD system is yet to come

- BorgWarner will continue to be a Leader in AWD Solutions for traditional AWD as well as e-AWD systems
Thank you!