Electrification of Mobile Applications
Agenda

1. Electrification of Off-Highway Applications
2. Customer Application & Rexroth Solutions
3. Bosch Rexroth Mobile Product Portfolio
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Drivers for Electrification

Emission Regulations - Impact to Worldwide Off-Highway Market

**USA:**
- TIER 4 final
- SCR for 56...560 kW

**California:**
- TIER 5 in discussion
- ZEV for specific use cases needed (fork lifts, airport ground equipment)
- Large segments e.g. locomotives

**Europe (EU):**
- EU 2016/1628 Stage V
  - Enforces wall flow DPF for 19...560 kW

**Paris (& many other cities):**
- City Government Restrictions
  - i.a. ZEV for municipal vehicle fleet

**Urban Access Regulations:**
[http://urbanaccessregulations.eu/userhome/map](http://urbanaccessregulations.eu/userhome/map)

**India:**
- < 19 kW: TIER 2; **from 2026:** Tier 4 final
- 19...56 kW: St IIIA; **from 2022:** St IIIB
- 56...560 kW: St IIIA; **from 2022:** St IV

- Affects AG tractors and construction equipment vehicles

**China:**
- Stage IIIA; **from 2019:** Phase IV

**USA (California):**
- SCR: Selective catalytic reduction
- DPF: Diesel particulate filter
- ZEV: Zero emission vehicle
- AG: Agricultural

**California Environmental Protection Agency**
- Air Resources Board
Drivers for Electrification
Off-Highway Applications

- Energy Efficiency
- Productivity
- Ease-of-use
- Fuel Cost Savings
- Zero Emission
- Precise Control
- Noise Reduction
- Future-proof

- Diesel w/ electric boost
- TCO
- Env. Protection
- User Benefits
Bosch Rexroth Off-Highway Proposition
Deep Technology Know-How in Hydraulics and...

- Individual and complete hydraulics and electronics solutions
- Years of experience in mobile and industrial equipment
- Use of synergies and know-how within the BOSCH Group
- Technology, quality and market leader in Mobile Hydraulics
- Worldwide presence
- Comprehensive systems expertise
- Unique product portfolio
- Expert engineering partner
- Expert and reliable service

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Bosch Rexroth Off-Highway Proposition
Deep Technology Know-How in Gears and …

Comprehensive product portfolio of track, swing and winch drives serving all kind of off-highway machines.

Torque range up to 600 kNm available

Full IoT connectivity

More than 50 years experience
in gear box technology
for mobile machinery

State-of-the-art engineering methods for lubrication and NVH-design.

Agile engineering
Bosch Rexroth Off-Highway Proposition
Deep Technology Know-How in Electrics and ...

More than 40 years experience in servo drives and motors

- Integrated and most extensive Safety-on-Board functions
- Millions of inverters working in machines & applications
- Power range from 100 W up to 4 MW available
- Full IoT connectivity
- Unrivaled communication variety
- Fast Engineering and commissioning
- Synchronous & asynchronous servo motors as well as kit motors

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# Bosch Rexroth Market View

## Application Segments for Electrification

### Main Segmentation

<table>
<thead>
<tr>
<th>Restricted Areas</th>
<th>Open Field</th>
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<tr>
<td>Underground, Mining, Urban, Construct. Sites ...</td>
<td>Agricultural, Construction</td>
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<tr>
<td>Electrification mandatory or optional</td>
<td>Elect. optional</td>
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### Additional Evaluation

<table>
<thead>
<tr>
<th>Electric Boost</th>
<th>Attachments</th>
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<tbody>
<tr>
<td>Diesel up to 56 kW</td>
<td>Agricultural</td>
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<tr>
<td>Elect. optional</td>
<td>Elect. optional</td>
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Bosch Rexroth Solutions Approach

System Topologies

- **Conventional System**
  - Diesel w/ electric boost & energy saving

- **Boost & Recuperation**
  - Energy saving, smaller Diesel

- **Hybrid without Battery**
  - Energy saving, smaller Diesel & emission free operation

- **Hybrid with Battery**
  - Highest energy saving & emission free operation

- **Full Electric**

The diagram illustrates various system solutions, each with distinct energy saving and emissions characteristics. The Conventional System uses diesel with electric boost for energy savings. Boost & Recuperation systems offer energy savings with smaller diesel engines. Hybrid systems, both with and without batteries, aim for highest energy savings and emission-free operation. The Full Electric system represents a full electric solution.
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## Bosch Rexroth Solutions Portfolio

### Product and Solution Portfolio

**Bosch Rexroth Vehicle Control**

- Hydraulics
- Electric Motors & Inverters
- Software

**OEM Vehicle Control**

- Gear Units and Transmissions
- Electronics
- Energy Storage

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**Hydraulic-, Electric- or Electrohydraulic-System**

<table>
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<tr>
<th>Hydraulics</th>
<th>Electric Motors &amp; Inverters</th>
<th>Software</th>
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<td><img src="image2.jpg" alt="Electric Motors &amp; Inverters" /></td>
<td><img src="image3.jpg" alt="Software" /></td>
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</tbody>
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**Energy Storage**

- Batteries
- Supercaps
- Kinetic Buffering

**Driving Control**

- Condition Monitoring
- Safety Software
- ePower Management

**Partnering and using deep Bosch know-how**
Permanent Magnet Synchronous Motors

Continuous Power:
- Up to 140kW at Bauma
- Further extension up to 250kW planned

- **Cooling:** Liquid
- **Ambient temperatures:** up to -40 / +85 °C
- **IP Class:** up to IP69K
- **Mechanical resistance:**
  up to Shock 30g, Vibration 10g
- **Motor:** sensor and data source for Industry4.0
Bosch Rexroth Mobile Product Portfolio
700V Inverters Target Specification

Inverters:
- Continuous Power:
  - Up to 140kW at Bauma
  - Further extension up to 250kW planned

- Cooling: Liquid

- Ambient temperatures: up to -40 / +85 °C

- IP Class: up to IP69K

- Mechanical resistance: up to Shock 30g, 10g

- PLC control: integrated

- Safety: integrated ISO13849 safety functions

- Connectivity: CAN J1939, CANopen, Ethernet and other available
Bosch Rexroth Mobile Product Portfolio

Gears Portfolio

Gear box:
- Compact design based on existing technology
- Low maintenance
- Emission-free-ready solution
- Direct replacement of hydrostatic drives

Shift on Fly:
- Enlarged conversion range
- Based on on-highway and automotive industry components
Bosch Rexroth Mobile Product Portfolio
Product Development Roadmap

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- **Samples**
- **SOP – Start of Series Production**

**48V**
- **700V Kit**
- **SW System Blocks for 48V & 700V**
- **48V Kit**

**Gear**
- **SOD**
- **GFTe 81xx Series**

**Partnering Strategy for System Accessories**
- **Energy storage**
- **Battery charger**
- **DC/DC converter**

Preliminary
Thank you for your kind attention