AVERE Webinar

„Did you know you can retrofit your car to electric today?“

e-troFit™ -
the world’s most sustainable and economic electrification KIT for commercial vehicles
The e-troFit approach – probably the most consistent implementation of sustainable mobility
Who we are

With professional electrification solutions for commercial vehicles, we offer solutions for a quick entry into electric mobility.

Our vision: We want to make an active contribution to reducing emissions in traffic.

e-troFit GmbH is redesigning the future of sustainable mobility and is supporting infrastructure providers, municipalities and fleet operators in their transformation towards new mobility. With the e-troFit concept commercial vehicles such as buses and trucks can be converted to the environmentally friendly electric drive.

2018, the solution was awarded the German Mobility Prize of the Federal Ministry of Transport and Digital Infrastructure and 2019 the company received the international sustainability Busplaner award.

e-troFit at a glance

42 Staff members

2 Project locations
   Ingolstadt, Garching

3 Countries
   Germany, Austria, Spain, Italy
A commercial vehicle receives an average of **3** diesel-replacement engines during its lifetime.

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**Fact Sheet Europe**

- **2%** of vehicles
- **30%** of emissions in cities
- China has about **99%** of all electric buses worldwide
- In 2025 there will still be over **200,000** old diesel buses in the EU
- On average, a European city bus travels **200 km a day**
- All European city buses emit approx. **70,000 t** of CO₂ every day

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**9.4 years**

The average age of the EU bus fleet

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- **-15%** emissions by 2025
- **-30%** emissions by 2030
- **-100%** emissions by 2050

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In 2025 there will still be over **200,000** old diesel buses in the EU.
Market Dynamics
The electrification of CVs is therefore a fast-growing and sustainable market.

Rate of electrification for different vehicle types

EV share of global vehicle fleet by segment

Electric buses worldwide

Electric trucks (HCV) worldwide

In terms of total volume, the HCV market is the much larger market than the bus market. Electrification of buses is already well underway today with almost 50% EV share of the global fleet in 2030. Electrification of trucks is set to accelerate in the late 2020s with almost 5% EV share of the global fleet in 2030.

Based on market know-how, we estimate that German bus manufacturers can only produce low three-digit volumes in 2020. Therefore, the strategy is to focus on the bus market first.
<table>
<thead>
<tr>
<th>Design</th>
<th>Possible Electric Propulsion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>City busses</strong></td>
<td><img src="image1" alt="Low-floor portal drive axle" /></td>
</tr>
<tr>
<td>✅ Low-floor technology</td>
<td></td>
</tr>
<tr>
<td><strong>Intercity busses</strong></td>
<td><img src="image2" alt="Central engine" /></td>
</tr>
<tr>
<td>✅ Low-floor technology in the front</td>
<td></td>
</tr>
<tr>
<td>✅ High-floor technology in the back</td>
<td></td>
</tr>
<tr>
<td><strong>Coaches</strong></td>
<td><img src="image3" alt="Central engine" /></td>
</tr>
<tr>
<td>✅ High-floor technology</td>
<td></td>
</tr>
</tbody>
</table>
# Benchmarking

<table>
<thead>
<tr>
<th>In-wheel drive</th>
<th>Near-wheel drive</th>
<th>Central drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradeability *</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Power consumption</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Price</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Retrofit</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Ranking **</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

* Gradeability of all drives sufficient
** Weighted ranking
Driving Functions
- Classic „Creeping“ or „E-Creeping“
- Hill-Holder
- Recuperation

Possible
- 4-Wheel-Drive (Atriculated busses)
- Cruise control

Electric portal axle AXTRAX
Influencing Factors

- Traffic, weather
- Distance of covered routes
- Rotation schedule

Solution

✓ Worst case consideration and determination of the necessary battery capacity

Telematics
Influencing factors and solutions
The modular battery system makes it possible to supply almost all large electric commercial vehicles with the necessary amount of energy.

Even before the e-troFit kit is assembled, the e-troFit GmbH uses its telematics to offer potential customers a perfectly tailored battery package. The telematics module is installed in advance in an existing customer vehicle in order to provide information about mileage, peripherals, consumption and operating times. Here e-troFit GmbH relies on a modular product solution. The battery system is scalable and individually configurable and thus meets the requirements of different markets and customers.

The design and development of the battery packs is also suitable for multicellular chemicals (e.g. Nickel-Manganese-Cobalt (NMC), Lithium-Titanate (LTO)) and can individually be adapted to the customers charging strategy and performance. This option not only makes the battery system an ideal plug & play solution for various commercial vehicle segments, but also allows technology changes to be easily and cost-effectively adjusted. In addition to the battery packs, the complete battery system also includes battery and thermal management.

Individual battery design
Modular battery system to supply almost all large electric commercial vehicle
Basic physical principles:

- Conductive charging
- Inductive charging not ready for series production with high performances

Variants of conductive electricity transmission:

- Plug CCS Type 2
  - DC-charging (up to 350 kW)
- Pantograph
  - Infrastructure side
  - Vehicle side

Charging Concept
Influencing factors and solutions
Basic Kit: Example Urban Buses
The e-troFit combines own intellectual property (IP) with premium components
The Vehicle Control Unit (VCU) is the core of e-troFit GmbH. The specially developed software according to automotive standards and ISO 26262 is the central control element that forms all components into a perfectly tuned drive train unit.

As the central element the VCU connects all new components among each other as well as the new components with the old vehicle. With this kind of system integration e-troFit GmbH develops exactly at the interface and thus uses the existing infrastructure of the used vehicles. This lean process leads to an enormously fast development time and thus to low development costs.

Besides system integration the VCU also sees itself as a translator between new (components) and old (used vehicle) system language. An absolute unique characteristic here is the possibility to integrate the retrofit solution into new vehicles as well. In this case the VCU does not translate an old language into a new language but another language into a uniform e-troFit language.

Depending on the vehicle type only minor adjustments have to be made. Therefore the kit is suitable for all vehicle types, from city buses to all other kind of commercial vehicles.

The e-troFit Vehicle Control Unit
A turnkey solution for the electrification of commercial vehicles
e-troFit and ZF Friedrichshafen
The world’s 3rd largest automotive supplier is e-troFit’s strategic partner
The e-trofit Kit makes every commercial vehicle the most sustainable in its class.
### Total cost of ownership (TCO) calculation in detail*

#### Investment Cost

<table>
<thead>
<tr>
<th></th>
<th>Upcycled Bus with e-troFit Kit</th>
<th>New E-Bus with e-troFit Kit</th>
<th>Mercedes Citaro Bus</th>
<th>Mercedes e-Citaro Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price Bus + e-troFit Kit</td>
<td>320.000,00</td>
<td>450.000,00</td>
<td>250.000,00</td>
<td>560.000,00</td>
</tr>
<tr>
<td>Refurbishment e-troFit Bus</td>
<td>30.000,00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtime costs by retrofitting</td>
<td>6.000,00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Investment</strong></td>
<td>356.000,00 €</td>
<td>450.000,00</td>
<td>250.000,00</td>
<td>560.000,00</td>
</tr>
</tbody>
</table>

#### Usage-related Cost

<table>
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<tr>
<th></th>
<th>Upcycled Bus with e-troFit Kit</th>
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<th>Mercedes Citaro Bus</th>
<th>Mercedes e-Citaro Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calc. Kilometer/year</td>
<td>60.000,00</td>
<td>60.000,00</td>
<td>60.000,00</td>
<td>60.000,00</td>
</tr>
<tr>
<td>Energy Consumption l/km kWh/km</td>
<td>1,20</td>
<td>1,20</td>
<td>0,40</td>
<td>1,20</td>
</tr>
<tr>
<td>AdBlue Consumption l/km</td>
<td></td>
<td></td>
<td>0,02</td>
<td>0,02</td>
</tr>
<tr>
<td>Price Diesel/Electricity in 2020</td>
<td>0,18</td>
<td>0,18</td>
<td>1,00</td>
<td>0,18</td>
</tr>
<tr>
<td>Price Diesel/Electricity in 2025 incl. CO2 cost</td>
<td>0,18</td>
<td>0,18</td>
<td>1,21</td>
<td>0,18</td>
</tr>
<tr>
<td>Price Diesel/Electricity in 2029 incl. CO2 cost</td>
<td>0,18</td>
<td>0,18</td>
<td>1,29</td>
<td>0,18</td>
</tr>
<tr>
<td><strong>Total Cost per km in 2020</strong></td>
<td>1,01</td>
<td>1,16</td>
<td>1,10</td>
<td>1,36</td>
</tr>
<tr>
<td><strong>Total Cost per km in 2025</strong></td>
<td>1,02</td>
<td>1,17</td>
<td>1,20</td>
<td>1,37</td>
</tr>
<tr>
<td><strong>Total Cost per km in 2029</strong></td>
<td>1,03</td>
<td>1,17</td>
<td>1,25</td>
<td>1,38</td>
</tr>
<tr>
<td><strong>Total cost for a 9-year usage period</strong></td>
<td><strong>580.618,83</strong></td>
<td><strong>649.280,48</strong></td>
<td><strong>684.436,58</strong></td>
<td><strong>759.280,48</strong></td>
</tr>
<tr>
<td>Residual value</td>
<td>40.000,00</td>
<td>70.000,00</td>
<td>30.000,00</td>
<td>80.000,00</td>
</tr>
<tr>
<td><strong>Real Costs (Total costs incl. residual value)</strong></td>
<td><strong>540.618,83</strong></td>
<td><strong>579.280,48</strong></td>
<td><strong>654.436,58</strong></td>
<td><strong>679.280,48</strong></td>
</tr>
<tr>
<td>Additional cost compared with e-troFit upcycled Bus</td>
<td>0,00</td>
<td>38.661,65</td>
<td>113.817,75</td>
<td>138.661,65</td>
</tr>
<tr>
<td>Average additional cost per year</td>
<td>0,00</td>
<td>4.295,74</td>
<td>12.646,42</td>
<td>15.406,85</td>
</tr>
</tbody>
</table>

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**The operation of a new diesel bus costs minimum 113.000€ more than an e-troFit electric bus for a period of 9 years from 2020!**

*Underlying assumptions of this TCO:*

- Calculations based on **German price and cost positions**
- **CO₂ regulation according to „German climate package“ included:**
  - CO₂ price until 2025 and afterwards with an increase of 5€/year for diesel
  - Reduction of the EEG levy on electricity for traction in public transport by 80% as expected from 2021
- **Underlying inflation rate of 1.2% assumed**
- **Usage period of 9 years assumed, corresponding to the German tax depreciation period for buses**
- **Average time lost including average downtime of 8 weeks**
- **All values without considering possible state subsidies.**
- **Residual values not calculated; it can be assumed that Diesel buses will have no value in 2029 anymore**

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**Upcycled Bus with e-troFit Kit**

Retrofitting is more cost-effective than operating a diesel bus in public transport
Impressions Citaro O530