

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.**

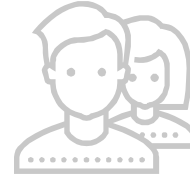


o11o deutscher 
mobilitätspreis

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**.



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

9.4 years

The average age of the EU bus fleet



2%

of vehicles

30%

of emissions in cities

-15%

emissions by 2025

-30%

emissions by 2030

-100%

emissions by 2050

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

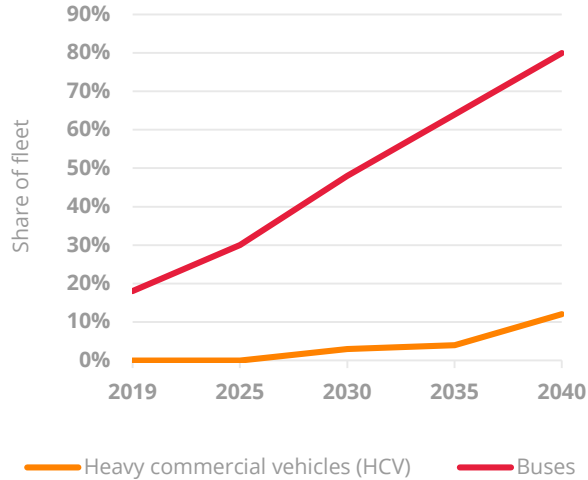
all European city buses emit approx.

70.000 t

of CO2 every day

Rate of electrification for different vehicle types

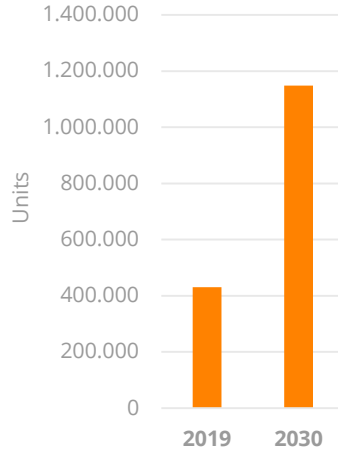
EV share of global vehicle fleet by segment



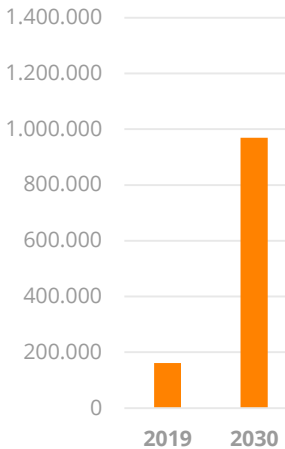
Source: BloombergNEF. Note: Commercial vehicle adoption figures include the main markets of China, Europe and the U.S.

Forecast: Global fleet of electric buses and heavy commercial vehicles

Electric buses worldwide



Electric trucks (HCV) worldwide



Source: e-trofit analysis with data from BloombergNEF, OICA, ACEA, KBA, Focus

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.

Market Dynamics

The electrification of CVs is therefore a fast-growing and sustainable market

Design

Possible Electric Propulsion

**City buses**

→ Low-floor technology

✓ **Low-floor portal drive axle**

**Intercity buses**

→ Low-floor technology in the front

→ High-floor technology in the back

✓ **Central engine**

**Coaches**

→ High-floor technology






✓ **Central engine**



Powertrain e-troFit

Drive unit benchmark

Benchmarking

	In-wheel drive	Near-wheel drive	Central drive
 Gradeability *	++	+++	++
 Power consumption	+++	++	K.A
 Price	+	++	+++
 Retrofit	+++	+++	+
 Ranking **	2	1	3

* Gradeability of all drives sufficient

** Weighted ranking

Powertrain e-troFit

Drive unit Benchmark

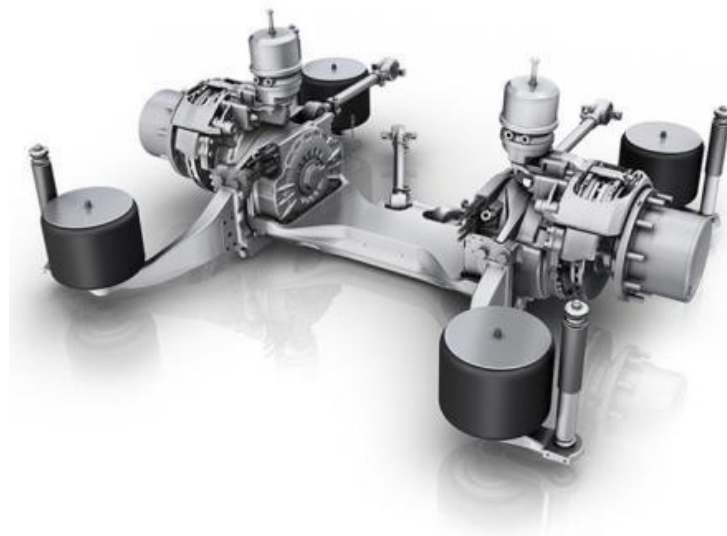
e-trofit

Driving Functions

- ✓ Classic „Creeping“ or „E-Creeping“
- ✓ Hill-Holder
- ✓ Recuperation

Possible

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



Electric portal axle AXTRAX



e-trofit



Influencing Factors

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



Solution

- ✓ Worst case consideration and determination of the necessary battery capacity



 OPENMATICS



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)

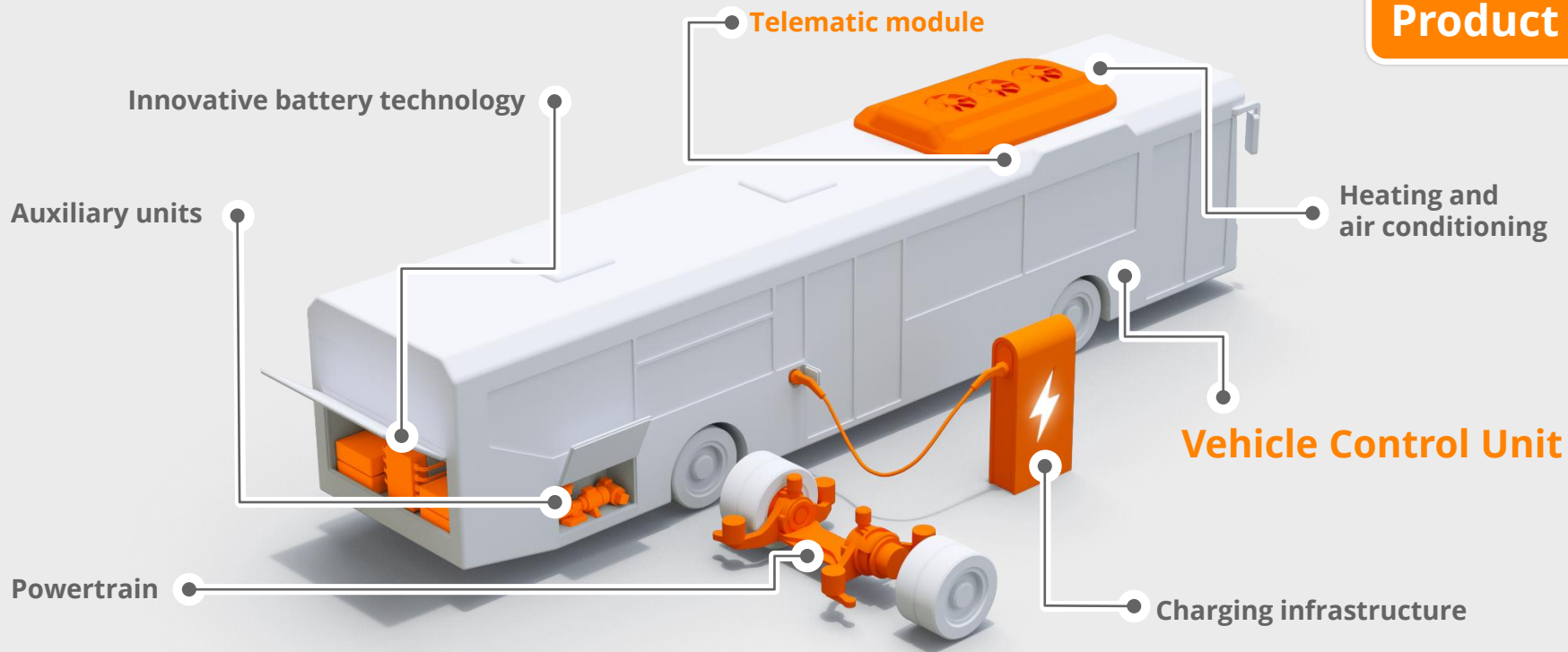
✓ Pantograph

- Infrastructure side
- Vehicle side



Charging Concept

Influencing factors and solutions



Basic Kit: Example Urban Buses

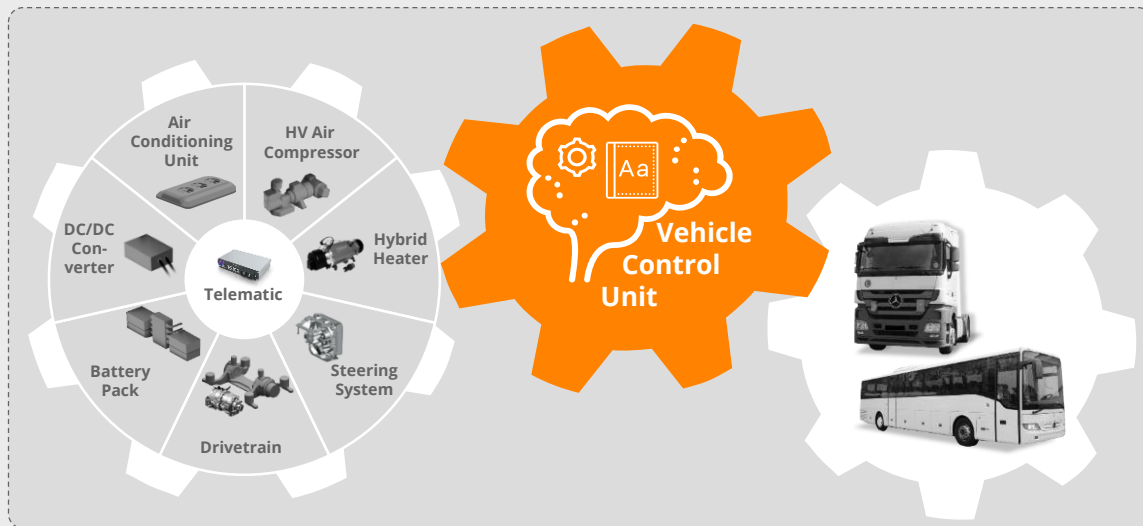
The e-troFit combines own intellectual property (IP) with premium components

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

Partnership with ZF

ZF believes in the product e-troFit and sees a strong market demand for it

ZF is:

- ✓ a strong and reliable brand
- ✓ an expert in helping to scale and industrialize products globally
- ✓ a market leader on power train for busses

ZF is a service partner, sales partner and preferred (not exclusive) supplier for e-troFit

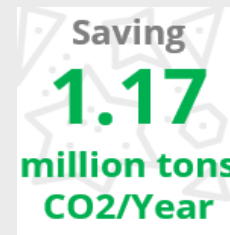
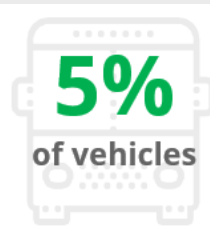
Through this partnership, e-troFit has access to ZF's global end customer sales network, workshop and supplier network in 120 locations in 40 countries and 650 service partners



e-troFit and ZF Friedrichshafen

The world's 3rd largest automotive supplier is e-troFit's strategic partner

CO2 – footprint with 60.000 km/year [t]				
	Diesel Citybus solo [Euro 6]	New e-Citybus solo	Converted e-troFit Bus solo	
100 % Green Energy	Production	22,12	43,48	32,42
	60.000	120,55	46,72	35,39
	120.000	218,98	49,96	38,36
	180.000	317,41	53,20	41,32
	240.000	415,84	56,43	44,29
	300.000	514,27	59,67	47,26
	360.000	612,71	62,91	50,23
	420.000	711,14	66,15	53,20
	480.000	809,57	69,38	56,16
	540.000	908,00	72,62	59,13
	600.000	1.006,43	75,86	62,10
	CO2 savings through e-troFit [t]	944,33	13,76	-



The e-trofit Kit makes every commercial vehicle the most sustainable in its class

Total cost of ownership (TCO) calculation in detail*

	Upcycled Bus with e-troFit Kit	New E-Bus with e-troFit Kit	Mercedes Citaro Bus	Mercedes e-Citaro Bus
Investment Cost				
Price Bus + e-troFit Kit	320.000,00	450.000,00	250.000,00	560.000,00
Refurbishment e-troFit Bus	30.000,00			
Downtime costs by retrofitting	6.000,00			
Total Investment Bus	356.000,00 €	450.000,00	250.000,00	560.000,00
Usage-related Cost				
Calc. Kilometer/year	60.000,00	60.000,00	60.000,00	60.000,00
Energy Consumption l/km kWh/km	1,20	1,20	0,40	1,20
AdBlue Consumption l/km			0,02	
Price Diesel/Electricity in 2020	0,18	0,18	1,00	0,18
Price Diesel/Electricity in 2025 incl. CO2 cost	0,18	0,18	1,21	0,18
Price Diesel/Electricity in 2029 incl. CO2 cost	0,18	0,18	1,29	0,18
Total Cost per km in 2020	1,01	1,16	1,10	1,36
Total Cost per km in 2025	1,02	1,17	1,20	1,37
Total Cost per km in 2029	1,03	1,17	1,25	1,38
Total cost for a 9-year usage period	580.618,83	649.280,48	684.436,58	759.280,48
Residual value	40.000,00	70.000,00	30.000,00	80.000,00
Real Costs (Total costs incl. residual value)	540.618,83	579.280,48	654.436,58	679.280,48
Additional cost compared with e-troFit upcycled Bus	0,00	38.661,65	113.817,75	138.661,65
Average additional cost per year	0,00	4.295,74	12.646,42	15.406,85

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

Upcycled Bus with e-troFit Kit

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



Impressions Citaro O530

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e-trofit



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