

TUMIVolt Charging Station: E-Bus Retrofitting for developing countries

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1. Introduction

2. How does it work?

- **What is „Retrofit“?**
- **Example of a „Kit“**

3. New versus Retrofitting

- **Requirements of the operator**
- **Type and condition of the base bus**
- **Comparison New <-> Retrofit**

4. Service and maintenance

In 2021, the INM (Institute New Mobility) carried out a feasibility study for an East Europe Capital.

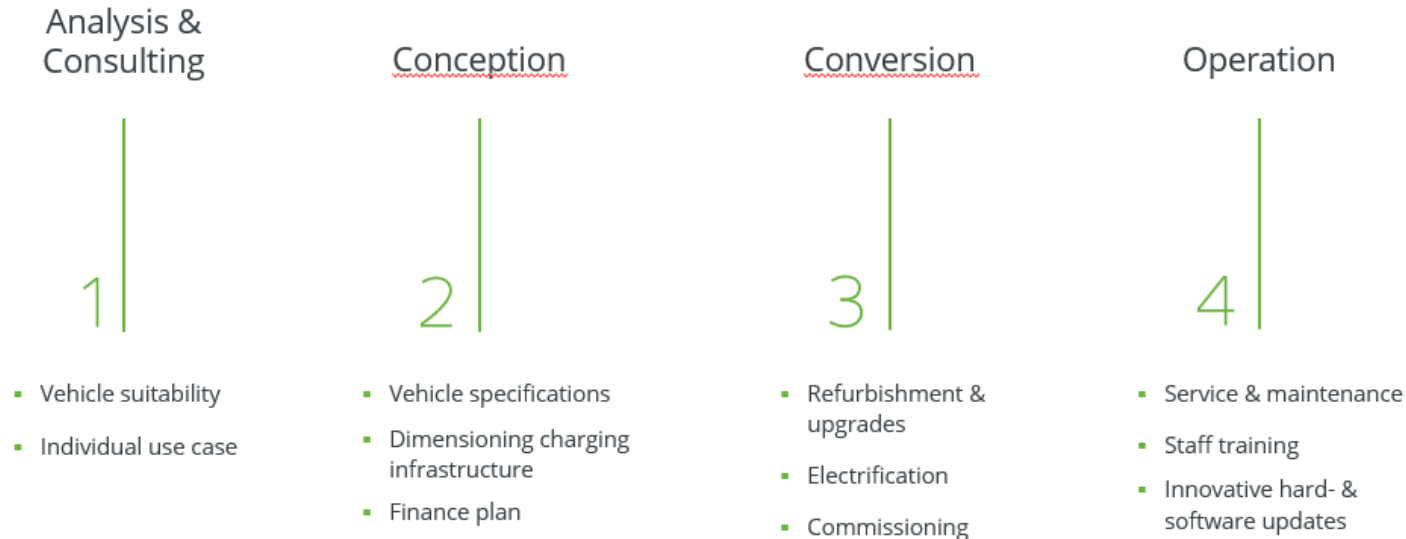
The target was to compare the retrofitting of parts of the existing Diesel bus fleet against the purchase of new Electric busses

Parts of this study will be presented during this Webinar. Since the Ukraine war however, conditions around energy from fossile and regenerative sources have significantly changed. Pressure to fight against climate change as well is continuously rising

What is „Retrofit“?

In short words, “retrofit” means replacing the combustion engine drivetrain by an electrical one. This is normally been done in several steps. The content of these 4 Phases are:

PROJECT SCHEDULE

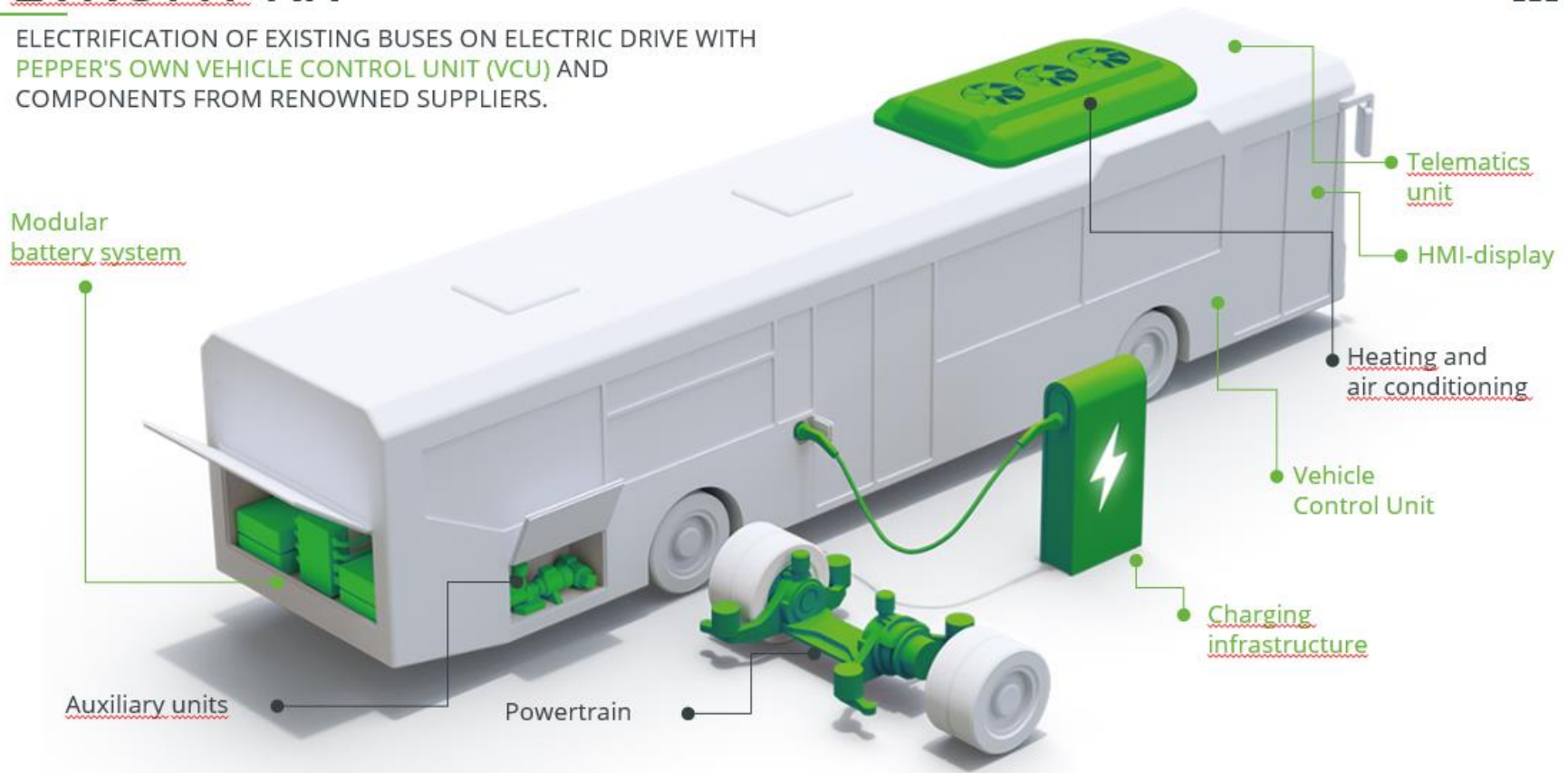


the retrofitting process (example Peppermotion)

Example of a “Kit” (Optional: LED Exterior lights, Data Logger)

ETROFIT KIT

ELECTRIFICATION OF EXISTING BUSES ON ELECTRIC DRIVE WITH PEPPER'S OWN VEHICLE CONTROL UNIT (VCU) AND COMPONENTS FROM RENOWNED SUPPLIERS.



the “Kit” (example Peppermotion)

Requirements of the operator

One of the advantages of a retrofitted E-Bus is the cost aspect. This cost advantage is partly since significant parts of the base bus are kept. Well known Bus manufacturers offer long lasting spare parts- and overhaul service. Also, maintenance personnel is trained on existing bus chassis repair. Finally existing spare parts stock can further be used.

The compromises customers must accept in exchange are:

- out fashioned design, no “modern” perception by the public
- no state-of-the-art safety and electronic assistance systems
- driver area not optimized according to modern standards
- noise and thermal isolation of the chassis might be inferior

Type and condition of the base bus

Not each bus is suitable to be retrofitted. Important criteria are brand, model, fleet size, age and condition

Retrofit kits need to be electrically and mechanically adapted to the base vehicle. Conversion costs will depend on the development and validation effort. Thus “Kits” are normally available for busses from renown manufacturers that have been produced in high volumes

Rule of thumb: The bigger the fleet of nearly identical vehicles to retrofit, the less is the overhead cost's part that needs to be paid.

If the base bus is too old, corrosion and usage level might have reached a point that the refurbishment costs get too high. As well, the technology level will be too old, essential functionality might be missing.

An average age of the base bus between 10-15 years as a general guideline is reasonable

Type and condition of the base bus

Example of a fleet analysis with key figures – Part 1

Model	Roadworthy 2019	Scraped 2020	Delivered	Roadworthy 2020	Usability % 2019	Usability % 2020	Total mileage from new km
18 meters	300	28		272			
Mercedes O345 G	34	26		8	65		over 1 100 000
Mercedes O345 G Conecto	50			50	76	52	over 700 000
MAN SG 262	30	2		28	90	68	over 1 000 000
MAN Lion's City G	186			186	92	94	over 200 000
12 meters	366	22	5	349			
Mercedes O302T	4	4					
Mercedes O345 S	5	2		3	60	60	over 800 000
Mercedes O345 S Conecto	30			30	60	60	over 800 000
MAN SL 232	2	2					over 800 000
BMC 220 SLF	61	12		49	64	51	over 600 000
Mercedes C628.310	35			35	77	80	over 500 000
TEDOM C12G	7	2		5			over 80 000
Yutong ZK6126HGA	110			110	73	78	over 50000
Yutong ZK6128BEVC	20			20	70	75	over 50000
BMC320Procity CNG	60			60	68	85	over 300000
Mercedec-Benz Inturo	10		5	15	60	87	over 50000
Yutong ZK6126HGA CNG	22			22	86	91	over 50000
Total	666	50	5	621	74	76	

Type and condition of the base bus

Example of a fleet analysis with key figures – Part 2

Model	Total	Origin	EURO	FUEL	AGE	PAYLOAD	
12 meters						Standing	Seating
Mercedes O345S	3	Turkey	2	Diesel	20	65	36+1
Mercedes O345SC	30	Turkey	2	Diesel	18	60	36+1
BMC Belde 220 SLF	49	Turkey	3	Diesel	15	66	34+1
Mercedec C628.310	35	Turkey	4	Diesel	12	74	31+1
Tedom C12G	5	Czech Republic	5	CNG	12	54	29+4
Yutong ZK6126HGA	110	China	6	Diesel	4	57	32+1
Yutong ZK6128BEVG	20	China		Electricity	2	58	27+1
BMC320Procity CNG	60	Turkey	6	CNG	2	62	30+1
Mercedes-Benz Intouro	10	Germany	5	Diesel	9	23	63+1
Mercedes-Benz Intouro	5	Germany	6	Diesel	5	21	55+1
Yutong ZK6126HGA CNG	22	China	12	CNG	2	57	32+1
Total	349				7.3		
18 meters							
Mercedec O345G	8	Turkey	2	Diesel	22	100	49+1
Mercedes O345GC	50	Turkey	3	Diesel	17	98	48+1
MAN SG 262	28	Turkey	2	Diesel	21	120	49+1
MAN Lion's City G	126	Poland	6	CNG	6	106	44+1
MAN Lion's City G	60	Poland	6	CNG	1	113	38+1
Total	272				8.4		
Grand Total	621				7.8		

As of today, retrofit is not offered by the Bus OEM themselves. Lots of smaller and start-up companies disappear from the market quite quickly again.

This is not a problem for vehicles that have been produced as prototypes or in small volumes, e.g., for feasibility studies or marketing activities. However, retrofitting a bigger amount of busses, with high invests and a projected lifetime of 7-10 years requires a very well settled and healthy supplier.

He must be able to supply spare parts and services and maintenance support over a long period.

Several questions need to be asked when deciding for a supplier:




- Is the company well established in the industry?
- where is the headquarters and production facilities?
- does the provider have own technical expertise?
- does the provider take full responsibility of the process, or are major parts outsourced?
- Are there any reference projects or reference customers' existing?
- Does the Retrofit Bus and all its components fulfil legal requirements, relevant technical standards?
- Is functional safety according ISO 26262 implemented?
- Are those projects well documented, can the results be made accessible on request?
- Are warranty conditions clear and sufficient, especially for the lifetime of the battery?
- Is the financial strength of the company good enough to cover big warranty cases or official recalls from authorities?

The following companies offer retrofit solutions for 12m Electric busses for public transport:

Peppermotion:	https://www.peppermotion.com/en/
Orten Trucks:	https://www.electric-trucks.de/en/
I See Electric Busses:	https://www.i-see-busses.de/
Quantron E-Bus Remanufacturing:	https://www.quantron.net/en/q-company/q-remanufacturing/

Amongst those, Peppermotion GmbH (formerly known as e-trofit GmbH) is the first to have started a real business with a long term roadmap, serious financing and huge experience within the automotive industry. For this reason, their concept will be taken as a reference for the following cost comparison.

Comparison Chart New <-> Retrofit (source: e-trofit GmbH 2021)

Drivetrain Comparison			
	Diesel MB Citaro	e Citaro - Mercedes Benz	e-trofit-Bus
Usage time [years]	10	10	10
mileage/year [km]	60000,00	60000,00	60000,00
Energy consumption [l/km], [kWh/km] ¹⁾	0,45	1,30	1,30
Costs/energy unit [€/l], [€/kWh] ²⁾	0,77	0,08	0,08
AdBlue consumption [l/km] ³⁾	0,02	-	-
Costs/AdBlue [€/l] ²⁾	0,60	-	-
Maintenance costs/km [€] ⁴⁾	0,23	0,11	0,12
Purchase Costs Bus [€]	250000,00	560000,00	340000,00
Purchase Costs 60 kW Charging Station	-	20000,00	20000,00
Tax Depreciation/year/vehicle [€]	25000,00	56000,00	34000,00
Tax Depreciation/year/Charging Station [€]	-	2000,00	2000,00
Maintenance costs/yer [€]	13500,00	6750,00	7200,00
Energy Costs/year (Diesel-AdBlue/Electricity) [€]	21600,00	6240,00	6240,00
Investment surplus costs/year (3%) [€]	300,00	10200,00	3600,00
Refurbishment/year	-	-	2500,00
Rest value old Dieselbus before Retrofit/year (8a 50-60K km/Jahr, RW ca. 10%)	-	-	2500,00
Rest value after Usage time [€]	30000,00	80000,00	50000,00
Total Costs/year [€]	60400,00	81190,00	58040,00
value loss per km	0,37	0,80	0,48
Usage costs per km [€/km]	1,01	1,35	0,97
cost savings during Usage time with e-troFit	23600,00	231500,00	-

Amongst the operational costs, personnel is a main contributor.

Thus, it is important to have a detailed look into this area. With buying a new bus, purchase, spare parts supply, maintenance schedules, service locations is normally provided by the manufacturer himself or his contracting companies

Operational costs (example east Europe operator 2020)

- fuel consumption /diesel: 0.16361 € / km (@ 0,77€/l)
- maintenance: 0.06647 € / km
- personnel: 0.74649 € / km
- others: 0.43686 € / km

With retrofit busses, this is different, as there is a split between old base vehicle and new electric “kit”. Interfaces need to be clearly defined when it comes to responsibility and warranty for service repairs

Retrofit can create additional local jobs in the area of operation. Not only service and maintenance are affected. Depending on the volume of retrofit conversions, it make sense to carry out the conversion process at customer facilities, under the supervision and with support of the retrofit supplier.