EVS32 A world of E MOTION
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EVS 50th anniversary 1969-2019

The life cycle assessment of electrification of heavy duty vehicles

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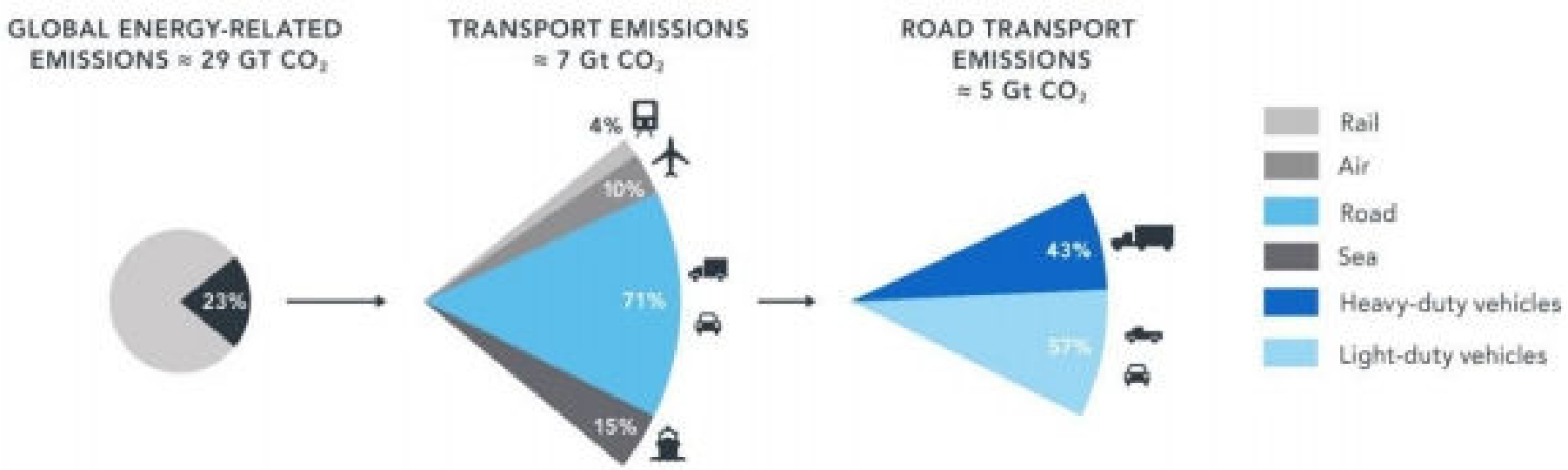
Introduction



Mohammad hossein mohammadi ashani et al., 2015

ORCA project

ORCA
FURTHER GREENER BETTER

Design affordable and clean hybrid bus and freight truck

TNO · VUB Vrije Universiteit Brussel · VOLVO · IVECO · CRF Centro Ricerche Fiat · BOSCH · Fraunhofer LBF · ALTRA · BLUWAYS · Valeo

Project website: www.h2020-orca.eu

ORCA project

ORCA
FURTHER GREENER BETTER

Further

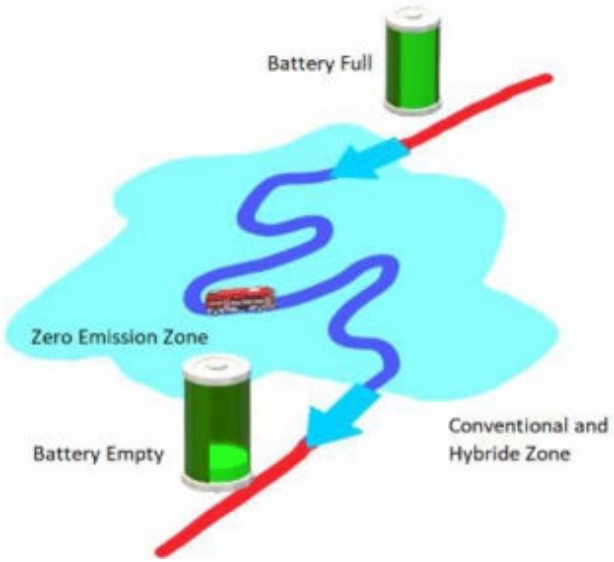
- Increase the electric range from 10 to 30km
- Improve hybrid power train efficiency by 5%

Greener

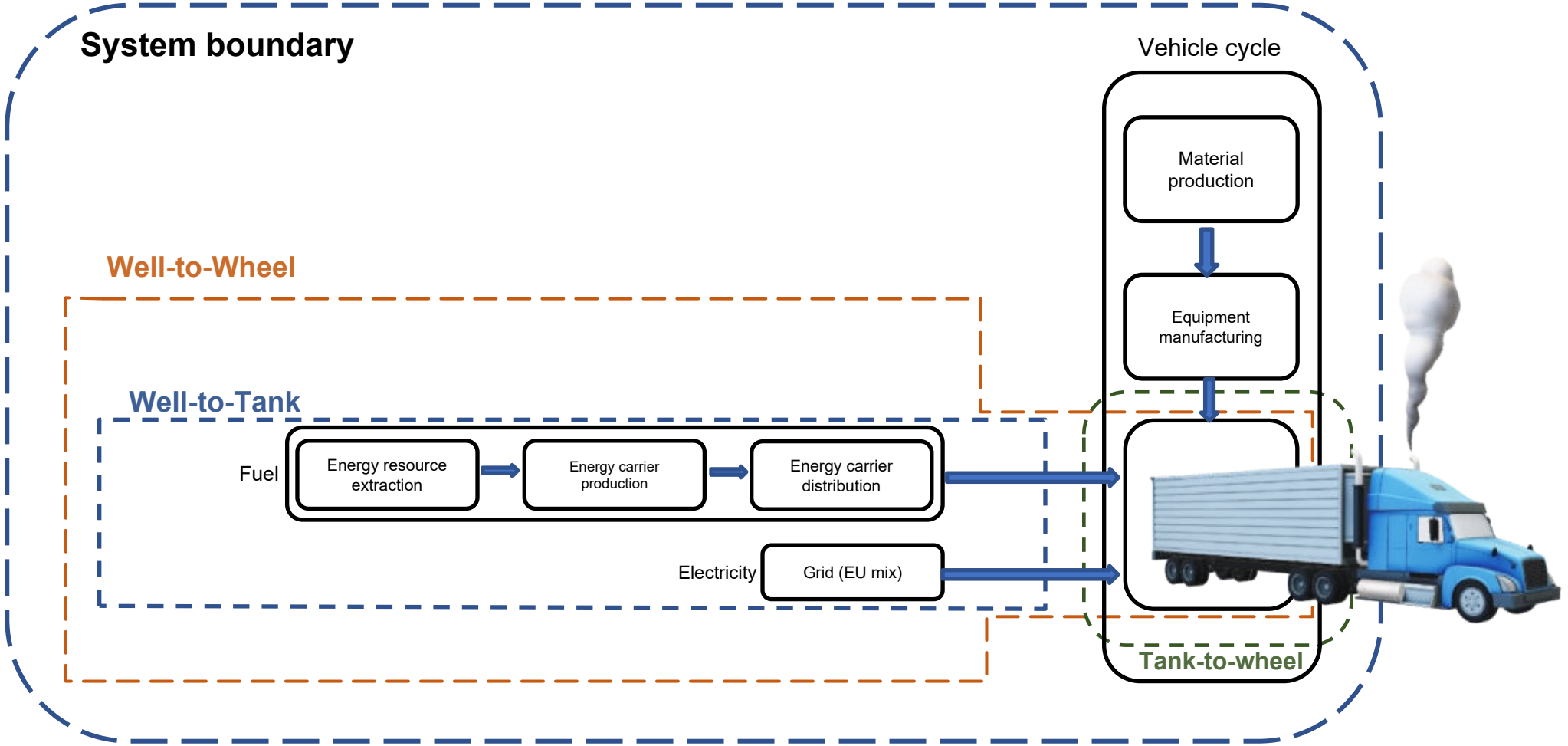
- Reduce the fuel consumption by 40%

Better

- Reduce the Total Cost of Ownership
- Downsize the engine by at least 50%

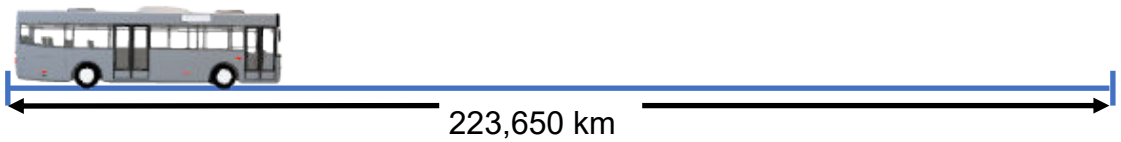


Life Cycle assessment (LCA) Method

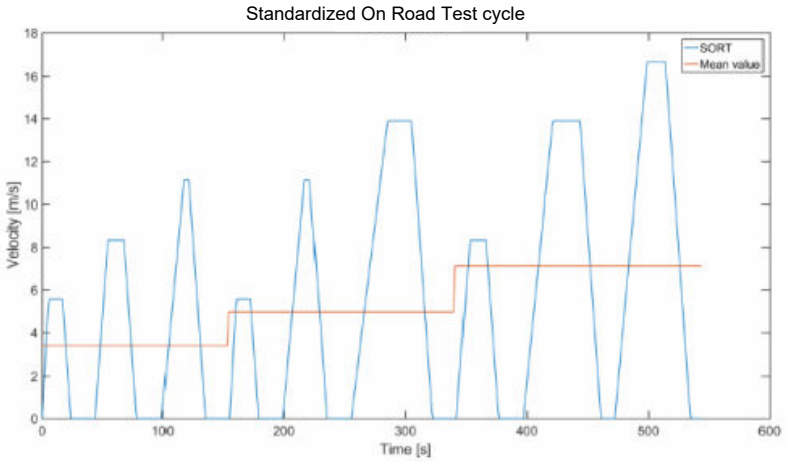


Functional Unit

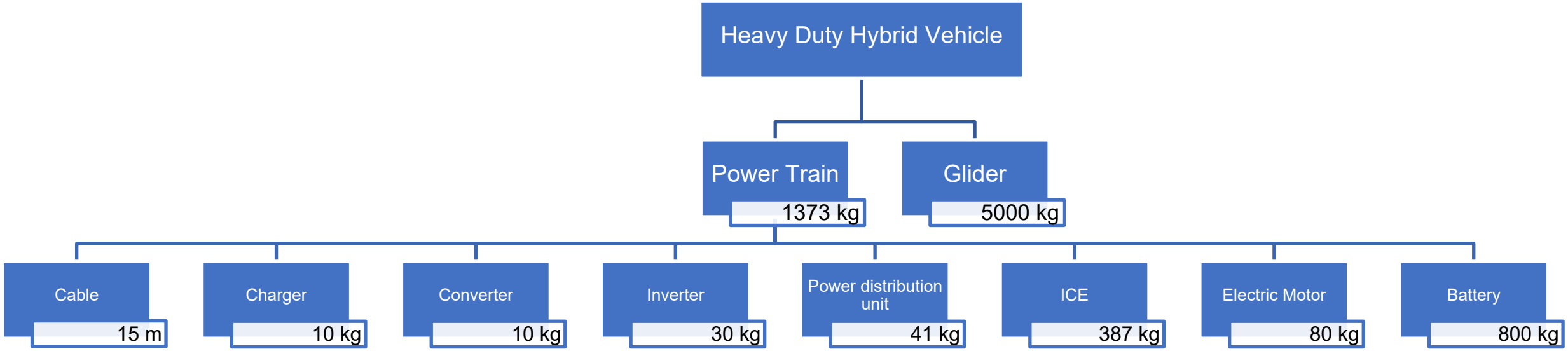
Heavy duty hybrid bus running in



for 7 years with total mileage of 223,650 km

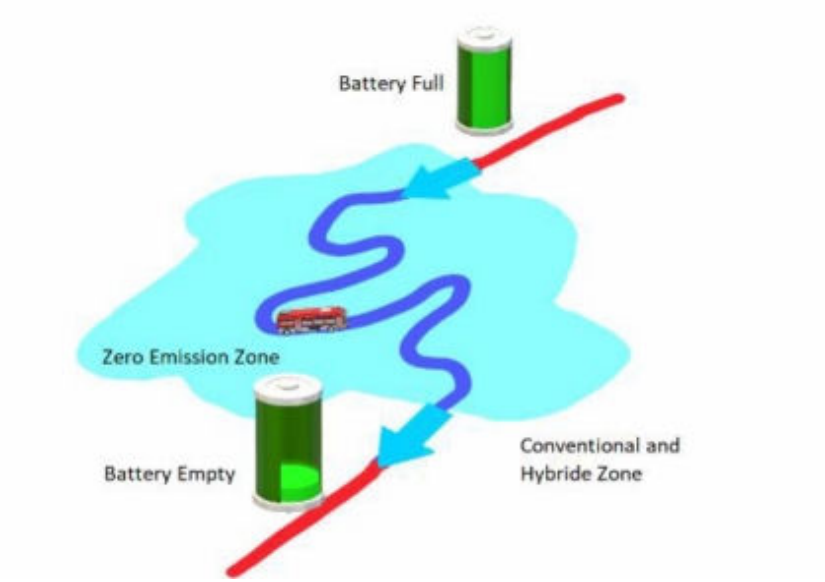


Life cycle inventory: Manufacturing data

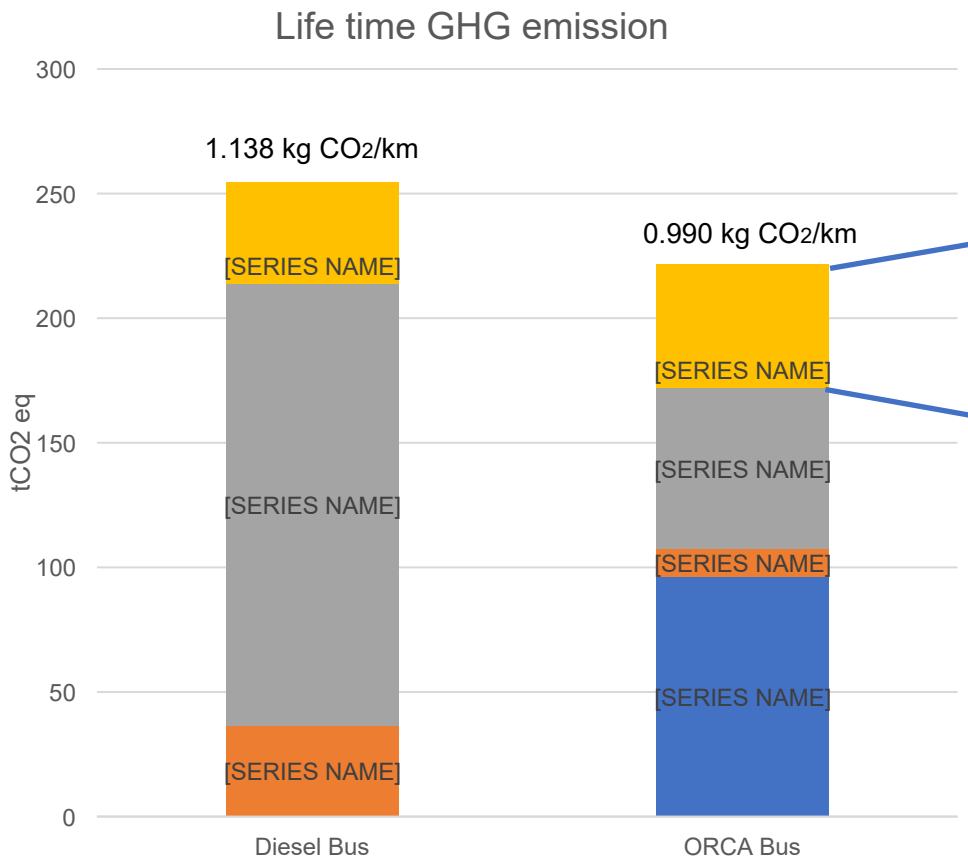


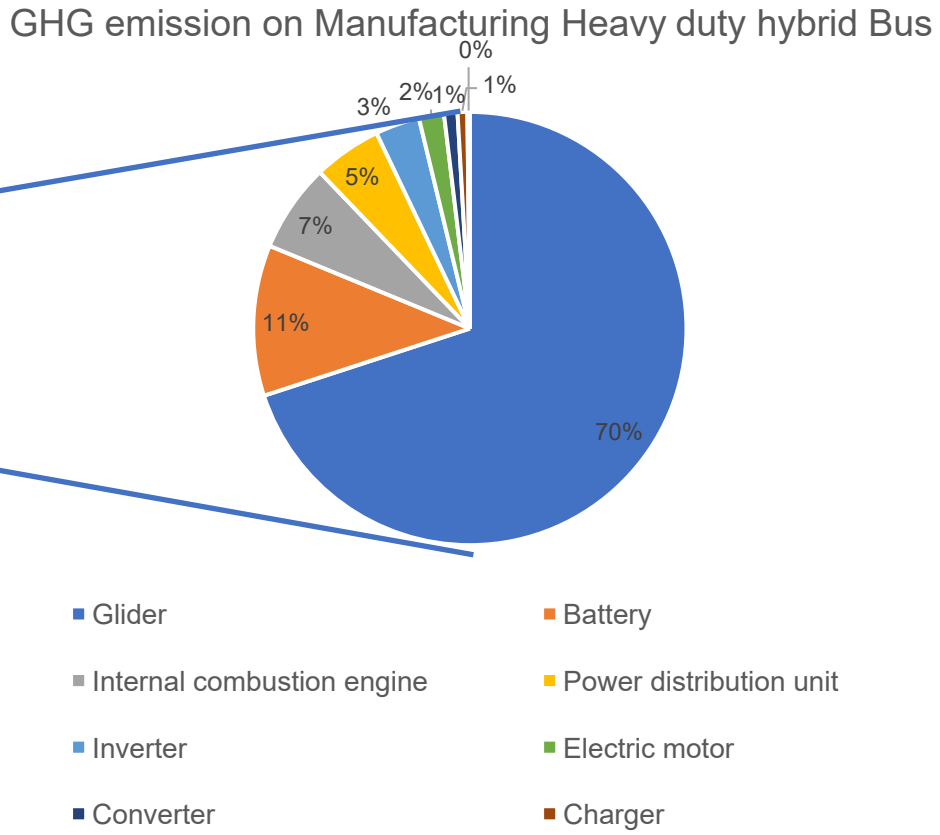
Life cycle inventory: Well to Wheel data

- Daily travel mileage 128 km
- Pure electric mode daily 30 km (~57 kWh)
- In lifetime consumption will be ~ 199.5 MWh

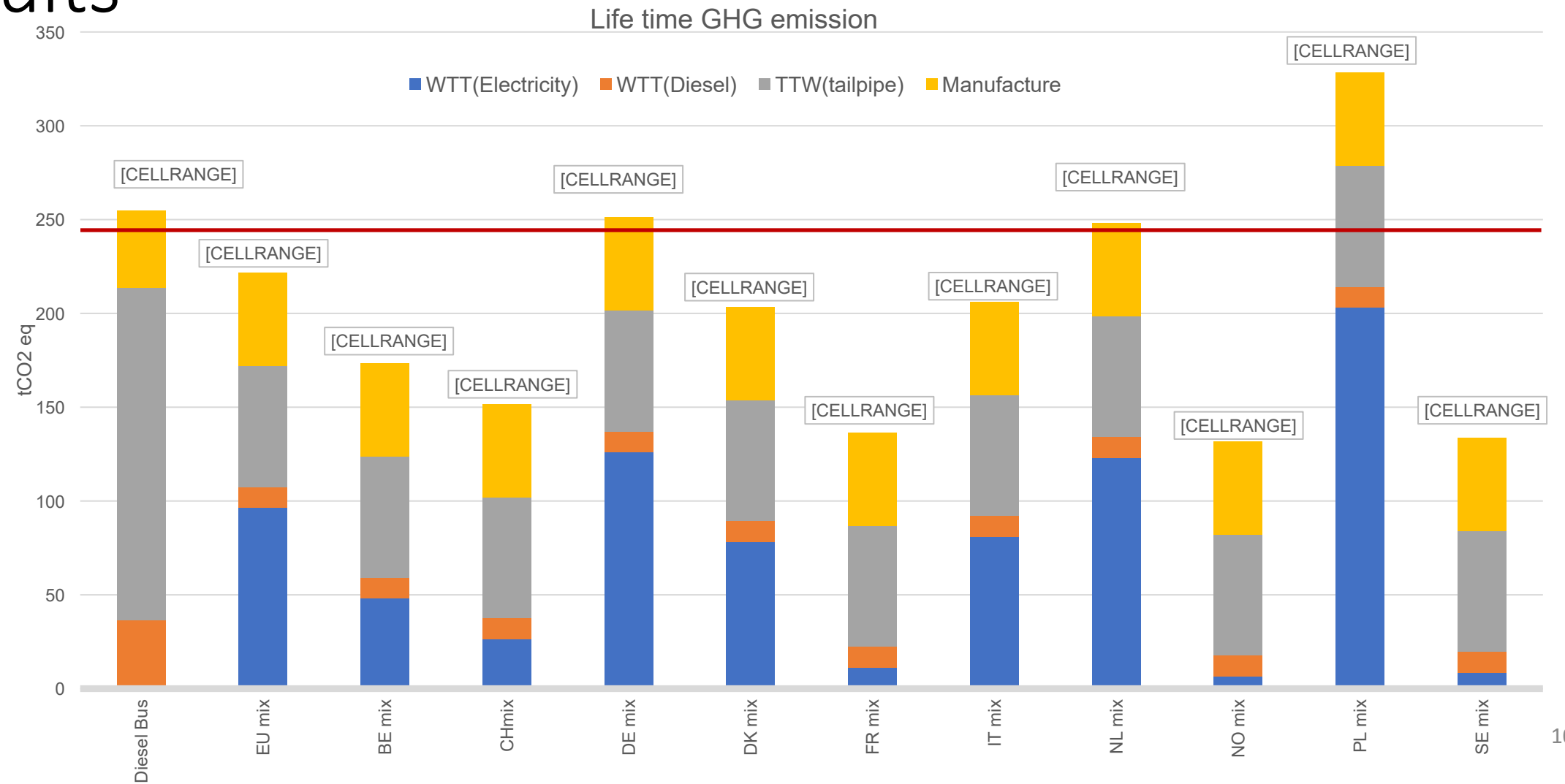


Results


Life time GHG emission
300
250
200
150
100
50
0
tCO2 eq
1.138 kg CO2/km
0.990 kg CO2/km
[SERIES NAME]
[SERIES NAME]
[SERIES NAME]
[SERIES NAME]
[SERIES NAME]
[SERIES NAME]
Diesel Bus
ORCA Bus


GHG emission on Manufacturing Heavy duty hybrid Bus
0%
1%
3%
2%
1%
5%
7%
11%
70%
Glider
Battery
Internal combustion engine
Power distribution unit
Inverter
Electric motor
Converter
Charger

Results


Life time GHG emission
WTT(Electricity)
WTT(Diesel)
TTW(tailpipe)
Manufacture
tCO2 eq
350
300
250
200
150
100
50
0
[CELLRANGE]
Diesel Bus
EU mix
BE mix
CHmix
DE mix
DK mix
FR mix
IT mix
NL mix
NO mix
PL mix
SE mix

Literature benchmark

Heavy duty vehicle type	Technology	Region	Methodology	GHG emission (kg CO_2 eq/km)	Reference
Trucks	Hybrid	Germany	LCA (Cradle to gate)	1.45	C. M. Martinez *et al.*, 2017
Bus	Diesel	South Korea	WTW	1.8	K. Jwa and O. Lim , 2018
Bus	Hybrid	China	WTW	0.912	N.Wang *et al.*, 2011
Bus	Diesel	China	Streamlined LCA	1.28	Q.Song *et al.*, 2018
Bus	Hybrid	China	WTW	0.75	R.Wang *et al.*, 2015
Bus	Diesel	China	WTW	1.4	B.Zhou *et al.*, 2016
Truck	Diesel	Canada	LCA	1.95	M.El Hannach *et al.*, 2019
ORCA bus	Hybrid	Europe	LCA (Cradle to gate)	0.99	

Conclusion

- Plug Heavy duty hybrid vehicle have potential to reduce the GHG emission.
- Clean electricity production is the key to future clean transportation.

Future works

- Inclusion of other impact category like human toxicity, Air Pollution etc.
- Sensitivity analysis of battery types and sizes

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Thank you!

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VUB mobi MOBILITY, LOGISTICS & AUTOMOTIVE TECHNOLOGY RESEARCH CENTRE

- ORCA
  - Optimized
  - Real world
  - Cost competitive modular hybrid
  - Architecture for heavy duty vehicle.

Table 4: Carbon intensity of countries generated from SimaPro 8.5

Country	Carbon intensity (kg/kWh)
Belgium	0.25
Denmark	0.41
Germany	0.63
France	0.06
Italy	0.43
Poland	1.08
Netherlands	0.64
Norway	0.03
Sweden	0.05
Switzerland	0.13
EU average	0.48

- battery's cathode is LiMn2O4 and electrolyte is LiPF6