Environmental Footprints and Reduction of E-mobility in/for Biosphere Reserves

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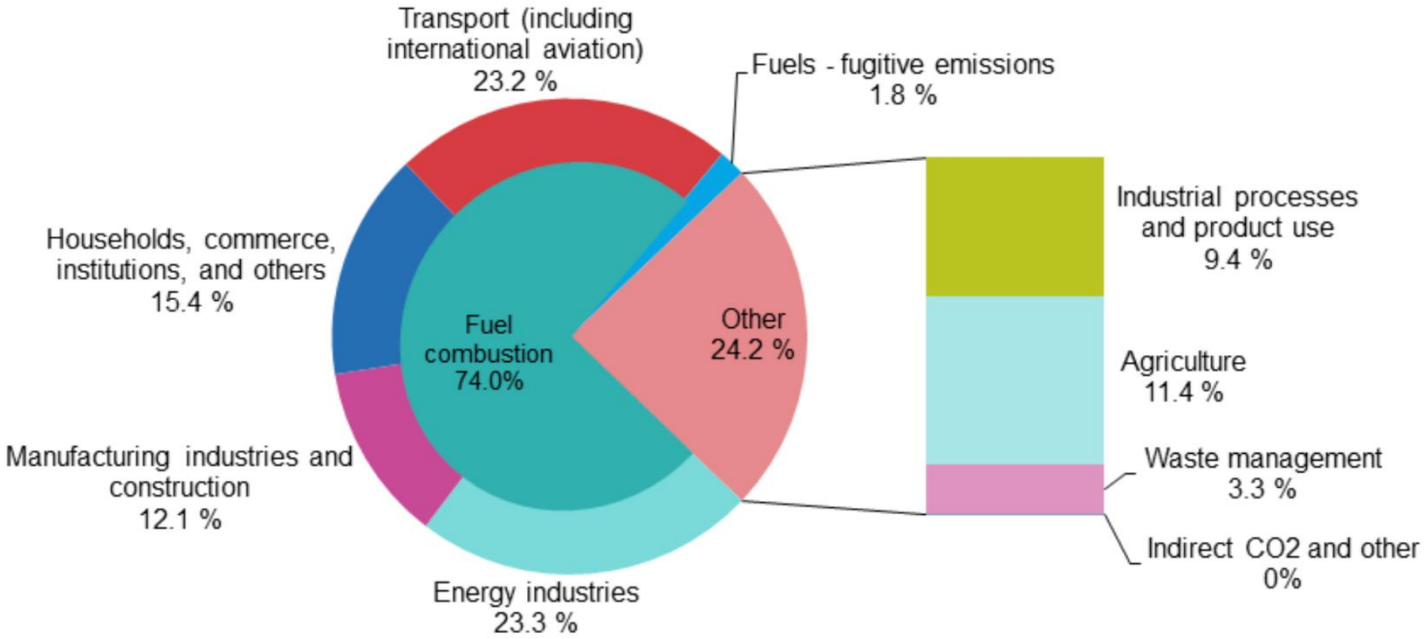
❑ Greenhouse gas emissions by source sector, EU, 2020

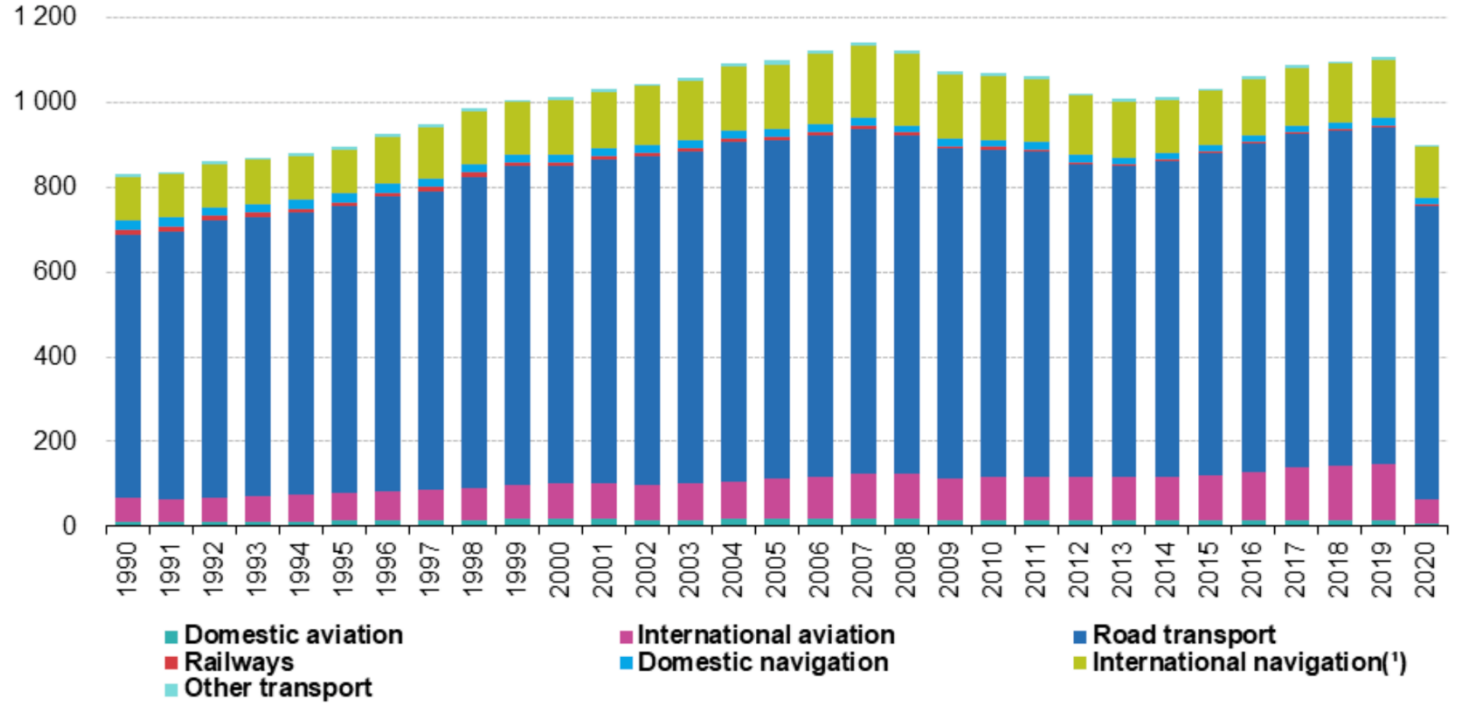


Source: EEA, republished by Eurostat (online data code: env_air_gge)

eurostat

✓ **The transport and energy sectors are responsible for the highest greenhouse gas emissions in the EU.**

❑ Greenhouse gas emissions of transport, EU, 1990-2020 (million tonnes of CO2 eqv.)



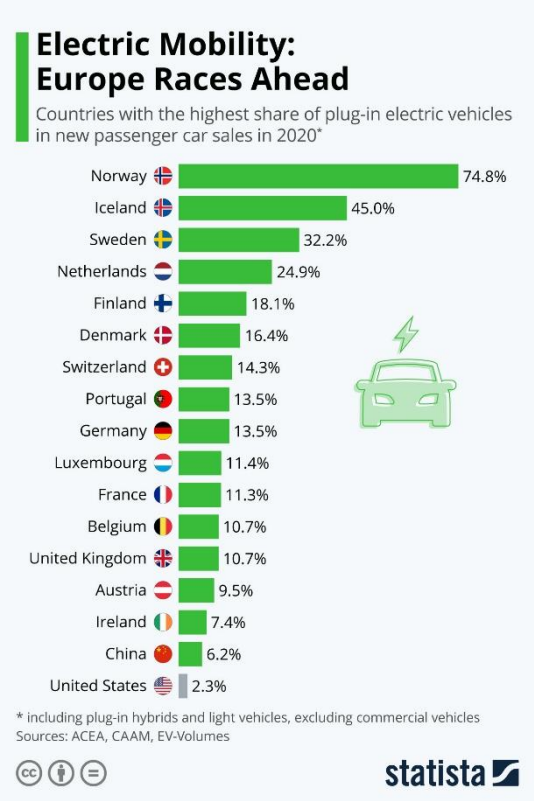
(1) Not included in the EU emissions totals relevant for the energy and climate packages

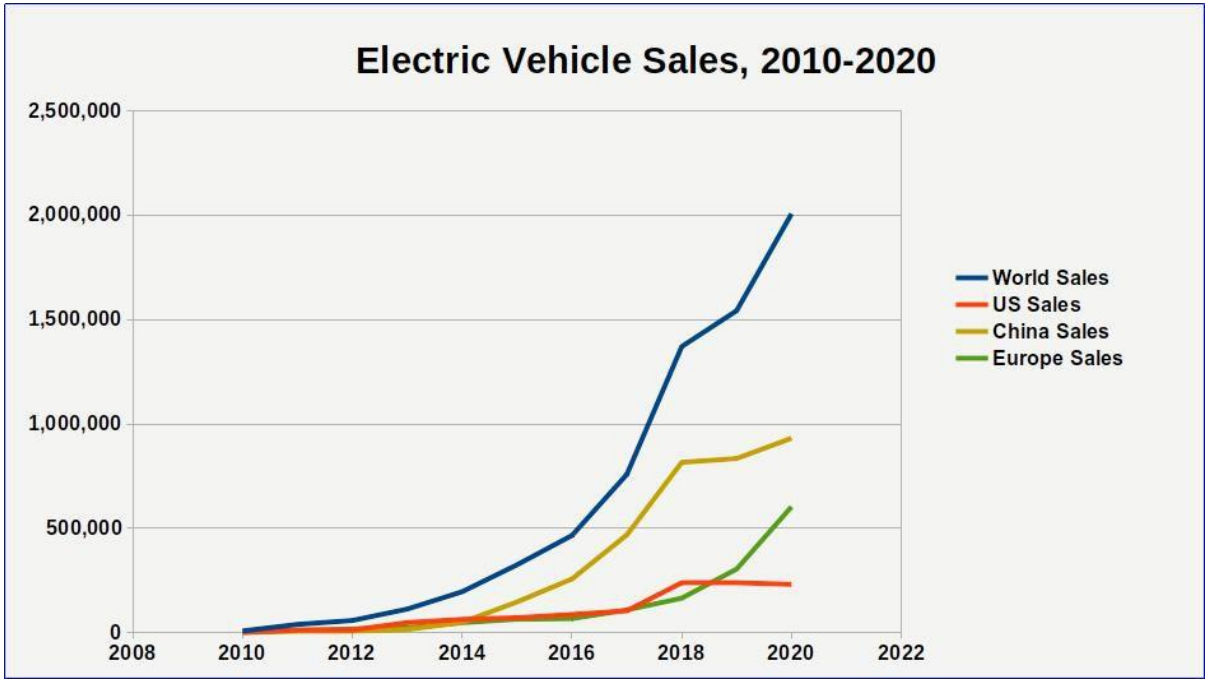
Source: EEA, republised by Eurostat (online data code: env_air_gge)

eurostat

✓ **The transport and energy sectors are responsible for the highest greenhouse gas emissions in the EU.**

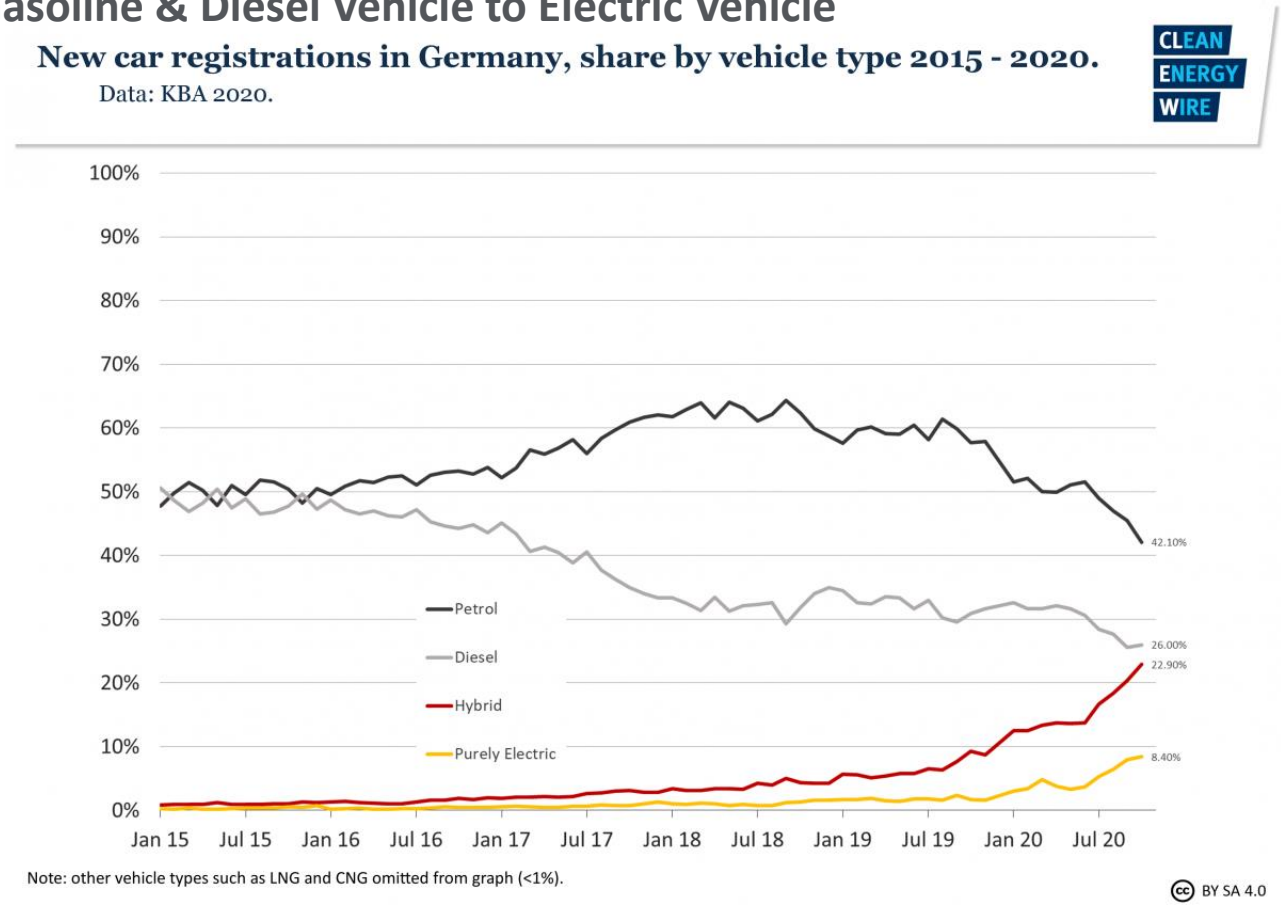
From Gasoline & Diesel Vehicle to Electric Vehicle



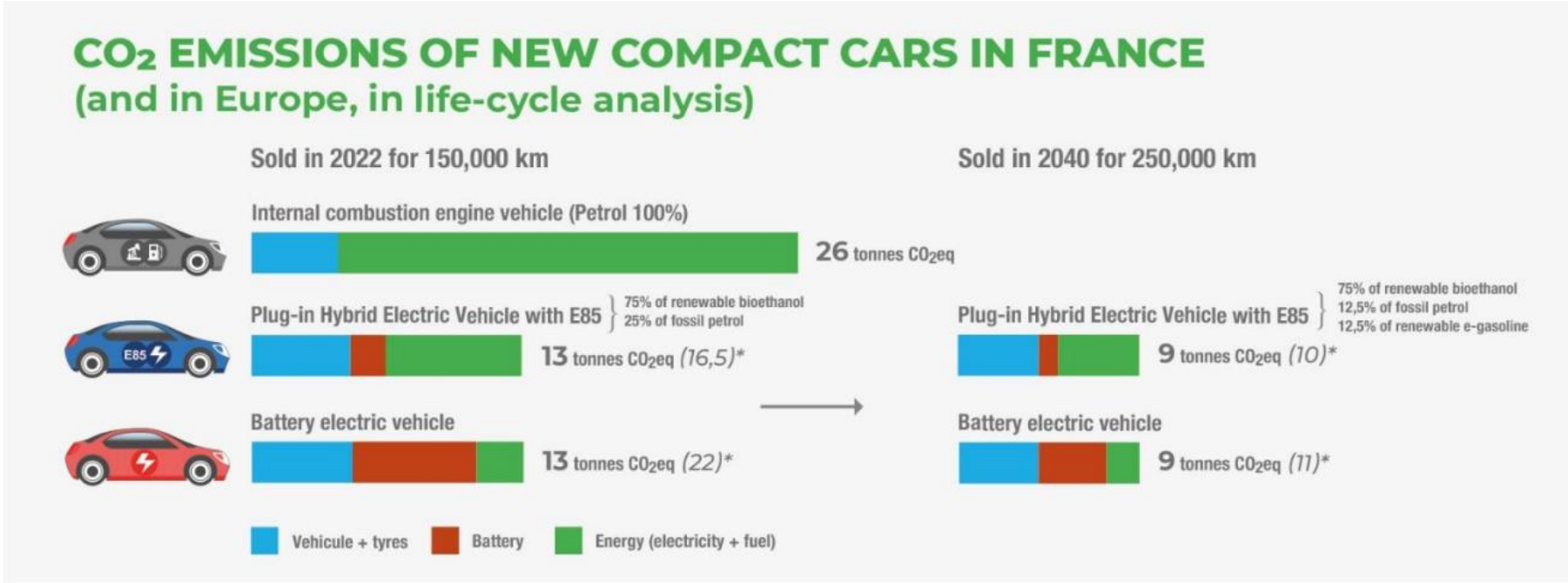


IEA (2021), Electric Vehicles, IEA, Paris https://www.iea.org/reports/electric-vehicles

From Gasoline & Diesel Vehicle to Electric Vehicle



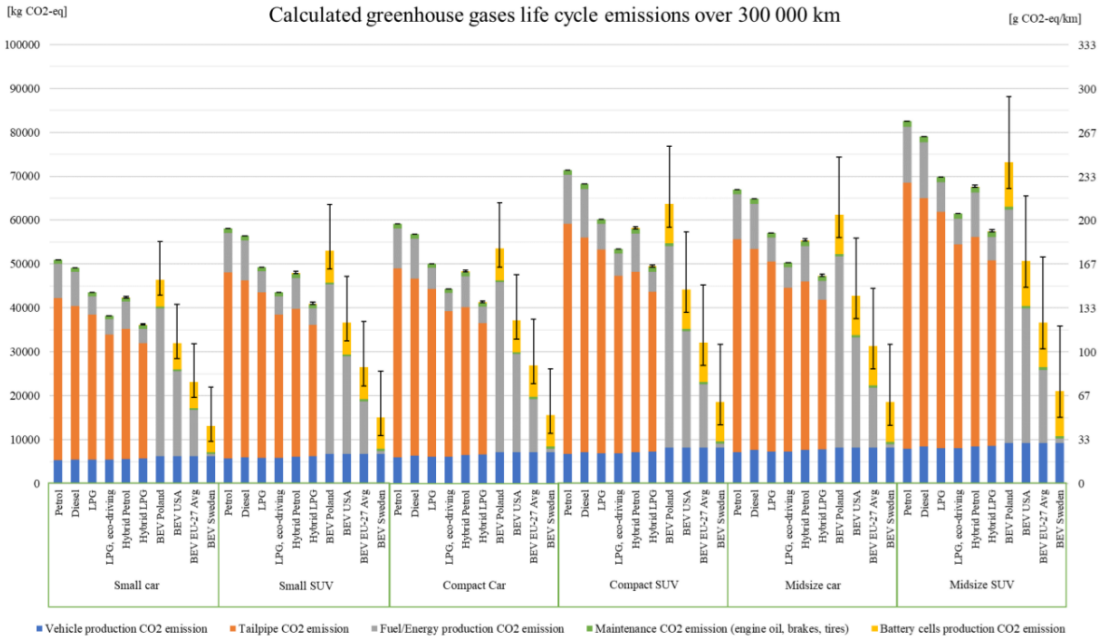
❑ Environmental Impact Comparison Gasoline & Diesel Vehicle vs. Electric Vehicle



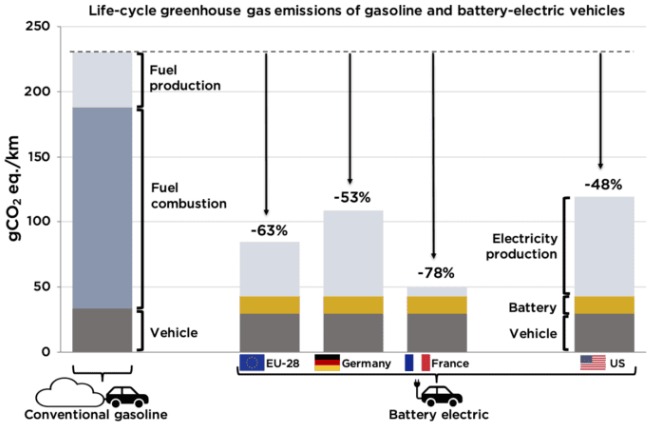
* With the European electricity mix

Source: IFPEN study for SNPAA, AIBS and Intercéréales (June 2022)

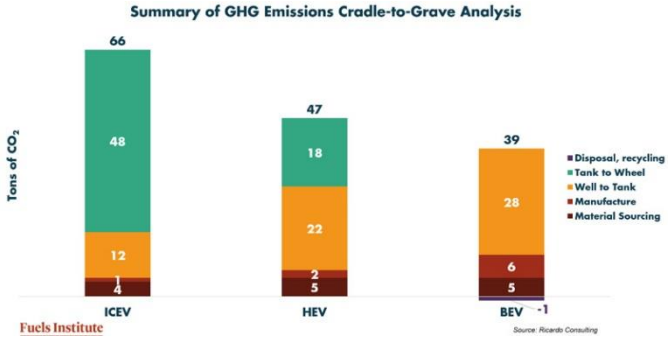
❑ Life cycle CO_2 Comparison Gasoline & Diesel Vehicle vs. Electric Vehicle



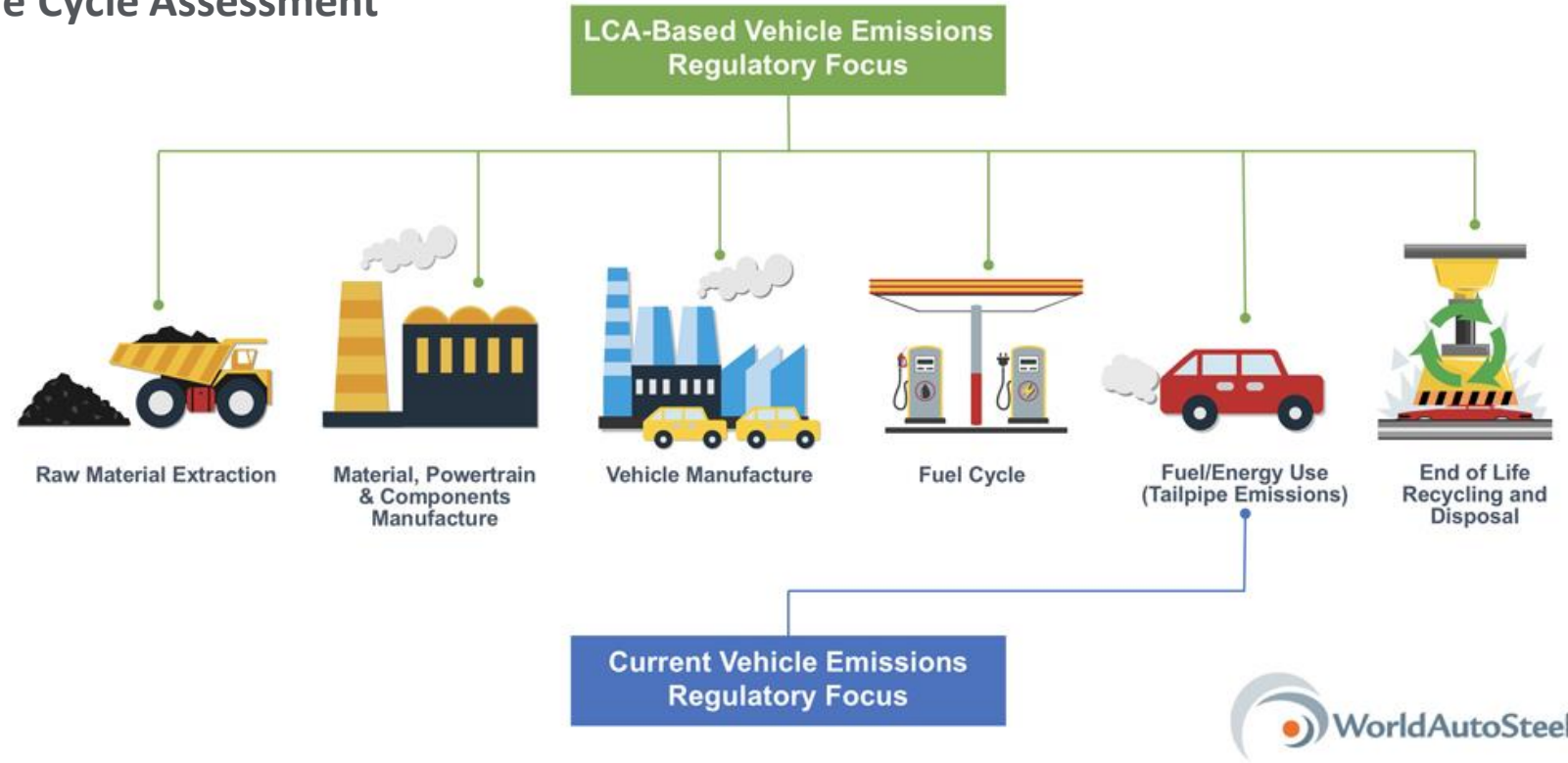
Combustion Engines 2023,192(1), 3–10



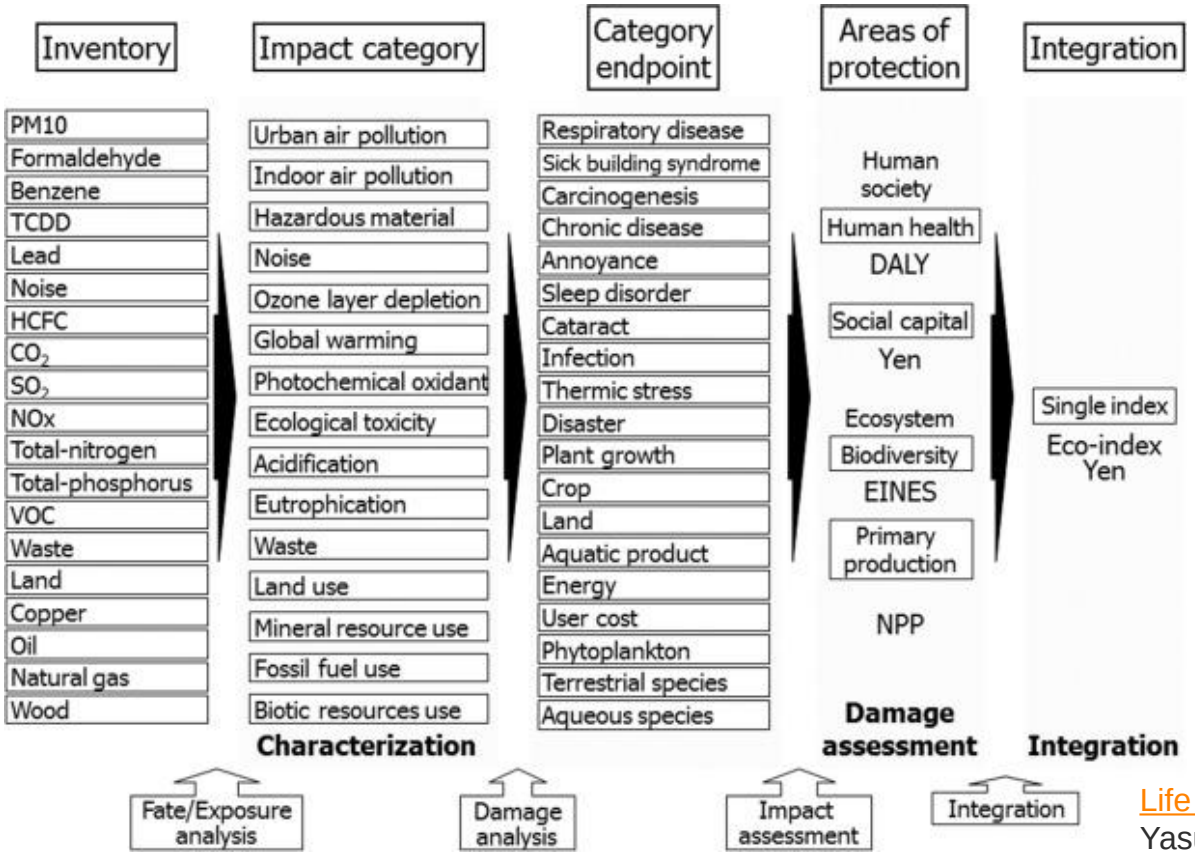
https://theicct.org/stack/explaining-evs/



- ❑ Other Environmental Emissions Comparison Gasoline & Diesel Vehicle vs. Electric Vehicle ?
- ❑ Life Cycle Assessment



Life Cycle Impact Assessment



Life Cycle Assessment
Yasunori Kikuchi, in Plant Factory, 2016

Environmental Footprints and Reduction of E-mobility

: Carbon footprint and Reduction
: Particulate Matter Footprint and Reduction
: Human Toxicity Footprint and Reduction by heavy metals

❑ Compact E-Mobility and Sharing Service Project (2022-2023)

국토교통부 Ministry of Land, Infrastructure and Transport · 충청북도 CHUNGCHEONGBUK-DO · CHEONGJU UNIVERSITY · SDX 재단 SDX FOUNDATION

Chungbuk Innovation City

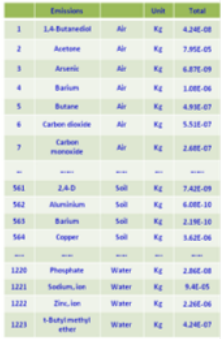
Osong

Ochang

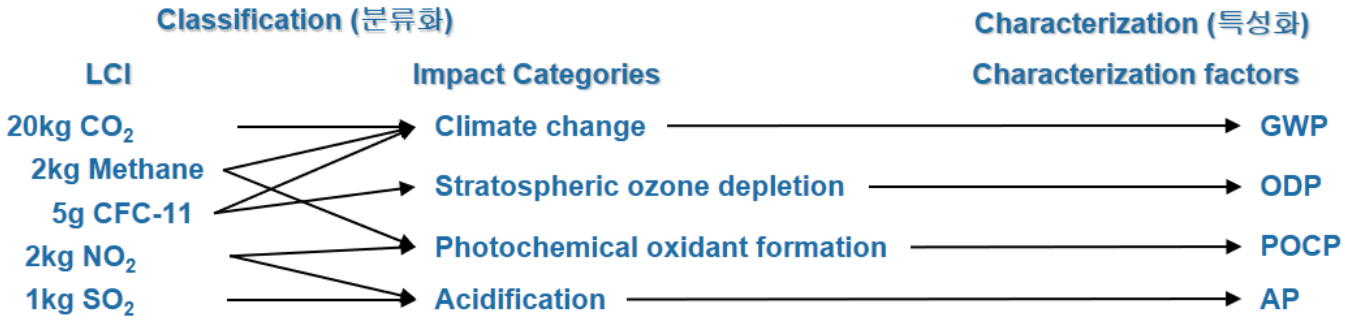
- **Ten compact E-vehicles sharing services**
- **Figure out the blind spot areas for public transportation in Chungbuk innovation city, Osong, Ochang (mart, public offices, etc.)**
- **Improve mobility in 15 min. area (no Taxi and bus area)**
- **Short-distance mode of transfer**

❑ Carbon Footprint Calculation

Total LCI



Total emission/Gallon ethanol



Substance	Amount (kg)	GWP_{100} (kg CO_2 eq/kg)	ODP_{∞} (kg CFC-11 eq/kg)	POCP (kg ethylene eq/kg)	AP (kg SO_2 eq/kg)
CO_2	20	1			
Methane	2	21		0.006	
CFC-11	0.005	4000	1		
NO_2	2			0.028	0.70
SO_2	1				1.00

$20 \cdot 1 = 20$ kg CO_2eq

$2 \cdot 21 = 42$ kg CO_2eq

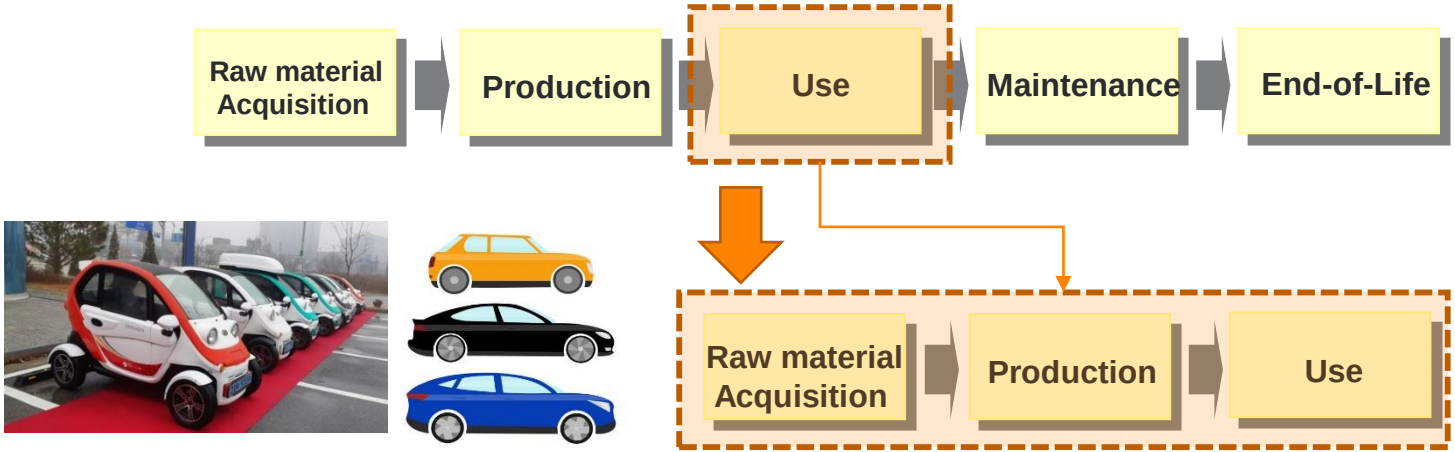
$0.005 \cdot 4000 = 20$ kg CO_2eq

(20 + 42 + 20) kg CO_2eq
= 82 kg CO_2eq

Indicator Result

❑ Life Cycle Assessment and Carbon Footprint

- ✓ System Boundary: Just use phase (Gate to Gate approach)
- ✓ Use phase
  : Raw material aquisition, production and use were considered of Electricity/Gasoline/Diesel
- ✓ Electricity
  : Korean LCI database
  : 5.3km/kWh (0.182kWh/km)
- ✓ Gasoline/Diesel
  : Korean LCI database
  : 14.5 km/L (Korea Energy Agency)

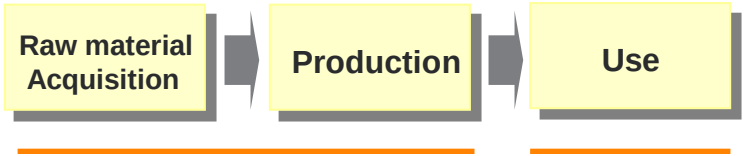


❑ Life Cycle Assessment and Carbon Footprint

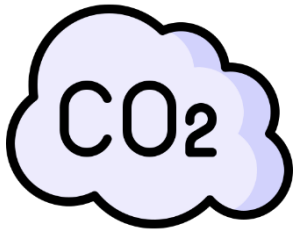
E-mobility

✓ Electricity
: Korean National LCI DB
: 5.3km/kWh
: 0.182kWh/km
: 94.28CO2 eqv./km

Number	Distance km	Use Electricity	Unit	CO2 emission	Unit
1	28.203	5.12781818	kwh	2562.37075	gCO2 eqv.
2	27.337	4.97036364	kwh	2483.69071	gCO2 eqv.
3	23.934	4.35163636	kwh	2174.51269	gCO2 eqv.
4	22.054	4.00981818	kwh	2003.70615	gCO2 eqv.
5	21.215	3.85727273	kwh	1927.47918	gCO2 eqv.
6	21.087	3.834	kwh	1915.8498	gCO2 eqv.
7	20.783	3.77872727	kwh	1888.23002	gCO2 eqv.
8	20.655	3.75545455	kwh	1876.60064	gCO2 eqv.
9	20.147	3.66309091	kwh	1830.44653	gCO2 eqv.
10	19.848	3.60872727	kwh	1803.28102	gCO2 eqv.
11	18.904	3.43709091	kwh	1717.51433	gCO2 eqv.
12	18.89	3.43454545	kwh	1716.24236	gCO2 eqv.
13	18.614	3.38436364	kwh	1691.16651	gCO2 eqv.
14	18.197	3.30854545	kwh	1653.28016	gCO2 eqv.
...	...	.....	..	....	..



✓ Total use: 1,012 times
✓ Total distance: 1996.60 km
✓ Total CO2 emissions

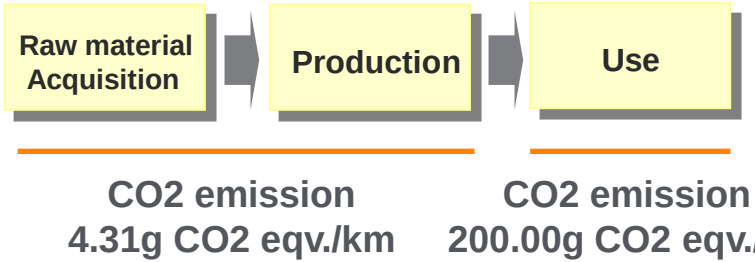


188.74 kg CO2 eqv.

❑ Life Cycle Assessment and Carbon Footprint

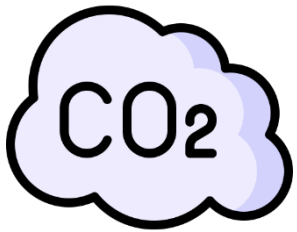
Small Gasoline Vehicle

✓ Gasoline vehicles
: Korean National LCI DB
: Ecoinvent LCI DB GLO (Use)
: Small size gasoline vehicle
: 14.5 km/L (Korea Energy Agency)
: **205.08 g CO2 eqv./km**



Number	Distance km	CO2 emission	Unit
1	28.203	8,012.47	gCO2 eqv.
2	27.337	7,766.44	gCO2 eqv.
3	23.934	6,799.65	gCO2 eqv.
4	22.054	6,265.54	gCO2 eqv.
5	21.215	6,027.18	gCO2 eqv.
6	21.087	5,990.82	gCO2 eqv.
7	20.783	5,904.45	gCO2 eqv.
8	20.655	5,868.09	gCO2 eqv.
9	20.147	5,723.76	gCO2 eqv.
10	19.848	5,638.82	gCO2 eqv.
11	18.904	5,370.63	gCO2 eqv.
…	…	….	..

✓ Total distance: 1996.60 km
✓ Total CO2 emissions

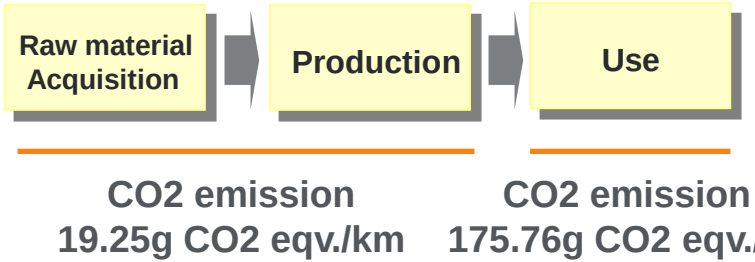


409.67 kg CO2 eqv.

❑ Life Cycle Assessment and Carbon Footprint

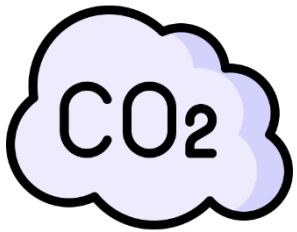
Small Diesel Vehicle

✓ Diesel vehicles
: Korean National LCI DB
: Ecoinvent LCI DB GLO (Use)
: Small size diesel vehicle
: 17.2 km/L (Korea Energy Agency)
: **195.01 g CO2 eqv./km**



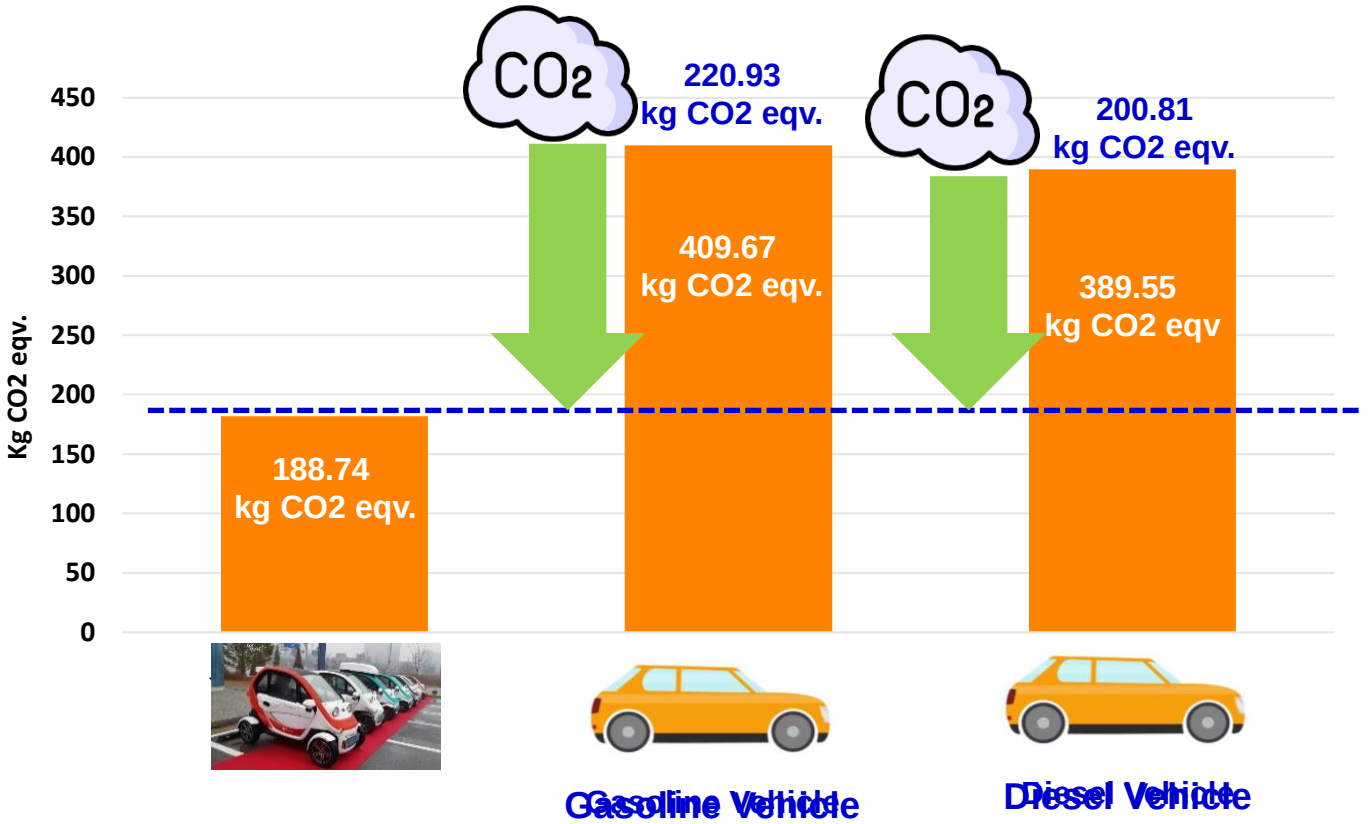
Number	Distance km	CO2 emissions	Unit
1	28.203	5,499.87	gCO2 eqv.
2	27.337	5,330.99	gCO2 eqv.
3	23.934	4,667.37	gCO2 eqv.
4	22.054	4,300.75	gCO2 eqv.
5	21.215	4,137.14	gCO2 eqv.
6	21.087	4,112.18	gCO2 eqv.
7	20.783	4,052.89	gCO2 eqv.
8	20.655	4,027.93	gCO2 eqv.
9	20.147	3,928.87	gCO2 eqv.
10	19.848	3,870.56	gCO2 eqv.
11	18.904	3,686.47	gCO2 eqv.
…	…	….	..

✓ Total distance: 1996.60 km
✓ Total CO2 emissions



389.55 kg CO2 eqv.

❑ Carbon Footprint and Reduction



❑ Particulate Matter Footprint

✓ **The PM Footprint is the kg or ton PM2.5 eqv. value, which is considered ammonia (NH3), nitrogen dioxide, nitrogen oxides, sulfur dioxide, PM10, PM2.5, produced from raw materials acquisition, manufacturing to use (cradle to gate) of product, process, and service. (KIM 2017, KIM 2022)**

Emission	Unit	Midpoint	Endpoint
		kg $PM_{2.5}$ eq.	DALY*(year)
Ammonia (NH_3)	kg	0,32	8,32E-05
Dust,$PM_{10+2.5}$	kg	1	2,60E-04
Nitrogen Oixdes(NO_X)	kg	0,22	5,72E-05
Nitrogen Dioxide(N_2O)	kg	0,22	5,72E-05
Sulfur Dioxide(SO_2)	kg	0,2	5,20E-05
Sulfur Monoxide(SO_X)	kg	0,2	5,20E-05

$$I_m(midpoint\ impact) = \sum_i CF_{mi} \times mi \quad (1)$$

$$I_m(endpoint\ impact) = \sum_i DALY_{mi} \times mi \quad (2)$$

where mi is the magnitude of intervention i (e.g., the mass of NOx released to air), CF_{mi} the characterization factor that connects intervention i with midpoint impact category m (here, particulate matter formation), $DALY_{mi}$ the DALY factor that connects intervention i with endpoint impact category m (here, particulate matter formation) and I_m the indicator result for midpoint impact category m. (De Schryver and Goedkoop 2009; Goedkoop et. al. 2009, Kim et.al 2016)

❑ Particulate Matter Footprint

Raw material Acquisition → Production → Use

PMF 0.132g PM2.5 eqv./km

PMF 0g PM2.5 eqv./km

PM2.5

263.36g PM2.5 eqv.

(Total distance: 1996.60 km)

Gasoline Vehicle

Raw material Acquisition → Production → Use

PMF 0.002g PM2.5 eqv./km

PMF 0.009g PM2.5 eqv./km

PM2.5

21.37g PM2.5 eqv.

(Total distance: 1996.60 km)

Diesel Vehicle

Raw material Acquisition → Production → Use

PMF 0.07g PM2.5 eqv./km

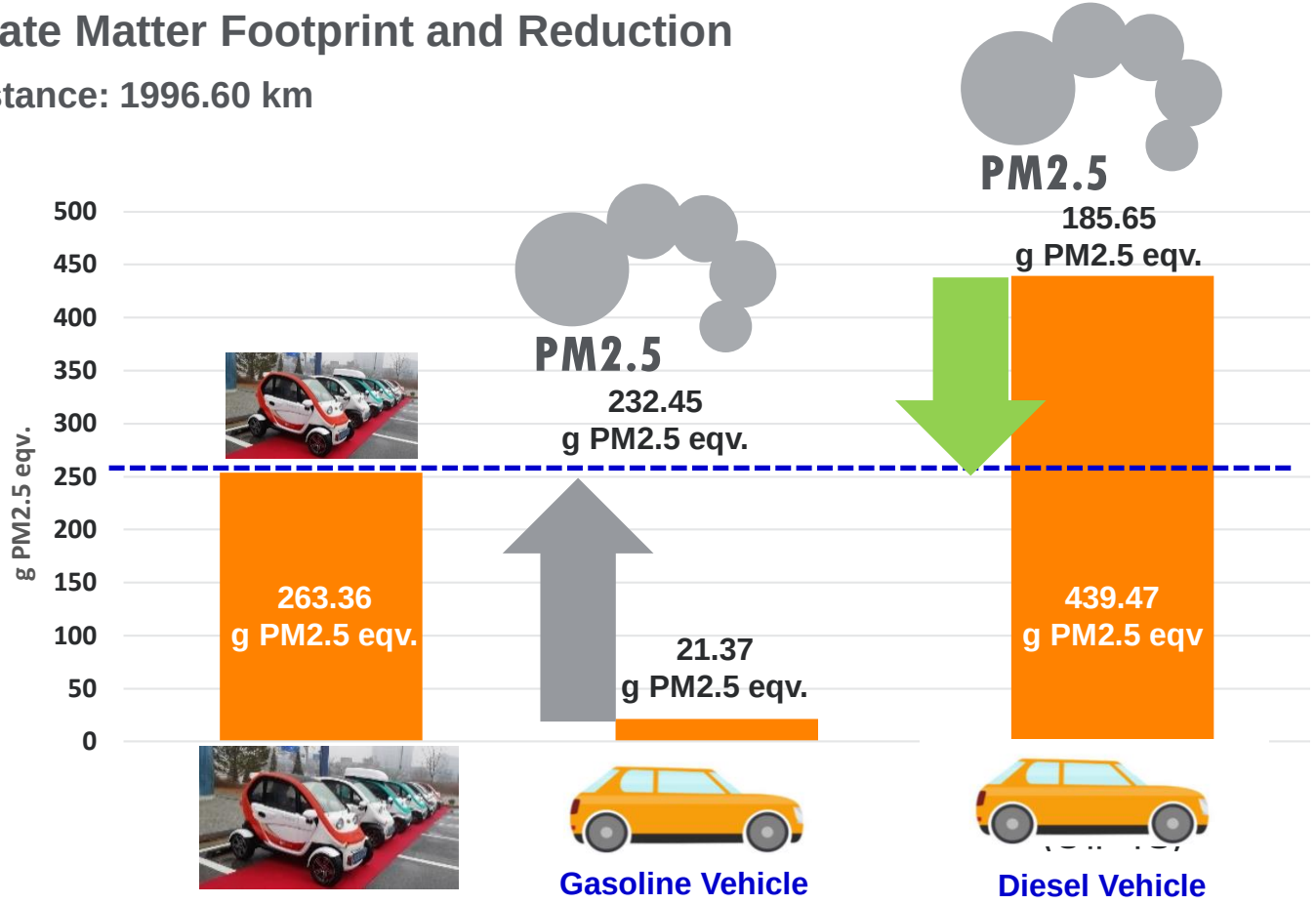
PM2.5

439.47g PM2.5 eqv.

(Total distance: 1996.60 km)

❑ Particulate Matter Footprint and Reduction

✓ Total distance: 1996.60 km



❑ Human Toxicity Footprint

✓ **Human Carcinogenic Toxicity Footprint is quantifying human toxicity impact (μg 1,4 DCB eqv) by heavy metals such as Pb, Cd, Cr, Cu, Mn, Fe, Ni, As, Be, Al, Ca, Mg etc.**

- **ReCiPe method, Characterization factors for Ecotoxicity and Human toxicity (kg 14-DCB eq.) : 6 elements are in the list**

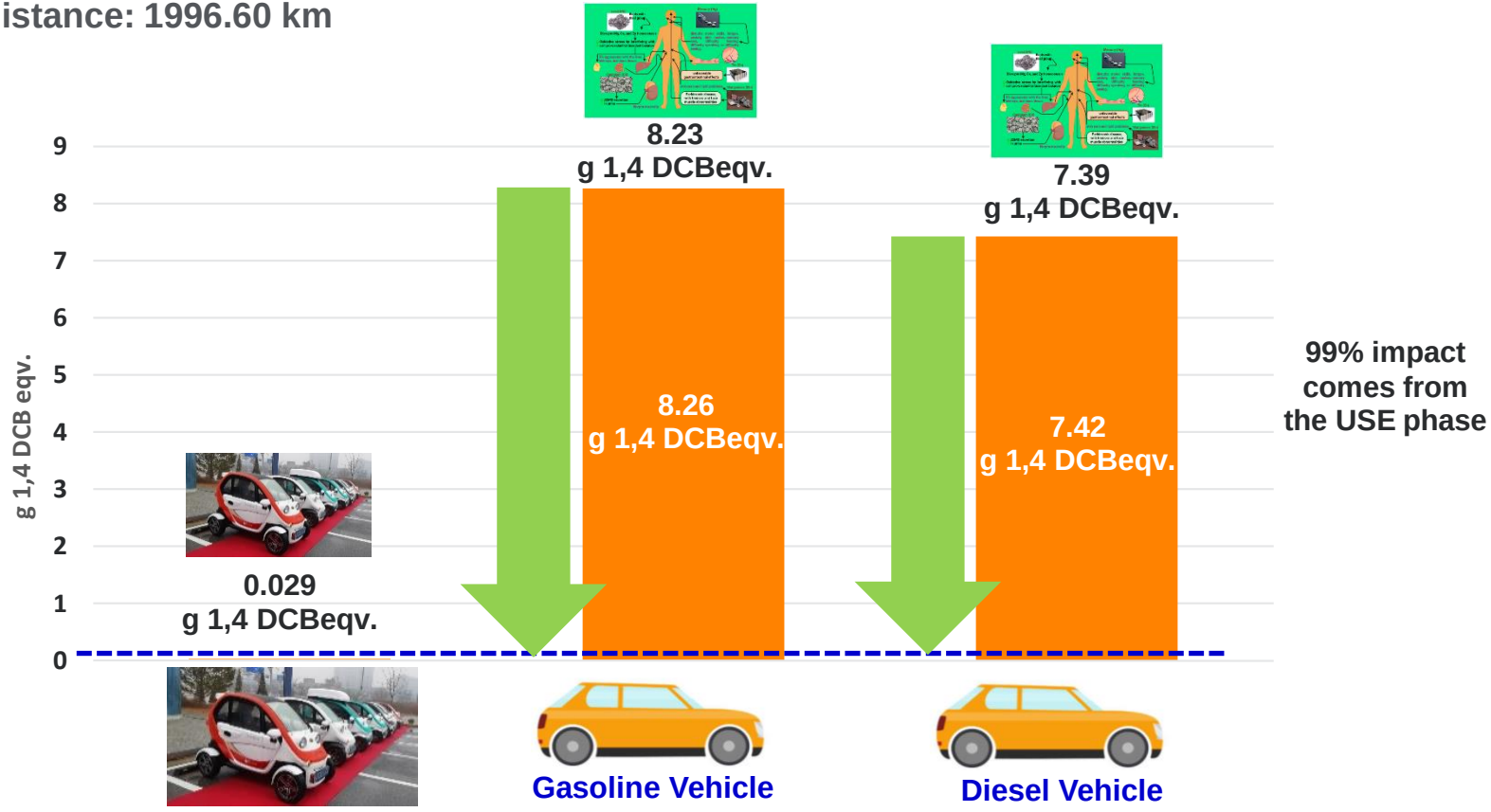
Name	freshwater ecotoxicity	human toxicity	terrestrial ecotoxicity	Unit
Antimony	2.13	35,234.00	6.72	kg 1,4-DCB-Eq
Arsenic	1.74	649,510.00	5.76	kg 1,4-DCB-Eq
Barium	0.40	53,378.00	0.86	kg 1,4-DCB-Eq
Chromium	0.12	0.22	4.66	kg 1,4-DCB-Eq
Silver	50.54	57,119.00	2,179.90	kg 1,4-DCB-Eq
Zinc	0.62	2,614.30	28.76	kg 1,4-DCB-Eq

$$I_m(midpoint\ impact) = \sum_i CF_{mi} \times mi \qquad (1)$$

where mi is the magnitude of intervention i (e.g., the mass of Cr released to air), CFmi the characterization factor that connects intervention i with midpoint impact category m (here, human carcinogenic toxicity)[8]

❑ Human Toxicity Footprint

✓ Total distance: 1996.60 km

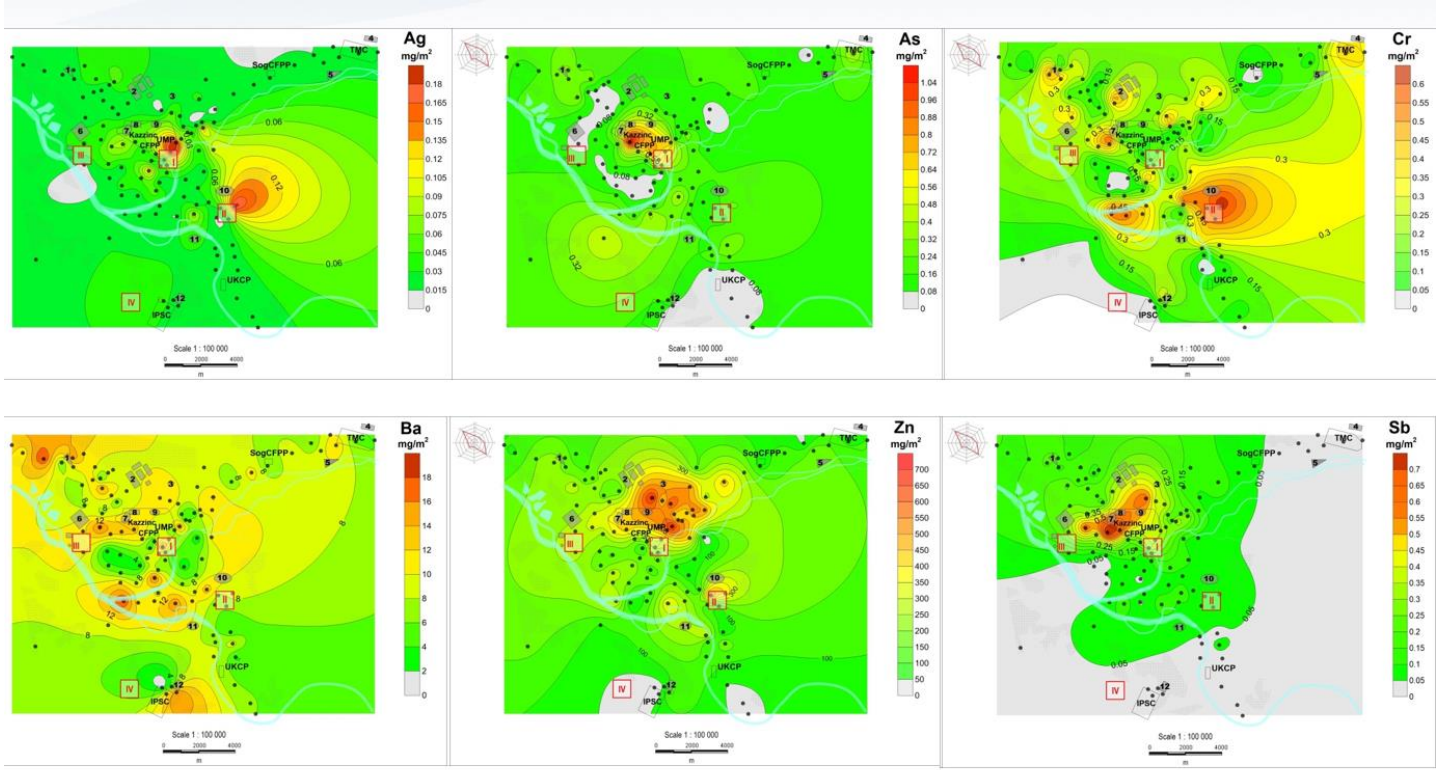


99% impact comes from the USE phase

❑ Human Toxicity Footprint in Urban system (local and regional system)

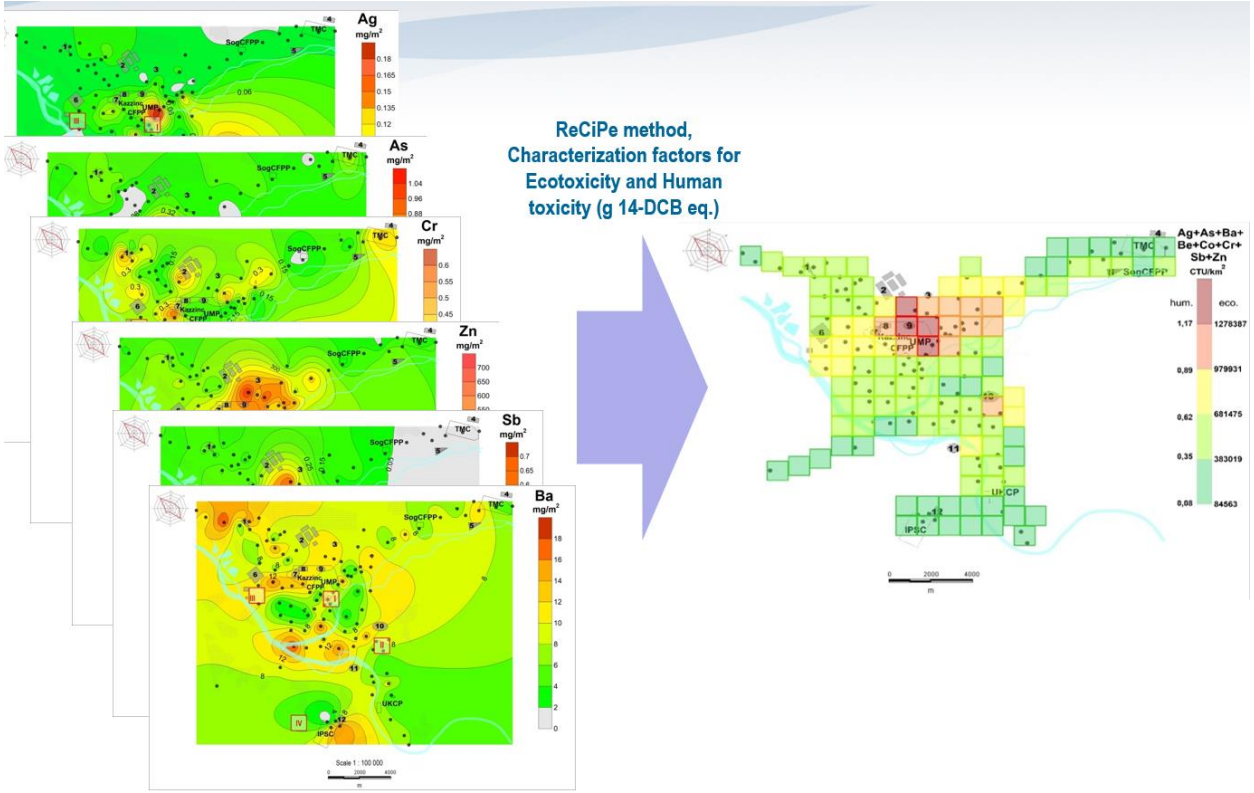
❑ Human Toxicity Footprint (local and regional aspect)

- ✓ Air monitoring data, Soil and tree leaves (bio-indicators) sampling and analysis
- ✓ Emission mapping

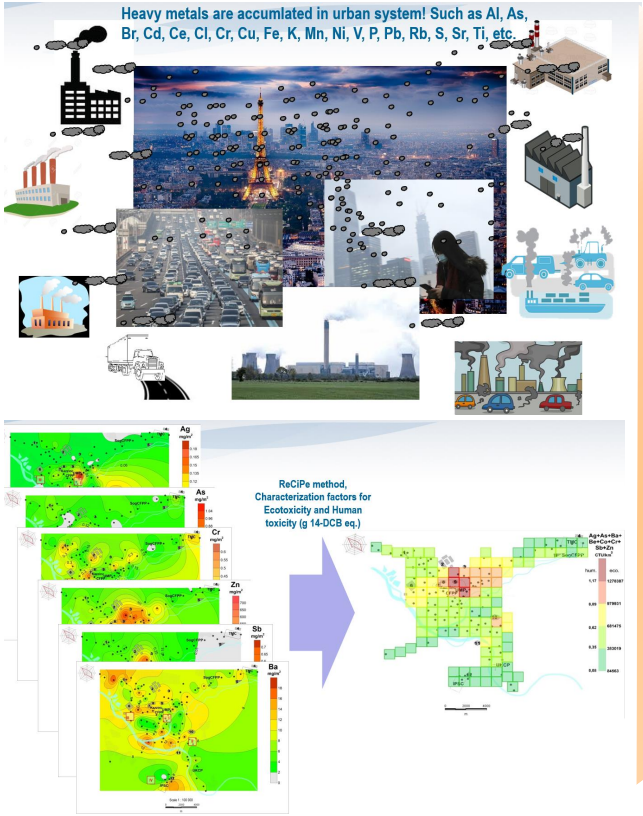


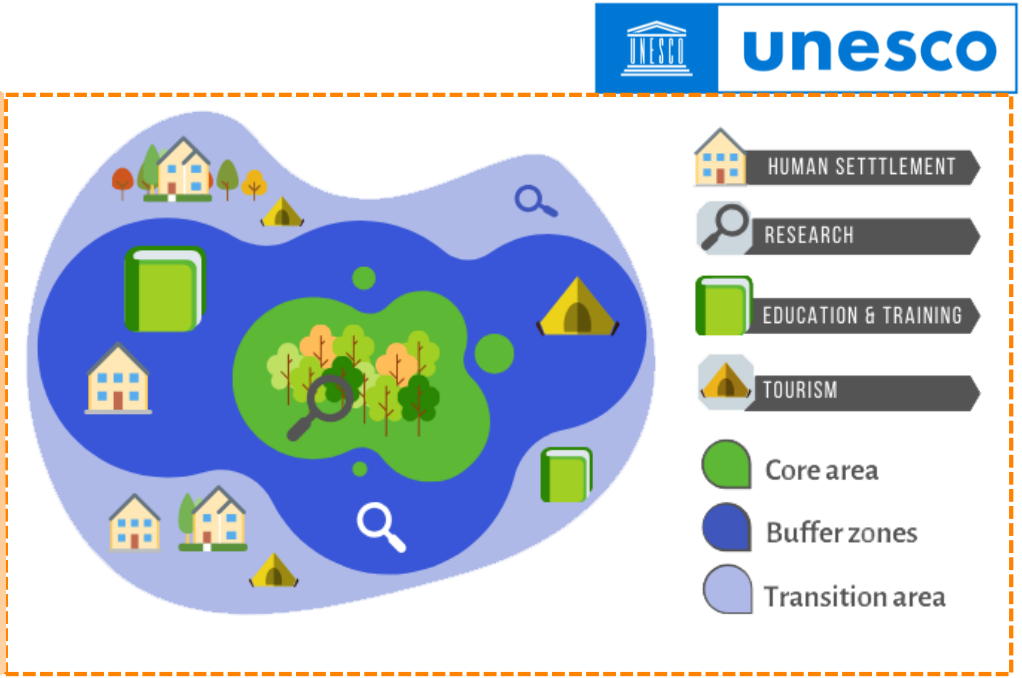
❑ Human Toxicity Footprint (local and regional aspect)

- ✓ Air monitoring data, Soil and tree leaves (bio-indicators) sampling and analysis
- ✓ Emission mapping to Toxicity mappling



❑ Human Toxicity Footprint in/for Biosphere Reserves





The Biosphere Reserves' three main zones

Thank you! Merci! 감사합니다!

Q & A