

# LCA Gasoline vs electric car

# Background and objective

## Background:

- The transportation sector generated 29% of greenhouse gas emissions in the USA in 2019, the largest share of emissions (US EPA 2021).
- Producing Lithium-Ion batteries involves mining and extracting specific metals and minerals, leading to considerable environmental impacts.

**Objective:** Compare the environmental impacts of a **gasoline** vs an **electric car**

Study various electricity sources and different distances driven over the car lifetime

# Function

PRODUCTS	MAIN FUNCTION	SECONDARY FUNCTION & OTHER PERFORMANCES
Product A  Product B	Human and goods transport	Feel good factor etc.

# environmental parameters

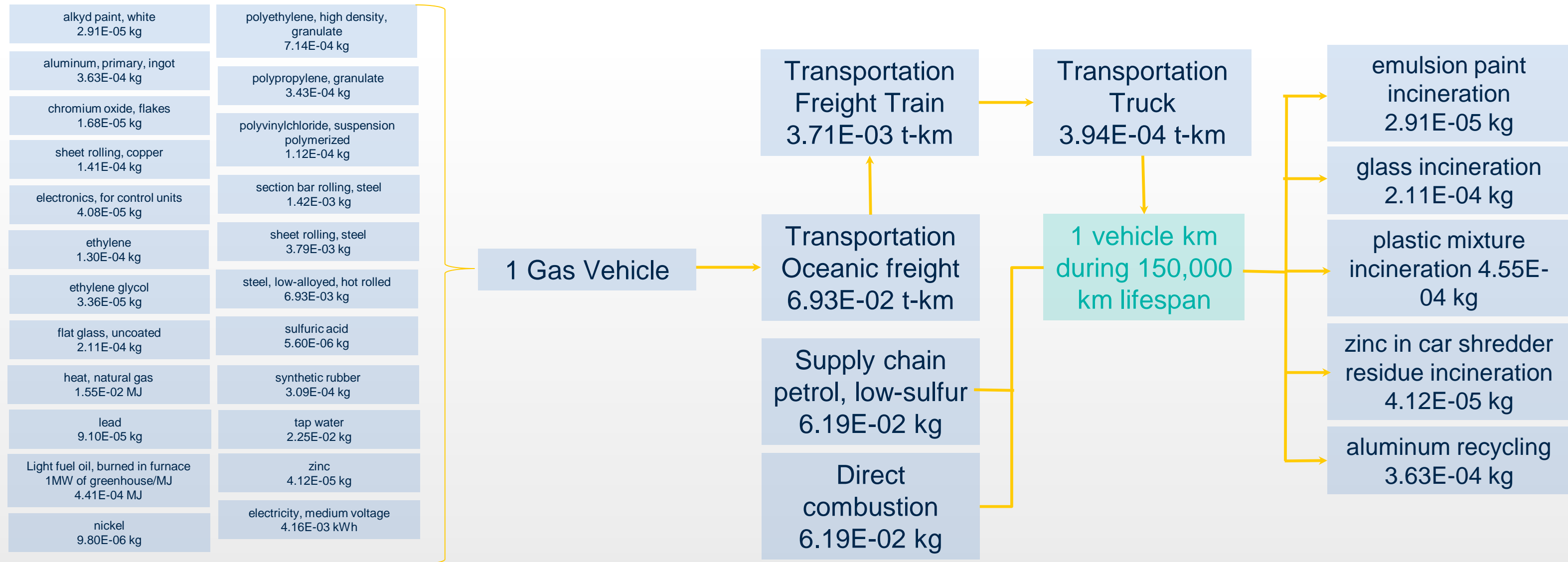
PRODUCTS OR SYSTEM	FUNCTIONAL UNIT (service offered)	REFERENCE FLOWS (what is purchased)	KEY ENVIRONMENTAL PARAMETERS (linking reference flows to functional unit)
Gasoline car	1 Vehicle km (V-km)	1/150,000 of a gas car  6.19 kg gas	Factors such as fuel efficiency, total distance driven over its lifetime, and car weight and material composition impact a vehicle's overall environmental footprint.
Electric car		1/225,000 of an electric car  0.26 kWh electricity	

# Assumptions

## **Lifetime distance:**

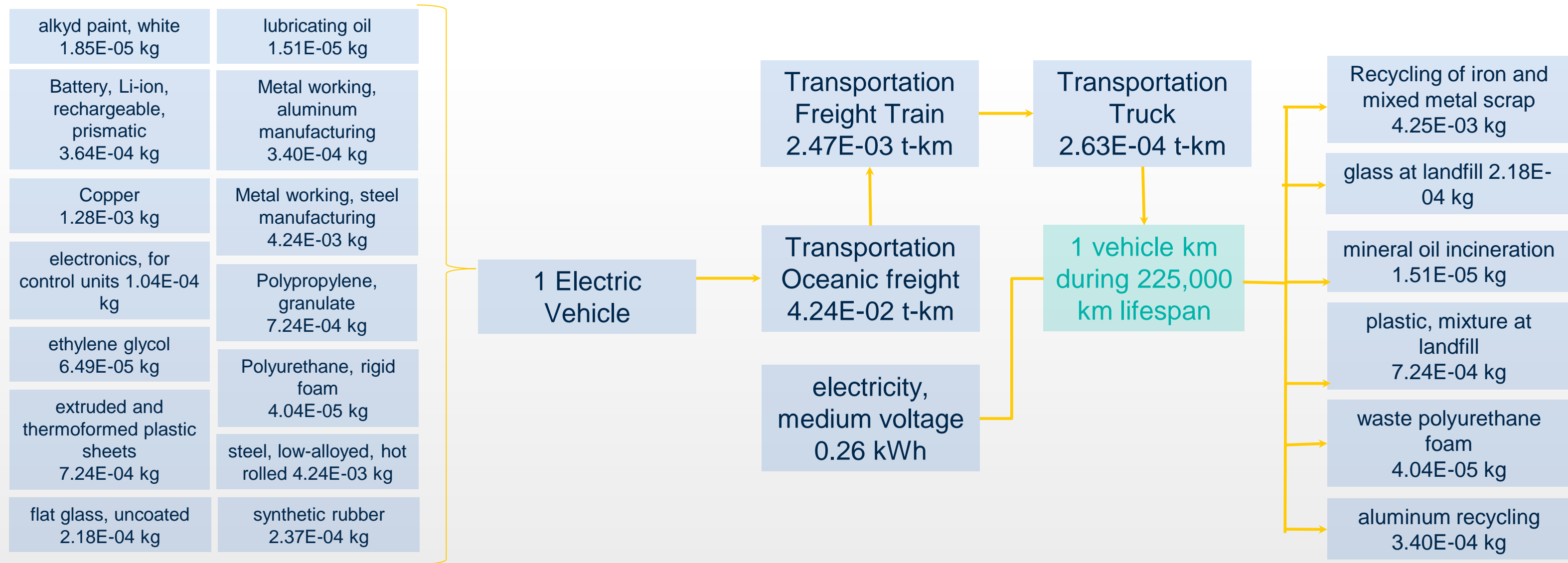
- Gasoline car: 150000 km
- Electric car: 1.5 x distance of the gasoline car
- Gasoline car: input data from ecoinvent documentation: petrol car 2010 x 1.05 for weights, and / 1.05 for consumption and emissions, consumption of 0.065/1.05 kg gasoline/V-km
- Electric car : input data from conference paper Tesla 3.0
- No battery replacement

# Process Tree: Gasoline car – summary Neil



Note: For direct comparisons, we assume the same weight and distances divided by a different lifespan. The exact numbers calculated will be different for transportation.

# Process Tree: Electric car summary Neil



Note: For direct comparisons, we assume the same weight and distances divided by a different lifespan. The exact numbers calculated will be different for transportation.

# Energy, CO<sub>2</sub> and CO<sub>2equ</sub> balance: Gasoline car

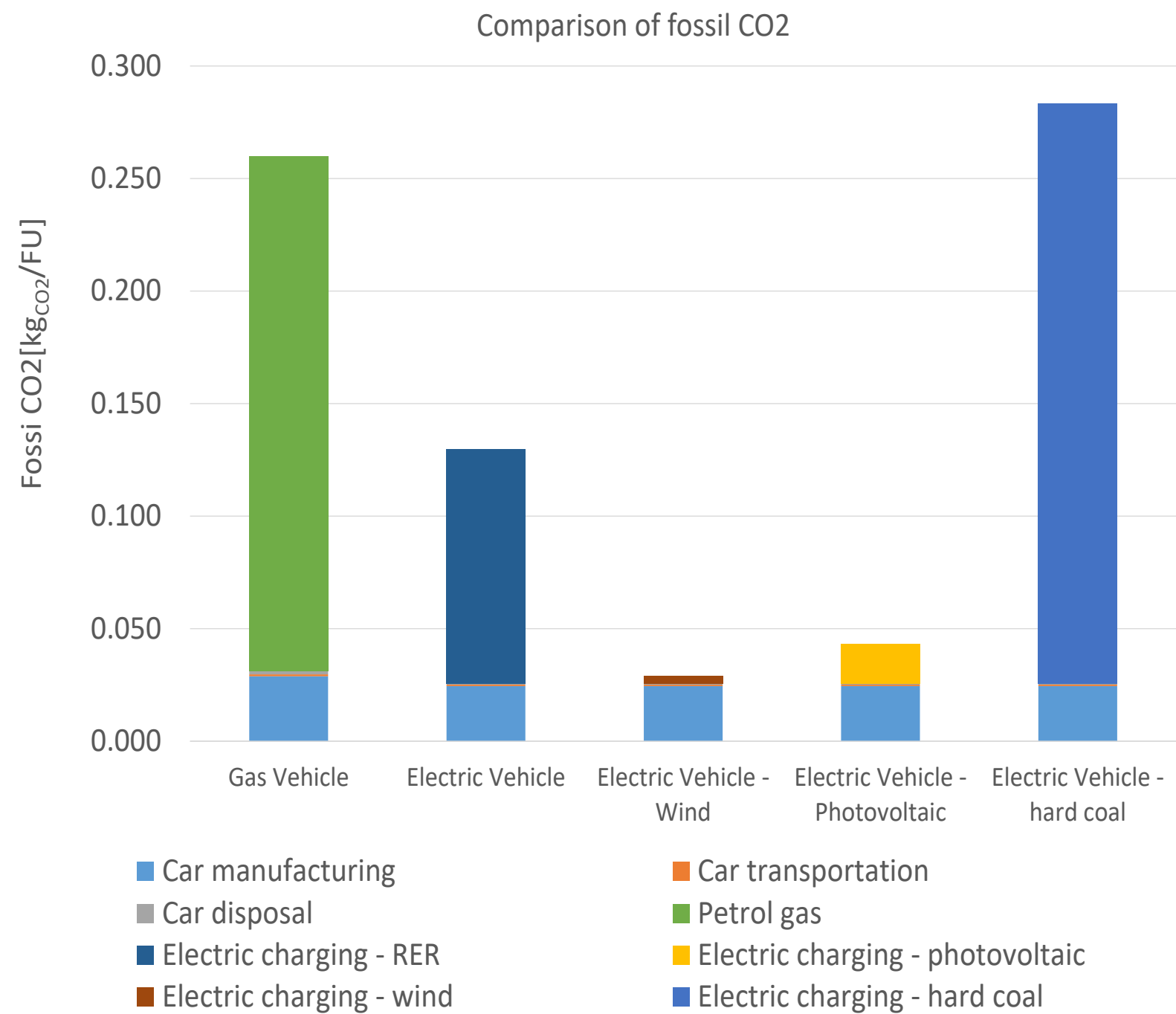
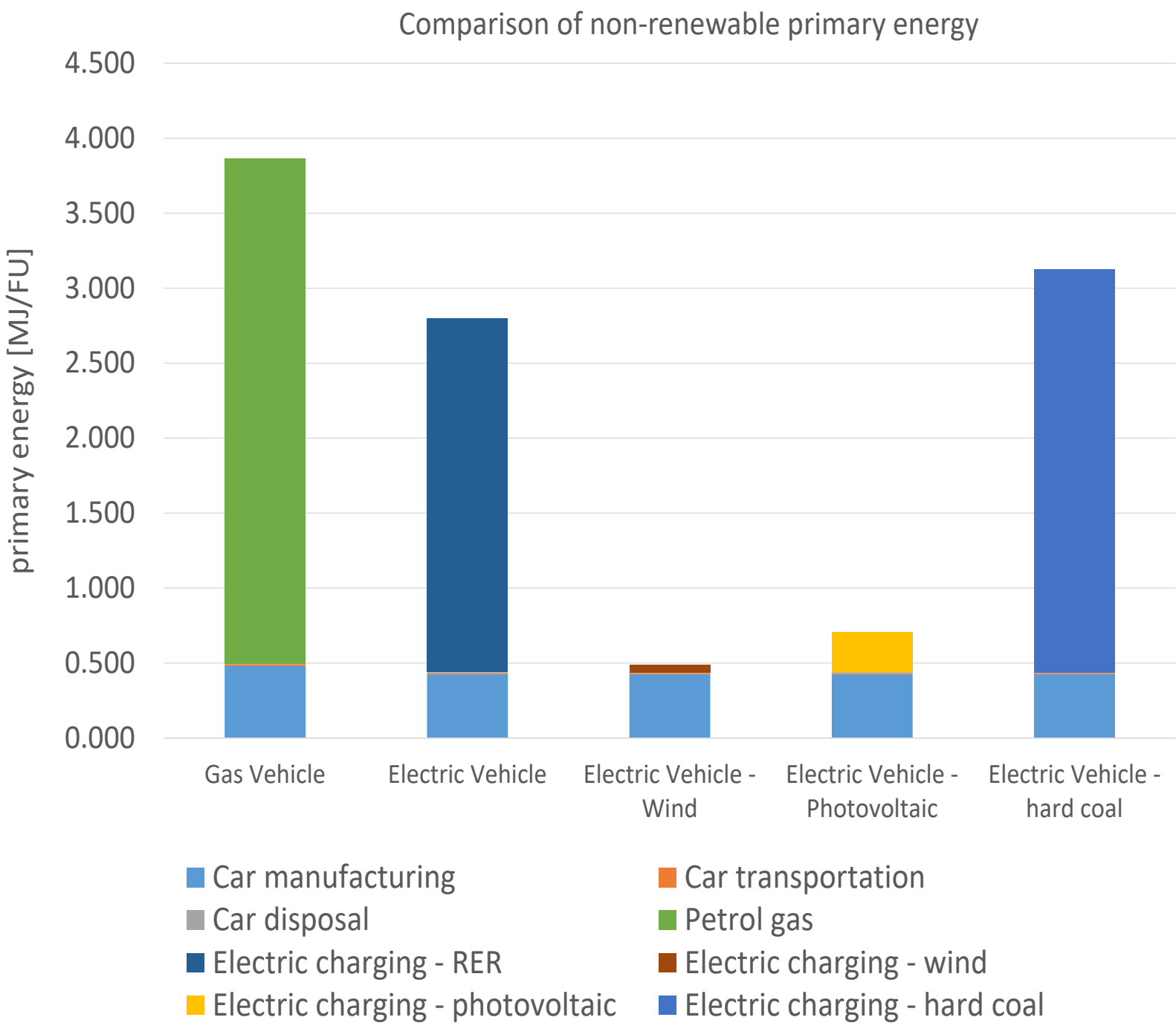
Transportation by Gas Vehicle FU= 1 vehicle km Life Cycle stage (150,000 km lifespan)	Quantity per FU	Unit	Energy/Unit [MJ/Unit]	Energy per FU [MJ/FU]	fraction	CO2/Unit [kg/unit]	CO2 fossil/FU	fraction2	Check g CO2/MJ	CO2equ/Unit [kg/unit]2	CO2equ./FU	fraction3
<b>Manufacturing (Materials + Processing)</b>												
alkyd paint, white, without solvent, in 60% so	2.91E-05	kg	61.91	1.80E-03	0.0%	4.89	1.42E-04	0.1%	79	5.44	1.58E-04	0.1%
aluminium, primary, ingot	3.63E-04	kg	218.90	7.94E-02	2.1%	19.25	6.98E-03	2.7%	88	20.97	7.61E-03	2.9%
chromium oxide, flakes	1.68E-05	kg	56.40	9.47E-04	0.0%	5.63	9.46E-05	0.0%	100	6.02	1.01E-04	0.0%
sheet rolling, copper	1.41E-04	kg	7.02	9.92E-04	0.0%	0.42	5.93E-05	0.0%	60	0.47	6.68E-05	0.0%
electronics, for control units	4.08E-05	kg	448.25	1.83E-02	0.5%	27.93	1.14E-03	0.4%	62	31.50	1.28E-03	0.5%
ethylene	1.30E-04	kg	66.77	8.65E-03	0.2%	1.13	1.46E-04	0.1%	17	1.45	1.88E-04	0.1%
ethylene glycol	3.36E-05	kg	49.88	1.68E-03	0.0%	1.29	4.33E-05	0.0%	26	1.52	5.10E-05	0.0%
flat glass, uncoated	2.11E-04	kg	11.44	2.41E-03	0.1%	0.96	2.02E-04	0.1%	84	1.01	2.14E-04	0.1%
heat, district or industrial, natural gas	1.55E-02	MJ	0.67	1.04E-02	0.3%	0.03	5.25E-04	0.2%	51	0.04	5.89E-04	0.2%
lead	9.10E-05	kg	16.67	1.52E-03	0.0%	1.22	1.11E-04	0.0%	73	1.36	1.24E-04	0.0%
Light fuel oil, burned in furnace 1MW of gree	4.41E-04	MJ	1.28	5.64E-04	0.0%	0.09	3.75E-05	0.0%	66	0.09	3.82E-05	0.0%
nickel, class 1	9.80E-06	kg	275.14	2.70E-03	0.1%	14.80	1.45E-04	0.1%	54	18.71	1.83E-04	0.1%
polyethylene, high density, granulate	7.14E-04	kg	79.36	5.67E-02	1.5%	1.92	1.37E-03	0.5%	24	2.32	1.65E-03	0.6%
polypropylene, granulate	3.43E-04	kg	77.07	2.64E-02	0.7%	1.52	5.20E-04	0.2%	20	1.90	6.52E-04	0.2%
polyvinylchloride, suspension polymerised	1.12E-04	kg	57.35	6.42E-03	0.2%	2.11	2.37E-04	0.1%	37	2.42	2.71E-04	0.1%
section bar rolling, steel	1.42E-03	kg	1.52	2.16E-03	0.1%	0.16	2.27E-04	0.1%	105	0.17	2.42E-04	0.1%
sheet rolling, steel	3.79E-03	kg	4.96	1.88E-02	0.5%	0.28	1.07E-03	0.4%	57	0.32	1.21E-03	0.5%
steel, low-alloyed, hot rolled	6.93E-03	kg	25.22	1.75E-01	4.5%	1.92	1.33E-02	5.1%	76	2.21	1.53E-02	5.8%
sulfuric acid	5.60E-06	kg	3.28	1.84E-05	0.0%	0.09	5.19E-07	0.0%	28	0.11	5.91E-07	0.0%
synthetic rubber	3.09E-04	kg	83.60	2.58E-02	0.7%	2.44	7.53E-04	0.3%	29	2.73	8.42E-04	0.3%
tap water	2.25E-02	kg	0.01	1.18E-04	0.0%	0.00	6.91E-06	0.0%	58	0.00	7.51E-06	0.0%
zinc	4.12E-05	kg	42.35	1.75E-03	0.0%	2.52	1.04E-04	0.0%	60	2.71	1.12E-04	0.0%
electricity, medium voltage	4.16E-03	kWh	9.07	3.77E-02	1.0%	0.40	1.67E-03	0.6%	44	0.43	1.78E-03	0.7%
<b>Transportation</b>												
transport, freight train	3.71E-03	t-km	0.70	0.003	0.07%	0.04	1.55E-04	0.1%	60	0.04	1.66E-04	0.1%
transport, freight, lorry 16-32 metric ton	3.94E-04	t-km	2.71	0.001	0.03%	0.17	6.52E-05	0.0%	61	0.17	6.77E-05	0.0%
transport, freight, sea, container ship	6.93E-02	t-km	0.13	0.009	0.23%	0.01	6.31E-04	0.2%	71	0.01	6.52E-04	0.2%
<b>Use phase</b>												
Supply chain petrol, low-sulfur	6.19E-02	kg	54.40	<b>3.368</b>	87.2%	0.58	0.036086	13.9%	11	0.64	3.93E-02	1.47E-01
Direct combustion	6.19E-02	kg	0.00	<b>0.000</b>	0.0%	3.11	0.192762	74.2%	<b>57</b>	3.11	<b>1.93E-01</b>	<b>7.22E-01</b>
<b>Disposal</b>												
emulsion paint incineration	2.91E-05	kg	1.83	5.34E-05	0.0%	1.11	3.23E-05	0.0%	606	1.12	3.27E-05	0.0%
glass incineration	2.11E-04	kg	0.27	5.70E-05	0.0%	0.01	2.35E-06	0.0%	41	0.01	2.83E-06	0.0%
plastic mixture incineration	4.55E-04	kg	0.48	2.20E-04	0.0%	2.33	1.06E-03	0.4%	4830	2.35	1.07E-03	0.4%
zinc in car shredder residue incineration	4.12E-05	kg	1.68	6.91E-05	0.0%	0.22	9.16E-06	0.0%	132	0.23	9.59E-06	0.0%
aluminium recycling	3.63E-04	kg	9.02	3.27E-03	0.1%	0.73	2.64E-04	0.1%	81	0.80	2.90E-04	0.1%
<b>Total</b>		-		<b>3.861</b>	100.0%		<b>0.260</b>	100.0%	67		<b>0.267</b>	100.0%



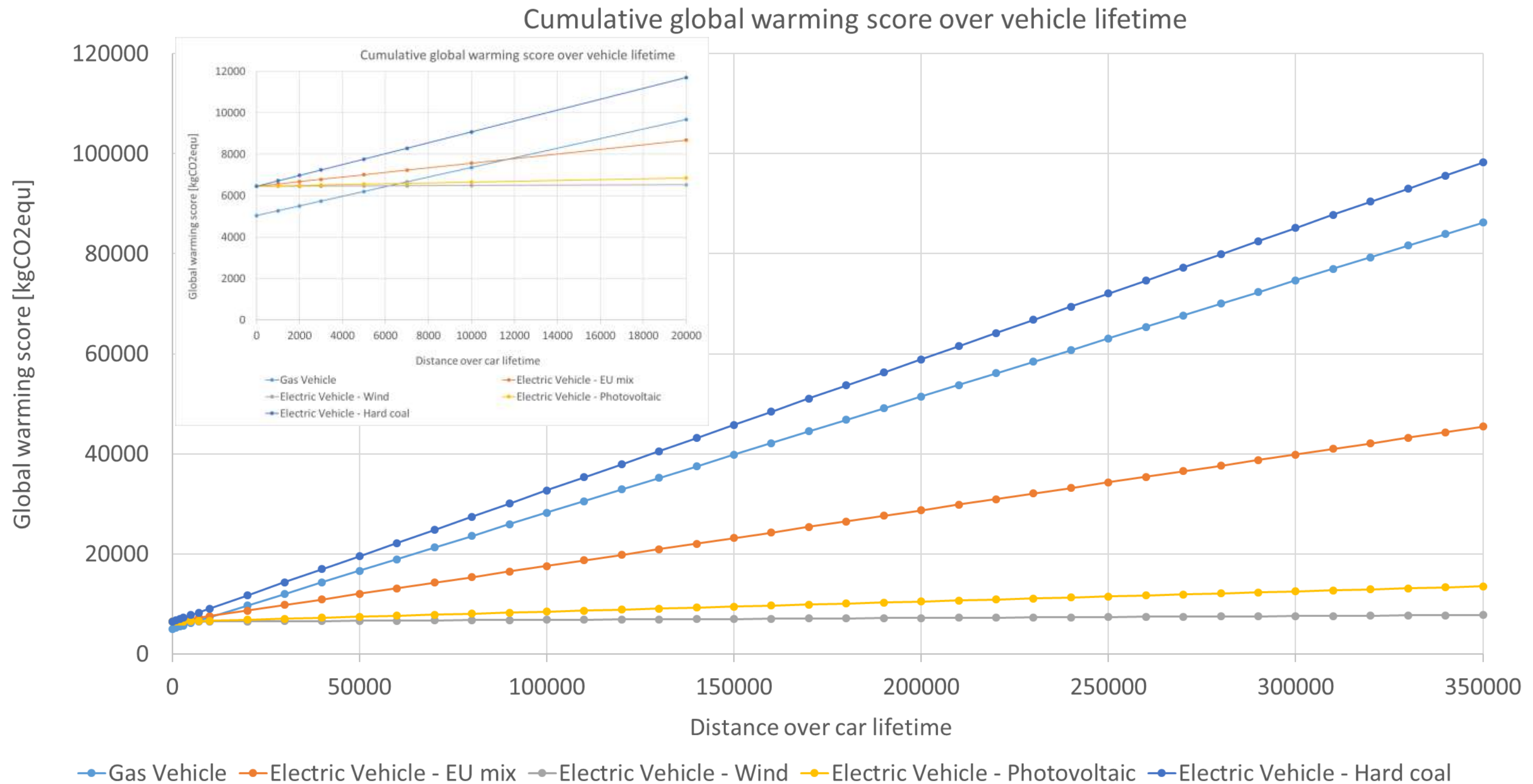
# Energy, CO<sub>2</sub> and CO<sub>2equ</sub> balance: Electric car

Transportation by Electric Vehicle FU= 1 vehicle km Life Cycle stage (225,000 km lifespan)	Quantity per FU	Unit	Energy/Unit [MJ/Unit]	Energy per FU [MJ/FU]	fraction	CO2/Unit [kg/unit]	CO2/FU	fraction2	Check g CO2/MJ	CO2equ/Unit [kg/unit]2	CO2equ./FU	fraction3
<b>Manufacturing (Materials + Processing)</b>												
alkyd paint, white, without solvent, in 60% solvent	1.85E-05	kg	61.91	1.14E-03	0.041%	4.89	9.04E-05	0.0%	79	5.44	1.01E-04	0.071%
Battery, Li-ion, rechargeable, prismatic	3.64E-04	kg	114.57	4.18E-02	1.5%	7.05	2.57E-03	2.0%	62	8.17	2.98E-03	2.1%
Copper	1.28E-03	kg	7.02	8.96E-03	0.3%	0.42	5.35E-04	0.4%	60	0.47	6.03E-04	0.4%
Electronics, for control units	1.04E-04	kg	448.25	4.64E-02	1.7%	27.93	2.89E-03	2.2%	62	31.50	3.26E-03	2.3%
ethylene glycol	6.49E-05	kg	49.88	3.24E-03	0.1%	1.29	8.36E-05	0.1%	26	1.52	9.84E-05	0.1%
extruded and thermoformed plastic sheets	7.24E-04	kg	14.30	1.04E-02	0.4%	0.97	7.00E-04	0.5%	68	1.08	7.81E-04	0.6%
flat glass, uncoated	2.18E-04	kg	11.44	2.49E-03	0.1%	0.96	2.09E-04	0.2%	84	1.01	2.21E-04	0.2%
lubricating oil	1.51E-05	kg	65.31	9.87E-04	0.0%	1.06	1.61E-05	0.0%	16	1.19	1.79E-05	0.0%
Metal working, average for aluminium products	3.40E-04	kg	45.98	1.56E-02	0.6%	3.46	1.18E-03	0.9%	75	4.06	1.38E-03	1.0%
Metal working, average for steel products	4.24E-03	kg	25.19	1.07E-01	3.8%	1.48	6.27E-03	4.8%	59	1.66	7.04E-03	5.0%
Polypropylene, granulate	7.24E-04	kg	77.07	5.58E-02	2.0%	1.52	1.10E-03	0.8%	20	1.90	1.38E-03	1.0%
Polyurethane, rigid foam	4.04E-05	kg	121.67	4.92E-03	0.2%	4.97	2.01E-04	0.2%	41	6.41	2.59E-04	0.2%
steel, low-alloyed, hot rolled	4.24E-03	kg	25.22	1.07E-01	3.8%	1.92	8.13E-03	6.3%	76	2.21	9.38E-03	6.7%
synthetic rubber	2.37E-04	kg	83.60	1.98E-02	0.7%	2.44	5.78E-04	0.4%	29	2.73	6.46E-04	0.5%
<b>Transportation</b>												
transport, freight train	2.47E-03	t-km	0.70	1.74E-03	0.1%	0.04	1.03E-04	0.1%	60	0.04	1.11E-04	0.1%
transport, freight, lorry 16-32 metric ton	2.63E-04	t-km	2.71	7.12E-04	0.0%	0.17	4.35E-05	0.0%	61	0.17	4.51E-05	0.0%
transport, freight, sea, container ship	4.24E-02	t-km	0.13	5.42E-03	0.2%	0.01	3.85E-04	0.3%	71	0.01	3.99E-04	0.3%
<b>Use phase</b>												
electricity, medium voltage RER	0.26	kWh	9.07	2.358	84.3%	0.40	0.104	80.2%	44	0.43	1.11E-01	79.1%
electricity, wind, 1-3MW turbine, onshore	0.26	kWh	0.20	0.051	10.3%	0.01	0.003	11.5%	66	0.01	3.77E-03	2.7%
electricity, photovoltaic, 570kWp open ground	0.26	kWh	1.03	0.267	37.8%	0.07	0.018	40.9%	67	0.08	2.03E-02	14.4%
electricity, hard coal	0.26	kWh	10.34	2.688	86.0%	0.99	0.258	91.0%	96	1.01	2.62E-01	186.2%
<b>Disposal</b>										0		
Recycling of iron and mixed metal scrap	4.25E-03	kg	0.73	3.10E-03	0.1%	0.05	2.18E-04	0.2%	70	0.09	3.82E-04	0.3%
glass at landfill	2.18E-04	kg	0.15	3.18E-05	0.0%	0.00	8.67E-07	0.0%	27	0.00	9.23E-07	0.0%
mineral oil incineration	1.51E-05	kg	0.25	3.73E-06	0.0%	2.84	4.29E-05	0.0%	11494	2.84	4.30E-05	0.0%
plastic, mixture at landfill	7.24E-04	kg	0.24	1.73E-04	0.0%	0.02	1.74E-05	0.0%	100	0.10	7.01E-05	0.0%
waste polyurethane foam	4.04E-05	kg	0.67	2.71E-05	0.0%	0.47	1.90E-05	0.0%	702	0.63	2.54E-05	0.0%
aluminium recycling	3.40E-04	kg	9.02	3.07E-03	0.1%	0.73	2.48E-04	0.2%	81	0.80	2.72E-04	0.2%
<b>Total</b>										0		0
Total EU electricity grid		-		<b>2.797</b>	100.0%		<b>0.130</b>	100.0%	46		<b>0.141</b>	52.8%
Total EU electricity wind		-		<b>0.490</b>	17.5%		<b>0.029</b>	22.3%	59		<b>0.033</b>	23.6%
Total EU electricity photovoltaic		-		<b>0.706</b>	25.2%		<b>0.043</b>	33.5%	61		<b>0.050</b>	35.3%
Total EU electricity hard coal		-		<b>3.128</b>	111.8%		<b>0.283</b>	218.6%	91		<b>0.292</b>	207.1%

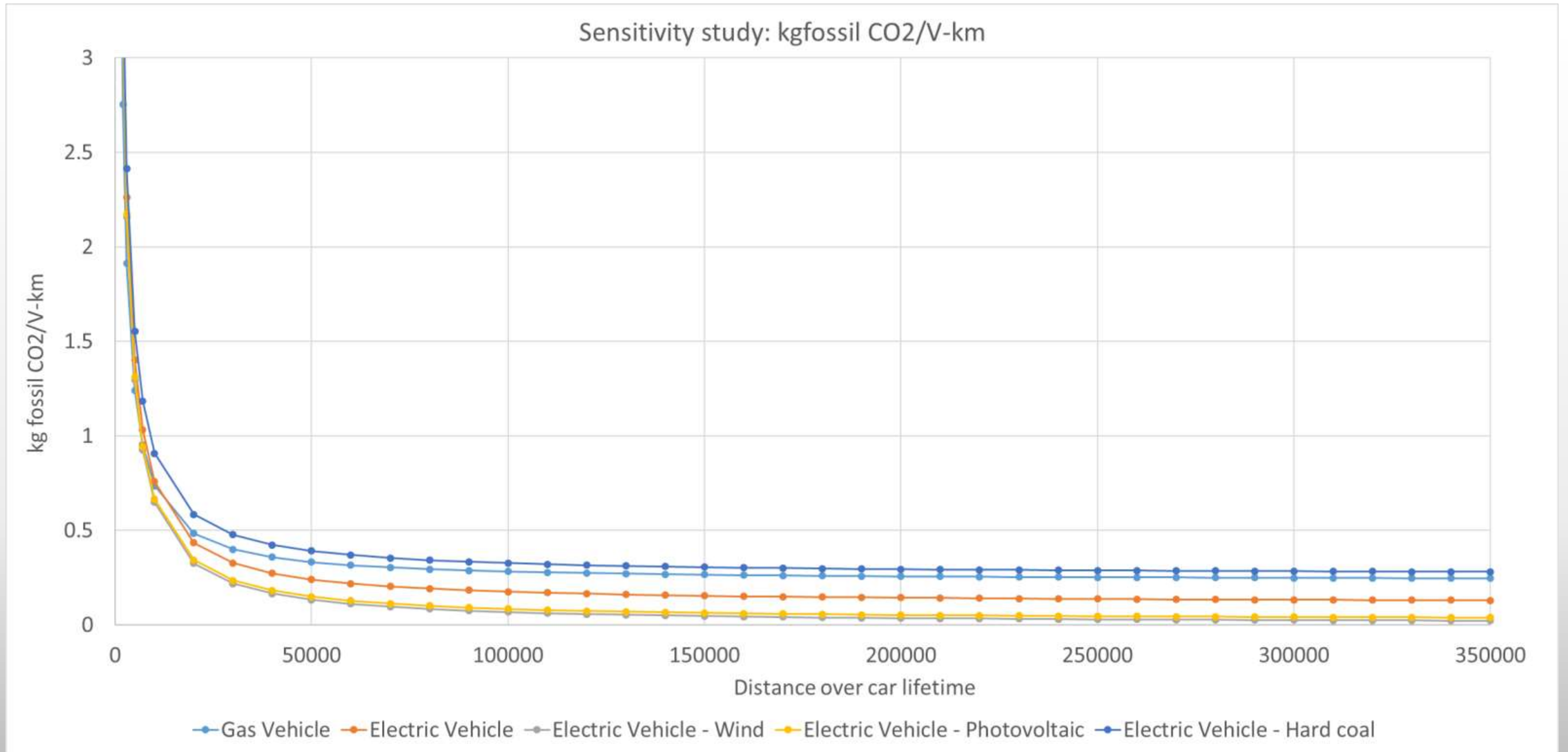
# Comparison of scenarios



# Sensitivity Analysis



# Sensitivity Analysis



# Summary

- The gas vehicle scenario generates higher environmental impacts in terms of energy use and carbon footprint compared to the electric vehicle with UCTE electricity, medium voltage production mix.
- However, the electric vehicle scenario with hard coal generates higher environmental impacts in terms of carbon footprint compared to the gas vehicle.
- The performance of electric vehicles drastically improves with wind or photovoltaic electricity – a key change towards sustainable consumption
- Use phase is dominant for the gasoline and the electric car with EU mix, but manufacturing has a substantial contribution with improved photovoltaic and wind electricity