Supplementary Information

LCA of a Proton Exchange Membrane Fuel Cell Electric Vehicle Considering Different Power System Architectures

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1. Manufacturing of Proton Exchange Membrane Fuel Cell

Table S1 Membrane production inventory.

MEMBRANE				
NAFION				
Inputs	**amount**	**unit**	**remarks**	**source**
tetrafluoroethylene (TFE), at plant, EU	0.50698	kg		[1]
sulfuric acid, at plant, EU	0.37674	kg		
titanium dioxide, at plant, EU	0.08837	kg		
transport, freight, rail, EU	0.00058	tkm		
transport, freight, road, Euro5, EU	0.00010	tkm		
Output	**amount**	**unit**	**remarks**	**source**
Nafion	1	kg		[1]
NAFION DISPERSION SOLUTION				
Inputs	**amount**	**unit**	**remarks**	**source**
Isopropanol	0.75	kg		[1]
Nafion	1	kg		
Water (desalinated; deionized)	0.75	kg		
Output	**amount**	**unit**	**remarks**	**source**
Nafion dispersion solution	2.5	kg	intermediate product	[1]
ROLL COATING				
Inputs	**amount**	**unit**	**remarks**	**source**
Electricity	0.13	MJ		[1]
Nafion dispersion solution	2.5	kg	see Nafion dispersion solution	
Polyethylene-film (PE)	1.37	kg		
Thermal energy (MJ)	0.71	MJ		

Output	amount	unit	remarks	source
Coated Nafion film	3.87	kg	intermediate product	[1]
LAMINATION				
Inputs	**amount**	**unit**	**remarks**	**source**
RER: polypropylene, granulate, at plant	0.00655	kg		[1]
Electricity	1.02	MJ		
Coated Nafion film	3.87	kg		
Output	**amount**	**unit**	**remarks**	**source**
Nafion cast dispersion membrane	1	kg	Final product	[1]

Table S2 Gas diffusion layer production inventory.

GAS DIFFUSION LAYER – thermoforming				
Inputs	**amount**	**unit**	**remarks**	**source**
Steam (MJ)	0.085	MJ		[1]
RER: heat, natural gas, at industrial furnace >100kW	0.169	MJ		
PTFE	0.1	kg		
Electricity	3.58	MJ		
CN: graphite, battery grade, at plant	0.05	kg		
CH: heat, heavy fuel oil, at industrial furnace 1MW	0.222	MJ		
carbon cloth (fiber)	0.9	kg		
Output	**amount**	**unit**	**remarks**	**source**
Gas diffusion layer	1	kg	Final product	[1]

Table S3 Inventory for the production of PTFE and Carbon fiber for GDLs.

GAS DIFFUSION LAYER				
POLYTETRAFLUOROETHYLENE (PTFE)				
Inputs	**amount**	**unit**	**remarks**	**source**
Water (desalinated; deionized)	0.003	kg		[1]
RER: tetrafluoroethylene, at plant	0.097	kg		
Borax	$4.26 \cdot 10^{-5}$	kg		
Ammonium sulfate/RER	0.0057	kg		
Output	**amount**	**unit**	**remarks**	**source**
PTFE	0.1	kg	intermediate product	[1]
CARBON FIBER				
Inputs	amount	unit	remarks	source
Thermal energy	88.7	MJ		[1]
Polyacrylonitrile fiber (PAN)	0.9	kg	Propylene 0.9kg; ammonia 0.36kg	
Electricity	235.87	MJ		
Output	**amount**	**unit**	**remarks**	**source**
Carbon fiber	0.9	kg	intermediate product	[1]

Table S4 Catalyst layer production inventory.

CATALYST LAYER				
BALL MILLING				
Inputs	**amount**	**unit**	**remarks**	**source**
Water (desalinated; deionized)	0.037	kg		[1]
NAFION DE-521 solution	0.41	kg		
Methanol	0.037	kg		
Electricity	473.32	MJ		
Pt/C	0.034	kg		
Carbon black	0.05	kg		
Output	**amount**	**unit**	**remarks**	**source**
Catalyst ink	0.568	kg	intermediate product	[1]
SPRAY COATING				
Inputs	**amount**	**unit**	**remarks**	**source**
Nafion membrane	0.432	kg		[1]
Catalyst ink	0.568	kg		
Output	**amount**	**unit**	**remarks**	**source**
Coated membrane	1	kg	intermediate product	[1]
ROLL CALENDARING				
Inputs	**amount**	**unit**	**remarks**	**source**
Electricity	39.18	MJ		[1]
Coated membrane	1	kg		
Output	**amount**	**unit**	**remarks**	**source**
Catalyzed membrane	1	kg		[1]

Table S5 Production of Nafion and Pt on carbon for catalyst layer.

CATALYST LAYER				
NAFION DE-521 SOLUTION				
Inputs	**amount**	**unit**	**remarks**	**source**
Water (desalinated; deionized)	0.184	kg		[1]
RER: 1-propanol, at plant	0.2045	kg		
Polyethylene low linear density granulate (LLDPE/PE-LLD)	0.02045	kg		
Output	**amount**	**unit**	**remarks**	**source**
Nafion DE-521 solution	0.409	kg	intermediate product	[1]
CARBON PRETREATMENT				
Inputs	**amount**	**unit**	**remarks**	**source**
potassium hydroxide, at regional storage/RER	4	g		[1]
water, deionized	0.07	kg		
carbon black, at plant/GLO	1.4	g		
tap water, at user/RER	0.28	kg		

electricity, medium voltage, at grid/IT	442.2	kJ		
heat, natural gas, at industrial furnace >100kW/RER	34	kJ		
Output	**amount**	**unit**	**remarks**	**source**
carbon pretreatment	1.4	g		[1]
Pt/C				
Inputs	**amount**	**unit**	**remarks**	**source**
carbon pretreatment	1.715	g		[1]
water, deionized, at plant/CH	1.056	kg		
Platinum, secondary, at refinery/RER	0.23	g		
sodium borates ROW | production	0.368	g		
electricity, medium voltage, at grid/IT	158.5	kJ		
heat, natural gas, at industrial furnace >100kW/RER	56.5	kJ		
Output	**amount**	**unit**	**remarks**	**source**
Pt/C	1	g		[1]

Table S6 MEA assembly inventory.

MEA ASSEMBLY				
HOT PRESSING				
Inputs	**amount**	**unit**	**remarks**	**source**
Gas diffusion layers	0.84	kg		[1]
Catalyzed membrane	0.16	kg		
Electricity	5.248	MJ		
Output	**amount**	**unit**	**remarks**	**source**
MEA, uncut	1	kg		[1]
DIE CUTTING				
Inputs	**amount**	**unit**	**remarks**	**source**
Electricity	0.262	MJ		[1]
MEA, uncut	1	kg		
Output	**amount**	**unit**	**remarks**	**source**
MEA	1	kg	Final product	[1]

Table S7 Bipolar plates production inventory.

BIPOLAR PLATES				
GRAPHITE COMPOSITE				
Inputs	**amount**	**unit**	**remarks**	**source**
graphite, battery grade, at plant	0.7175	kg		[1]
Vinyl acetate (acetic acid vinyl ester, VAM)	0.3075	kg		
Output	**amount**	**unit**	**remarks**	**source**
Graphite composite	1.025	kg	Intermediate product	[1]

COMPRESSION MOLDING				
Inputs	**amount**	**unit**	**remarks**	**source**
Electricity	21.525	MJ		[1]
Graphite composite	1.025	kg		
Output	**amount**	**unit**	**remarks**	**source**
Bipolar plate intermediate product	1	kg	Intermediate product	[1]
Waste for recovery (incineration)	0.025	kg	Assuming 2.5% material loss	
POST BAKING				
Inputs	**amount**	**unit**	**remarks**	**source**
Bipolar plate intermediate product	1	kg		[1]
Electricity	0.7236	MJ		
Output	**amount**	**unit**	**remarks**	**source**
Bipolar plate	1	kg	Final product	[1]

Table S8 Gaskets, end plates, and fittings production inventory.

COOLANT GASKETS, END PLATES, FITTINGS				
DIE CUTTING				
Inputs	**amount**	**unit**	**remarks**	**source**
Electricity	0.127	MJ		[1]
RER: synthetic rubber, at plant	1	kg		
Output	**amount**	**unit**	**remarks**	**source**
Coolant gaskets	1	kg		[1]
END PLATES AND FITTINGS				
Inputs	**amount**	**unit**	**remarks**	**source**
RER: aluminum, production mix, cast alloy, at plant	0.503	kg		[1]
RER: steel product manufacturing, average metal working	0.497	kg		
Output	**amount**	**unit**	**remarks**	**source**
End plates and tie-rods	1	kg		[1]

2. Manufacturing of balance of plant, converters, and hydrogen tank

Table S9 Inventory of the production of the balance of plant.

BALANCE OF PLANT				
Inputs	**amount**	**unit**	**remarks**	**source**
Steel, low-alloyed, at plant/RER	3.470	kg		[2]
Reinforcing steel, at plant/RER	60.370	kg		
Aluminum, production mix, at plant/RER	3.470	kg		
Polyphenylene sulfide, at plant/GLO	7.633	kg		
Synthetic rubber, at plant/RER	1.388	kg		
Tetrafluoroethylene film, on glass/RER	0.634	kg		
Transport, lorry>16t, fleet average/RER	7.696	tkm		
Transport, freight, rail/RER	19.255	tkm		
Output	**amount**	**unit**	**remarks**	**source**
BoP	76.33	kg	Final Product	

Table S10 Converters production inventory.

CONVERTERS				
FUEL CELL CONVERTER				
Inputs	**amount**	**unit**	**remarks**	**source**
iron sinter [RER]| iron sinter production	11.92	kg	magnetic core	
copper, at regional storage/RER	4.5	kg		
capacitor, film, through-hole mounting, at plant/GLO	0.28	kg		
transistor, auxiliaries and energy use [GLO]|production	0.03	kg		
diode, unspecified, at plant/GLO	0.25	kg		
Output	**amount**	**unit**	**remarks**	**source**
FC converter	16.98	kg		
BATTERY CONVERTER				
Inputs	**amount**	**unit**	**remarks**	**source**
iron sinter [RER]| iron sinter production	4.16	kg	magnetic core	
copper, at regional storage/RER	3.5	kg		
capacitor, film, through-hole mounting, at plant/GLO	0.056	kg		
transistor, auxiliaries and energy use [GLO]|production	0.32	kg		
Output	**amount**	**unit**	**remarks**	**source**
Battery converter	8.036	kg		

Table S11 Hydrogen tank production inventory.

HYDROGEN TANK				
Inputs	**amount**	**unit**	**remarks**	**source**
aluminum, primary, at plant/RER	7.09	kg		[2]
carbon fiber cloth	19.78	kg		
electricity	12.87	MJ		
epoxy resin, liquid, at plant/RER	29.67	kg		
glass fiber, at plant/RER	5.6	kg		
polyethylene, HDPE, granulate, at plant/RER	10.26	kg		
polyurethane, flexible foam, at plant/RER	4.67	kg		
steel, low-alloyed, at plant/RER	10.64	kg		
Output	**amount**	**unit**	**remarks**	**source**
Hydrogen tank	87.71	kg		

3. Manufacturing of battery pack

Table S12 Battery cell and battery pack production inventory.

BATTERY PACK				
BATTERY CELL				
Inputs	**amount**	**unit**	**remarks**	**source**
Anode	0.39	kg		[3]
Cathode	0.43	kg		
Electrolyte	0.16	kg		
Separator	0.022	kg		
Cell container	0.0067	kg		
Output	**amount**	**unit**	**remarks**	**source**
Battery cell	1	kg		[3]
BATTERY PACK				
Inputs	**amount**	**unit**	**remarks**	**source**
Cooling system	1.73184	kg		[3]
Battery cell	25.344	kg		
Battery packaging	13.5168	kg		
BMS	1.56288	kg		
electricity, medium voltage, at grid/NO	0.016896	kWh		
facilities precious metal refinery/SE/unit	$8.0256 \cdot 10^{-7}$	p		
transport, lorry >16t, fleet average/RER	6.7584	tkm		
transport, transoceanic freight ship/OCE	206.976	tkm		
Output	**amount**	**unit**	**remarks**	**source**
Battery pack	42.24	kg		[3]
heat, waste/air/unspecified	0.1816	MJ	heat emission	

Table S13 Inventory for the production of anode, cathode, and electrolyte of the battery cell.

BATTERY				
LITHIUM MANGANESE OXIDE				
Inputs	**amount**	**unit**	**remarks**	**source**
Manganese (III) oxide [RoW] production	0.918	kg		[4]
Lithium carbonate, at plant/GLO	0.215	kg		
Oxygen, liquid, at plant/RER	0.715	kg		
Nitrogen, liquid, at plant/RER	0.786	kg		
Water, deionized, at plant/CH	3.4	kg		
electricity, medium voltage, at grid/IT	0.005	kWh		
heat, natural gas, at industrial furnace >100kW/RER	15.3	MJ		
transport, lorry >16t, fleet average/RER	0.564	tkm		
Transport_freight_rail/RER U	3.23	tkm		
chemical plant, organics	$4.00 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**

Lithium manganese oxide - cathode	1	kg		[4]
ANODE				
Inputs	**amount**	**unit**	**remarks**	**source**
Latex, at plant/RER	0.0185	kg		[4]
Water, deionized, at plant/CH	0.424	kg		
Graphite, battery grade/RoW production	0.494	kg		
Carbon black, at plant/GLO	0.0159	kg		
Copper, at regional storage/RER	0.57	kg		
sulfuric acid, liquid, at plant/RER	0.0808	kg		
heat, natural gas, at industrial furnace >100kW/RER	1.22	MJ		
electricity, medium voltage, at grid/IT	0.002	kWh		
transport, lorry >16t, fleet average/RER	0.113	tkm		
Transport_freight_rail/RER U	0.47	tkm		
chemical plant, organics	$4.00 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Anode for Li-ion battery	1	kg		[4]
LITHIUM HEXAFLUOROPHOSPHATE				
Inputs	**amount**	**unit**	**remarks**	**source**
lithium fluoride [RoW] production	0.197	kg		[4]
phosphorous pentachloride [RoW] production	1.98	kg		
hydrogen fluoride, at plant/GLO	4.04	kg		
Nitrogen, liquid, at plant/RER	0.00125	kg		
lime, hydrated, packed, at plant/CH	7.44	kg		
Electricity, medium voltage, at grid/IT	0.539	kWh		
electricity, medium voltage, at grid/IT	0.002	kWh		
transport, lorry >16t, fleet average/RER	1.37	tkm		
Transport_freight_rail/RER U	8.19	tkm		
chemical plant, organics	$4.00 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
lithium hexafluorophosphate - electrolyte	1	kg		[4]

Table S14 Inventory for the production of battery cell auxiliaries.

BATTERY CELL AUXILIARIES				
SEPARATOR				
Inputs	**amount**	**unit**	**remarks**	**source**
Polypropylene, granulate, at plant/RER	1	kg	Polyolefin	[3]
injection molding/RER	1	kg	Proxy for production of separator	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
plastics processing factory/RER/unit	$7.40 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**

Separator	1	kg		[3]
CELL CONTAINER				
Inputs	**amount**	**unit**	**remarks**	**source**
Aluminum Tab	0.22	kg		[3]
Copper Tab	0.38	kg		
Multilayer pouch	0.4	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
Output	**amount**	**unit**	**remarks**	**source**
Cell container	1	kg		[3]
ALUMINUM TAB				
Inputs	**amount**	**unit**	**remarks**	**source**
aluminum, production mix, at plant, RER	1	kg		[3]
sheet rolling, aluminum/RER	1	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
aluminum casting, plant/RER/unit	$1.50 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Aluminum Tab	1	kg		[3]
COPPER TAB				
Inputs	**amount**	**unit**	**remarks**	**source**
copper, primary, at refinery/GLO	0.85	kg	Tab, primary copper share	[3]
copper, secondary, at refinery/RER	0.15	kg	Tab, secondary copper share	
sheet rolling, copper/RER	1	kg	Production of copper tab	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$4.60 \cdot 10^{-10}$	p	facility	
Output	**amount**	**unit**	**remarks**	**source**
Copper Tab	1	kg		[3]
MULTILAYER POUCH				
Inputs	**amount**	**unit**	**remarks**	**source**
aluminum, production mix, at plant, RER	0.5	kg	Aluminum	[3]
polyethylene terephthalate, granulate, at plant	0.078	kg	PETP	
nylon 6, at plant/RER	0.08	kg	Oriented nylon	
Polypropylene, granulate, at plant/RER	0.32	kg	PP	
packaging film, LDPE, at plant/RER	0.025	kg	Dry lamination	
injection molding/RER	0.47	kg	Production of nylon, PP or PETP	

sheet rolling, aluminum/RER	0.5	kg	Production of Al material in pouch	
aluminum casting, plant/RER/unit	$7.70 \cdot 10^{-11}$	p		
plastics processing factory/RER/unit	$3.50 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Multilayer pouch	1	kg		[3]

Table S15 Battery packaging production inventory.

BATTERY PACKAGING				
MODULE PACKAGING				
MODULE FASTENERS				
Inputs	**amount**	**unit**	**remarks**	**source**
steel, low-alloyed, at plant/RER	0.96	kg	Total fasteners, steel	[3]
nylon 6, at plant/RER	0.042	kg	washer, nylon	
steel product manufacturing, avg metal working/RER	0.96	kg	process	
injection molding/RER	0.042	kg	process	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$4.40 \cdot 10^{-10}$	p	facility	
plastics processing factory/RER/unit	$3.10 \cdot 10^{-11}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Module fasteners	1	kg		
OUTER FRAME				
Inputs	**amount**	**unit**	**remarks**	**source**
nylon 66, glass-filled, at plant/RER	0.3	kg	Cassette outside frame, zytel	[3]
aluminum, production mix, at plant, RER	0.7	kg	Heat transfer plate, anodized aluminum	
injection molding/RER	0.3	kg	production cassette outside frame	
anodizing, aluminum sheet/RER/m2	0.03	m2	anodizing heat transfer plate	
sheet rolling, aluminum/RER	0.7	kg	production of heat transfer plate	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
plastics processing factory/RER/unit	$2.20 \cdot 10^{-10}$	p	facility	
aluminum casting, plant/RER/unit	$1.10 \cdot 10^{-10}$	p	facility	
Output	**amount**	**unit**	**remarks**	**source**
Outer frame	1	kg		[3]
INNER FRAME				
Inputs	**amount**	**unit**	**remarks**	**source**

nylon 66, glass-filled, at plant/RER	0.35	kg	Cassette inside frame, zytel	[3]
aluminum, production mix, at plant/RER	0.65	kg	Heat transfer plate, anodized aluminum	
injection molding/RER	0.35	kg	production of cassette inside frame	
anodizing, aluminum sheet/RER/m^2	0.03	m^2	anodizing heat transfer plate	
sheet rolling, aluminum/RER	0.65	kg	production of transfer plate	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
plastics processing factory/RER/unit	$2.60 \cdot 10^{-10}$	p	facility	
aluminum casting, plant/RER/unit	$1.00 \cdot 10^{-10}$	p	facility	
Output	**amount**	**unit**	**remarks**	**source**
Inner frame	1	kg		[3]
BIMETALLIC BUSBARS AND WASHERS				
Inputs	**amount**	**unit**	**remarks**	**source**
aluminum, production mix, at plant/RER	0.25	kg	busbar and washer, aluminum (30%)	[3]
copper, primary, at refinery/GLO	0.49	kg	busbar and washer, copper (70%*85%, primary)	
copper, secondary, at refinery/RER	0.086	kg	busbar and washer, copper (70%*15%, secondary)	
acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER	0.17	kg	Double busbar holder	
aluminum product manufacturing, avg metal working/RER	0.25	kg		
copper product manufacturing, avg metal working/RER	0.57	kg		
injection molding/RER	0.17	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$3.80 \cdot 10^{-10}$	p		
plastics processing factory/RER/unit	$1.30 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
bimetallic busbars and washers	1	kg		[3]
ALUMINUM END-BUSBARS				
Inputs	**amount**	**unit**	**remarks**	**source**
aluminum, production mix, at plant/RER	0.91	kg	Endbusbar, aluminum	[3]
acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER	0.091	kg	Endbusbar holder, ABS	

aluminum product manufacturing, avg metal working/RER	0.91	kg	Production of aluminum parts	
injection molding/RER	0.091	kg	Production of endbusbar holder	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
aluminum casting, plant/RER/unit	$1.40 \cdot 10^{-10}$	p		
plastics processing factory/RER/unit	$6.70 \cdot 10^{-11}$	p		
Output	**amount**	**unit**	**remarks**	**source**
End-busbar, aluminum	1	kg		[3]
COPPER END-BUSBARS				
Inputs	**amount**	**unit**	**remarks**	**source**
copper, primary, at refinery/GLO	0.82	kg	Endbusbar, primary copper	[3]
copper, secondary, at refinery/RER	0.15	kg	Endbusbar, secondary copper	
acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER	0.031	kg	Endbusbar holder, ABS	
copper product manufacturing, avg metal working/RER	0.97	kg	Production of Cu endbusbar	
injection molding/RER	0.031	kg	Production of endbusbar holder	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$4.40 \cdot 10^{-10}$	p		
plastics processing factory/RER/unit	$2.30 \cdot 10^{-11}$	p		
Output	**amount**	**unit**	**remarks**	**source**
End-busbar, copper	1	kg		[3]
MODULE LID				
Inputs	**amount**	**unit**	**remarks**	**source**
acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER	1	kg	plastic lid	[3]
injection molding/RER	1	kg	production of lid	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
plastics processing factory/RER/unit	$7.40 \cdot 10^{-10}$	p	facility	
Output	**amount**	**unit**	**remarks**	**source**
Module lid	1	kg		[3]
MODULE PACKAGING				
Inputs	**amount**	**unit**	**remarks**	**source**
Module fasteners	0.048	kg		[3]
Outer frame	0.48	kg		
Inner frame	0.4	kg		
Bimetallic busbars and washers	0.034	kg		
End-busbar, aluminum	0.0016	kg		

End-busbar, copper	0.0049	kg		
Module lid	0.028	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
facilities precious metal refinery/SE/unit	$1.90 \cdot 10^{-8}$	p	infrastructure	
Output	**amount**	**unit**	**remarks**	**source**
Module packaging	1	kg		[3]
BATTERY RETENTION				
STRAP RETENTION				
Inputs	**amount**	**unit**	**remarks**	**source**
steel, low-alloyed, at plant/RER	0.49	kg	screws, bolts, and retainer plate	[3]
nylon 6, at plant/RER	0.13	kg	straps	
Polypropylene, granulate, at plant/RER	0.38	kg	bracket	
steel product manufacturing, avg metal working/RER	0.49	kg	production of steel products	
injection molding/RER	0.51	kg	production of straps and bracket	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$2.20 \cdot 10^{-10}$	p		
plastics processing factory/RER/unit	$3.80 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Strap retention	1	kg		[3]
LOWER RETENTION				
Inputs	**amount**	**unit**	**remarks**	**source**
steel, low-alloyed, at plant/RER	1	kg		[3]
steel product manufacturing, avg metal working/RER	1	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$4.60 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
lower retention	1	kg		[3]
HEAT TRANSFER PLATE				
Inputs	**amount**	**unit**	**remarks**	**source**
steel, low-alloyed, at plant/RER	1	kg	Heat transfer plate, steel	[3]
steel product manufacturing, avg metal working/RER	1	kg	production of heat transfer plate	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$4.60 \cdot 10^{-10}$	p	facility	
Output	**amount**	**unit**	**remarks**	**source**
Heat transfer plate	1	kg		[3]

BATTERY RETENTION				
Inputs	**amount**	**unit**	**remarks**	**source**
Strap retention	0.087	kg		[3]
Lower retention	0.35	kg		
Heat transfer plate	0.46	kg		
synthetic rubber, at plant/RER	0.1	kg	foam retention	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
Output	**amount**	**unit**	**remarks**	**source**
Battery retention	1	kg		[3]
BATTERY TRAY				
TRAY WITH FASTENERS				
Inputs	**amount**	**unit**	**remarks**	**source**
steel, low-alloyed, at plant/RER	1	kg	battery tray and fixings, steel	[3]
steel product manufacturing, avg metal working/RER	1	kg	production of tray and fixings	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$4.60 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Tray with fasteners	1	kg		[3]
TRAY LID				
Inputs	**amount**	**unit**	**remarks**	**source**
Polypropylene, granulate, at plant/RER	1	kg	tray lid, polypropylene	[3]
injection molding/RER	1	kg	production of lid	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
plastics processing factory/RER/unit	$7.40 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Tray lid	1	kg		[3]
TRAY SEAL				
Inputs	**amount**	**unit**	**remarks**	**source**
butyl acrylate, at plant/RER	1	kg	tray seal, butyl acrylate	[3]
injection molding/RER	1	kg	production of seal	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
plastics processing factory/RER/unit	$7.40 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Tray seal	1	kg		[3]
BATTERY TRAY				
Inputs	**amount**	**unit**	**remarks**	**source**

tray with fasteners	0.79	kg		[3]
tray lid	0.21	kg		
tray seal	$4.10 \cdot 10^{-4}$	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
Output	**amount**	**unit**	**remarks**	**source**
Battery tray	1	kg		[3]
BATTERY PACKAGING				
Inputs	**amount**	**unit**	**remarks**	**source**
Module packaging	0.59	kg		[3]
Battery retention	0.11	kg		
Battery tray	0.3	kg		
transport, lorry >16t, fleet average/RER	0.15	tkm		
transport, transoceanic freight ship/OCE	4.8	tkm		
Output	**amount**	**unit**	**remarks**	**source**
Battery packaging	1	kg		[3]

Table S16 Battery management system production inventory.

BMS – battery management system				
IBIS - battery interface system				
Inputs	**amount**	**unit**	**remarks**	**source**
acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER	$2.00 \cdot 10^{-4}$	kg	BMS_GLAND_O-RING	[3]
printed wiring board, THM, unspec., Pb free, at plant/GLO	0.11	kg	BMS printed circuit board	
integrated circuit, IC, logic type, at plant/GLO	$1.70 \cdot 10^{-5}$	kg	BMS_Firmware	
steel, low-alloyed, at plant/RER	0.85	kg	Components, steel	
connector, clamp connection, at plant/GLO	0.021	kg	Connectors	
polyethylene terephthalate, granulate, amorphous, at plant/RER	0.0068	kg	Crimp housing	
nylon 6, at plant/RER	0.0019	kg	Standoffs, nylon part	
brass, at plant/CH	0.0057	kg	Standoffs, brass part	
steel product manufacturing, avg metal working/RER	0.85	kg		
injection molding/RER	0.0088	kg		
casting, brass/CH	0.0057	kg		
Transport_freight_rail/RER U	0.17	tkm		
Transport, lorry >32t	0.087	tkm		
electronic component production plant/GLO/unit	$2.00 \cdot 10^{-8}$	p		
Output	**amount**	**unit**	**remarks**	**source**
IBIS	1	kg		[3]
IBIS FASTENERS				

Inputs	amount	unit	remarks	source
steel, low-alloyed, at plant/RER	1	kg	Fixings	[3]
steel product manufacturing, avg metal working/RER	1	kg	production of fixings	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$4.60 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
IBIS fasteners	1	kg		[3]
HIGH VOLTAGE SYSTEM				
Inputs	**amount**	**unit**	**remarks**	**source**
steel, low-alloyed, at plant/RER	0.0014	kg	Steel products	[3]
aluminum, production mix, at plant/RER	0.12	kg	HVC and lid	
nylon 66, at plant/RER	0.044	kg	Clip & fasteners	
synthetic rubber, at plant/RER	0.0036	kg	Neoprene gasket	
polyethylene terephthalate, granulate, amorphous, at plant, RER	0.057	kg	Plastic	
copper, primary, at refinery/GLO	0.23	kg	Intermodule fuse	
copper, secondary, at refinery/RER	0.041	kg	Intermodule fuse	
polyphenylene sulfide, at plant/GLO	0.032	kg	Intermodule fuse	
tin, at regional storage/RER	0.016	kg	Intermodule fuse	
cable, ribbon cable, 20-pin, with plugs, at plant/GLO	0.45	kg	Cables	
steel product manufacturing, avg metal working/RER	0.0014	kg	production of steel products	
aluminum product manufacturing, avg metal working/RER	0.12	kg	Production of aluminum products	
injection molding/RER	0.14	kg	production of plastic products	
copper product manufacturing, avg metal working/RER	0.27	kg	production of copper for fuse	
metal product manufacturing, avg metal working/RER	0.016	kg	production of tin products	
Transport_freight_rail/RER U	0.11	tkm		
Transport, lorry >32t	0.055	tkm		
electronic component production plant/GLO/unit	$2.00 \cdot 10^{-8}$	p	facility	
Output	**amount**	**unit**	**remarks**	**source**
High voltage system	1	kg		[3]
LOW VOLTAGE SYSTEM				
Inputs	**amount**	**unit**	**remarks**	**source**
nylon 66, at plant/RER	0.029	kg	Clips	[3]
electronic component, passive, unspecified, at plant/GLO	0.97	kg	Harnesses	
injection molding/RER	0.029	kg	Production of clips	

Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
electronic component production plant/GLO/unit	$2.00 \cdot 10^{-8}$	p	Manufacture facility	
Output	**amount**	**unit**	**remarks**	**source**
Low voltage system	1	kg		[3]
BMS				
Inputs	**amount**	**unit**	**remarks**	**source**
printed wiring board, THM, unspec., Pb free, at plant/GLO	0.089	kg		[3]
IBIS	0.48	kg		
IBIS fasteners	0.003	kg		
High voltage system	0.3	kg		
Low voltage system	0.13	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
Output	**amount**	**unit**	**remarks**	**source**
BMS	1	kg		[3]

Table S17 Battery cooling system production inventory.

COOLING SYSTEM				
RADIATOR				
Inputs	**amount**	**unit**	**remarks**	**source**
aluminum, production mix, at plant/RER	1	kg	insulation pad, top plate, matrix plate	[3]
sheet rolling, aluminum/RER	1	kg	production	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
aluminum casting, plant/RER/unit	$1.50 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Radiator	1	kg		[3]
MANIFOLDS				
Inputs	**amount**	**unit**	**remarks**	**source**
aluminum, production mix, at plant/RER	1	kg	manifolds	[3]
aluminum product manufacturing, avg metal working/RER	1	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
aluminum casting, plant/RER/unit	$1.50 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Manifolds	1	kg		[3]
CLAMPS & FASTENERS				
Inputs	**amount**	**unit**	**remarks**	**source**

steel, low-alloyed, at plant/RER	1	kg	Clamps & fasteners	[3]
steel product manufacturing, avg metal working/RER	1	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
metal working factory/RER/unit	$4.60 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Clamps & fasteners	1	kg		[3]
PIPE FITTING				
Inputs	**amount**	**unit**	**remarks**	**source**
polyvinylchloride, at regional storage/RER	0.75	kg		[3]
synthetic rubber, at plant/RER	0.25	kg		
injection molding/RER	1	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
plastics processing factory/RER/unit	$7.40 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Pipe fitting	1	kg		[3]
THERMAL PAD				
Inputs	**amount**	**unit**	**remarks**	**source**
glass fiber, at plant/RER	0.1	kg	thermal pad, glass fiber	[3]
silicon, electronic grade, at plant/DE	0.3	kg	thermal pad, silicon electronic	
acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER	0.6	kg	thermal pad, ABS	
injection molding/RER	1	kg		
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
plastics processing factory/RER/unit	$7.40 \cdot 10^{-10}$	p		
Output	**amount**	**unit**	**remarks**	**source**
Thermal pad	1	kg		[3]
COOLING SYSTEM				
Inputs	**amount**	**unit**	**remarks**	**source**
Radiator	0.87	kg		[3]
Manifolds	0.038	kg		
Clamps & fasteners	0.023	kg		
Pipe fitting	0.00096	kg		
Thermal pad	0.002	kg		
ethylene glycol, at plant/RER	0.048	kg	coolant	
Transport_freight_rail/RER U	0.2	tkm		
Transport, lorry >32t	0.1	tkm		
Output	**amount**	**unit**	**remarks**	**source**
Cooling system	1	kg		[3]

4. Manufacturing of glider, electric motor, and auxiliaries.

Table S18 Glider production inventory.

GLIDER				
Inputs	**amount**	**unit**	**remarks**	**source**
Steel_mix	0.6887	kg		[5]
Alu_mix	0.005418	kg		
Magnesium, at plant/RER	0.0008509	kg		
Copper, at regional storage/RER	0.004212	kg		
Lead, at regional storage/RER	0.002978	kg		
Zinc, primary, at regional storage/RER	0.001702	kg		
Copper, at regional storage/RER	0.004255	kg		
Plastic_mix	0.1229	kg		
Flat glass, uncoated, at plant/RER	0.04002	kg		
Glass fiber reinforced plastic, polyester resin, hand lay-up, at plant/RER	0.007337	kg		
Epoxy resin, liquid, at plant/RER	0.01467	kg		
Viscose fibers, at plant/GLO	0.02201	kg		
Polyurethane, flexible foam, at plant/RER	0.01467	kg		
Coating powder, at plant/RER	0.014676	kg		
Light emitting diode, LED, at plant/RER	0.0001334	kg		
Printed wiring board, mixed mounted, unspec., solder mix, at plant/GLO	0.002535	kg		
Sheet rolling, aluminum/RER	0.005418	kg		
Sheet rolling, steel/RER	0.6887	kg		
Tempering, flat glass/RER	0.04002	kg		
Wire drawing, copper/RER	0.004212	kg		
Road vehicle plant/RER/I	$2.75 \cdot 10^{-10}$	p		
Tap water, at user/RER	3.039	kg		
Transport, freight, rail/RER	0.5002	tkm		
Transport, lorry >16t, fleet average/RER	0.05002	tkm		
Electricity, medium voltage, at grid/IT	2.02	kWh		
Heat, natural gas, at industrial furnace >100kW/RER	2.095	MJ		
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	0.059946	MJ		
Output	**amount**	**unit**	**remarks**	**source**
Glider production	1	kg	total weight 1570 kg	
Heat, waste	7.268	MJ	emissions to air	
NMVOC, non-methan volatile organic compounds	0.0045341	kg	emissions to air	
BOD5, Biological Oxygen Demand	0.00002454	kg	emissions to water	
COD, Chemical Oxygen Demand	0.0001822	kg	emissions to water	
Phosphate	$9.44 \cdot 10^{-7}$	kg	emissions to water	

STEEL_MIX				
Inputs	**amount**	**unit**	**remarks**	**source**
Reinforcing steel, at plant/RER	1.17	kg		[5]
Chromium steel 18/8, at plant/RER	0.0038	kg		
Steel, low-alloyed, at plant/RER	0.238	kg		
Output	**amount**	**unit**	**remarks**	**source**
Steel_mix	1	kg		
ALU_MIX				
Inputs	**amount**	**unit**	**remarks**	**source**
Aluminum, production mix, cast alloy, at plant/RER	0.88	kg		[5]
Aluminum, production mix, wrought alloy, at plant/RER	0.25	kg		
Output	**amount**	**unit**	**remarks**	**source**
Alu_mix	1	kg		
PLASTIC_MIX				
Inputs	**amount**	**unit**	**remarks**	**source**
Polypropylene, granulate, at plant/RER	0.515	kg		[5]
Polyethylene, LDPE, granulate, at plant/RER	0.152	kg		
Polyethylene terephthalate, granulate, amorphous, at plant/RER	0.015	kg		
Nylon 6, at plant/RER	0.03	kg		
Polyurethane, flexible foam, at plant/RER	0.165	kg		
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER	0.045	kg		
Polyvinylchloride, at regional storage/RER	0.101	kg		
Output	**amount**	**unit**	**remarks**	**source**
Plastic_mix	1	kg		

Table S19 Fluids inventory.

FLUIDS				
Inputs	**amount**	**unit**	**remarks**	**source**
brake fluid	0.91	kg	modelled as lubricating oil	[2]
transmission fluid	0.84	kg	modelled as lubricating oil	
powertrain coolant	7.15	kg	40% decarbonized H_2O, 60% ethylene glycol	
windscreen fluid	2.72	kg	40% decarbonized H_2O, 60% ethylene glycol	
adhesives	13.61	kg	adhesive for metals	

Table S20 Hydrogen fuel system production inventory.

HYDROGEN FUEL SYSTEM				
Inputs	**amount**	**unit**	**remarks**	**source**
Copper, at regional storage/RER	3.94	kg		[2]
Polyvinylchloride, at regional storage/RER	0.92	kg		
Output	**amount**	**unit**	**remarks**	**source**
Hydrogen fuel system	4.86	kg	Final product	

Table S21 Tires production inventory.

TIRES				
Inputs	**amount**	**unit**	**remarks**	**source**
Synthetic rubber, at plant/RER	2.47	kg		[2]
Natural rubber based sealing, at plant/DE	1.87	kg		
Carbon black, at plant/GLO	1.90	kg		
Silica sand, at plant/DE	0.96	kg		
Secondary sulfur, at refinery/RER	0.13	kg		
Zinc oxide, at plant/RER	0.16	kg		
Petroleum coke, at refinery/RER	0.61	kg		
Viscose fibers, at plant/GLO	1.61	kg		
Steel, low-alloyed, at plant/RER	2.86	kg		
Electricity, medium voltage, production RER, at grid/RER	0.79	kWh		
Output	**amount**	**unit**	**remarks**	**source**
One tire (production)	10	kg	final product	[6]

Table S22 Gearbox production inventory.

GEARBOX				
Inputs	**amount**	**unit**	**remarks**	**source**
Aluminum, production mix, at plant/RER	34.31	kg	17*G casing 100% secondary AlSi9	[2]
Steel, low-alloyed, at plant/RER	14.13	kg	7*G input shaft with gears	
Steel, low-alloyed, at plant/RER	16.15	kg	8*G output shaft with gears	
Steel, low-alloyed, at plant/RER	18.16	kg	9*G differential	
Steel, low-alloyed, at plant/RER	2.02	kg	1*G shift parts	
Steel, low-alloyed, at plant/RER	16.15	kg	8*G others	
Steel, low-alloyed, at plant/RER	10.09	kg	5*G clutch	
Output	**amount**	**unit**	**remarks**	**source**
Gearbox	111.00	kg	G=2.01818	

Table S23 Electric motor production inventory.

ELECTRIC MOTOR				
Inputs	**amount**	**unit**	**remarks**	**source**
Steel, low alloyed, at plant/RER	50.46	kg	A*25; magnetic circuit sheet	[2]
Steel, low alloyed, at plant/RER	4.04	kg	A*2; shaft	
Ferrite, at plant/GLO	2.32	kg	A*1.15; permanent magnet	
Neodymium oxide, at plant/CN	0.85	kg	A*0.42; permanent magnet	
Boron carbide, at plant/GLO	0.04	kg	A*0.02; permanent magnet	
Copper, at regional storage/RER	20.19	kg	A*10; Windings	
Aluminum, production mix, at plant/RER	28.26	kg	A*14; Housing	
Polyphenylene sulfide, at plant/GLO	2.22	kg	A*1.10; Housing	
Cable, three-conductor cable, at plant/GLO	6.30	m	A*3.12; high power 3x16 mm^2 cables	
Output	**amount**	**unit**	**remarks**	**source**
Electric Motor	108.38	kg	A=2.018545, total power: 111.2 kW	

Table S24 AC/DC inverter production inventory.

INVERTER				
Inputs	**amount**	**unit**	**remarks**	**source**
Aluminum oxide, at plant/RER	0.0282	kg		[5]
Aluminum, production mix, at plant/RER	0.0506	kg		
Aluminum, production mix, wrought alloy, at plant/RER	6.255	kg		
Brass, at plant/CH	0.3262	kg		
Capacitor, film, through-hole mounting, at plant/GLO	0.8992	kg		
Copper, at regional storage	1.45	kg		
Ferrite, at plant/GLO	0.304	kg		
Polyester resin, unsaturated, at plant/RER	0.2427	kg		
Polyethylene, LDPE, granulate, at plant/RER	0.0242	kg		
Polystyrene, high impact, HIPS, at plant/RER	0.2	kg		
Printed wiring board, surface mounted, unspec., solder mix, at plant/GLO	0.681	kg		
Printed wiring board, through-hole, at plant/GLO	0.02283	kg		
Silicone product, at plant/RER	0.00404	kg		
Steel, low-alloyed, at plant/RER	0.405	kg		

Production efforts, resistors/GLO	0.028	kg		
Selective coating, aluminum sheet, nickel pigmented aluminum oxide/SK	0.002815	m^2		
Sheet rolling, aluminum/RER	6.306	kg		
Sheet rolling, steel/RER	0.405	kg		
Wire drawing, copper/RER	1.45	kg		
Output	**amount**	**unit**	**remarks**	**source**
AC/DC inverter	9.5	kg		[5]

5. Hydrogen production

Table S25 Hydrogen production from SMR.

HYDROGEN FROM SMR				
Inputs	**amount**	**unit**	**remarks**	**source**
Natural gas, high pressure, at consumer/IT	165	MJ		[7]
water, deionized [Europe without Switzerland], water production, deionized	21.869	kg		
electricity, medium voltage, at grid/IT	1.11	kWh		
Output	**amount**	**unit**	**remarks**	**source**
hydrogen form SMR	1	kg		

Table S26 Hydrogen production from coal gasification

HYDROGEN FROM CS				
Inputs	**amount**	**unit**	**remarks**	**source**
hard coal supply mix/IT	7.8	kg		[7]
tap water, at user/RER	2.91	kg		
electricity, medium voltage, at grid/IT	1.72	kWh		
Output	**amount**	**unit**	**remarks**	**source**
hydrogen from CS	1	kg		

Table S27 Hydrogen production from electrolysis

HYDROGEN FROM ELECTROLYSIS				
Inputs	**amount**	**unit**	**remarks**	**source**
water, deionized, [Europe without Switzerland] |water production, deionized	18.04	kg		
electricity, medium voltage, at grid/IT	54.6	kWh		
Output	**amount**	**unit**	**remarks**	**source**
hydrogen from electrolysis	1	kg		

Table S28 Green hydrogen production from electrolysis.

GREEN HYDROGEN PRODUCTION				
Inputs	**amount**	**unit**	**remarks**	**source**
Water, deionized [Europe without Switzerland]|market for water, deionized	10	kg		[8]
Electricity, high voltage [NL]|electricity production, wind, 1-3 MW turbine, offshore	55	kWh		
Output	**amount**	**unit**	**remarks**	**source**
Green hydrogen	1	kg		

6. Total environmental impacts (ReCiPe midpoint)

Table S29 Environmental impacts of the vehicle with architecture A.

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack	Balance of plant	Hydrogen production	Converters
Global warming	kg CO_2 eq	$2.413 \cdot 10^{-1}$	$5.437 \cdot 10^{-2}$	$5.622 \cdot 10^{-3}$	$2.183 \cdot 10^{-3}$	$9.855 \cdot 10^{-3}$	$5.669 \cdot 10^{-3}$	$3.662 \cdot 10^{-3}$	$1.589 \cdot 10^{-1}$	$1.036 \cdot 10^{-3}$
Terrestrial acidification	kg SO_2 eq	$9.827 \cdot 10^{-4}$	$2.111 \cdot 10^{-4}$	$4.254 \cdot 10^{-5}$	$2.152 \cdot 10^{-5}$	$3.576 \cdot 10^{-5}$	$1.515 \cdot 10^{-5}$	$6.564 \cdot 10^{-6}$	$6.401 \cdot 10^{-4}$	$5.256 \cdot 10^{-10}$
Freshwater eutrophication	kg P eq	$4.916 \cdot 10^{-6}$	$3.093 \cdot 10^{-6}$	$3.029 \cdot 10^{-7}$	$4.173 \cdot 10^{-7}$	$8.975 \cdot 10^{-8}$	$3.752 \cdot 10^{-7}$	$1.020 \cdot 10^{-7}$	$3.226 \cdot 10^{-7}$	$3.266 \cdot 10^{-4}$
Marine eutrophication	kg N eq	$2.356 \cdot 10^{-6}$	$9.717 \cdot 10^{-7}$	$9.692 \cdot 10^{-8}$	$1.303 \cdot 10^{-7}$	$9.465 \cdot 10^{-8}$	$5.004 \cdot 10^{-8}$	$1.674 \cdot 10^{-8}$	$9.409 \cdot 10^{-7}$	$3.538 \cdot 10^{-6}$
Terrestrial ecotoxicity	kg 1,4-DCB	$8.922 \cdot 10^{-1}$	$3.564 \cdot 10^{-1}$	$2.361 \cdot 10^{-1}$	$6.591 \cdot 10^{-2}$	$1.325 \cdot 10^{-2}$	$5.758 \cdot 10^{-3}$	$4.328 \cdot 10^{-3}$	$1.427 \cdot 10^{-1}$	$4.019 \cdot 10^{-6}$
Freshwater ecotoxicity	kg 1,4-DCB	$1.104 \cdot 10^{-3}$	$7.324 \cdot 10^{-4}$	$9.193 \cdot 10^{-5}$	$9.049 \cdot 10^{-5}$	$2.526 \cdot 10^{-5}$	$1.968 \cdot 10^{-5}$	$2.196 \cdot 10^{-5}$	$9.812 \cdot 10^{-5}$	$3.735 \cdot 10^{-6}$
Marine ecotoxicity	kg 1,4-DCB	$2.132 \cdot 10^{-3}$	$1.251 \cdot 10^{-3}$	$2.654 \cdot 10^{-4}$	$1.516 \cdot 10^{-4}$	$4.565 \cdot 10^{-5}$	$3.165 \cdot 10^{-5}$	$2.701 \cdot 10^{-5}$	$2.955 \cdot 10^{-4}$	$9.912 \cdot 10^{-6}$
Human carcinogenic toxicity	kg 1,4-DCB	$1.752 \cdot 10^{-2}$	$1.395 \cdot 10^{-2}$	$9.570 \cdot 10^{-4}$	$2.612 \cdot 10^{-4}$	$2.888 \cdot 10^{-4}$	$8.929 \cdot 10^{-5}$	$4.973 \cdot 10^{-4}$	$1.405 \cdot 10^{-3}$	$2.139 \cdot 10^{-7}$
Human non-carcinogenic toxicity	kg 1,4-DCB	$5.330 \cdot 10^{-2}$	$2.579 \cdot 10^{-2}$	$1.187 \cdot 10^{-2}$	$4.294 \cdot 10^{-3}$	$9.949 \cdot 10^{-4}$	$8.217 \cdot 10^{-4}$	$5.748 \cdot 10^{-4}$	$5.747 \cdot 10^{-3}$	$5.453 \cdot 10^{-8}$
Mineral resource scarcity	kg Cu eq	$3.939 \cdot 10^{-3}$	$2.926 \cdot 10^{-3}$	$5.359 \cdot 10^{-4}$	$1.290 \cdot 10^{-4}$	$5.681 \cdot 10^{-5}$	$1.054 \cdot 10^{-5}$	$4.868 \cdot 10^{-5}$	$1.408 \cdot 10^{-4}$	$6.765 \cdot 10^{-2}$
Fossil resource scarcity	kg oil eq	$1.190 \cdot 10^{-1}$	$1.696 \cdot 10^{-2}$	$1.620 \cdot 10^{-3}$	$5.969 \cdot 10^{-4}$	$3.222 \cdot 10^{-3}$	$1.394 \cdot 10^{-3}$	$1.076 \cdot 10^{-3}$	$9.389 \cdot 10^{-2}$	$2.440 \cdot 10^{-5}$

Table S30 Environmental impacts of the vehicle with architecture B.

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack	Balance of plant	Hydrogen production	Fuel Cell converter
Global warming	kg CO_2 eq	$2.490 \cdot 10^{-1}$	$5.437 \cdot 10^{-2}$	$5.622 \cdot 10^{-3}$	$2.183 \cdot 10^{-3}$	$9.855 \cdot 10^{-3}$	$5.669 \cdot 10^{-3}$	$3.662 \cdot 10^{-3}$	$1.670 \cdot 10^{-1}$	$6.225 \cdot 10^{-4}$
Terrestrial acidification	kg SO_2 eq	$1.011 \cdot 10^{-3}$	$2.111 \cdot 10^{-4}$	$4.254 \cdot 10^{-5}$	$2.152 \cdot 10^{-5}$	$3.576 \cdot 10^{-5}$	$1.515 \cdot 10^{-5}$	$6.564 \cdot 10^{-6}$	$6.730 \cdot 10^{-4}$	$5.900 \cdot 10^{-6}$
Freshwater eutrophication	kg P eq	$4.763 \cdot 10^{-6}$	$3.093 \cdot 10^{-6}$	$3.029 \cdot 10^{-7}$	$4.173 \cdot 10^{-7}$	$8.975 \cdot 10^{-8}$	$3.752 \cdot 10^{-7}$	$1.020 \cdot 10^{-7}$	$3.391 \cdot 10^{-7}$	$4.440 \cdot 10^{-8}$
Marine eutrophication	kg N eq	$2.379 \cdot 10^{-6}$	$9.717 \cdot 10^{-7}$	$9.692 \cdot 10^{-8}$	$1.303 \cdot 10^{-7}$	$9.465 \cdot 10^{-8}$	$5.004 \cdot 10^{-8}$	$1.674 \cdot 10^{-8}$	$9.892 \cdot 10^{-7}$	$2.969 \cdot 10^{-8}$
Terrestrial ecotoxicity	kg 1,4-DCB	$8.707 \cdot 10^{-1}$	$3.564 \cdot 10^{-1}$	$2.361 \cdot 10^{-1}$	$6.591 \cdot 10^{-2}$	$1.325 \cdot 10^{-2}$	$5.758 \cdot 10^{-3}$	$4.328 \cdot 10^{-3}$	$1.500 \cdot 10^{-1}$	$3.888 \cdot 10^{-2}$
Freshwater ecotoxicity	kg 1,4-DCB	$1.091 \cdot 10^{-3}$	$7.324 \cdot 10^{-4}$	$9.193 \cdot 10^{-5}$	$9.049 \cdot 10^{-5}$	$2.526 \cdot 10^{-5}$	$1.968 \cdot 10^{-5}$	$2.196 \cdot 10^{-5}$	$1.031 \cdot 10^{-4}$	$5.810 \cdot 10^{-6}$
Marine ecotoxicity	kg 1,4-DCB	$2.110 \cdot 10^{-3}$	$1.251 \cdot 10^{-3}$	$2.654 \cdot 10^{-4}$	$1.516 \cdot 10^{-4}$	$4.565 \cdot 10^{-5}$	$3.165 \cdot 10^{-5}$	$2.701 \cdot 10^{-5}$	$3.107 \cdot 10^{-4}$	$2.685 \cdot 10^{-5}$
Human carcinogenic toxicity	kg 1,4-DCB	$1.755 \cdot 10^{-2}$	$1.395 \cdot 10^{-2}$	$9.570 \cdot 10^{-4}$	$2.612 \cdot 10^{-4}$	$2.888 \cdot 10^{-4}$	$8.929 \cdot 10^{-5}$	$4.973 \cdot 10^{-4}$	$1.477 \cdot 10^{-3}$	$3.495 \cdot 10^{-5}$
Human non-carcinogenic toxicity	kg 1,4-DCB	$5.207 \cdot 10^{-2}$	$2.579 \cdot 10^{-2}$	$1.187 \cdot 10^{-2}$	$4.294 \cdot 10^{-3}$	$9.949 \cdot 10^{-4}$	$8.217 \cdot 10^{-4}$	$5.748 \cdot 10^{-4}$	$6.042 \cdot 10^{-3}$	$1.690 \cdot 10^{-3}$
Mineral resource scarcity	kg Cu eq	$3.916 \cdot 10^{-3}$	$2.926 \cdot 10^{-3}$	$5.359 \cdot 10^{-4}$	$1.290 \cdot 10^{-4}$	$5.681 \cdot 10^{-5}$	$1.054 \cdot 10^{-5}$	$4.868 \cdot 10^{-5}$	$1.480 \cdot 10^{-4}$	$6.065 \cdot 10^{-5}$
Fossil resource scarcity	kg oil eq	$1.237 \cdot 10^{-1}$	$1.696 \cdot 10^{-2}$	$1.620 \cdot 10^{-3}$	$5.969 \cdot 10^{-4}$	$3.222 \cdot 10^{-3}$	$1.394 \cdot 10^{-3}$	$1.076 \cdot 10^{-3}$	$9.870 \cdot 10^{-2}$	$1.730 \cdot 10^{-4}$

Table S31 Environmental impacts of the vehicle with architecture C.

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel Cell stack C	Balance of plant	Hydrogen production	Battery converter
Global warming	kg CO_2 eq	$2.854 \cdot 10^{-1}$	$5.437 \cdot 10^{-2}$	$5.622 \cdot 10^{-3}$	$2.183 \cdot 10^{-3}$	$9.855 \cdot 10^{-3}$	$5.566 \cdot 10^{-3}$	$3.662 \cdot 10^{-3}$	$2.037 \cdot 10^{-1}$	$4.139 \cdot 10^{-4}$
Terrestrial acidification	kg SO_2 eq	$1.157 \cdot 10^{-3}$	$2.111 \cdot 10^{-4}$	$4.254 \cdot 10^{-5}$	$2.152 \cdot 10^{-5}$	$3.576 \cdot 10^{-5}$	$1.488 \cdot 10^{-5}$	$6.564 \cdot 10^{-6}$	$8.207 \cdot 10^{-4}$	$4.012 \cdot 10^{-6}$
Freshwater eutrophication	kg P eq	$4.956 \cdot 10^{-6}$	$3.093 \cdot 10^{-6}$	$3.029 \cdot 10^{-7}$	$4.173 \cdot 10^{-7}$	$8.975 \cdot 10^{-8}$	$3.685 \cdot 10^{-7}$	$1.020 \cdot 10^{-7}$	$4.136 \cdot 10^{-7}$	$1.695 \cdot 10^{-7}$
Marine eutrophication	kg N eq	$2.591 \cdot 10^{-6}$	$9.717 \cdot 10^{-7}$	$9.692 \cdot 10^{-8}$	$1.303 \cdot 10^{-7}$	$9.465 \cdot 10^{-8}$	$4.914 \cdot 10^{-8}$	$1.674 \cdot 10^{-8}$	$1.206 \cdot 10^{-6}$	$2.484 \cdot 10^{-8}$
Terrestrial ecotoxicity	kg 1,4-DCB	$8.934 \cdot 10^{-1}$	$3.564 \cdot 10^{-1}$	$2.361 \cdot 10^{-1}$	$6.591 \cdot 10^{-2}$	$1.325 \cdot 10^{-2}$	$5.654 \cdot 10^{-3}$	$4.328 \cdot 10^{-3}$	$1.830 \cdot 10^{-1}$	$2.877 \cdot 10^{-2}$
Freshwater ecotoxicity	kg 1,4-DCB	$1.126 \cdot 10^{-3}$	$7.324 \cdot 10^{-4}$	$9.193 \cdot 10^{-5}$	$9.049 \cdot 10^{-5}$	$2.526 \cdot 10^{-5}$	$1.933 \cdot 10^{-5}$	$2.196 \cdot 10^{-5}$	$1.258 \cdot 10^{-4}$	$1.859 \cdot 10^{-5}$
Marine ecotoxicity	kg 1,4-DCB	$2.188 \cdot 10^{-3}$	$1.251 \cdot 10^{-3}$	$2.654 \cdot 10^{-4}$	$1.516 \cdot 10^{-4}$	$4.565 \cdot 10^{-5}$	$3.108 \cdot 10^{-5}$	$2.701 \cdot 10^{-5}$	$3.789 \cdot 10^{-4}$	$3.694 \cdot 10^{-5}$
Human carcinogenic toxicity	kg 1,4-DCB	$1.788 \cdot 10^{-2}$	$1.395 \cdot 10^{-2}$	$9.570 \cdot 10^{-4}$	$2.612 \cdot 10^{-4}$	$2.888 \cdot 10^{-4}$	$8.770 \cdot 10^{-5}$	$4.973 \cdot 10^{-4}$	$1.802 \cdot 10^{-3}$	$3.675 \cdot 10^{-5}$
Human non-carcinogenic toxicity	kg 1,4-DCB	$5.322 \cdot 10^{-2}$	$2.579 \cdot 10^{-2}$	$1.187 \cdot 10^{-2}$	$4.294 \cdot 10^{-3}$	$9.949 \cdot 10^{-4}$	$8.070 \cdot 10^{-4}$	$5.748 \cdot 10^{-4}$	$7.368 \cdot 10^{-3}$	$1.528 \cdot 10^{-3}$
Mineral resource scarcity	kg Cu eq	$3.917 \cdot 10^{-3}$	$2.926 \cdot 10^{-3}$	$5.359 \cdot 10^{-4}$	$1.290 \cdot 10^{-4}$	$5.681 \cdot 10^{-5}$	$1.035 \cdot 10^{-5}$	$4.868 \cdot 10^{-5}$	$1.805 \cdot 10^{-4}$	$2.973 \cdot 10^{-5}$
Fossil resource scarcity	kg oil eq	$1.453 \cdot 10^{-1}$	$1.696 \cdot 10^{-2}$	$1.620 \cdot 10^{-3}$	$5.969 \cdot 10^{-4}$	$3.222 \cdot 10^{-3}$	$1.369 \cdot 10^{-3}$	$1.076 \cdot 10^{-3}$	$1.204 \cdot 10^{-1}$	$1.040 \cdot 10^{-4}$

Table S32 Relative contributions to the whole life cycle for architecture A. All values expressed in percentage.

Impact category	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack	Balance of plant	Hydrogen production	Converter
Global warming	22.53	2.33	0.90	4.08	2.35	1.52	65.85	0.43
Terrestrial acidification	21.48	4.33	2.19	3.64	1.54	0.67	65.14	1.01
Freshwater eutrophication	62.91	6.16	8.49	1.83	7.63	2.07	6.56	4.35
Marine eutrophication	41.25	4.11	5.53	4.02	2.12	0.71	39.94	2.31
Terrestrial ecotoxicity	39.95	26.47	7.39	1.48	0.65	0.49	16.00	7.58
Freshwater ecotoxicity	66.33	8.32	8.19	2.29	1.78	1.99	8.89	2.21
Marine ecotoxicity	58.69	12.45	7.11	2.14	1.48	1.27	13.86	2.99
Human carcinogenic toxicity	79.62	5.46	1.49	1.65	0.51	2.84	8.02	0.41
Human non-carcinogenic toxicity	48.38	22.26	8.06	1.87	1.54	1.08	10.78	6.04
Mineral resource scarcity	74.30	13.61	3.28	1.44	0.27	1.24	3.57	2.29
Fossil resource scarcity	14.25	1.36	0.50	2.71	1.17	0.90	78.88	0.23

Table S33 Relative contributions to the whole life cycle for architecture B. All values expressed in percentage.

Impact category	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack	Balance of plant	Hydrogen production	Converter
Global warming	21.83	2.26	0.88	3.96	2.28	1.47	67.08	0.25
Terrestrial acidification	20.87	4.21	2.13	3.54	1.50	0.65	66.53	0.58
Freshwater eutrophication	64.93	6.36	8.76	1.88	7.88	2.14	7.12	0.93
Marine eutrophication	40.84	4.07	5.48	3.98	2.10	0.70	41.57	1.25
Terrestrial ecotoxicity	40.93	27.12	7.57	1.52	0.66	0.50	17.23	4.46
Freshwater ecotoxicity	67.15	8.43	8.30	2.32	1.80	2.01	9.46	0.53
Marine ecotoxicity	59.29	12.58	7.19	2.16	1.50	1.28	14.73	1.27
Human carcinogenic toxicity	79.46	5.45	1.49	1.64	0.51	2.83	8.42	0.20
Human non-carcinogenic toxicity	49.52	22.79	8.25	1.91	1.58	1.10	11.60	3.25
Mineral resource scarcity	74.73	13.68	3.29	1.45	0.27	1.24	3.78	1.55
Fossil resource scarcity	13.71	1.31	0.48	2.60	1.13	0.87	79.76	0.14

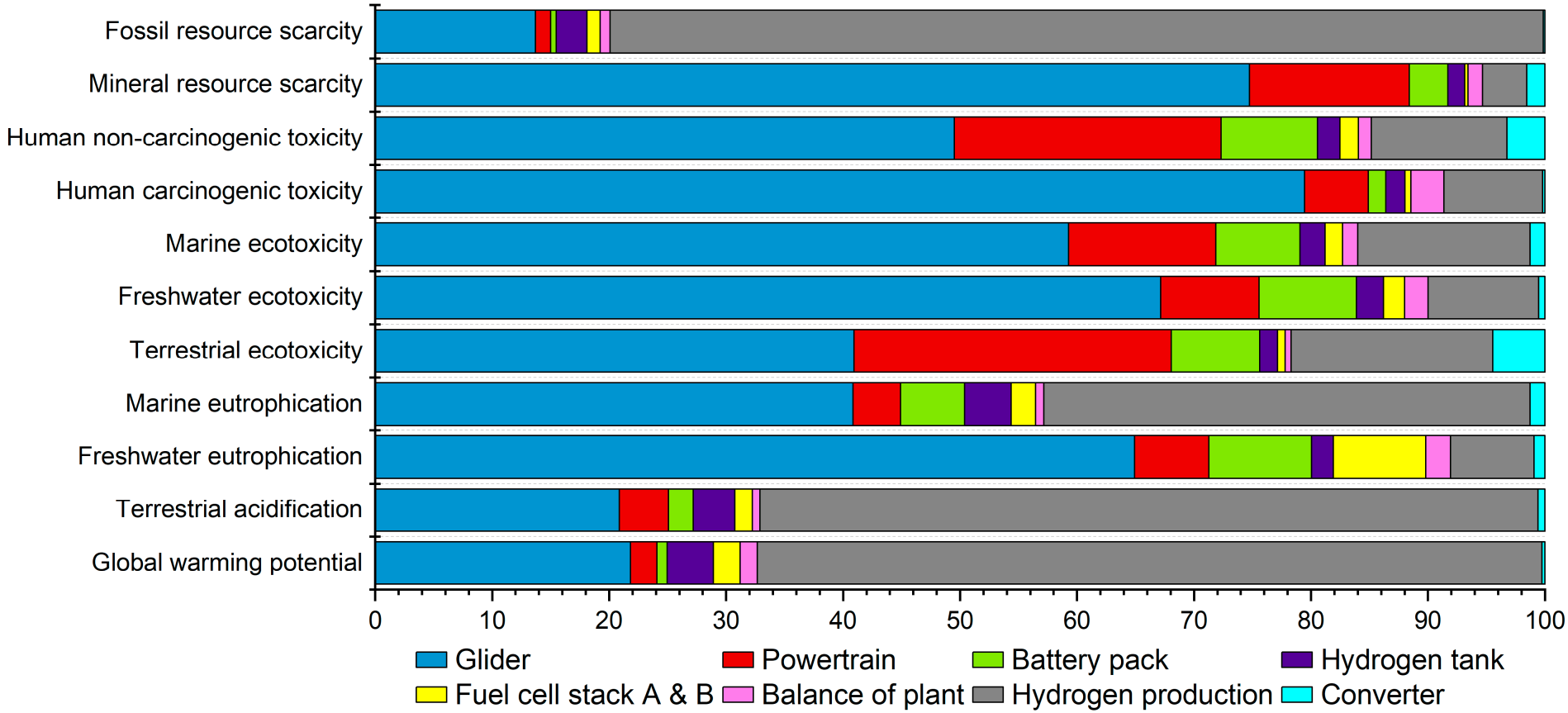

Figure S1 Relative contributions to the whole life cycle of architecture B.

Table S34 Relative contributions to the whole life cycle for architecture C. All values expressed in percentage.

Impact category	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel Cell stack	Balance of plant	Hydrogen production	Converter
Global warming	19.05	1.97	0.76	3.45	1.95	1.28	71.38	0.15
Terrestrial acidification	18.24	3.68	1.86	3.09	1.29	0.57	70.93	0.35
Freshwater eutrophication	62.40	6.11	8.42	1.81	7.43	2.06	8.34	3.42
Marine eutrophication	37.51	3.74	5.03	3.65	1.90	0.65	46.56	0.96
Terrestrial ecotoxicity	39.89	26.43	7.38	1.48	0.63	0.48	20.48	3.22
Freshwater ecotoxicity	65.06	8.17	8.04	2.24	1.72	1.95	11.17	1.65
Marine ecotoxicity	57.19	12.13	6.93	2.09	1.42	1.23	17.32	1.69
Human carcinogenic toxicity	78.02	5.35	1.46	1.62	0.49	2.78	10.08	0.21
Human non-carcinogenic toxicity	48.45	22.30	8.07	1.87	1.52	1.08	13.85	2.87
Mineral resource scarcity	74.70	13.68	3.29	1.45	0.26	1.24	4.61	0.76
Fossil resource scarcity	11.67	1.11	0.41	2.22	0.94	0.74	82.83	0.07

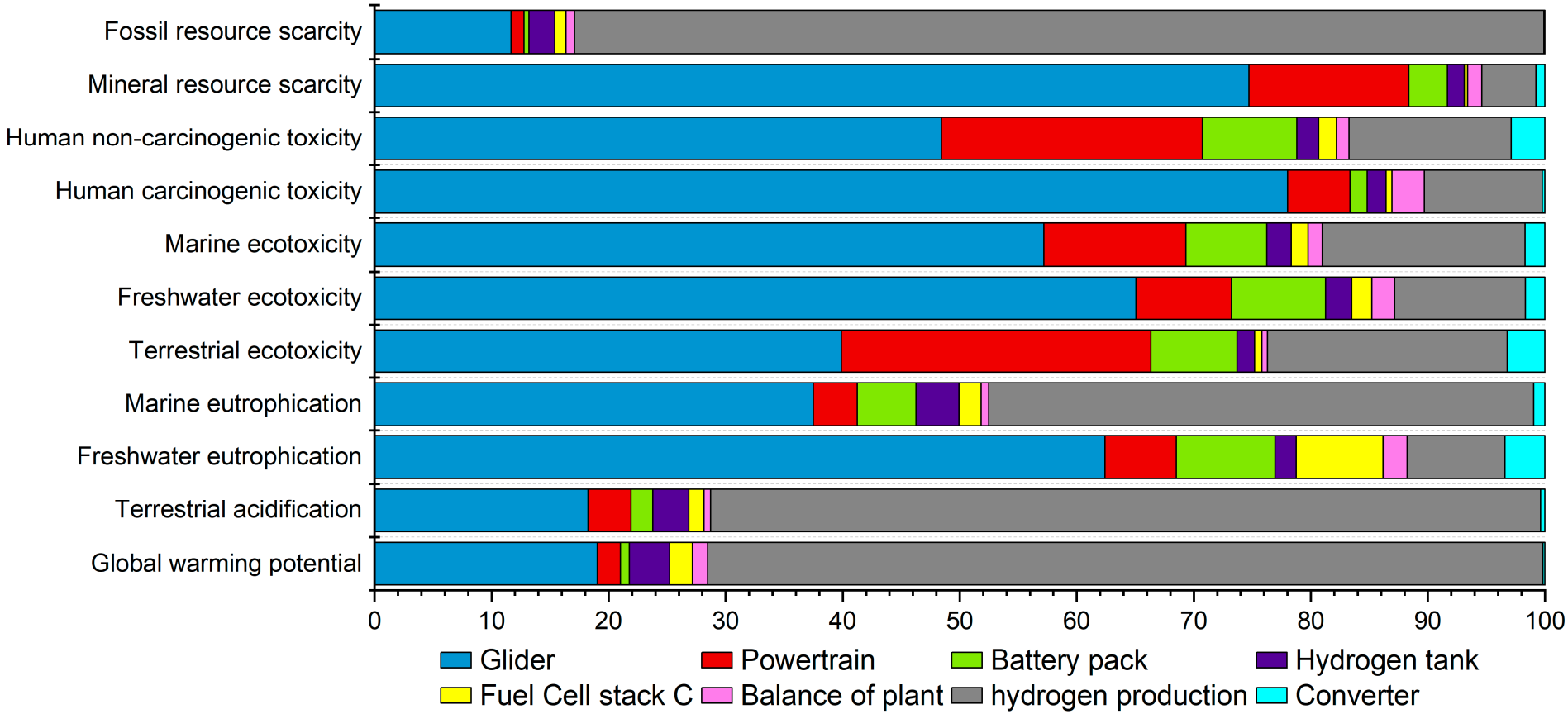

Figure S2 Relative contributions to the whole life cycle of architecture C.

7. Total environmental impacts (EF adapted)

Table S35 Environmental impacts for architecture A.

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack A & B	Fuel Cell converter	Battery converter	Balance of plant	Hydrogen production
Total	µPt	446.1430	94.4414	27.3075	5.8467	18.3422	7.6827	1.7857	0.5508	2.9511	287.2350
Climate change	µPt	6.5838	1.4919	0.1535	0.0597	0.2683	0.1543	0.0170	0.0113	0.1001	4.3277
Ozone depletion	µPt	0.2746	0.0105	0.0012	0.0006	0.0022	0.0932	0.0001	0.0000	0.0865	0.0802
Ionizing radiation, HH	µPt	0.4769	0.1245	0.0197	0.0067	0.0156	0.0086	0.0035	0.0008	0.0034	0.2941
Photochemical ozone formation, HH	µPt	0.9573	0.2773	0.0265	0.0109	0.0341	0.0151	0.0037	0.0032	0.0081	0.5783
Respiratory inorganics	µPt	1.1341	0.4228	0.0508	0.0251	0.0673	0.0186	0.0044	0.0037	0.0144	0.5270
Non-cancer human health effects	µPt	1.2293	0.7741	0.1698	0.0455	0.0232	0.0076	0.0218	0.0155	0.0231	0.1487
Cancer human health effects	µPt	4.0236	3.1408	0.2216	0.0581	0.0678	0.0175	0.0090	0.0070	0.1026	0.3992
Acidification terrestrial and freshwater	µPt	1.6005	0.3456	0.0670	0.0333	0.0590	0.0245	0.0093	0.0063	0.0107	1.0449
Eutrophication freshwater	µPt	0.0539	0.0339	0.0033	0.0046	0.0010	0.0041	0.0005	0.0019	0.0011	0.0035
Eutrophication marine	µPt	0.2196	0.0501	0.0061	0.0027	0.0091	0.0032	0.0008	0.0006	0.0015	0.1453
Eutrophication terrestrial	µPt	0.5023	0.1146	0.0154	0.0058	0.0201	0.0071	0.0021	0.0014	0.0034	0.3323
Ecotoxicity freshwater	µPt	0.2599	0.1553	0.0289	0.0056	0.0062	0.0019	0.0021	0.0014	0.0083	0.0501
Land use	µPt	0.0584	0.0341	0.0031	0.0012	0.0005	0.0004	0.0004	0.0003	0.0003	0.0181
Water scarcity	µPt	415.2582	82.6104	24.3421	5.3320	17.5471	7.2342	1.3842	0.3990	2.5067	273.9025
Resource use, energy carriers	µPt	6.9080	1.0717	0.1102	0.0406	0.1935	0.0847	0.0132	0.0069	0.0634	5.3238
Resource use, mineral and metals	µPt	6.6025	3.7838	2.0882	0.2143	0.0269	0.0076	0.3136	0.0914	0.0175	0.0591

Table S36 Environmental impacts for architecture B.

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack A & B	Fuel Cell converter	Balance of plant	Hydrogen production
Total	µPt	460.3227	94.4414	27.3075	5.8467	18.3422	7.6827	1.7857	2.9511	301.9654
Climate change	µPt	6.794451	1.4919	0.1535	0.0597	0.2683	0.1543	0.0170	0.1001	4.5497
Ozone depletion	µPt	0.27871	0.0105	0.0012	0.0006	0.0022	0.0932	0.0001	0.0865	0.0844
Ionizing radiation, HH	µPt	0.49119	0.1245	0.0197	0.0067	0.0156	0.0086	0.0035	0.0034	0.3092
Photochemical ozone formation, HH	µPt	0.983816	0.2773	0.0265	0.0109	0.0341	0.0151	0.0037	0.0081	0.6080
Respiratory inorganics	µPt	1.157424	0.4228	0.0508	0.0251	0.0673	0.0186	0.0044	0.0144	0.5540
Non-cancer human health effects	µPt	1.221356	0.7741	0.1698	0.0455	0.0232	0.0076	0.0218	0.0231	0.1563
Cancer human health effects	µPt	4.03705	3.1408	0.2216	0.0581	0.0678	0.0175	0.0090	0.1026	0.4196
Acidification terrestrial and freshwater	µPt	1.647807	0.3456	0.0670	0.0333	0.0590	0.0245	0.0093	0.0107	1.0985
Eutrophication freshwater	µPt	0.052221	0.0339	0.0033	0.0046	0.0010	0.0041	0.0005	0.0011	0.0037
Eutrophication marine	µPt	0.226474	0.0501	0.0061	0.0027	0.0091	0.0032	0.0008	0.0015	0.1528
Eutrophication terrestrial	µPt	0.517937	0.1146	0.0154	0.0058	0.0201	0.0071	0.0021	0.0034	0.3494
Ecotoxicity freshwater	µPt	0.261025	0.1553	0.0289	0.0056	0.0062	0.0019	0.0021	0.0083	0.0527
Land use	µPt	0.059044	0.0341	0.0031	0.0012	0.0005	0.0004	0.0004	0.0003	0.0190
Water scarcity	µPt	428.9059	82.6104	24.3421	5.3320	17.5471	7.2342	1.3842	2.5067	287.9492
Resource use, energy carriers	µPt	7.174121	1.0717	0.1102	0.0406	0.1935	0.0847	0.0132	0.0634	5.5968
Resource use, mineral and metals	µPt	6.514175	3.7838	2.0882	0.2143	0.0269	0.0076	0.3136	0.0175	0.0622

Table S37 Environmental impacts for architecture C.

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel Cell stack C	Battery converter	Balance of plant	hydrogen production
Total	µPt	525.2333	94.4414	27.3075	5.8467	18.3422	7.5434	0.5508	2.9511	368.2502
Climate change	µPt	7.7846	1.4919	0.1535	0.0597	0.2683	0.1515	0.0113	0.1001	5.5484
Ozone depletion	µPt	0.2954	0.0105	0.0012	0.0006	0.0022	0.0915	0.0000	0.0865	0.1029
Ionizing radiation, HH	µPt	0.5562	0.1245	0.0197	0.0067	0.0156	0.0085	0.0008	0.0034	0.3770
Photochemical ozone formation, HH	µPt	1.1165	0.2773	0.0265	0.0109	0.0341	0.0149	0.0032	0.0081	0.7414
Respiratory inorganics	µPt	1.2780	0.4228	0.0508	0.0251	0.0673	0.0183	0.0037	0.0144	0.6756
Non-cancer human health effects	µPt	1.2493	0.7741	0.1698	0.0455	0.0232	0.0075	0.0155	0.0231	0.1906
Cancer human health effects	µPt	4.1269	3.1408	0.2216	0.0581	0.0678	0.0172	0.0070	0.1026	0.5118
Acidification terrestrial and freshwater	µPt	1.8855	0.3456	0.0670	0.0333	0.0590	0.0240	0.0063	0.0107	1.3396
Eutrophication freshwater	µPt	0.0543	0.0339	0.0033	0.0046	0.0010	0.0040	0.0019	0.0011	0.0045
Eutrophication marine	µPt	0.2597	0.0501	0.0061	0.0027	0.0091	0.0032	0.0006	0.0015	0.1863
Eutrophication terrestrial	µPt	0.5938	0.1146	0.0154	0.0058	0.0201	0.0070	0.0014	0.0034	0.4260
Ecotoxicity freshwater	µPt	0.2719	0.1553	0.0289	0.0056	0.0062	0.0019	0.0014	0.0083	0.0643
Land use	µPt	0.0631	0.0341	0.0031	0.0012	0.0005	0.0004	0.0003	0.0003	0.0232
Water scarcity	µPt	490.9977	82.6104	24.3421	5.3320	17.5471	7.1030	0.3990	2.5067	351.1573
Resource use, energy carriers	µPt	8.3948	1.0717	0.1102	0.0406	0.1935	0.0831	0.0069	0.0634	6.8254
Resource use, mineral and metals	µPt	6.3055	3.7838	2.0882	0.2143	0.0269	0.0075	0.0914	0.0175	0.0758

8. Sensitivity analysis results

Table S38 Environmental impacts of architecture A considering green hydrogen production (ReCiPe midpoint method).

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack A & B	Balance of plant	green hydrogen production	Fuel Cell converter	Battery converter
Global warming	kg CO_2 eq	$9.602 \cdot 10^{-2}$	$5.437 \cdot 10^{-2}$	$5.622 \cdot 10^{-3}$	$2.183 \cdot 10^{-3}$	$9.855 \cdot 10^{-3}$	$5.669 \cdot 10^{-3}$	$3.662 \cdot 10^{-3}$	$1.362 \cdot 10^{-2}$	$6.225 \cdot 10^{-4}$	$4.139 \cdot 10^{-4}$
Terrestrial acidification	kg SO_2 eq	$3.902 \cdot 10^{-4}$	$2.111 \cdot 10^{-4}$	$4.254 \cdot 10^{-5}$	$2.152 \cdot 10^{-5}$	$3.576 \cdot 10^{-5}$	$1.515 \cdot 10^{-5}$	$6.564 \cdot 10^{-6}$	$4.764 \cdot 10^{-5}$	$5.900 \cdot 10^{-6}$	$4.012 \cdot 10^{-6}$
Freshwater eutrophication	kg P eq	$1.066 \cdot 10^{-5}$	$3.093 \cdot 10^{-6}$	$3.029 \cdot 10^{-7}$	$4.173 \cdot 10^{-7}$	$8.975 \cdot 10^{-8}$	$3.752 \cdot 10^{-7}$	$1.020 \cdot 10^{-7}$	$6.062 \cdot 10^{-6}$	$4.440 \cdot 10^{-8}$	$1.695 \cdot 10^{-7}$
Marine eutrophication	kg N eq	$2.723 \cdot 10^{-6}$	$9.717 \cdot 10^{-7}$	$9.692 \cdot 10^{-8}$	$1.303 \cdot 10^{-7}$	$9.465 \cdot 10^{-8}$	$5.004 \cdot 10^{-8}$	$1.674 \cdot 10^{-8}$	$1.308 \cdot 10^{-6}$	$2.969 \cdot 10^{-8}$	$2.484 \cdot 10^{-8}$
Terrestrial ecotoxicity	kg 1,4-DCB	$8.594 \cdot 10^{-1}$	$3.564 \cdot 10^{-1}$	$2.361 \cdot 10^{-1}$	$6.591 \cdot 10^{-2}$	$1.325 \cdot 10^{-2}$	$5.758 \cdot 10^{-3}$	$4.328 \cdot 10^{-3}$	$1.099 \cdot 10^{-1}$	$3.888 \cdot 10^{-2}$	$2.877 \cdot 10^{-2}$
Freshwater ecotoxicity	kg 1,4-DCB	$5.259 \cdot 10^{-3}$	$7.324 \cdot 10^{-4}$	$9.193 \cdot 10^{-5}$	$9.049 \cdot 10^{-5}$	$2.526 \cdot 10^{-5}$	$1.968 \cdot 10^{-5}$	$2.196 \cdot 10^{-5}$	$4.252 \cdot 10^{-3}$	$5.810 \cdot 10^{-6}$	$1.859 \cdot 10^{-5}$
Marine ecotoxicity	kg 1,4-DCB	$7.176 \cdot 10^{-3}$	$1.251 \cdot 10^{-3}$	$2.654 \cdot 10^{-4}$	$1.516 \cdot 10^{-4}$	$4.565 \cdot 10^{-5}$	$3.165 \cdot 10^{-5}$	$2.701 \cdot 10^{-5}$	$5.339 \cdot 10^{-3}$	$2.685 \cdot 10^{-5}$	$3.694 \cdot 10^{-5}$
Human carcinogenic toxicity	kg 1,4-DCB	$3.234 \cdot 10^{-2}$	$1.395 \cdot 10^{-2}$	$9.570 \cdot 10^{-4}$	$2.612 \cdot 10^{-4}$	$2.888 \cdot 10^{-4}$	$8.929 \cdot 10^{-5}$	$4.973 \cdot 10^{-4}$	$1.622 \cdot 10^{-2}$	$3.495 \cdot 10^{-5}$	$3.675 \cdot 10^{-5}$
Human non-carcinogenic toxicity	kg 1,4-DCB	$8.548 \cdot 10^{-2}$	$2.579 \cdot 10^{-2}$	$1.187 \cdot 10^{-2}$	$4.294 \cdot 10^{-3}$	$9.949 \cdot 10^{-4}$	$8.217 \cdot 10^{-4}$	$5.748 \cdot 10^{-4}$	$3.793 \cdot 10^{-2}$	$1.690 \cdot 10^{-3}$	$1.528 \cdot 10^{-3}$
Mineral resource scarcity	kg Cu eq	$4.268 \cdot 10^{-3}$	$2.926 \cdot 10^{-3}$	$5.359 \cdot 10^{-4}$	$1.290 \cdot 10^{-4}$	$5.681 \cdot 10^{-5}$	$1.054 \cdot 10^{-5}$	$4.868 \cdot 10^{-5}$	$4.700 \cdot 10^{-4}$	$6.065 \cdot 10^{-5}$	$2.973 \cdot 10^{-5}$
Fossil resource scarcity	kg oil eq	$2.852 \cdot 10^{-2}$	$1.696 \cdot 10^{-2}$	$1.620 \cdot 10^{-3}$	$5.969 \cdot 10^{-4}$	$3.222 \cdot 10^{-3}$	$1.394 \cdot 10^{-3}$	$1.076 \cdot 10^{-3}$	$3.373 \cdot 10^{-3}$	$1.730 \cdot 10^{-4}$	$1.040 \cdot 10^{-4}$

Table S39 Environmental impacts of architecture B considering green hydrogen production (ReCiPe midpoint method).

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack A & B	Balance of plant	green hydrogen production	Fuel Cell converter
Global warming	kg CO_2 eq	$9.631 \cdot 10^{-2}$	$5.437 \cdot 10^{-2}$	$5.622 \cdot 10^{-3}$	$2.183 \cdot 10^{-3}$	$9.855 \cdot 10^{-3}$	$5.669 \cdot 10^{-3}$	$3.662 \cdot 10^{-3}$	$1.432 \cdot 10^{-2}$	$6.225 \cdot 10^{-4}$
Terrestrial acidification	kg SO_2 eq	$3.886 \cdot 10^{-4}$	$2.111 \cdot 10^{-4}$	$4.254 \cdot 10^{-5}$	$2.152 \cdot 10^{-5}$	$3.576 \cdot 10^{-5}$	$1.515 \cdot 10^{-5}$	$6.564 \cdot 10^{-6}$	$5.008 \cdot 10^{-5}$	$5.900 \cdot 10^{-6}$
Freshwater eutrophication	kg P eq	$1.080 \cdot 10^{-5}$	$3.093 \cdot 10^{-6}$	$3.029 \cdot 10^{-7}$	$4.173 \cdot 10^{-7}$	$8.975 \cdot 10^{-8}$	$3.752 \cdot 10^{-7}$	$1.020 \cdot 10^{-7}$	$6.372 \cdot 10^{-6}$	$4.440 \cdot 10^{-8}$
Marine eutrophication	kg N eq	$2.765 \cdot 10^{-6}$	$9.717 \cdot 10^{-7}$	$9.692 \cdot 10^{-8}$	$1.303 \cdot 10^{-7}$	$9.465 \cdot 10^{-8}$	$5.004 \cdot 10^{-8}$	$1.674 \cdot 10^{-8}$	$1.375 \cdot 10^{-6}$	$2.969 \cdot 10^{-8}$
Terrestrial ecotoxicity	kg 1,4-DCB	$8.362 \cdot 10^{-1}$	$3.564 \cdot 10^{-1}$	$2.361 \cdot 10^{-1}$	$6.591 \cdot 10^{-2}$	$1.325 \cdot 10^{-2}$	$5.758 \cdot 10^{-3}$	$4.328 \cdot 10^{-3}$	$1.156 \cdot 10^{-1}$	$3.888 \cdot 10^{-2}$
Freshwater ecotoxicity	kg 1,4-DCB	$5.458 \cdot 10^{-3}$	$7.324 \cdot 10^{-4}$	$9.193 \cdot 10^{-5}$	$9.049 \cdot 10^{-5}$	$2.526 \cdot 10^{-5}$	$1.968 \cdot 10^{-5}$	$2.196 \cdot 10^{-5}$	$4.470 \cdot 10^{-3}$	$5.810 \cdot 10^{-6}$
Marine ecotoxicity	kg 1,4-DCB	$7.412 \cdot 10^{-3}$	$1.251 \cdot 10^{-3}$	$2.654 \cdot 10^{-4}$	$1.516 \cdot 10^{-4}$	$4.565 \cdot 10^{-5}$	$3.165 \cdot 10^{-5}$	$2.701 \cdot 10^{-5}$	$5.613 \cdot 10^{-3}$	$2.685 \cdot 10^{-5}$
Human carcinogenic toxicity	kg 1,4-DCB	$3.313 \cdot 10^{-2}$	$1.395 \cdot 10^{-2}$	$9.570 \cdot 10^{-4}$	$2.612 \cdot 10^{-4}$	$2.888 \cdot 10^{-4}$	$8.929 \cdot 10^{-5}$	$4.973 \cdot 10^{-4}$	$1.706 \cdot 10^{-2}$	$3.495 \cdot 10^{-5}$
Human non-carcinogenic toxicity	kg 1,4-DCB	$8.590 \cdot 10^{-2}$	$2.579 \cdot 10^{-2}$	$1.187 \cdot 10^{-2}$	$4.294 \cdot 10^{-3}$	$9.949 \cdot 10^{-4}$	$8.217 \cdot 10^{-4}$	$5.748 \cdot 10^{-4}$	$3.987 \cdot 10^{-2}$	$1.690 \cdot 10^{-3}$
Mineral resource scarcity	kg Cu eq	$4.262 \cdot 10^{-3}$	$2.926 \cdot 10^{-3}$	$5.359 \cdot 10^{-4}$	$1.290 \cdot 10^{-4}$	$5.681 \cdot 10^{-5}$	$1.054 \cdot 10^{-5}$	$4.868 \cdot 10^{-5}$	$4.942 \cdot 10^{-4}$	$6.065 \cdot 10^{-5}$
Fossil resource scarcity	kg oil eq	$2.859 \cdot 10^{-2}$	$1.696 \cdot 10^{-2}$	$1.620 \cdot 10^{-3}$	$5.969 \cdot 10^{-4}$	$3.222 \cdot 10^{-3}$	$1.394 \cdot 10^{-3}$	$1.076 \cdot 10^{-3}$	$3.546 \cdot 10^{-3}$	$1.730 \cdot 10^{-4}$

Table S40 Environmental impacts of architecture C considering green hydrogen production (ReCiPe midpoint method).

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel Cell stack C	Balance of plant	green hydrogen production	Battery converter
Global warming	kg CO_2 eq	$9.914 \cdot 10^{-2}$	$5.437 \cdot 10^{-2}$	$5.622 \cdot 10^{-3}$	$2.183 \cdot 10^{-3}$	$9.855 \cdot 10^{-3}$	$5.566 \cdot 10^{-3}$	$3.662 \cdot 10^{-3}$	$1.746 \cdot 10^{-2}$	$4.139 \cdot 10^{-4}$
Terrestrial acidification	kg SO_2 eq	$3.974 \cdot 10^{-4}$	$2.111 \cdot 10^{-4}$	$4.254 \cdot 10^{-5}$	$2.152 \cdot 10^{-5}$	$3.576 \cdot 10^{-5}$	$1.488 \cdot 10^{-5}$	$6.564 \cdot 10^{-6}$	$6.108 \cdot 10^{-5}$	$4.012 \cdot 10^{-6}$
Freshwater eutrophication	kg P eq	$1.231 \cdot 10^{-5}$	$3.093 \cdot 10^{-6}$	$3.029 \cdot 10^{-7}$	$4.173 \cdot 10^{-7}$	$8.975 \cdot 10^{-8}$	$3.685 \cdot 10^{-7}$	$1.020 \cdot 10^{-7}$	$7.771 \cdot 10^{-6}$	$1.695 \cdot 10^{-7}$
Marine eutrophication	kg N eq	$3.061 \cdot 10^{-6}$	$9.717 \cdot 10^{-7}$	$9.692 \cdot 10^{-8}$	$1.303 \cdot 10^{-7}$	$9.465 \cdot 10^{-8}$	$4.914 \cdot 10^{-8}$	$1.674 \cdot 10^{-8}$	$1.677 \cdot 10^{-6}$	$2.484 \cdot 10^{-8}$
Terrestrial ecotoxicity	kg 1,4-DCB	$8.514 \cdot 10^{-1}$	$3.564 \cdot 10^{-1}$	$2.361 \cdot 10^{-1}$	$6.591 \cdot 10^{-2}$	$1.325 \cdot 10^{-2}$	$5.654 \cdot 10^{-3}$	$4.328 \cdot 10^{-3}$	$1.409 \cdot 10^{-1}$	$2.877 \cdot 10^{-2}$
Freshwater ecotoxicity	kg 1,4-DCB	$6.452 \cdot 10^{-3}$	$7.324 \cdot 10^{-4}$	$9.193 \cdot 10^{-5}$	$9.049 \cdot 10^{-5}$	$2.526 \cdot 10^{-5}$	$1.933 \cdot 10^{-5}$	$2.196 \cdot 10^{-5}$	$5.452 \cdot 10^{-3}$	$1.859 \cdot 10^{-5}$
Marine ecotoxicity	kg 1,4-DCB	$8.654 \cdot 10^{-3}$	$1.251 \cdot 10^{-3}$	$2.654 \cdot 10^{-4}$	$1.516 \cdot 10^{-4}$	$4.565 \cdot 10^{-5}$	$3.108 \cdot 10^{-5}$	$2.701 \cdot 10^{-5}$	$6.845 \cdot 10^{-3}$	$3.694 \cdot 10^{-5}$
Human carcinogenic toxicity	kg 1,4-DCB	$3.688 \cdot 10^{-2}$	$1.395 \cdot 10^{-2}$	$9.570 \cdot 10^{-4}$	$2.612 \cdot 10^{-4}$	$2.888 \cdot 10^{-4}$	$8.770 \cdot 10^{-5}$	$4.973 \cdot 10^{-4}$	$2.080 \cdot 10^{-2}$	$3.675 \cdot 10^{-5}$
Human non-carcinogenic toxicity	kg 1,4-DCB	$9.448 \cdot 10^{-2}$	$2.579 \cdot 10^{-2}$	$1.187 \cdot 10^{-2}$	$4.294 \cdot 10^{-3}$	$9.949 \cdot 10^{-4}$	$8.070 \cdot 10^{-4}$	$5.748 \cdot 10^{-4}$	$4.863 \cdot 10^{-2}$	$1.528 \cdot 10^{-3}$
Mineral resource scarcity	kg Cu eq	$4.340 \cdot 10^{-3}$	$2.926 \cdot 10^{-3}$	$5.359 \cdot 10^{-4}$	$1.290 \cdot 10^{-4}$	$5.681 \cdot 10^{-5}$	$1.035 \cdot 10^{-5}$	$4.868 \cdot 10^{-5}$	$6.026 \cdot 10^{-4}$	$2.973 \cdot 10^{-5}$
Fossil resource scarcity	kg oil eq	$2.927 \cdot 10^{-2}$	$1.696 \cdot 10^{-2}$	$1.620 \cdot 10^{-3}$	$5.969 \cdot 10^{-4}$	$3.222 \cdot 10^{-3}$	$1.369 \cdot 10^{-3}$	$1.076 \cdot 10^{-3}$	$4.325 \cdot 10^{-3}$	$1.040 \cdot 10^{-4}$

Table S41 Relative contributions to the whole life cycle for architecture A considering green hydrogen production. All values expressed in percentage.

Impact category	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack A & B	Balance of plant	green hydrogen production	Converters
Global warming	56.63	5.86	2.27	10.26	5.90	3.81	14.19	1.08
Terrestrial acidification	54.10	10.90	5.52	9.17	3.88	1.68	12.21	2.54
Freshwater eutrophication	29.03	2.84	3.92	0.84	3.52	0.96	56.89	2.01
Marine eutrophication	35.69	3.56	4.79	3.48	1.84	0.61	48.03	2.00
Terrestrial ecotoxicity	41.47	27.48	7.67	1.54	0.67	0.50	12.79	7.87
Freshwater ecotoxicity	13.93	1.75	1.72	0.48	0.37	0.42	80.87	0.46
Marine ecotoxicity	17.43	3.70	2.11	0.64	0.44	0.38	74.41	0.89
Human carcinogenic toxicity	43.13	2.96	0.81	0.89	0.28	1.54	50.17	0.22
Human non-carcinogenic toxicity	30.16	13.88	5.02	1.16	0.96	0.67	44.37	3.77
Mineral resource scarcity	68.57	12.56	3.02	1.33	0.25	1.14	11.01	2.12
Fossil resource scarcity	59.47	5.68	2.09	11.30	4.89	3.77	11.83	0.97

Table S42 Relative contributions to the whole life cycle for architecture B considering green hydrogen production. All values expressed in percentage.

Impact category	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack A & B	Balance of plant	green hydrogen production	Fuel Cell converter
Global warming	56.46	5.84	2.27	10.23	5.89	3.80	14.87	0.65
Terrestrial acidification	54.32	10.95	5.54	9.20	3.90	1.69	12.89	1.52
Freshwater eutrophication	28.65	2.81	3.86	0.83	3.47	0.94	59.02	0.41
Marine eutrophication	35.14	3.51	4.71	3.42	1.81	0.61	49.72	1.07
Terrestrial ecotoxicity	42.62	28.24	7.88	1.58	0.69	0.52	13.82	4.65
Freshwater ecotoxicity	13.42	1.68	1.66	0.46	0.36	0.40	81.91	0.11
Marine ecotoxicity	16.88	3.58	2.05	0.62	0.43	0.36	75.73	0.36
Human carcinogenic toxicity	42.10	2.89	0.79	0.87	0.27	1.50	51.48	0.11
Human non-carcinogenic toxicity	30.02	13.81	5.00	1.16	0.96	0.67	46.42	1.97
Mineral resource scarcity	68.66	12.57	3.03	1.33	0.25	1.14	11.59	1.42
Fossil resource scarcity	59.33	5.67	2.09	11.27	4.88	3.76	12.41	0.61

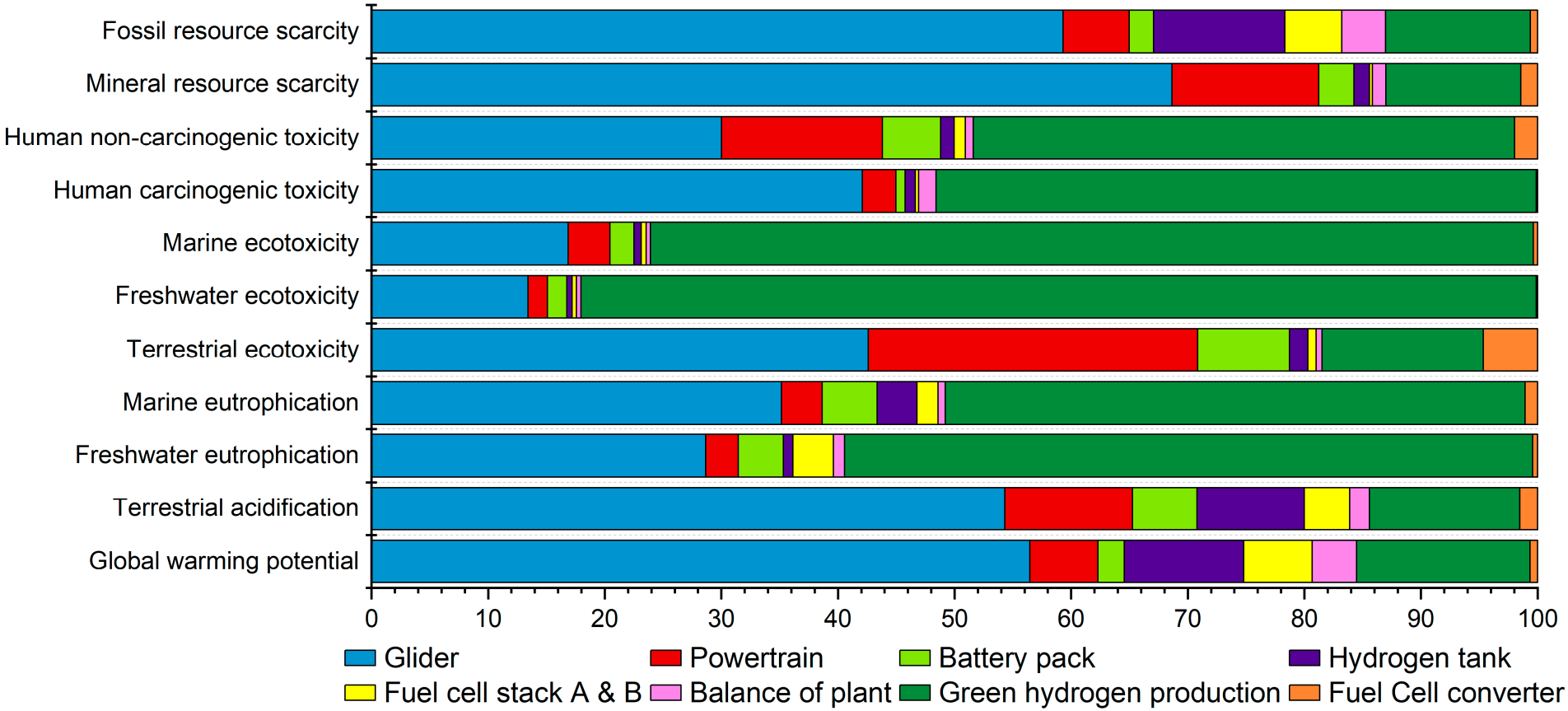

Figure S3 Relative contributions to the whole life cycle of architecture B, considering green hydrogen production.

Table S43 Relative contributions to the whole life cycle for architecture C considering green hydrogen production. All values expressed in percentage.

Impact category	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel Cell stack C	Balance of plant	green hydrogen production	Battery converter
Global warming	54.85	5.67	2.20	9.94	5.61	3.69	17.62	0.42
Terrestrial acidification	53.11	10.70	5.41	9.00	3.74	1.65	15.37	1.01
Freshwater eutrophication	25.12	2.46	3.39	0.73	2.99	0.83	63.11	1.38
Marine eutrophication	31.75	3.17	4.26	3.09	1.61	0.55	54.77	0.81
Terrestrial ecotoxicity	41.86	27.74	7.74	1.56	0.66	0.51	16.55	3.38
Freshwater ecotoxicity	11.35	1.42	1.40	0.39	0.30	0.34	84.50	0.29
Marine ecotoxicity	14.46	3.07	1.75	0.53	0.36	0.31	79.10	0.43
Human carcinogenic toxicity	37.82	2.60	0.71	0.78	0.24	1.35	56.40	0.10
Human non-carcinogenic toxicity	27.29	12.56	4.55	1.05	0.85	0.61	51.47	1.62
Mineral resource scarcity	67.44	12.35	2.97	1.31	0.24	1.12	13.89	0.68
Fossil resource scarcity	57.94	5.53	2.04	11.01	4.68	3.68	14.77	0.36

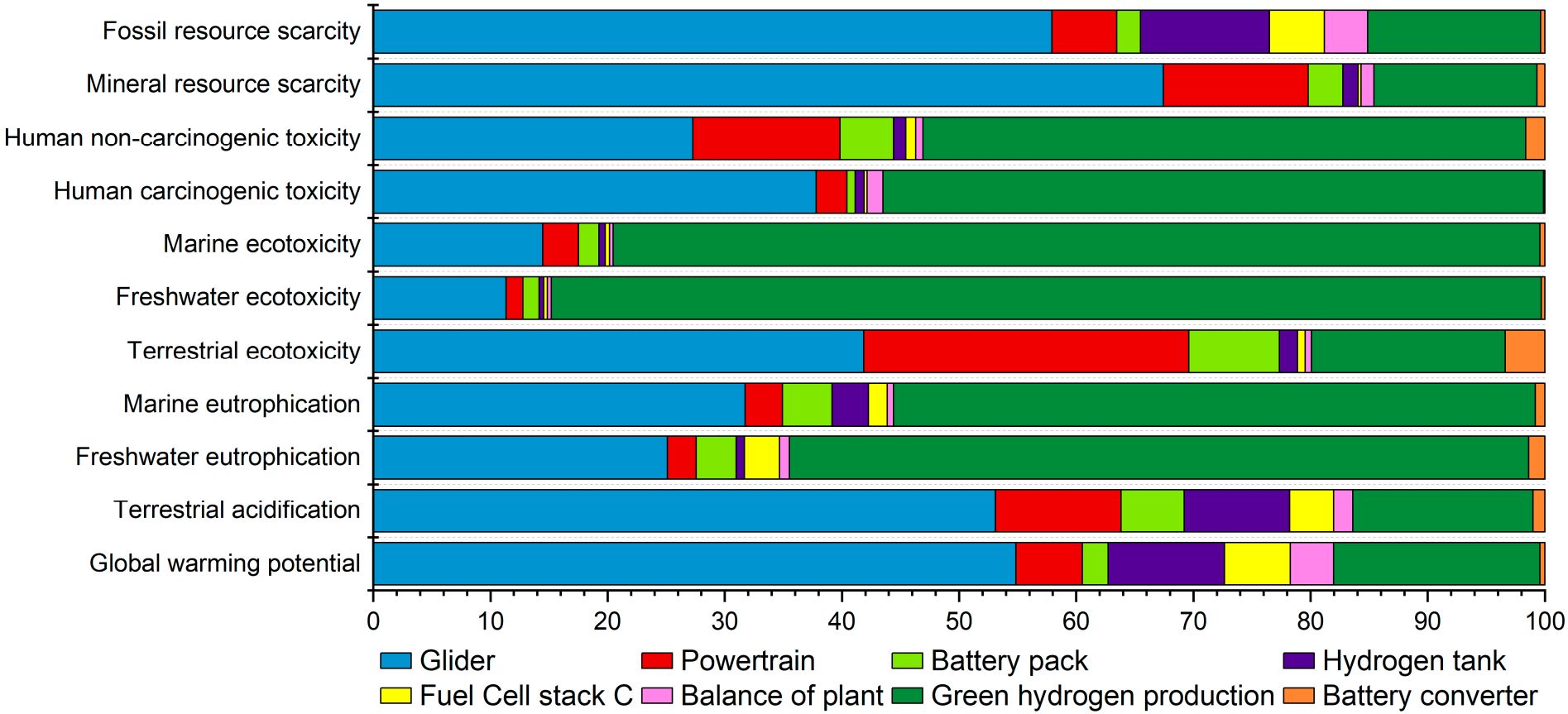

Figure S4 Relative contributions to the whole life cycle of architecture B, considering green hydrogen production.

Table S44 Environmental impacts of architecture A considering green hydrogen production (EF adapted method).

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack A & B	Fuel Cell converter	Battery converter	Balance of plant	green hydrogen production
Total	µPt	165.0688	94.4414	27.3075	5.8467	18.3422	7.6827	1.7857	0.5508	2.9511	6.1608
Climate change	µPt	2.6287	1.4919	0.1535	0.0597	0.2683	0.1543	0.0170	0.0113	0.1001	0.3726
Ozone depletion	µPt	0.1966	0.0105	0.0012	0.0006	0.0022	0.0932	0.0001	0.0000	0.0865	0.0022
Ionizing radiation, HH	µPt	0.1924	0.1245	0.0197	0.0067	0.0156	0.0086	0.0035	0.0008	0.0034	0.0096
Photochemical ozone formation, HH	µPt	0.4425	0.2773	0.0265	0.0109	0.0341	0.0151	0.0037	0.0032	0.0081	0.0635
Respiratory inorganics	µPt	0.7446	0.4228	0.0508	0.0251	0.0673	0.0186	0.0044	0.0037	0.0144	0.1376
Non-cancer human health effects	µPt	1.2705	0.7741	0.1698	0.0455	0.0232	0.0076	0.0218	0.0155	0.0231	0.1899
Cancer human health effects	µPt	7.1714	3.1408	0.2216	0.0581	0.0678	0.0175	0.0090	0.0070	0.1026	3.5469
Acidification terrestrial and freshwater	µPt	0.6365	0.3456	0.0670	0.0333	0.0590	0.0245	0.0093	0.0063	0.0107	0.0808
Eutrophication freshwater	µPt	0.1169	0.0339	0.0033	0.0046	0.0010	0.0041	0.0005	0.0019	0.0011	0.0665
Eutrophication marine	µPt	0.0931	0.0501	0.0061	0.0027	0.0091	0.0032	0.0008	0.0006	0.0015	0.0188
Eutrophication terrestrial	µPt	0.2046	0.1146	0.0154	0.0058	0.0201	0.0071	0.0021	0.0014	0.0034	0.0346
Ecotoxicity freshwater	µPt	0.3360	0.1553	0.0289	0.0056	0.0062	0.0019	0.0021	0.0014	0.0083	0.1263
Land use	µPt	0.0465	0.0341	0.0031	0.0012	0.0005	0.0004	0.0004	0.0003	0.0003	0.0062
Water scarcity	µPt	141.4660	82.6104	24.3421	5.3320	17.5471	7.2342	1.3842	0.3990	2.5067	0.1103
Resource use, energy carriers	µPt	1.7868	1.0717	0.1102	0.0406	0.1935	0.0847	0.0132	0.0069	0.0634	0.2027
Resource use, mineral and metals	µPt	7.7356	3.7838	2.0882	0.2143	0.0269	0.0076	0.3136	0.0914	0.0175	1.1922

Table S45 Environmental impacts of architecture B considering green hydrogen production (EF adapted method).

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel cell stack A & B	Fuel Cell converter	Balance of plant	green hydrogen production
Total	µPt	164.8340	94.4414	27.3075	5.8467	18.3422	7.6827	1.7857	2.9511	6.4767
Climate change	µPt	2.6365	1.4919	0.1535	0.0597	0.2683	0.1543	0.0170	0.1001	0.3918
Ozone depletion	µPt	0.1966	0.0105	0.0012	0.0006	0.0022	0.0932	0.0001	0.0865	0.0023
Ionizing radiation, HH	µPt	0.1921	0.1245	0.0197	0.0067	0.0156	0.0086	0.0035	0.0034	0.0101
Photochemical ozone formation, HH	µPt	0.4426	0.2773	0.0265	0.0109	0.0341	0.0151	0.0037	0.0081	0.0668
Respiratory inorganics	µPt	0.7480	0.4228	0.0508	0.0251	0.0673	0.0186	0.0044	0.0144	0.1446
Non-cancer human health effects	µPt	1.2647	0.7741	0.1698	0.0455	0.0232	0.0076	0.0218	0.0231	0.1996
Cancer human health effects	µPt	7.3463	3.1408	0.2216	0.0581	0.0678	0.0175	0.0090	0.1026	3.7288
Acidification terrestrial and freshwater	µPt	0.6343	0.3456	0.0670	0.0333	0.0590	0.0245	0.0093	0.0107	0.0850
Eutrophication freshwater	µPt	0.1184	0.0339	0.0033	0.0046	0.0010	0.0041	0.0005	0.0011	0.0699
Eutrophication marine	µPt	0.0935	0.0501	0.0061	0.0027	0.0091	0.0032	0.0008	0.0015	0.0198
Eutrophication terrestrial	µPt	0.2049	0.1146	0.0154	0.0058	0.0201	0.0071	0.0021	0.0034	0.0364
Ecotoxicity freshwater	µPt	0.3411	0.1553	0.0289	0.0056	0.0062	0.0019	0.0021	0.0083	0.1328
Land use	µPt	0.0466	0.0341	0.0031	0.0012	0.0005	0.0004	0.0004	0.0003	0.0066
Water scarcity	µPt	141.0726	82.6104	24.3421	5.3320	17.5471	7.2342	1.3842	2.5067	0.1160
Resource use, energy carriers	µPt	1.7903	1.0717	0.1102	0.0406	0.1935	0.0847	0.0132	0.0634	0.2131
Resource use, mineral and metals	µPt	7.7054	3.7838	2.0882	0.2143	0.0269	0.0076	0.3136	0.0175	1.2534

Table S46 Environmental impacts of architecture C considering green hydrogen production (EF adapted method).

Impact category	Unit	Total	Glider	Powertrain	Battery pack	Hydrogen tank	Fuel Cell stack C	Battery converter	Balance of plant	green hydrogen production
Total	µPt	164.8815	94.4414	27.3075	5.8467	18.3422	7.5434	0.5508	2.9511	7.8985
Climate change	µPt	2.7140	1.4919	0.1535	0.0597	0.2683	0.1515	0.0113	0.1001	0.4778
Ozone depletion	µPt	0.1953	0.0105	0.0012	0.0006	0.0022	0.0915	0.0000	0.0865	0.0028
Ionizing radiation, HH	µPt	0.1914	0.1245	0.0197	0.0067	0.0156	0.0085	0.0008	0.0034	0.0123
Photochemical ozone formation, HH	µPt	0.4565	0.2773	0.0265	0.0109	0.0341	0.0149	0.0032	0.0081	0.0814
Respiratory inorganics	µPt	0.7788	0.4228	0.0508	0.0251	0.0673	0.0183	0.0037	0.0144	0.1764
Non-cancer human health effects	µPt	1.3022	0.7741	0.1698	0.0455	0.0232	0.0075	0.0155	0.0231	0.2435
Cancer human health effects	µPt	8.1625	3.1408	0.2216	0.0581	0.0678	0.0172	0.0070	0.1026	4.5474
Acidification terrestrial and freshwater	µPt	0.6496	0.3456	0.0670	0.0333	0.0590	0.0240	0.0063	0.0107	0.1036
Eutrophication freshwater	µPt	0.1351	0.0339	0.0033	0.0046	0.0010	0.0040	0.0019	0.0011	0.0852
Eutrophication marine	µPt	0.0975	0.0501	0.0061	0.0027	0.0091	0.0032	0.0006	0.0015	0.0241
Eutrophication terrestrial	µPt	0.2121	0.1146	0.0154	0.0058	0.0201	0.0070	0.0014	0.0034	0.0443
Ecotoxicity freshwater	µPt	0.3695	0.1553	0.0289	0.0056	0.0062	0.0019	0.0014	0.0083	0.1619
Land use	µPt	0.0479	0.0341	0.0031	0.0012	0.0005	0.0004	0.0003	0.0003	0.0080
Water scarcity	µPt	139.9818	82.6104	24.3421	5.3320	17.5471	7.1030	0.3990	2.5067	0.1414
Resource use, energy carriers	µPt	1.8292	1.0717	0.1102	0.0406	0.1935	0.0831	0.0069	0.0634	0.2598
Resource use, mineral and metals	µPt	7.7581	3.7838	2.0882	0.2143	0.0269	0.0075	0.0914	0.0175	1.5285

9. Monte Carlo analysis

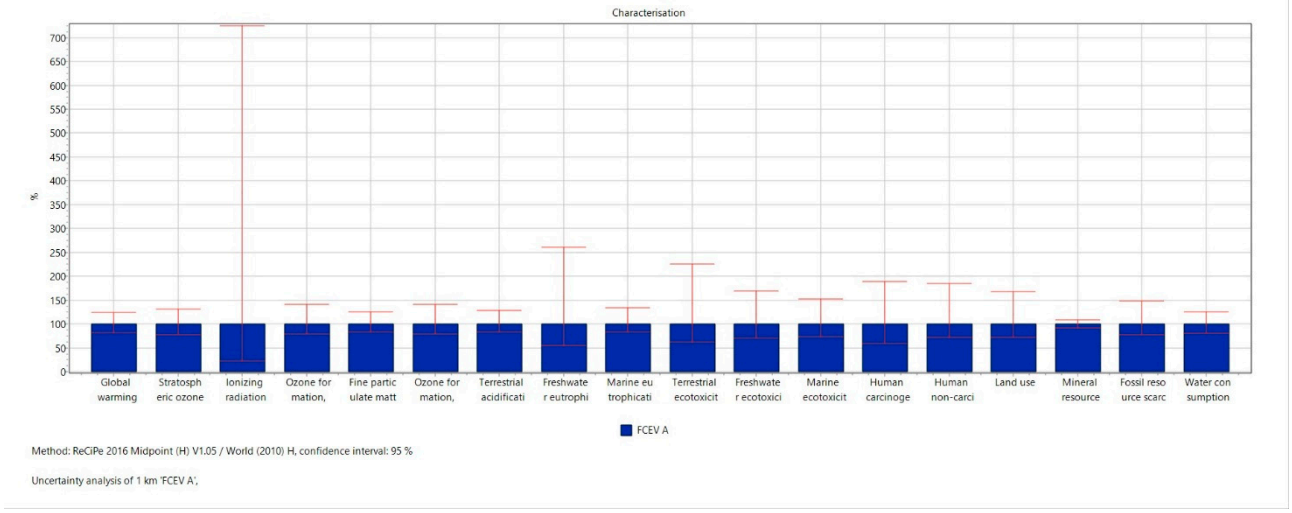

Figure S5 Uncertainty analysis results of architecture A.

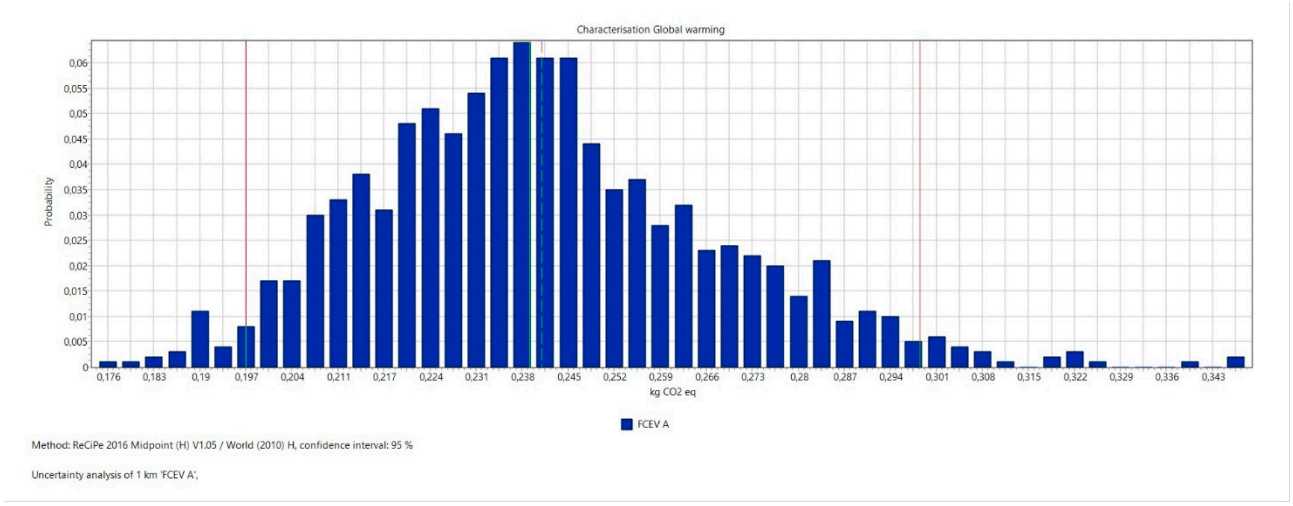

Figure S6 Uncertainty analysis characterization of Global warming potential for architecture A.

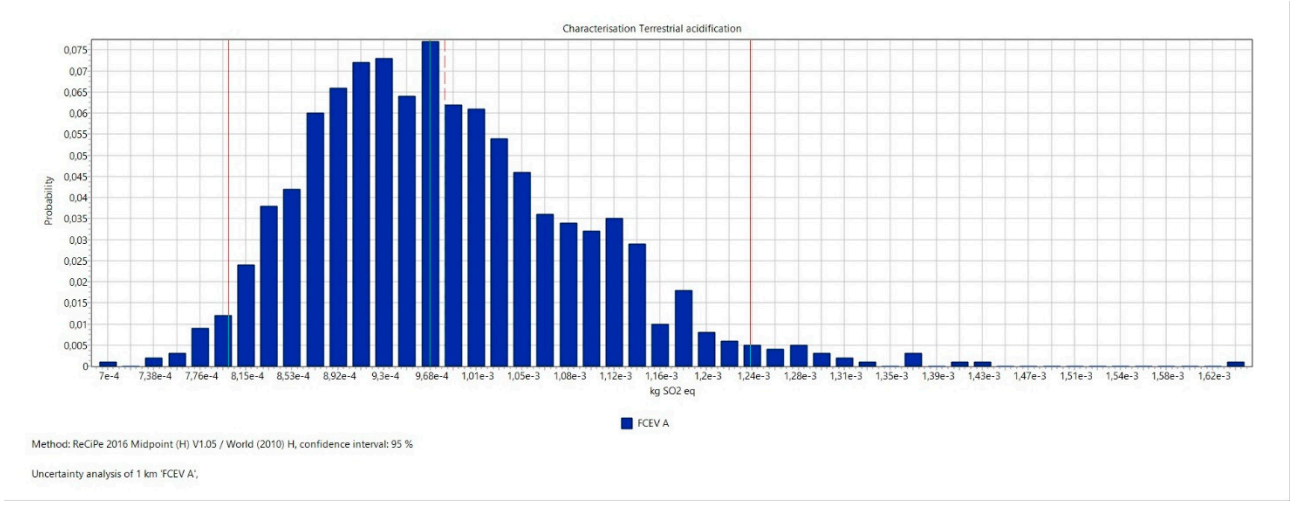

Figure S7 Uncertainty analysis characterization of Terrestrial acidification for architecture A.

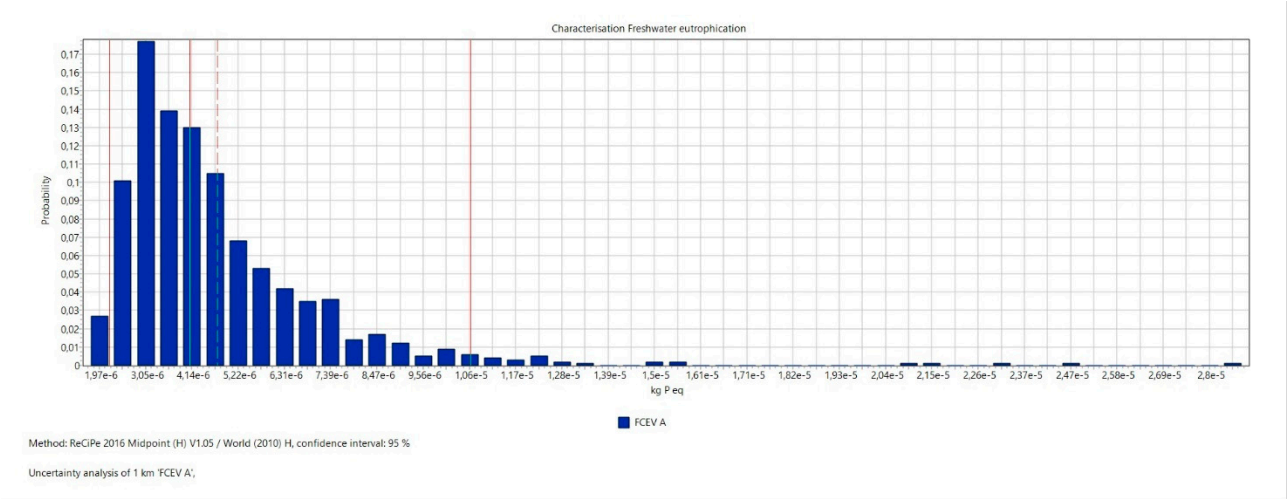

Figure S8 Uncertainty analysis characterization of Freshwater eutrophication for architecture A.

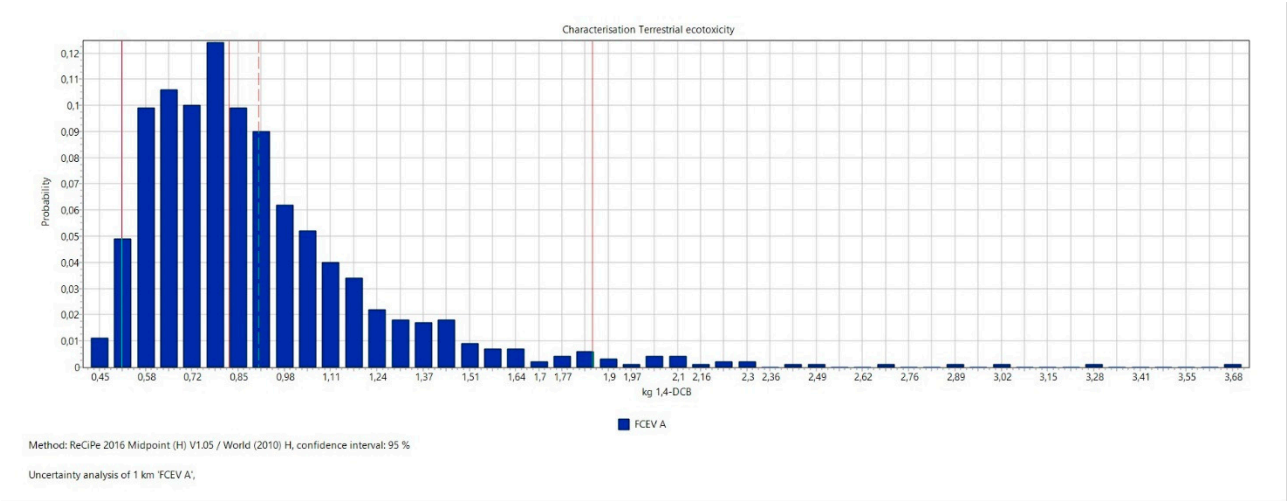

Figure S9 Uncertainty analysis characterization of Terrestrial ecotoxicity for architecture A.

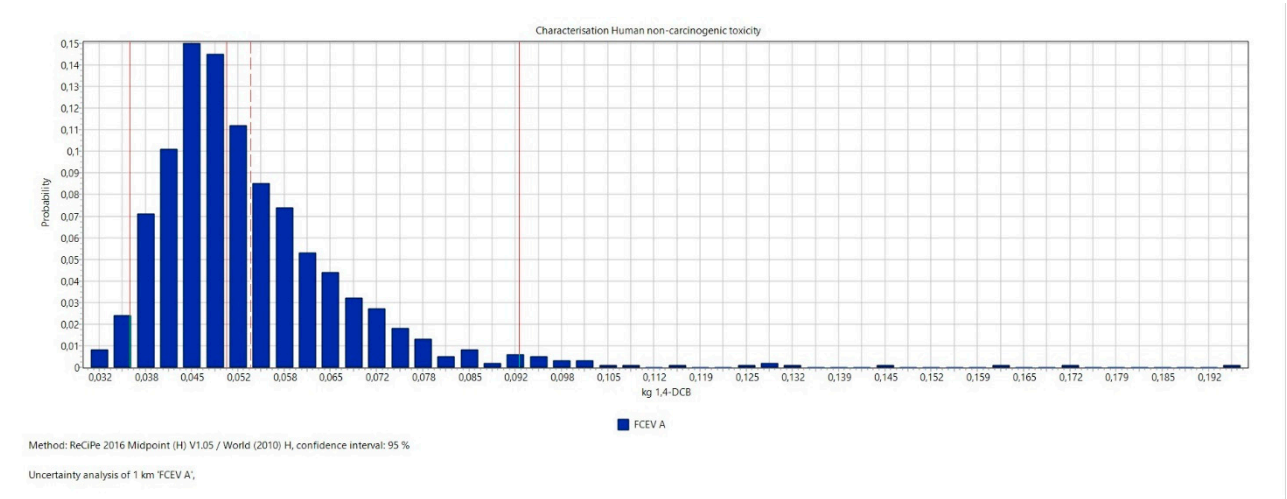

Figure S10 Uncertainty analysis characterization of Human non-carcinogenic toxicity for architecture A.

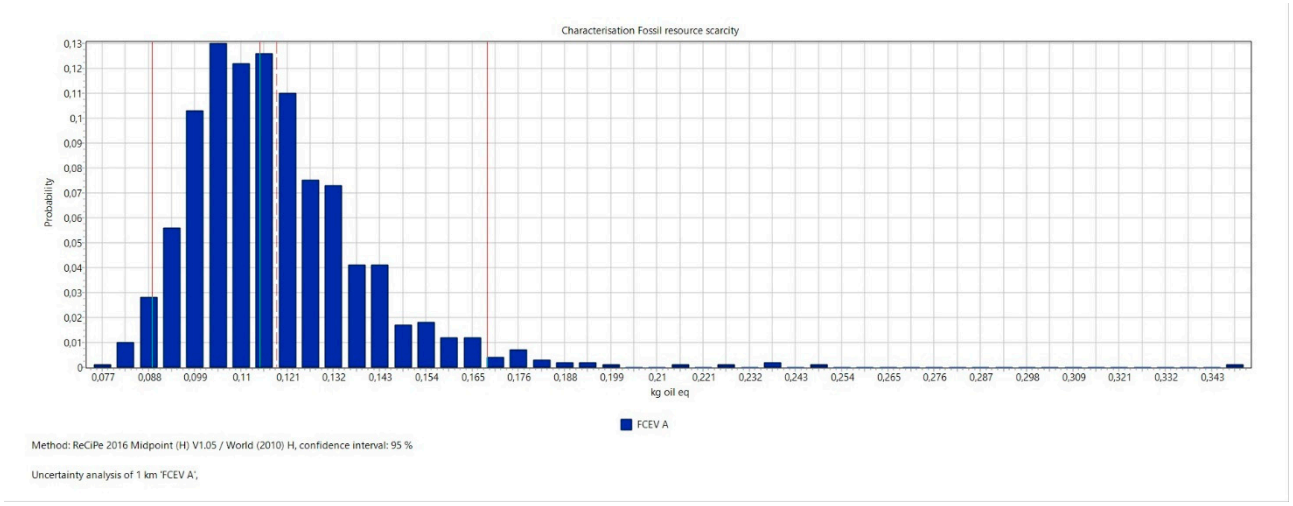

Figure S11 Uncertainty analysis characterization of Fossil resource scarcity for architecture A.

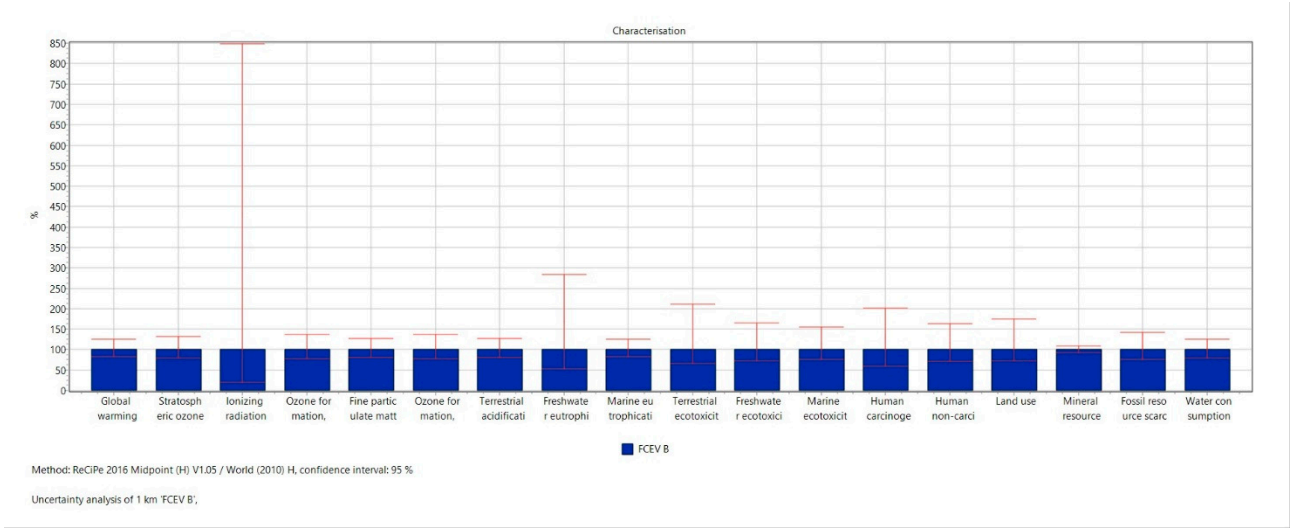

Figure S12 Uncertainty analysis of architecture B.

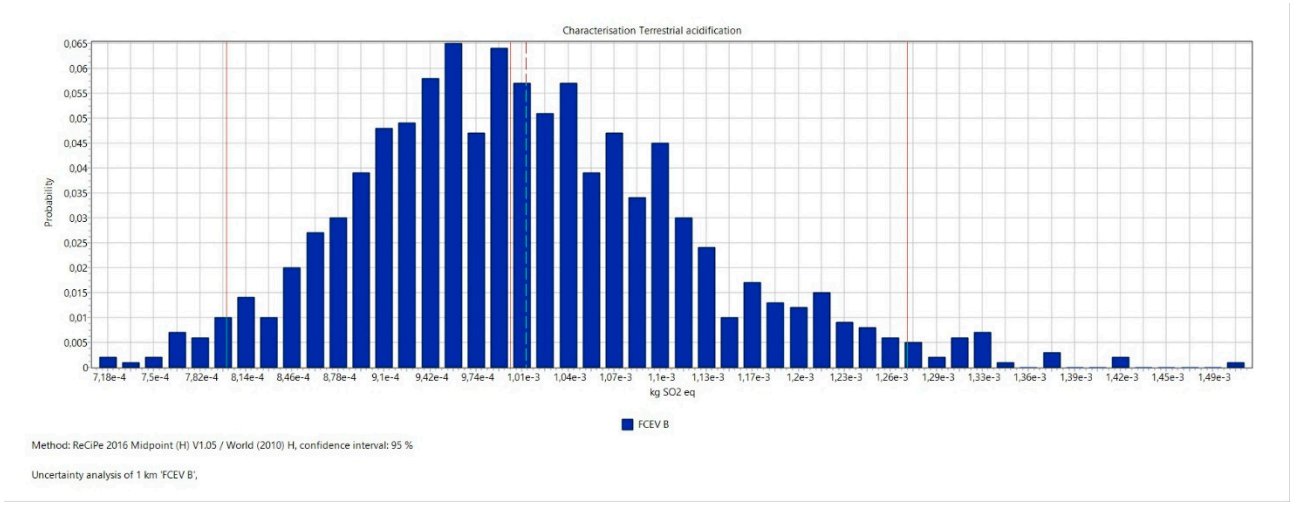

Figure S13 Uncertainty analysis characterization of Global warming potential for architecture B.

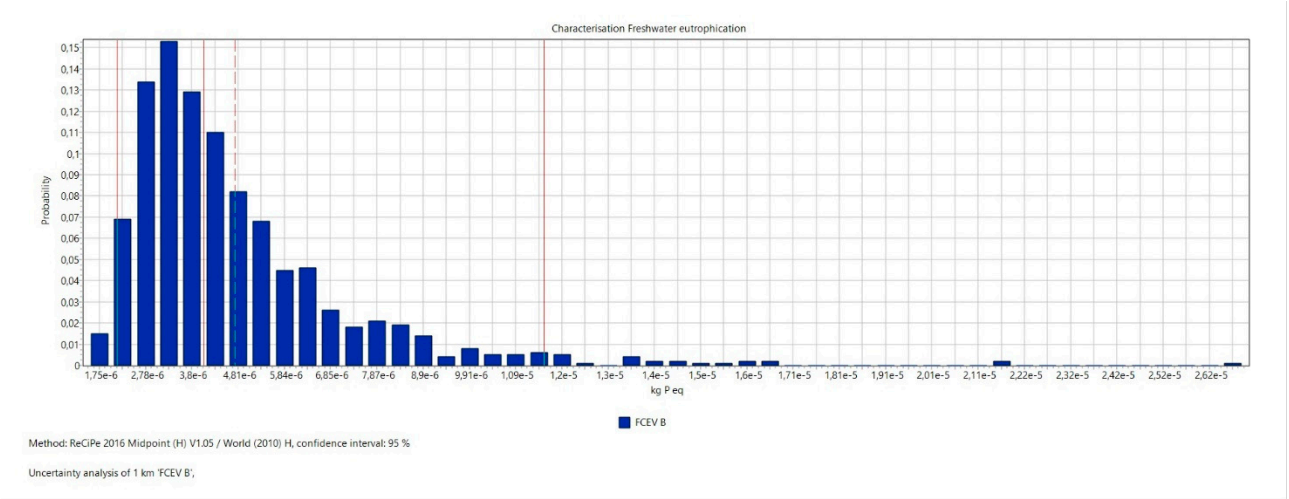

Figure S14 Uncertainty analysis characterization of Freshwater eutrophication for architecture B.

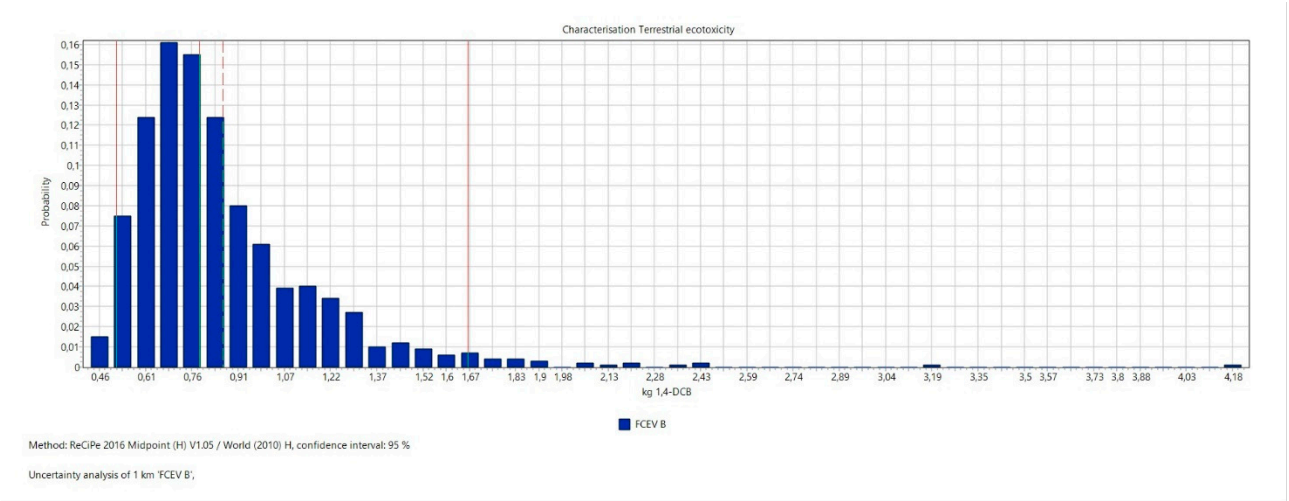

Figure S15 Uncertainty analysis characterization of Terrestrial ecotoxicity for architecture B.

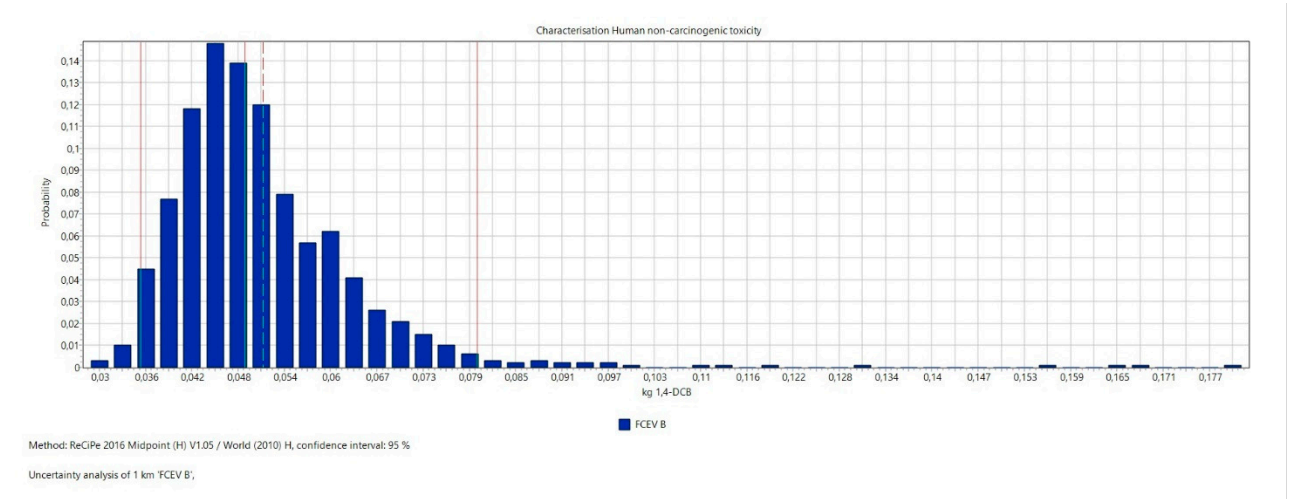

Figure S16 Uncertainty analysis characterization of Human non-carcinogenic toxicity for architecture B.

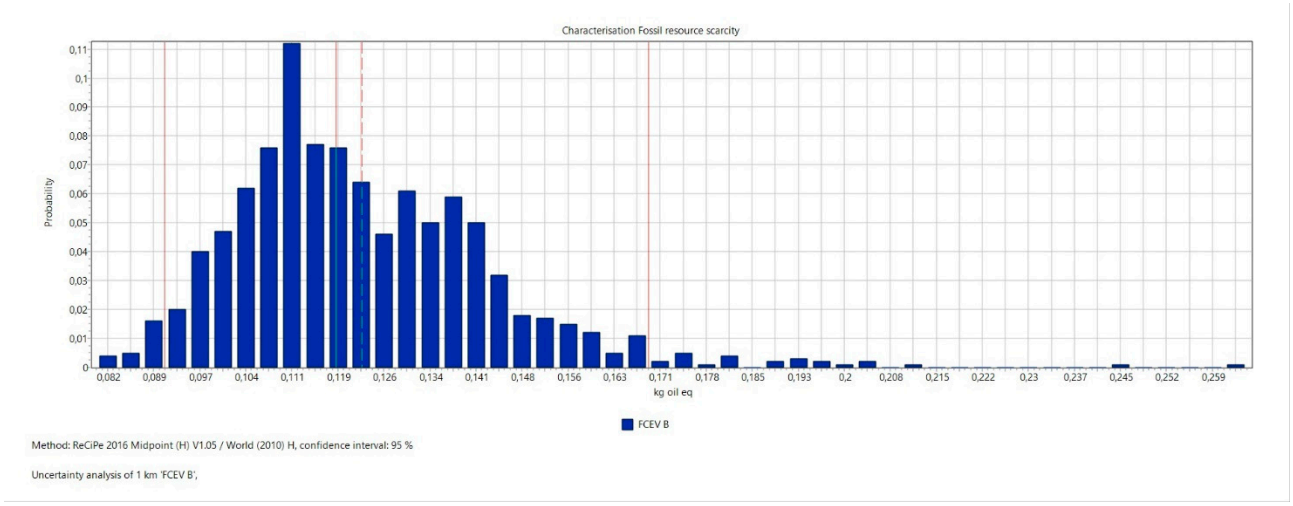

Figure S17 Uncertainty analysis characterization of Fossil resource scarcity for architecture B.

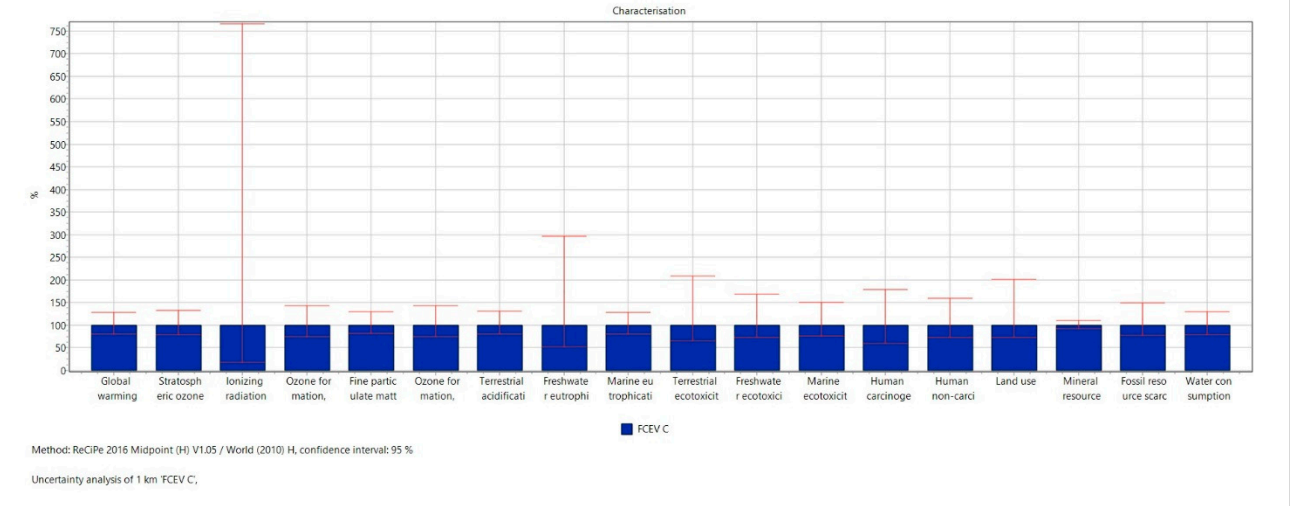

Figure S18 Uncertainty analysis results of architecture C.

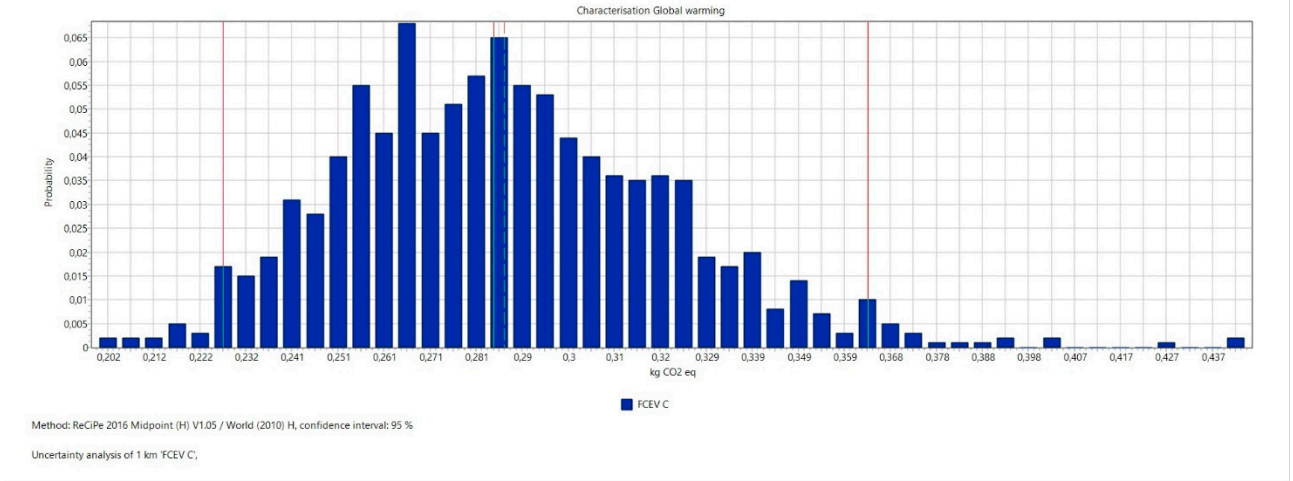

Figure S19 Uncertainty analysis characterization of Global warming potential for architecture C.

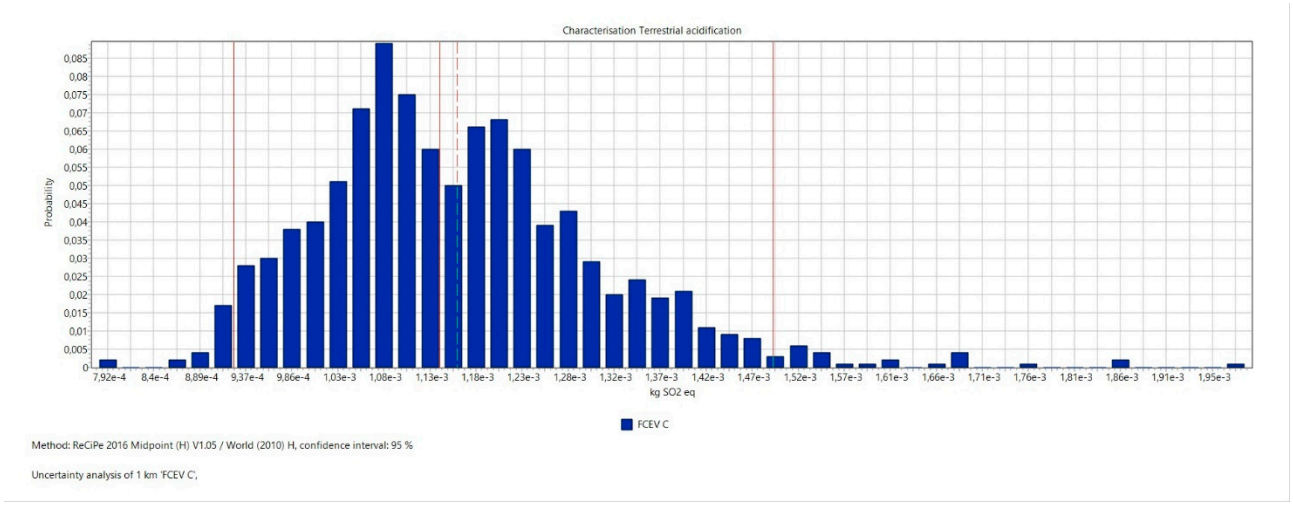

Figure S20 Uncertainty analysis characterization of Terrestrial acidification for architecture C.

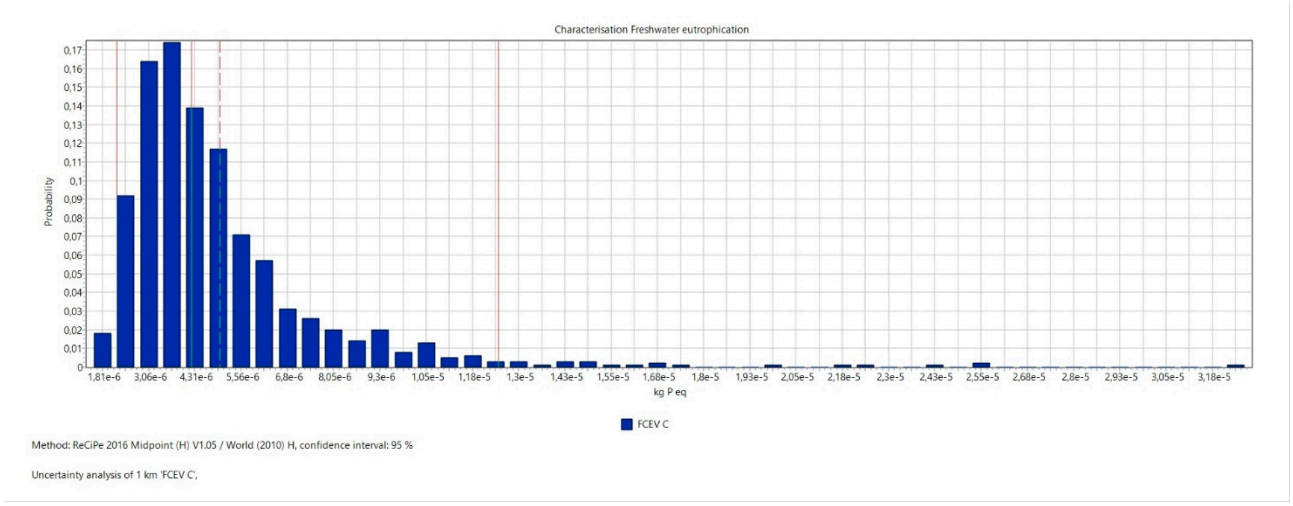

Figure S21 Uncertainty analysis characterization of Freshwater eutrophication for architecture C.

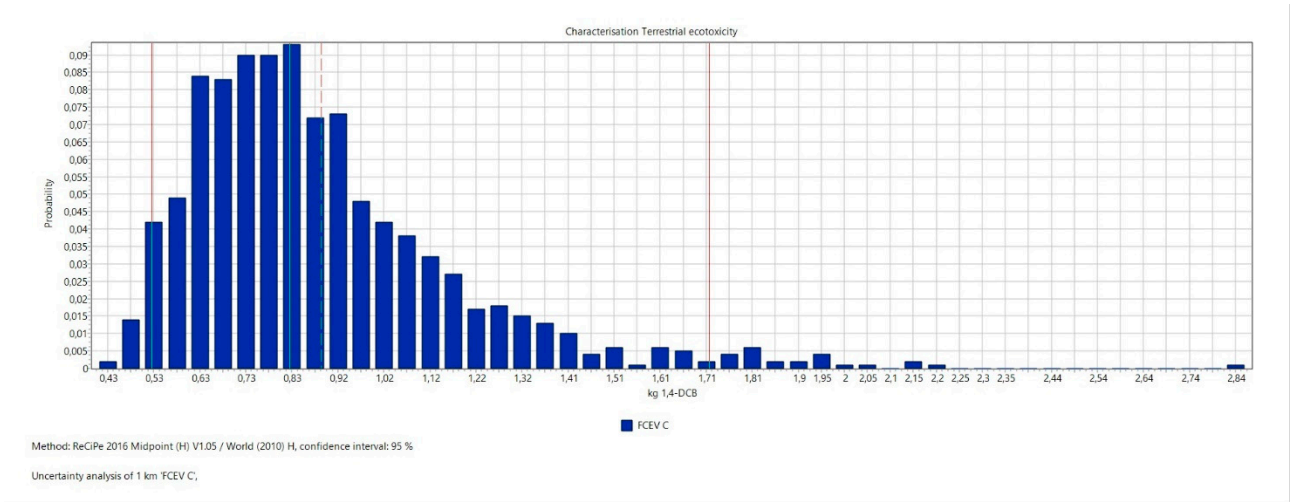

Figure S22 Uncertainty analysis characterization of Terrestrial ecotoxicity for architecture C.

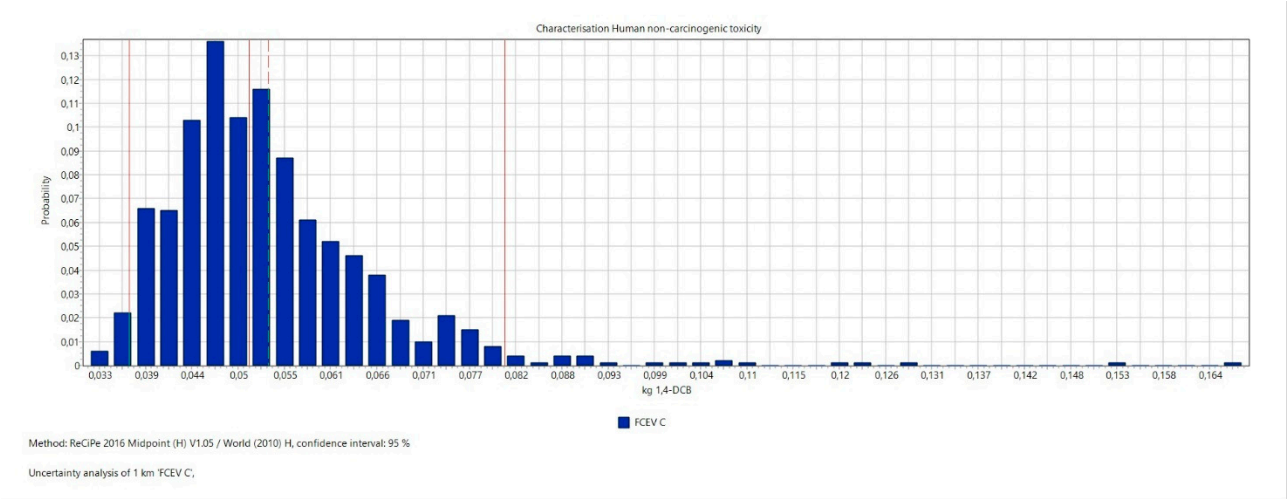

Figure S23 Uncertainty analysis characterization of Human non-carcinogenic toxicity for architecture C.

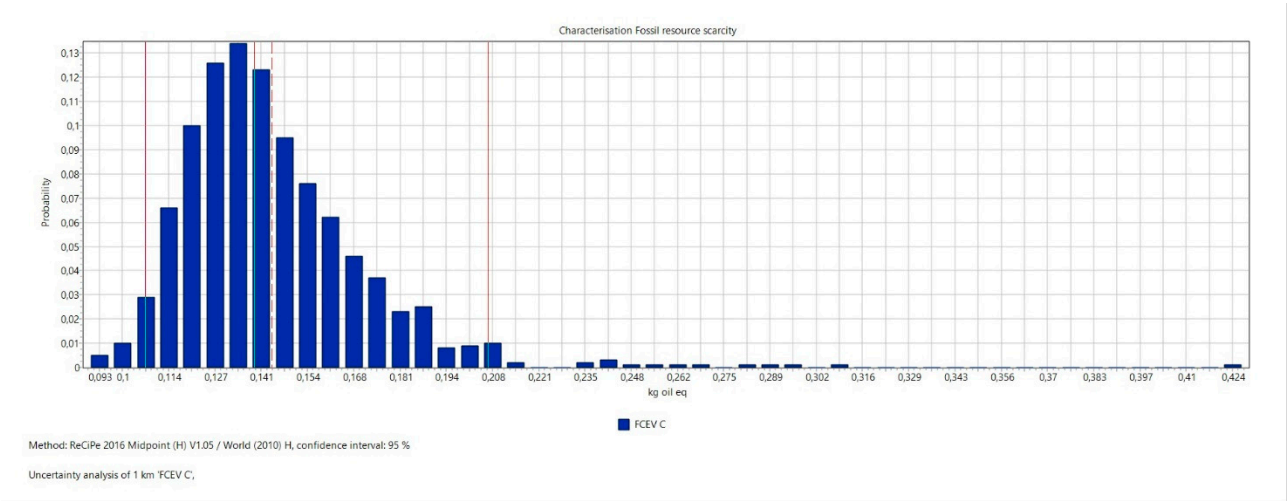

Figure S24 Uncertainty analysis characterization of Fossil resource scarcity for architecture C.

Bibliography

1. Evangelisti, S.; Tagliaferri, C.; Brett, D.J.L.; Lettieri, P. Life Cycle Assessment of a Polymer Electrolyte Membrane Fuel Cell System for Passenger Vehicles. *J. Clean. Prod.* **2017**, *142*, 4339–4355, doi:10.1016/j.jclepro.2016.11.159.
2. Candelaresi, D.; Valente, A.; Iribarren, D.; Dufour, J.; Spazzafumo, G. Comparative Life Cycle Assessment of Hydrogen-Fuelled Passenger Cars. *Int. J. Hydrog. Energy* **2021**, *46*, 35961–35973, doi:10.1016/j.ijhydene.2021.01.034.
3. Ellingsen, L.A.-W.; Majeau-Bettez, G.; Singh, B.; Srivastava, A.K.; Valøen, L.O.; Strømman, A.H. Life Cycle Assessment of a Lithium-Ion Battery Vehicle Pack. *J. Ind. Ecol.* **2014**, *18*, 113–124, doi:10.1111/jiec.12072.
4. Zhao, S.; You, F. Comparative Life-Cycle Assessment of Li-Ion Batteries through Process-Based and Integrated Hybrid Approaches. *ACS Sustain. Chem. Eng.* **2019**, *7*, 5082–5094, doi:10.1021/acssuschemeng.8b05902.
5. Habermacher, F. Modeling Material Inventories and Environmental Impacts of Electric Passenger Cars. Master thesis, Department of Enviropnmental Science, ETH Zurich, 2011.
6. Chen, Y.; Hu, X.; Liu, J. Life Cycle Assessment of Fuel Cell Vehicles Considering the Detailed Vehicle Components: Comparison and Scenario Analysis in China Based on Different Hydrogen Production Schemes. *Energies* **2019**, *12*, 1–24, doi:10.3390/en12153031.
7. Mehmeti, A.; Angelis-Dimakis, A.; Arampatzis, G.; McPhail, S.J.; Ulgiati, S. Life Cycle Assessment and Water Footprint of Hydrogen Production Methods: From Conventional to Emerging Technologies. *Environments* **2018**, *5*, 1–19, doi:10.3390/environments5020024.
8. Delpierre, M.; Quist, J.; Mertens, J.; Prieur-Vernat, A.; Cucurachi, S. Assessing the Environmental Impacts of Wind-Based Hydrogen Production in the Netherlands Using Ex-Ante LCA and Scenarios Analysis. *J. Clean. Prod.* **2021**, *299(126866)*, 1–12, doi:10.1016/j.jclepro.2021.126866.