Life Cycle Inventory for Structural Battery Cell Production

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LCA of emerging SBC Cell Technology produced in the laboratory

Battery

Swedish researchers report progress with 'structural' battery

Researchers at Sweden's Chalmers University of Technology in Gothenburg have reported progress in the development of their 'structural battery', which they claim could increase the range of an electric car by up to 70 per cent.

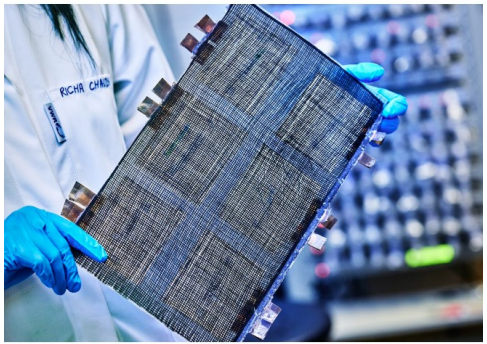


Image: Chalmers University of Technology | Henrik Sandsjö

Scientists turn batteries into building blocks for cars and planes

Story by Talker News • 6d • 3 min read

Structural battery cell: A composite material carrying mechanical load as construction material (i.e., in vehicles) while also storing energy as a battery.

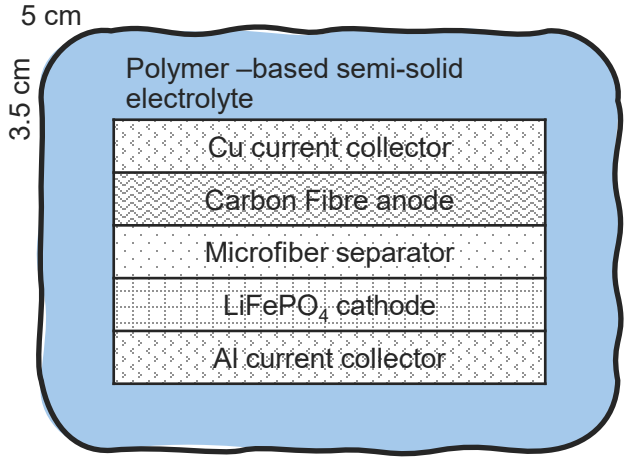


Figure 1. Simplified schematic of a Structural Battery Cell

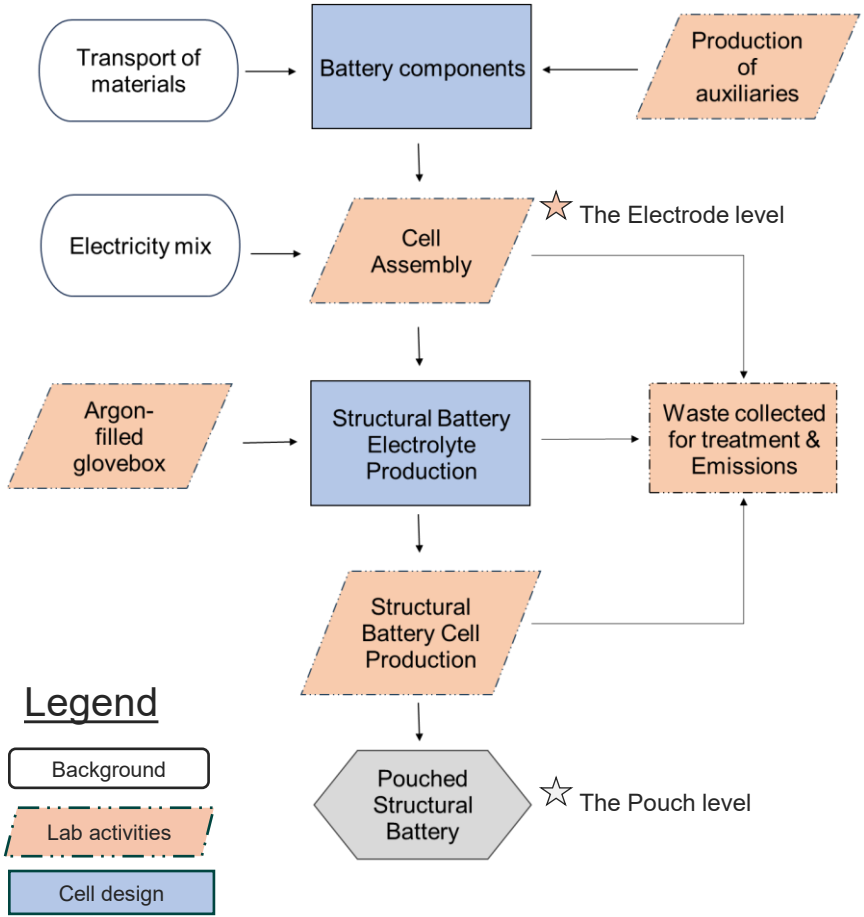


Figure 2. Simplified laboratory process flow diagram.

Structural Battery Cell Production

- Aim: To assess the environmental impacts of a Structural Battery Cell (SBC Cell) at early TRL (3) and provide input for further development.
- Reference flow: one (1) unit of structural lithium-ion battery cell.
- Scope: 'from cradle-to-laboratory gate'
- Method: ReCiPe midpoint (H)

LCI Data Collection

Table 1. Structural Battery Cell Production, following observations at Chalmers University of Technology, Material and Computational Mechanics laboratory, in Sweden. Site specific data.

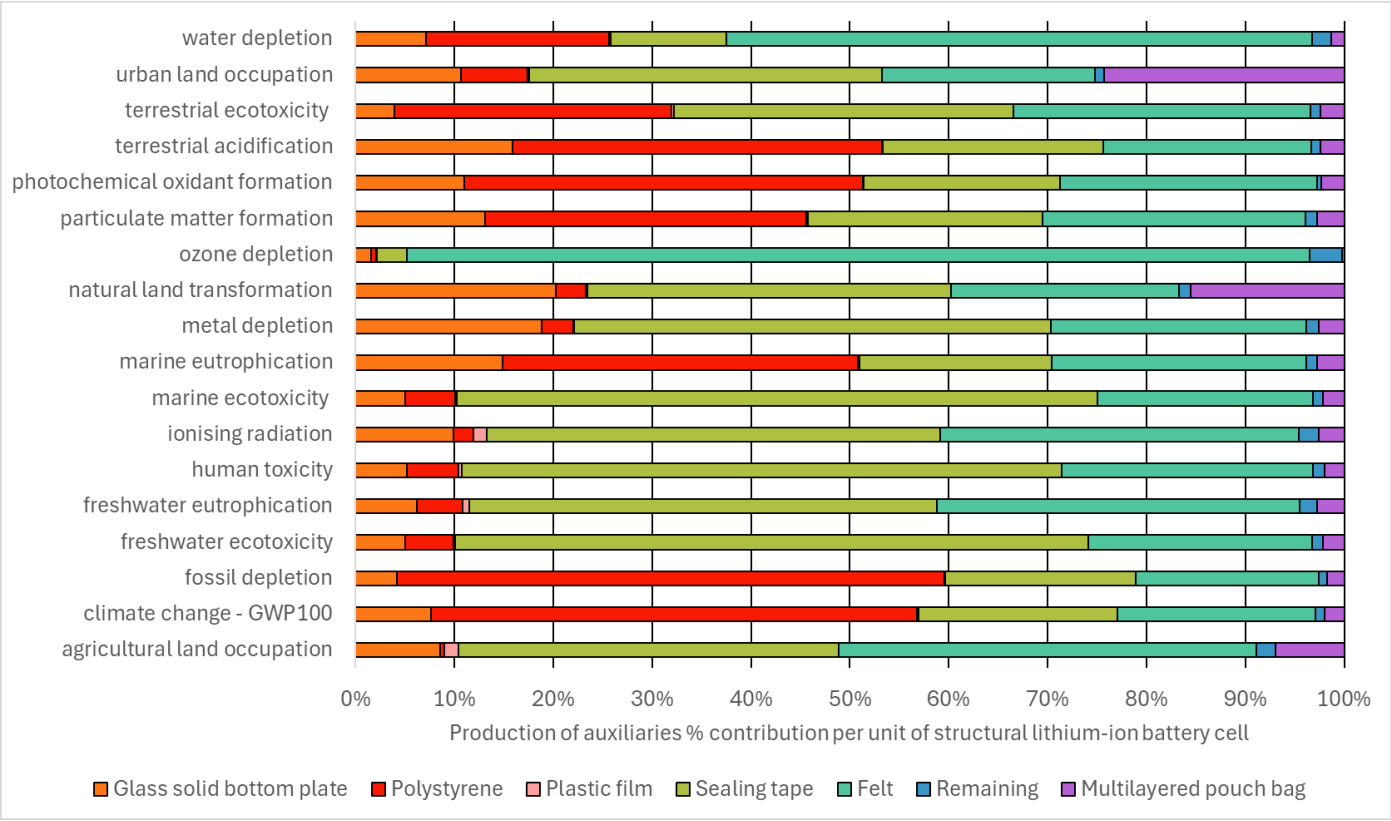
Process	Description	LCI data source	Values
Inputs			
Battery components	Lithium Iron Phosphate (LiFePO4) - coated Aluminium foil	Primary data (Reference cell)	0.25 g
	PAN-based Carbon Fibre (CF)	Primary data (Reference cell)	0.10 g
	Glass microfiber separator	Estimates (Reliant on the process level data)	0.15 g
	Aluminium foil	Primary data (Reference cell)	0.39 g
	Copper foil	Primary data (Reference cell)	0.19 g
	Silver conductive paint	Estimates (Reliant on the process level data)	1.03 g
Structural Battery Electrolyte Production	Liquid Electrolyte (Ethylene Carbonate:Propylene Carbonate)	Primary data (Reference cell)	0.06 g
	Liquid Electrolyte (LiTFSI)	Primary data (Reference cell)	0.68 g
	Polymer: Bisphenol A, Curing agent (azodicarbonamide – ADA*)	Primary data (Reference cell) *Proxy for Azobisisobutyronitrile (AIBN)	3.03 g
Transport of materials	Lorry	Average from literature	100 km
Production of auxiliaries	e.g. Glass, solid bottom plate. Polystyrene. Plastic film. Sealing tape. Multilayered pouch pack.	Primary data (Reference cell); Data calculated based on laboratory/process level data; Literature data.	240 g
Argon filled glovebox	Liquid argon production	Calculated based on process level data	138.3 g
Electricity generation sources (SE, 2022)	Cell Assembly (Drying to remove moisture)	Calculated based on process level data	5.4 kWh
	Structural Battery Electrolyte Production (SBE preparation in hot plate heating)	Calculated based on process level data	2.45 kWh
	Structural Cell Production (Resin thermal curing)	Calculated based on process level data	1.15 kWh
	Auxiliary processes	Calculated based on process level data	0.05 kWh
Outputs			
	Pouched Structural Cell	Reference cell	3.01 g
	Waste collected	Approximated from process level data	240 g
	Fugitive emissions	Approximated from process level data	138.3 g

Impact Assessment Results

Table 2. Life cycle impacts per unit of structural lithium-ion battery cell

			Battery components						Structural Battery Electrolyte Production			Transport of materials	Production of auxiliaries	Argon-filled glove box	Electricity	Waste collected
		Total impacts	LFP coated Aluminium foil	PAN based Carbon Fibre	Glass microfiber separator	Aluminium foil	Copper foil	Silver conductive paint	Liquid Electrolyte (EC:PC)	Liquid Electrolyte (LiTFSI)	Polymer	Road	Auxiliary materials	Liquid argon	Swedish electricity	Waste treatment
agricultural land occupation - ALOP	m2a	0.5643	4.19E-05	0.0009	0.0018	0.0001	0.0001	0.0008	0.0004	0.0004	0.0002	0.0001	0.0335	0.0161	0.5098	0.0001
climate change - GWP100	kg CO2-Eq	1.7067	0.0008	0.0125	0.0582	0.0060	0.0016	0.0263	0.0134	0.0091	0.0116	0.0068	0.7749	0.1882	0.1367	0.4606
fossil depletion - FDP	kg oil-Eq	0.5439	0.0003	0.0041	0.0222	0.0014	0.0004	0.0079	0.0071	0.0026	0.0068	0.0026	0.3898	0.0562	0.0398	0.0026
freshwater ecotoxicity - FETPinf	kg 1,4-DCB-Eq	0.0851	0.0001	0.0002	0.0013	0.0003	0.0043	0.0255	0.0004	0.0006	0.0002	0.0001	0.0169	0.0052	0.0121	0.0179
freshwater eutrophication - FEP	kg P-Eq	0.0005	3.96E-07	4.45E-06	1.41E-05	2.02E-06	8.75E-06	0.0001	5.14E-06	5.07E-06	2.86E-06	4.68E-07	0.0001	0.0002	0.0001	2.14E-06
human toxicity - HTPinf	kg 1,4-DCB-Eq	0.9506	0.0004	0.0037	0.0321	0.0023	0.0266	0.1264	0.0045	0.0111	0.0029	0.0021	0.1950	0.1330	0.3573	0.0532
ionising radiation - IRP_HE	kg U235-Eq	2.7776	0.0002	0.0039	0.0042	0.0002	0.0002	0.0035	0.0009	0.0005	0.0006	0.0005	0.0334	0.1235	2.6057	0.0004
marine ecotoxicity - METPinf	kg 1,4-DCB-Eq	0.0799	3.59E-05	0.0002	0.0012	0.0003	0.0039	0.0278	0.0003	0.0004	0.0002	0.0001	0.0150	0.0048	0.0112	0.0144
marine eutrophication - MEP	kg N-Eq	0.0017	2.17E-06	2.38E-05	0.0001	6.50E-06	5.55E-06	0.0001	0.0000	0.0001	1.14E-05	1.81E-05	0.0007	0.0002	0.0005	4.84E-05
metal depletion - MDP	kg Fe-Eq	0.1512	0.0001	0.0004	0.0041	0.0002	0.0074	0.0441	0.0008	0.0009	0.0005	0.0003	0.0498	0.0041	0.0377	0.0008
natural land transformation - NLTP	m2	0.0002	1.94E-07	3.53E-06	7.04E-06	6.65E-07	1.06E-06	1.08E-05	1.31E-06	1.39E-06	1.01E-06	2.69E-06	0.0001	1.98E-05	2.55E-05	-1.846E-06
ozone depletion - ODPinf	kg CFC-11-Eq	3.91E-07	1.13E-10	5.74E-10	5.09E-09	2.92E-10	1.18E-10	1.89E-09	1.10E-09	8.45E-10	4.90E-10	1.28E-09	3.55E-07	8.37E-09	1.48E-08	1.05E-09
particulate matter formation - PMFP	kg PM10-Eq	0.0024	4.33E-06	1.85E-05	0.0001	1.43E-05	2.57E-05	0.0001	2.00E-05	3.27E-05	1.94E-05	1.83E-05	0.0012	0.0003	0.0005	3.08E-05
photochemical oxidant formation - POFP	kg NMVOC	0.0051	3.72E-06	3.05E-05	0.0002	1.98E-05	2.10E-05	0.0003	4.93E-05	3.78E-05	0.0001	0.0001	0.0027	0.0004	0.0011	0.0001
terrestrial acidification - TAP100	kg SO2-Eq	0.0059	1.39E-05	0.0001	0.0002	3.08E-05	0.0001	0.0002	4.89E-05	0.0001	4.17E-05	3.54E-05	0.0031	0.0008	0.0011	0.0001
terrestrial ecotoxicity - TETPinf	kg 1,4-DCB-Eq	0.0002	2.11E-07	8.71E-07	6.85E-06	4.84E-07	3.02E-06	5.09E-06	9.85E-07	1.13E-06	6.39E-07	3.63E-06	0.0001	5.81E-06	0.0001	0.0001
urban land occupation - ULOP	m2a	0.0240	0.0001	0.0001	0.0006	0.0001	0.0003	0.0029	0.0001	0.0002	0.0001	0.0005	0.0086	0.0011	0.0090	0.0004
water depletion - WDP	m3	0.0137	8.29E-06	0.0001	0.0003	1.72E-05	3.17E-05	0.0001	3.50E-05	0.0001	3.17E-05	5.42E-06	0.0035	0.0012	0.0080	0.0003

Results for Auxiliary Materials Contribution



Conclusions

1. Life Cycle Inventory (LCI) generated for a pouched structural cell at lab scale, with good overall quality and completeness.
   - ✓ Cycling and first charge activities excluded.
2. Processes contributing to environmental impacts.
   - ✓ High contribution from on-site electricity.
     - ✓ Significance of drying ovens to remove moisture for consistency in cell production.
   - ✓ Important contribution from silver, followed by copper in the anode production.
     - ✓ Avoidance of silver and copper in new structural battery cell design.
   - ✓ Significance of the glass microfiber separator in the battery components.
     - ✓ Importance for the technology performance.
3. Big contribution from auxiliary materials and processes in the laboratory cell production.
   - ✓ Wastage reduction in up-scaled production.

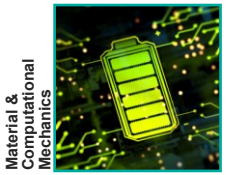
Recommendations

Improvement possibilities

- Results discussed in participatory up-scaling workshop. On-going work on TRL advancing.
- Of the battery components the carbon fibres in the anode have an important contribution.
- Replace the single use glass bottom plate with re-usable alternative e.g. steel plate (incl. the avoidance of polystyrene, e.g. ADP-f 55%).

Our team

Department of Technology Management and Economics
https://www.chalmers.se/en/departments/tme/research/environmental-systems-analysis/



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https://www.chalmers.se/en/departments/ims/research/material-computational-mechanics/lightweight-materials-and-structures/

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