Trina Energy Storage Solutions

ENVIRONMENTAL PRODUCT DECLARATION

PRODUCT NAME : LIQUID COOLED BATTERY CONTAINER TSMG4073-H-E

PLANTS: No.100 Suchu Road, Chuzhou, Anhui, China

in compliance with ISO 14025

Program Operator	UL
Publisher	EPDItaly

Declaration Number	4791371535.101.1
Registration Number	MR-EPDITALY0103

Issue Date	_2025_ / _01_ / __03__
Valid to	_2030_ / _01_ / __03__

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www.epditaly.it

Environmental Product Declaration

Liquid Cooled Battery Container

TRINA STORAGE
MODEL: TSMG4073-H-E

Systems that store electricity (produced by a renewable or non-renewable power source) for a certain time period, ensuring proper delivery of the electricity power when needed by the battery user.

TrinaStorage

Trina Storage has constructed an ESG governance structure covering 'governance - management - executive - supervisory' levels to enhance ESG operational efficiency. The company has set environmental targets for 2025 and 2030, focusing on reducing energy consumption and increasing the use of renewable energy across its global operations. Trina Solar has passed several key ISO certifications, including ISO 14001 and ISO 50001, affirming its commitment to environmental management and energy efficiency. Additionally, it emphasizes social responsibility, obtains certifications like ISO 27001 and ISO 45001. The company's achievements in sustainability have been recognized with multiple awards, including a score of 97 from the China Quality Certification Centre and recognition at the Asian Sustainability Reporting Awards.

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

ENVIRONMENTAL PRODUCT DECLARATION

TrinaStorage

TSMG4073-H-E Liquid Cooled Battery Container
Electronic and Electrical Products and Systems - Energy Storage

CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

According to ISO 14025

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL ENVIRONMENT 333 PFINGSTEN ROAD NORTHBROOK, IL 60611 HTTPS://WWW.UL.COM HTTPS://SPOT.UL.COM
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	PROGRAM OPERATOR RULES V2.7 2022
MANUFACTURER NAME AND ADDRESS	Trina Energy Storage (Chuzhou) Co., LTD No.100 Suchu Road, Chuzhou, Anhui, China
DECLARATION NUMBER	4791371535.101.1
DECLARED PRODUCT & FUNCTIONAL UNIT OR DECLARED UNIT	1 kWh stored by a TSMG4073-H-E liquid cooled battery container with 20 years RSL. The TSMG4073-H-E liquid cooled battery container is for industrial use with the cell technology of lithium iron phosphate and has a capacity of 4073kWh. The coupling type of the product is DC.
REFERENCE PCR AND VERSION NUMBER	EPD Italy 021 PCR for Energy Storage (5.0 and later)
DESCRIPTION OF PRODUCT APPLICATION/USE	The liquid cooled battery container is used to store and release energy on demand.
PRODUCT RSL DESCRIPTION (IF APPL.)	20 years
MARKETS OF APPLICABILITY	United States
DATE OF ISSUE	January 3, 2025
PERIOD OF VALIDITY	5 Years
EPD TYPE	Product-specific
RANGE OF DATASET VARIABILITY	Industry-average only
EPD SCOPE	Cradle to grave
YEAR(S) OF REPORTED PRIMARY DATA	2023
LCA SOFTWARE & VERSION NUMBER	SimaPro 9.6.0
LCI DATABASE(S) & VERSION NUMBER	ecoinvent 3.10
LCIA METHODOLOGY & VERSION NUMBER	ISO 14044:2006

The PCR review was conducted by:	EPD Italy Program PCR Moderator & Review Committee info@epditaly.it
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Skye Tang, UL Solutions *Skye Tang.*
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Zhuying Dai & Daqi Wang, CIRS Group CIRS
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Ik Kim, Smart-eco *Ik Kim*

LIMITATIONS

Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc.

Accuracy of Results: EPDs regularly rely on estimations of impacts; the level of accuracy in estimation of effect differs for any particular product line and reported impact.

Comparability: EPDs from different programs may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible". Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

1. Product Definition and Information

1.1. Description of Company

Trina Storage is a new energy storage products and solutions provider under Trina Solar, focusing on energy storage application scenarios under new power systems. The company's business covers the research, development, production and sales of energy storage core equipment such as energy storage cells, battery container, and converters, industrial, commercial, and customer energy storage, and integrated intelligent energy management systems, etc. The company is committed to providing users with safe and reliable, high-efficient, long lifetime, and intelligent application energy storage products and system solutions.

1.2. Product Description

Product Identification

TSMG4073-H-E liquid cooled battery container is a new generation, cutting-edge, grid-scale battery storage system built from the ground up using lithium iron phosphate battery cells.

The new design incorporates advanced features including a unique module design, precise thermal management enabled by smart liquid cooling technology, and a robust fire mitigation and suppression system to ensure unparalleled efficiency, comprehensive safety, and long-term reliability.

Key product features:

- High efficiency ESS
- Intelligence
- Highly integrated & flexible solution
- Comprehensive safety

Product Specification

Table 1: Product information of TSMG4073-H-E liquid cooled battery container

Parameters	Description
Product name	TSMG4073-H-E Liquid Cooled Battery Container
Cell Type	Lithium iron phosphate, LFP
Elementa	10P416S (10 racks in parallel)
Nominal energy	4073 kWh
Operating voltage	DC 1123.2-1497.6V
Weight	35000±700 kg
Dimension (W*D*H)	6058mm*2438mm*2896mm
RSL	20 years
UN CPC code	464 "Accumulators, primary cells and primary batteries, and parts thereof"
Location of production site	Anhui, China

Flow Diagram

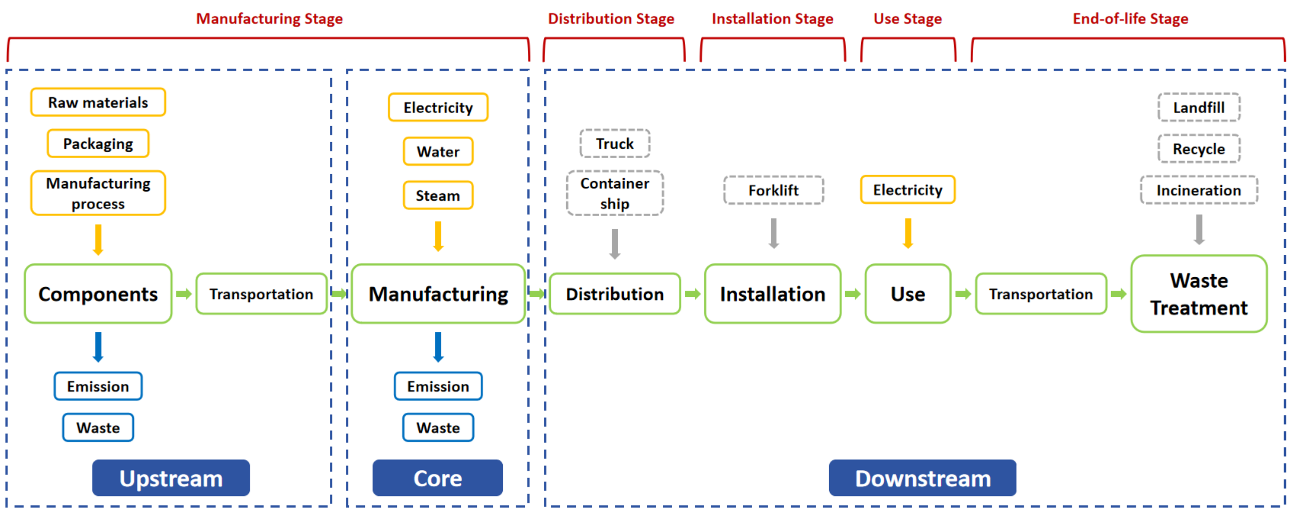

Figure 1: System boundary of the liquid cooled battery container

Product Average

In this study, the raw material inputs are determined according to the inventory on the process sheet. Data with regard to which raw materials and quantities per manufactured battery container were collected by Trina Storage, asked their suppliers for data and information for each component. The bill of materials (BOM) compiles information of the material composition into a comprehensive table.

The data of energy consumption including electricity, water, and steam for one battery container related to activities performed in Trina Storage Chuzhou Site has been estimated by allocation of the total consumption of the production site in one year to the production of energy(kWh) of all products.

The data of waste outputs used the same allocation method according to the records provided by the enterprise.

Three calculation formulas are used during use stage to estimate the energy consumed by the battery container to operate during its reference service life.

1.3. Material Composition

Table 2: Product components of liquid cooled battery container

Product components	kg/pc	kg/kWh
Battery cell	23296.0000	5.7196
Steel, chromium steel 18/8	9802.2466	2.4066
Aluminium alloy, metal matrix composite	409.6000	0.1006
Cables	384.9856	0.0945
Water pump	300.0000	0.0737

Polyvinylchloride	226.2279	0.0555
Adhesives	165.6000	0.0452
Water	107.5000	0.0264
Ethylene glycol	107.5000	0.0264
Other passive electronic components	87.6814	0.0215
Copper, cathode	87.3047	0.0214
Other active electronic components	79.5600	0.0195
Nylon 6	76.2069	0.0187
Brass	74.7204	0.0183
Steel, unalloyed	74.0000	0.0182
Acrylonitrile-butadiene-styrene copolymer	30.0000	0.0074
Bronze	14.5592	0.0036
Ceramic	6.5440	0.0016
Epoxy resin, liquid	3.2671	0.0009
Nylon 66	1.9742	0.0005
Liquid crystal display	0.5550	0.0001
Bisphenol A	0.1764	4.33E-05
Polyethylene terephthalate	0.1764	4.33E-05
Soft solder	0.1764	4.33E-05
Zinc oxide	0.1764	4.33E-05
Nylon 6, glass filled	0.1000	2.46E-05
Glass fibre	0.0035	8.47E-07
Total	35336.8421	8.6804

1.4. Manufacturing

This stage includes both upstream and core modules as indicated in the PCR. The upstream module considers the impacts related to the production of all components in the battery container, including extraction and production of raw materials, production of components and auxiliary materials for product assembly, and transportation from tier 1 suppliers to the manufacturing facility. The core module includes energy consumption during product assembly, waste generated and treatment and transportation of waste on the manufacturing site.

1.5. Packaging

The production, use, and disposal of packaging materials of components and semi-finished intermediates was cut off according to content declaration in PCR Chapter 4.2.3.9.

1.6. Transportation

This module includes the impact to the distribution of the product at the installation site. One TSMG4073-H-E liquid cooled battery container was transported from Trina Storage to United States. In this scenario, three transportation phases are considered: plant gate to harbors, ship to export countries, harbors to distribution centers. Distances in the first two phases are default values in PEFCR v6.3 Guidance, and the average distance in the third phase is assumed as 500 km is PCR EPD Italy 021. In the absence of any primary data on the fleet of vehicles used, a EURO 4 category vehicle is considered in this study.

1.7. Product Installation

This module includes impacts arising from the installation of the battery container in the operational site. According to the product instruction, 75t crane is used in installation, diesel with density of 0.85kg/L is assumed to be used in this crane with a working time of 4 hours and fuel consumption of 9.19L/h. The accessories listed in the instruction could be reused without any environmental burden. The container is large in size and does not have any packaging materials.

1.8. Use

The following formulas are used to calculate the electricity consumption during the product’ s service life:

$$E_{tot}[kWh] = E_{use} + E_{loss}$$

$$E_{use}[kWh] = \frac{P_{use} * 8760 * RSL}{1000}$$

$$E_{loss}[kWh] = \sum_{i=0}^{RSL} \frac{E_{useful,i} \times N_{cycles} \times 365}{DC\ RTE_i} \times (1 - DC\ RTE_i)$$

Where:

- P_{use} is the power consumed by the battery container auxiliaries services hourly, which is calculated by Trina Storage’s specialist as 5330W.

- RSL is the service life of the product, announced to be 20 years by Trina Storage.

- 8760 is the number of hours in a year and 1000 is the unit conversion factor.

- DC RTE_i is the DC Round Trip Efficiency in the year i

- $E_{useful,i}$ is the maximum energy dischargeable from the battery system in year i

- Nominal Operating Temperature is assumed to be 25℃±5℃ and N_{cycles} is assumed to be 1 entire charge/discharge cycle per day according to PCR EPD Italy 021 4.2.3.5.2

- 365 is the number of days in one year.

Table 3: Parameters of liquid cooled battery container during use stage

NAME	VALUE	UNIT
P_{use}	5.33E+03	W
RSL	20	years
E_{use}	9.34E+05	kWh

N_{cycles}	1	Cycle
E_{loss}	1.56E+06	kWh
E_{total}	2.50E+06	kWh

1.9. Reference Service Life

The reference service life of theTSMG4073-H-E liquid cooled battery container is 20 years.

1.10. Maintenance

During this phase, the product is subjected to regular inspection to ensure optimal performance and longevity. Based on the maintenance manual and relative information provided by Trina Storage, following table present the components that need to be changed after 15 years for preventive maintenance. The maintenance materials are supplied directly by the manufacturing facility and the maintenance procedures are conducted on-site. After preventive maintenance, the replaced components would be transported to waste treatment facilities. Waste treatment details depend on BS EN 50693. According to PEFCR 7.14.2, a transportation distance of 130 kilometers has been chosen for delivering these parts to the treatment facilities.

Table 4: Preventive maintenance material list

COMPONENTS NAME	REPLACE AMOUNT
Air Conditioner	1 pcs
Dehumidifier	3 pcs
Pipe Assembly	90 pcs
UPS	1 pcs
High Voltage Box	10 pcs
AC Lightning Protector	1 pcs
Switching Power Supply	2 pcs
Fuse	7 pcs
Ethernet Surge Protector	2 pcs
Coolant	168 L
DC Surge Protector	1 pcs

1.11. End-of-Life

When finishing the service life, the battery container would be delivered to a disassemble place, then all materials entering the final period of waste treatment: disposal and recycling. Each material has its specific material recovery rate, energy recovery rate, and disposal rate according to BS EN 50693.

2. Life Cycle Assessment Background Information

2.1 Functional or Declared Unit

1 kWh stored by a TSMG4073-H-E Liquid Cooled Battery Container with 20 years RSL. The TSMG4073-H-E Liquid Cooled Battery Container is for industrial use with the cell technology of lithium iron phosphate and has a capacity of 4073kWh. The coupling type of the product is DC.

2.2 System Boundary

Cradle-to-grave, including raw material acquisition and production, transportation to manufacturer, manufacturing, transportation to customer, installation, operational energy use, maintenance, and End-of-life.

Table 5: LCA stages and EPD modules

Manufacturing		Distribution	Installation	Use & Maintenance	EoL
Upstream	Core	Downstream			
Extraction of raw materials, including waste recycling processes and the production of semi-finished and ancillary products	Manufacturing of the product constituents, including all the stages	In accordance with EN 50693			
Transportation of raw materials to the manufacturing company	Product assembly	In accordance with EN 50693			
-	packaging	In accordance with EN 50693			
-	Waste handling	In accordance with EN 50693			

2.3 Estimates and Assumptions

Detailed recycling information was supported by EN 50693 Table G.4.

2.4 Cut-off Criteria

In this study, impacts related to the production, transportation, and installation of capital goods (buildings, infrastructure, machinery, internal transport packaging) and general operations (staff travel, marketing and communication actions) that cannot be directly allocated to products are excluded from the LCA study.

The packaging materials of the components is cut-off in this study.

No component of battery container is cut-off in this study.

The contribution of office activities, such as water and nature gas consumption, is excluded in this study.

Diesel used in forklift and crane is considered in installation phase, but other installation accessories and protective equipment such as bolts, screws, safety helmet and insulated gloves have been excluded as they could be reused.

The volatilization of glues used in the raw materials is considered, and 10% of of reduction in mass of glue is computed.

2.5 Data Sources

Primary data for raw material acquisition and transportation are from a questionnaire filled by Trina Storage and its suppliers.

Data for energy consumption and waste in manufacturing is collected from Trina Storage's production or bill records.

Transport data uses default values in PEFCR v6.3 Guidance and PCR EPD Italy 021.

After the liquid cooled battery container is launched into the market, downstream data in O&M and end-of-life treatment is calculated from the formulas in PCR and Table G.4 from EN 50693.

2.6 Data Quality

Primary data are checked by three parties at least during study period (data collector, EPD project manager in Trina Storage, LCA consultants in CIRS).

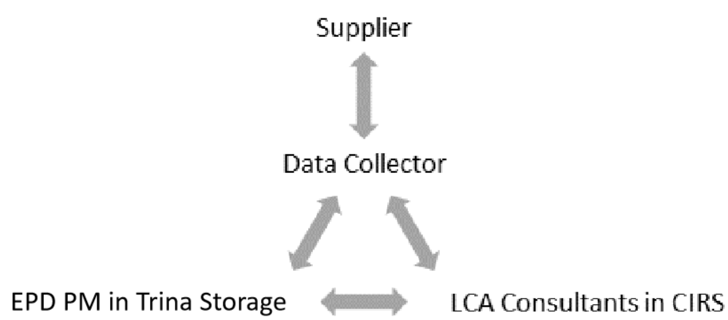

Figure 2: Data check process

When choosing generic data or making assumptions, all gap-filled data is double checked by the supervisor to make sure those are appropriate for modelling. After modelling, all modules have been checked by the supervisor.

According to ISO 14044:2006, 4.2.3.6, the data quality assessment shall address the following aspects:

- Precision
- Completeness
- Representativeness
- Consistency

In particular, the following specific requirements apply:

- Data shall be recent. Datasets used for calculations should be based on 1-year averaged data, they should have been updated within the past 10 years for generic data and within the past 5 years for producer specific data;

- The time period over which inputs to and outputs from the system shall be accounted for is 100 years from the year for which the data set is deemed representative. A longer time period should be used if relevant;

- The technological coverage shall reflect the physical reality for the reference product or product family;
- Geographic coverage shall reflect operational reality of the different life cycle stages;
- Data sets shall be aligned with the system boundaries defined.

In this project, primary data was the priority to be used, such as raw materials data from production or purchase records and electricity consumption from bill. The BOM for the battery cells is sourced from procurement data.

In addition, due to the lack of primary data in some process, generic data in related region or similar technology were chosen to keep consistency. The datasets used for calculations were based on the year 2023.

2.7 Period under Review

All activity data used for modelling is from 2023/01/01 to 2023/12/31. The raw material data provided by the suppliers are double checked by the client (Trina Storage) and LCA consultants (CIRS). The manufacturing data is checked on-site by LCA consultants. The purchase records, invoices, and other related documents were provided by the client and reviewed by LCA consultants.

2.8 Allocation

The data of energy consumption including electricity, water and steam are mass-based allocated according to the annual consumption of the enterprise, the annual production of all the products involved and the annual production of liquid cooled battery containers.

The data of waste outputs are mass-based allocated according to the annual consumption of the enterprise, the annual production of all the products involved and the annual production of liquid cooled battery containers.

There is no unit-based allocation used in this project.

3. Life Cycle Inventory Analysis

Resource use

The following table illustrates the results of life cycle inventory analysis for resource use.

Table 6: Parameters describing resource use

Parameter	Unit	Manufacturing		Distribution	Installation	Use & Maintenance	EoL	Total
		Upstream	Core					
PERE	MJ	5.50E+01	1.00E+01	1.95E-01	4.63E-04	4.68E+02	7.56E-02	5.33E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	5.50E+01	1.00E+01	1.95E-01	4.63E-04	4.68E+02	7.56E-02	5.33E+02
PENRE	MJ	1.33E+03	3.84E+02	4.12E+01	4.01E-01	5.55E+03	9.28E+00	7.32E+03
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.33E+03	3.84E+02	4.12E+01	4.01E-01	5.55E+03	9.28E+00	7.32E+03
SM	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

FW	m³	2.64E-05	3.31E-02	0.00E+00	0.00E+00	2.64E-05	0.00E+00	3.32E-02

PERE: Use of renewable primary energy excluding renewable primary energy resources used as raw materials

PERM: Use of renewable primary energy resources used as raw materials

PERT: Total use of renewable primary energy resources (primary energy and primary energy resources used as materials)

PENRE: Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials

PENRM: Use of non-renewable primary energy resources used as raw materials

PENRT: Total use of non-renewable primary energy resources (primary energy and primary energy resources used as materials)

SM: Use of secondary material

RSF: Use of renewable secondary fuels

NRSF: Use of non-renewable secondary fuels

FW: Net use of fresh water

Waste

The following table show the results of life cycle inventory analysis for waste.

Table 7: Environmental information describing waste categories

Parameter	Unit	Manufacturing		Distribution	Installation	Use & Maintenance	EoL	Total
		Upstream	Core					
HWD	Kg	1.30E-02	5.48E-03	0.00E+00	0.00E+00	1.42E-02	3.41E+00	3.44E+00
NHWD	Kg	4.51E+00	4.78E-03	0.00E+00	0.00E+00	6.59E-03	6.16E-01	5.13E+00
RWD	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

HWD: Hazardous waste disposed

NHWD: Non-hazardous waste disposed

RWD: Radioactive waste disposed

*The characteristics that render waste hazardous are described in existing applicable legislation, e.g. in the European Waste Framework Directive

Output flows

There are no components for re-use / materials for recycling and energy recovery.

Table 8: Environmental information describing out flows

Parameter	Unit	Manufacturing		Distribution	Installation	Use & Maintenance	EoL	Total
		Upstream	Core					
CRU	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	Kg	2.55E+00	0.00E+00	0.00E+00	0.00E+00	7.42E-02	4.61E+00	2.55E+00

MER	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.34E-03	4.08E-02	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CRU: Components for re-use

MFR: Materials for recycling

MER: Materials for energy recovery

EEE: Exported electric energy

ETE: Exported thermal energy

*The estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

4. Life Cycle Assessment Results

4.1. LCIA Result

The LCA results are presented below for the declared unit defined. EN 15804 + A2 method is chosen in SimaPro to get the indicators below.

Table 9: Mandatory parameters describing environmental impacts (NS-EN15804:2012+A2:2019/AC:2021)

Indicator	Unit	Manufacturing		Distribution	Installation	Use & Maintenance	EoL	Total
		Upstream	Core					
GWP-total	kg CO2 eq.	1.07E+02	3.37E+01	3.09E+00	6.46E-03	3.08E+02	8.79E-01	4.52E+02
GWP-fossil	kg CO2 eq.	1.06E+02	3.38E+01	3.09E+00	6.46E-03	3.06E+02	7.77E-01	4.50E+02
GWP-biogenic	kg CO2 eq.	8.17E-01	-1.34E-01	-4.64E-04	1.42E-06	1.44E+00	1.02E-01	2.22E+00
GWP-LULUC	kg CO2 eq.	1.38E-01	1.45E-02	1.45E-03	1.61E-06	1.68E-01	3.21E-04	3.22E-01
ODP	kg CFC11 eq.	3.72E-06	2.04E-07	4.62E-08	4.06E-10	2.80E-06	9.61E-09	6.78E-06
AP	mol H^+ eq.	8.31E-01	1.62E-01	5.46E-02	2.96E-05	1.05E+00	2.73E-03	2.10E+00
EP-freshwater	kg P eq.	7.12E-02	5.83E-03	1.66E-04	3.67E-07	2.06E-01	7.34E-05	2.83E-01
EP-marine	kg N eq.	1.51E-01	3.18E-02	1.43E-02	4.56E-06	1.91E-01	1.22E-03	3.89E-01
EP-terrestrial	mol N eq.	1.31E+00	3.38E-01	1.58E-01	4.86E-05	1.74E+00	1.01E-02	3.56E+00
POCP	kg NMVOC eq.	4.21E-01	1.01E-01	4.51E-02	5.55E-05	6.61E-01	3.58E-03	1.23E+00
ADP-M&M	kg Sb eq.	1.22E-02	1.14E-04	5.54E-06	5.08E-09	6.67E-03	2.84E-06	1.90E-02
ADP-fossil	MJ	1.33E+03	3.84E+02	4.12E+01	4.01E-01	5.55E+03	9.28E+00	7.32E+03
WDP	m^3	5.87E+01	6.34E+00	1.54E-01	3.79E-04	6.92E+01	1.43E-02	1.34E+02

GWP-fossil: Global Warming Potential fossil fuels

GWP-biogenic: Global Warming Potential biogenic

GWP-LULUC: Global Warming Potential land use and land use change

GWP-total: Global Warming Potential

ODP: Depletion potential of the stratospheric ozone layer

AP: Acidification potential, Accumulated Exceedance

EP-freshwater: Eutrophication potential, fraction of nutrients reaching freshwater end compartment.

EP-marine: Eutrophication potential, fraction of nutrients reaching freshwater end compartment.

EP-terrestrial: Eutrophication potential, Accumulated Exceedance

POCP: Formation potential of tropospheric ozone

ADP-M&M: Abiotic depletion potential for non-fossil resources (minerals and metals)

ADP-fossil: Abiotic depletion potential for fossil resources

WDP: Water deprivation potential, deprivation weighted water consumption

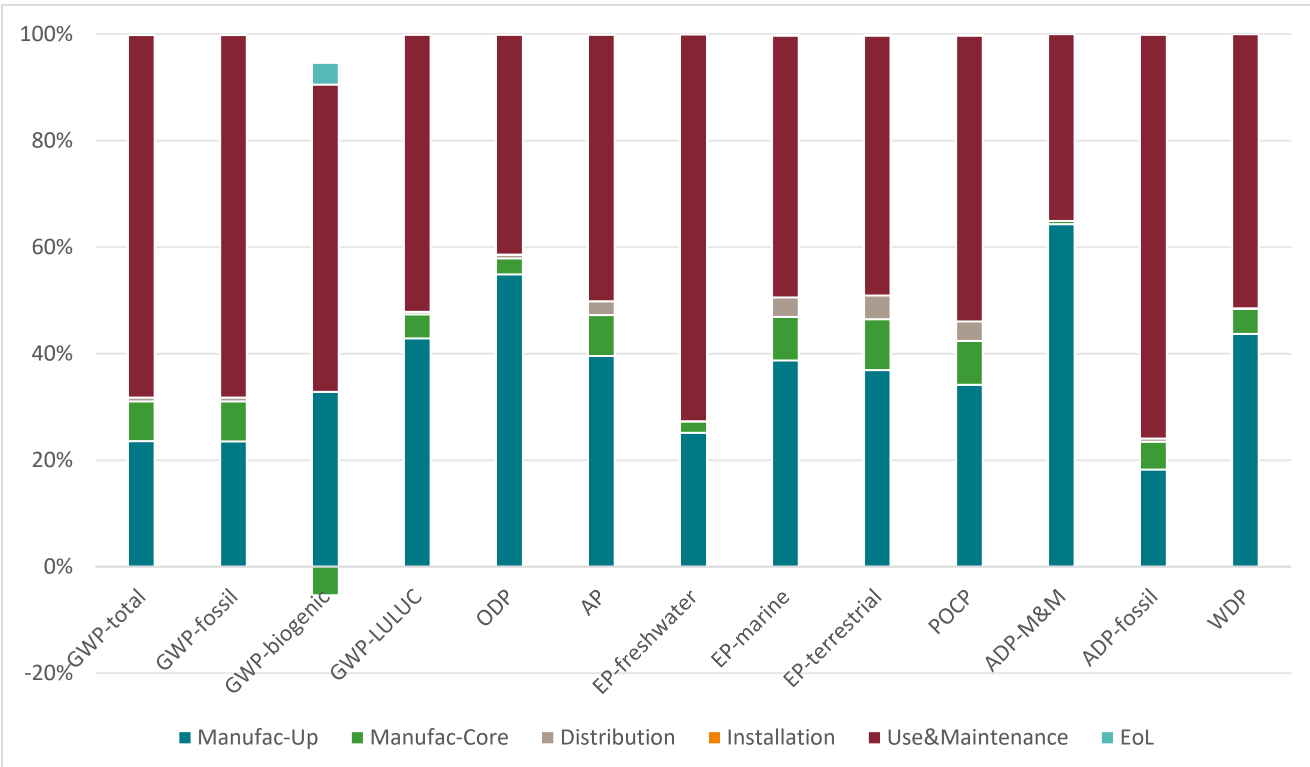

Figure 3: Life cycle impact assessment results of liquid cooled battery

5. LCA Interpretation

5.1. Interpretation of results

The use stage and the upstream module significantly influence the overall environmental impact of the functional unit. Specifically, the upstream module predominantly affects ozone depletion potential and the abiotic depletion potential of non-fossil resources, such as minerals and metals, and the use stage dominates the most of impact categories.

For use stage, electricity consumption contributes 100.00% of the environmental impacts in operation stage and 65.30% of the GWP across the entire life cycle.

For raw materials, aluminium and steel has the most significant environmental impacts among all metals. Electronic components (passive or active) have less total mass but plays a substantial role in all environmental impact categories. Lithium hexafluorophosphate, lithium iron phosphate, and N-methyl-2-pyrrolidone that come from battery cells has a large impact among all materials as well.

Minimize the energy loss to reduce electricity and use metals or materials that contain recycled content in the manufacturing process is recommended. And also the reuse of the material after final use could be considered.

5.2. Assumptions and limitations associated with the interpretation

Due to the lack of production data for components suppliers, all factors for upstream components in this study are sourced from ecoinvent v3.10, only the quality and transportation data of upstream components are collected.

A large contributor, end-of-life treatment after final use, is based on assumption.

6. Additional Environmental Information

6.1. Further Information

Since the maintenance operation are preventive maintenance, this section presents the results of the TSMG4073-H-E Liquid Cooled Battery Container that no components have been replaced.

Table 10: Parameters describing resource use

Parameter	Unit	Manufacturing		Distribution	Installation	Use & Maintenance	EoL	Total
		Upstream	Core					
PERE	MJ	5.50E+01	1.00E+01	1.95E-01	4.63E-04	4.60E+02	7.56E-02	5.26E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	5.50E+01	1.00E+01	1.95E-01	4.63E-04	4.60E+02	7.56E-02	5.26E+02
PENRE	MJ	1.33E+03	3.84E+02	4.12E+01	4.01E-01	5.39E+03	9.28E+00	7.16E+03
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.33E+03	3.84E+02	4.12E+01	4.01E-01	5.39E+03	9.28E+00	7.16E+03
SM	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	2.64E-05	3.31E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.32E-02

Table 11: Environmental information describing waste categories

Parameter	Unit	Manufacturing		Distribution	Installation	Use & Maintenance	EoL	Total
		Upstream	Core					
HWD	Kg	1.30E-02	5.48E-03	0.00E+00	0.00E+00	0.00E+00	3.41E+00	3.42E+00
NHWD	Kg	4.51E+00	4.78E-03	0.00E+00	0.00E+00	0.00E+00	6.16E-01	5.13E+00
RWD	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 12: Environmental information describing out flows

Parameter	Unit	Manufacturing		Distribution	Installation	Use & Maintenance	EoL	Total
		Upstream	Core					
CRU	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	Kg	2.55E+00	0.00E+00	0.00E+00	0.00E+00	7.42E-02	4.61E+00	7.16E+00
MER	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.34E-03	4.08E-02	4.08E-02

EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 13: Mandatory parameters describing environmental impacts (NS-EN15804:2012+A2:2019/AC:2021)

Indicator	Unit	Manufacturing		Distribution	Installation	Use & Maintenance	EoL	Total
		Upstream	Core					
GWP-total	kg CO2 eq.	1.07E+02	3.37E+01	3.09E+00	6.46E-03	2.95E+02	8.79E-01	4.40E+02
GWP-fossil	kg CO2 eq.	1.06E+02	3.38E+01	3.09E+00	6.46E-03	2.94E+02	7.77E-01	4.37E+02
GWP-biogenic	kg CO2 eq.	8.17E-01	-1.34E-01	-4.64E-04	1.42E-06	1.39E+00	1.02E-01	2.18E+00
GWP-LULUC	kg CO2 eq.	1.38E-01	1.45E-02	1.45E-03	1.61E-06	1.52E-01	3.21E-04	3.06E-01
ODP	kg CFC11 eq.	3.72E-06	2.04E-07	4.62E-08	4.06E-10	2.05E-06	9.61E-09	6.03E-06
AP	mol H^+ eq.	8.31E-01	1.62E-01	5.46E-02	2.96E-05	9.68E-01	2.73E-03	2.02E+00
EP-freshwater	kg P eq.	7.12E-02	5.83E-03	1.66E-04	3.67E-07	1.90E-01	7.34E-05	2.67E-01
EP-marine	kg N eq.	1.51E-01	3.18E-02	1.43E-02	4.56E-06	1.74E-01	1.22E-03	3.72E-01
EP-terrestrial	mol N eq.	1.31E+00	3.38E-01	1.58E-01	4.86E-05	1.56E+00	1.01E-02	3.38E+00
POCP	kg NMVOC eq.	4.21E-01	1.01E-01	4.51E-02	5.55E-05	6.07E-01	3.58E-03	1.18E+00
ADP-M&M	kg Sb eq.	1.22E-02	1.14E-04	5.54E-06	5.08E-09	2.45E-03	2.84E-06	1.48E-02
ADP-fossil	MJ	1.33E+03	3.84E+02	4.12E+01	4.01E-01	5.39E+03	9.28E+00	7.16E+03
WDP	m^3	5.87E+01	6.34E+00	1.54E-01	3.79E-04	6.64E+01	1.43E-02	1.32E+02

7. References

BS EN 50693:2019 - Product category rules for life cycle assessments of electronic and electrical products and systems

EPD Italy 021 PCR for Energy Storage (5.0 and later)

General Program Instructions for the International EPD System (Version 5.0.0)

ISO 14044:2006+A1:2018+A2:2020(2020) Environmental management - Life cycle assessment - Requirements and guidelines

PEFCR (2018) Product Environmental Footprint Category Rules Guidance (Version 6.3)

UL Environment (2022): General Program Instructions, v2.7, March

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