Product Carbon Footprint Report

Product Name	:	Energy Storage, Power Module, LUNA2000-5KW-C0, Including Flooring Bracket
Product Model	:	LUNA2000-5KW-C0
Product Name	:	Energy Storage, Battery Module, LUNA2000-5-E0, 5kWh
Product Model	:	LUNA2000-5-E0
Report Number	:	SYBH(G-L)10059527-01

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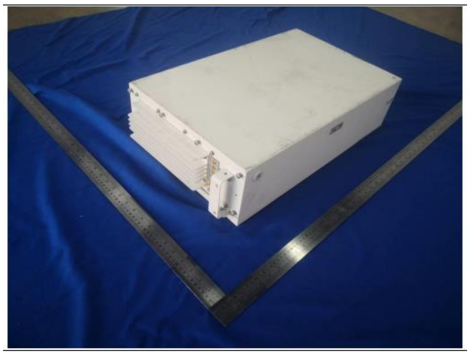
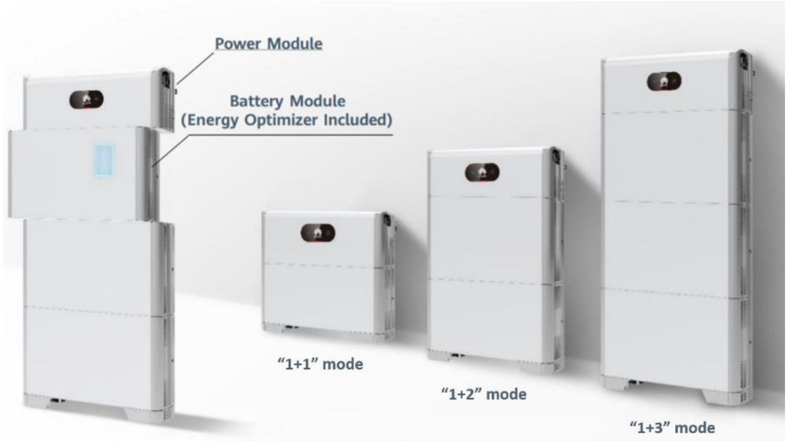
General information	
Report Number	SYBH(G-L)10059527-01
Report Traceability	Added two configurations based on the report "SYBH(G-L)10033660-01".
Company Name	Huawei Technologies Co., Ltd.
Address	Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C
Standard	ISO 14040 Life Cycle Assessment (LCA) –Principle and Framework ISO 14044 Life Cycle Assessment (LCA) –Requirements and Guidelines ETSI ES 203 199 V1.2.1 (2014-10) Environmental Engineering (EE); Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services
Software tool used	SimaPro 9.2
Product Description	Distributed energy storage, storaging the energy from the inverter.
Product Model	LUNA2000-5KW-C0, LUNA2000-5-E0
Input Power	2500W ("1+1" mode) 5000W ("1+2" mode/"1+3" mode) *(Note: "1+1" mode means one power module (LUNA2000-5KW-C0) & one battery module (LUNA2000-5-E0); "1+2" mode means one power module & two battery modules; "1+3" mode means one power module & three battery modules.)*
Efficiency	95.0%
Weight	60.8kg ("1+1" mode) 110.4kg ("1+2" mode) 160.0kg ("1+3" mode)
Functional Unit	10 years
Boundary	Cradle to grave
Environmental Impact Categories	Climate Change (CC) according to ReCiPe 2016 Midpoint (H) Version 1.03
Cut off Criteria	Raw Materials which constitute <1wt% of product weight and/or >95% of product weight included
Abbreviations	GHG: Greenhouse Gas PCB: Printed Circuit Board

	PCBA: Printed Circuit Board Assembly IC: Integrated Circuit
Reason for Carrying The Study	Market requirements
Target Audience(S)	Client
Result and Interpretation	
GWP Emission	1195.2 kg CO_2e (“1+1” mode) 1874.6 kg CO_2e (“1+2” mode) 2390.3 kg CO_2e (“1+3” mode)
Identify Hot Spot	RMA and Production stage
Conclusion	RMA and Production stage is 83.8%(“1+1” mode)/ 79.7%(“1+2” mode)/ 83.0%(“1+3” mode) of CC
Product picture	LUNA2000-5KW-C0:  LUNA2000-5-E0:  “1+1”&“1+2”&“1+3” modes:

Prepared by:	2022-01-13	Li Yeshuang	Li Yeshuang
	Date	Name	Signature
Approved by Senior Engineer:	2022-01-14	Zhang Jiaojiao	Zhang Jiaojiao
	Date	Name	Signature

Content

1 GOAL AND SCOPE DEFINITION

1.1 Goal definition

HUAWEI aims to carry out a Carbon Footprint assessment on an energy storage system that incorporate one power module (LUNA2000-5KW-C0) and some battery modules (LUNA2000-5-E0). Through this Carbon Footprint assessment, HUAWEI can use the results to find out what the most important contributor is within the upstreaming, manufacturing and downstreaming process chain of this energy storage system.

Furthermore, the parameters of the process chain that can potentially be improved in the future can be identified though this investigation.

The goal of this report is to estimate an indicator for Climate Change (CC) mid-point impact category of the energy storage system used in Germany during its lifetime.

1.2 Scope definition

1.2.1 Function Unit

The applicable functional unit is the product lifetime of use. All results below are based on an estimated lifetime of 10 years.

1.2.2 System Boundary

The studied product system is one power module (LUNA2000-5KW-C0) and some battery modules (LUNA2000-5-E0) used in Germany. To evaluate the life cycle greenhouse gas (GHG) emissions in relative scale to Global warming potential (GWP100), in kilograms (kg) of carbon dioxide equivalents (CO_2e) of the energy storage system is calculated. A lifetime of 10 years is be taken into account. The product is transported from Shenzhen, China to Germany.

The system boundary of this evaluation is set to include following life cycle stages:
– Raw Materials Acquisition (RMA)
– Production
– Distribution
– Use
– End of Life

The system boundary is shown in Figure 1.

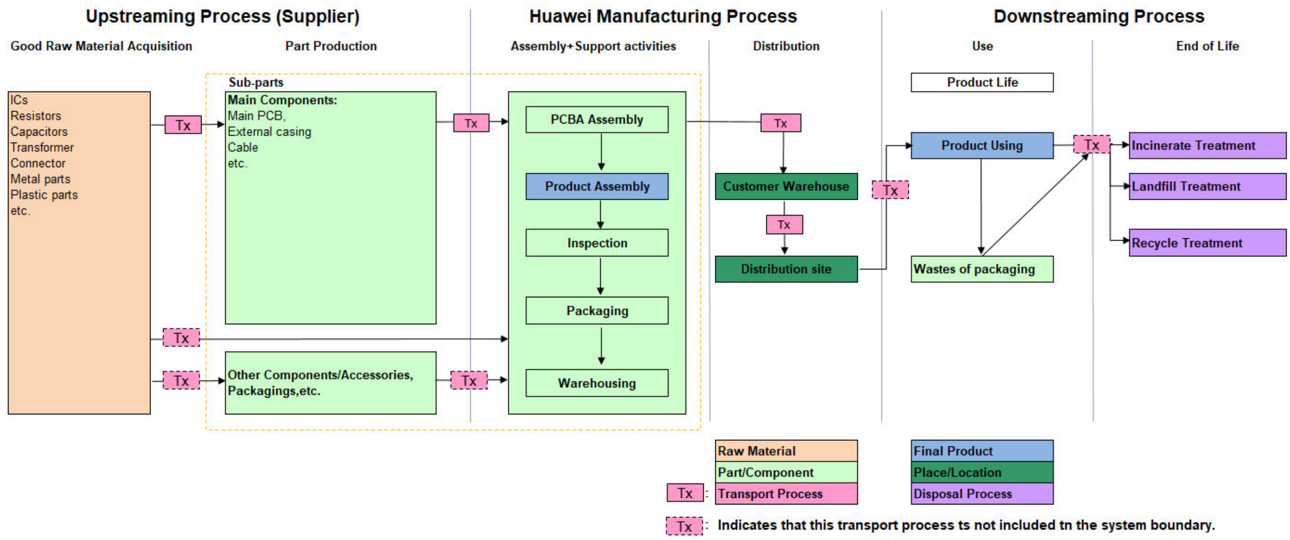


Figure 1 The Life Cycle Process Map of the energy storage system

The system boundary of the energy storage system includes all of the life cycle stages of the product, including raw material acquisition(RMA), part production, assembly (including inspection and packaging), main distribution steps, use stage and end of life (disposal/recycling) stage.

The capital goods (e.g. supporting facility, buildings, etc.) that are not directly associated with the production of this product are excluded.

2 LIFE CYCLE INVENTORY

2.1 Data collection

2.1.1 RMA and Production

The raw materials stage includes:
- Material extraction and manufacturing of electronic components (e.g. ICs, resistors, capacitors, etc.), plastics, metals, etc.
- Production/generation of energy used for raw material manufacturing.

The packaging material of raw material/components is not included in the system boundary.

The manufacturing of sub-parts includes:
- Transportation of raw materials to sub-parts of the product manufacturing.
- Manufacturing of product sub-parts and the generation of associated process waste and its treatment.
- Production/generation of energy used for sub-parts manufacturing.

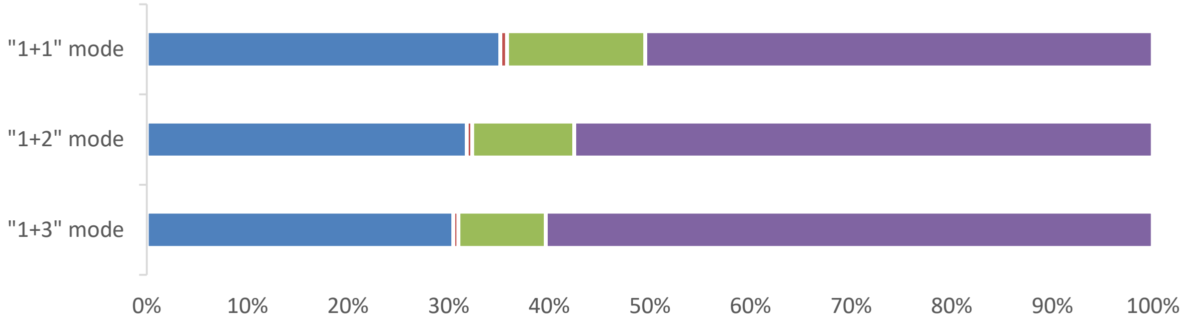
The packaging material of sub-parts is not included in the system boundary.
Transportation of raw materials to the manufacturing process of accessories and packaging materials is excluded.

The assembling and support activities stage includes:
- Transportation of product component/part to product assembly.

- Boards assembly (PCBA) and modules assembly, final product assembly, final product packaging and the generation of associated process waste and its treatment.
- Production/generation of energy used for product manufacturing.

The internal transportation is not included in the system boundary.

For the final product assembly processes, site-specific data (primary data) is collected from the relevant processes. Secondary data is used where primary data is not available, or may exist quality issues (e.g. when appropriate measurement are not available).



	"1+3" mode	"1+2" mode	"1+1" mode
Metal	30.5%	31.8%	35.2%
Plastic	0.5%	0.6%	0.6%
Electronic part	8.7%	10.1%	13.8%
Battery	60.3%	57.5%	50.4%

Figure 2 Main constitutive raw materials and parts of the energy storage system

Note: Single insignificant emissions source resulting in less than 1% of total emissions, but the total proportion of immaterial emission sources was not exceeded 5% of the full product carbon footprint.

Raw material GHG emission data for all electronic parts, other parts and ancillary materials, including their packaging material, the process energy, waste treatment and transportation GHG emission data were collected from the latest applicable ecoinvent database.

2.1.2 Distribution

The distribution stage includes:
- The transportation process from the manufacturing factory to the Shenzhen port. The distance is about 70km by truck.
- The transportation process from Shenzhen port to Trieste port, Italy. The distance is about 14150 km by seaway.
- The transportation process from Trieste port to the Budapest, Hungary. The distance is about 550km by truck.
- The transportation process from Budapest to the distribution site (assuming Berlin here). The distance is about 1000 km by truck.

Generic data (secondary data) is used for the transportation distance and the calculation of the GHG emission.

Distance Data from the manufacturing factory to the Shenzhen port, Trieste port to Budapest, and Budapest to Berlin are from Google Maps.

Maritime transport distances data is obtained from http://www.searates.com/services/.

2.1.3 Use

This section refers to the use of the the energy storage system by customers. However, the item associated with its maintenance is excluded, because HUAWEI has no control over the process.

A usage scenario refers to the EU Final Product Environmental Footprint Category Rules and Organisation Environmental Footprint Sector Rules of IT equipment (https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm) is evaluated and applied since it is the closest PCR to this product category. The energy storage system is used in conjunction with photovoltaic and inverters to store excess solar energy. The power generated by solar panels is related to the light intensity and the effective light time. Average annual sunshine time in Germany is 1896.1h in the year 2020. This data is obtained from Deutscher Wetterdienst (DWD). It is assumed that the loss of energy storage system in the process of electric energy conversion can be taken as the electric energy used during the work. The amount of electricity used by the energy storage system is calculated by the following equation:

$$\begin{aligned}&\text{Amount of electricity used by the energy storage system}\\&\qquad = \text{the input power} \times (1 - \text{Efficiency}) \times \text{average annual sunshine time}\\&\qquad \times \text{life time of the energy storage system}\end{aligned}$$

The product is produced for use in the Germany Market. The results of calculations are summarized in the following table.

Table1 Amount of electricity used by the energy storage system

Product Model	Input Power (W)	Efficiency	annual sunshine time (h)	Life time of product (years)	Amount of electricity (kWh)	GWP Emission(CO2e)
"1+1" mode	2500	95%	1896.1	10	2370.1	163.5
"1+2" mode	5000	95%	1896.1	10	4740.3	327.1
"1+3" mode	5000	95%	1896.1	10	4740.3	327.1

- According to the calculation result released by European Commission JRC Publications Repository, 69g of CO2 were emitted per kilowatt hour of PV electricity generated in German in 2013.

Considering the function and purpose of the energy storage system, it would help use clean energy instead of urban electricity, thereby reducing CO_2e emissions.

Table2 Amount of electricity stored by the energy storage system

Product Model	Theoretical storage electricity in 10 years (kWh)	Assumed storage electricity in 10 years (kWh)	GWP Emission(CO2e)
"1+1" mode	45032.4	13170	-4095.9
"1+2" mode	90064.8	26340	-8191.7

"1+3" mode	90064.8	39510	-12287.6

- Theoretical storage electricity=the input power×Efficiency) ×average annual sunshine time×life time of the energy storage system.

-The data of greenhouse gas emission intensity of electricity generation is obtained from European Environment Agency (https://www.eea.europa.eu/), 311g of CO2 were emitted per kilowatt hour in Germany 2020.

2.1.4 End-of-life stage

The GHG calculation is based on databases, and the assumed waste treatment mode is as below:

– 90% of the metal parts of the product can be recycled and 10% are sent to landfills.
– 65% of the electronic parts (PCBA, cable, fan, etc.) and other materials can be recycled, 10% are incinerated, and 25% are sent to landfills.
– 60% of plastic parts can be recycled, and 40% incinerated.
– 70% of battery can be recycled, and 30% are sent to landfills.

All recoverable waste is disposed through external company, and the recycling benefit, including material and energy recycling, is allocated to the production of the recycled materials, which may be used to produce other products. It will not be allocated to the energy storage system.

According to the assumption described, the detail waste treatment mode of material and component is explained as below:

Table3 The detail waste disposal mode of the energy storage system

Product	Weight percent of Material / Component (%)				Disposal mode (%)		
	Metal	Plastic	Electronic part	Battery	Recycling	Incineration	Landfill
"1+1" mode	35.2%	0.6%	13.8%	50.4%	76.3%	75.8%	75.6%
"1+2" mode	31.8%	0.6%	10.1%	57.5%	22.1%	23.0%	23.3%
"1+3" mode	30.5%	0.5%	8.7%	60.3%	1.6%	1.2%	1.1%

NOTE: all the incineration processes are calculated without energy recovery.

Secondary data is used for the calculation of the GHG emission directly. The database uses a cut-off approach. All incineration processes are calculated without energy recovery. For the material recycling in the end of life and manufacturing process, the scrap don't be considered as an input, all recyclable waste is disposed through open-loop recycling, and the recycling benefit is allocated to the production of the recycled materials which may use to produce other products. The GHG emission is calculated with the secondary data and the database has a default allocation method: cut-off approach.

2.2 Product Carbon Footprint Calculation

The collected primary data of the manufacturing of the energy storage system includes raw material consumption, process energy consumption, transportation information, use stage power consumption and total processes output flows. Most of the process data were collected in the year 2021. All data reflects the state of art production processes in Asia.

The generic data (secondary data) used in the SimaPro 9.2 for the GHG emission calculation is from the database Ecoinvent. The used datasets are selected timely and reflect consistent production data.

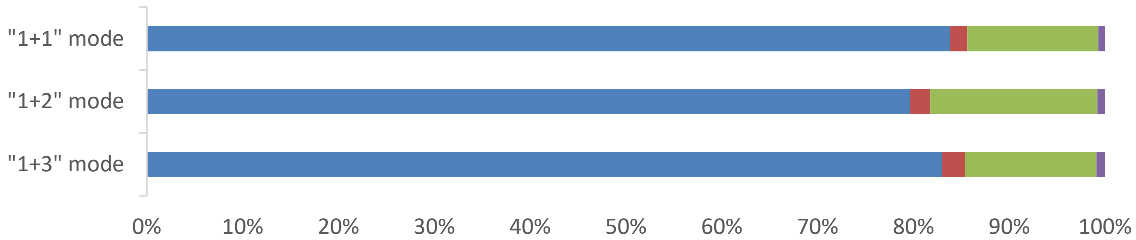
The life cycle model of the GHG emission calculation in Simapro 9.2 and the calculation results are as follows.

Table4 The calculation results of Greenhouse gas emissions

Product	GWP Emissions of life cycle stages (kgCO2e)				
	Raw Material Acquisition and Production	Distribution	Use	End of Life	Total
"1+1" mode	1001.8	21.8	163.5	8.1	1195.2
"1+2" mode	1493.1	39.6	327.1	14.7	1874.6
"1+3" mode	1984.4	57.5	327.1	21.4	2390.3

3 Life Cycle Impact Assessment

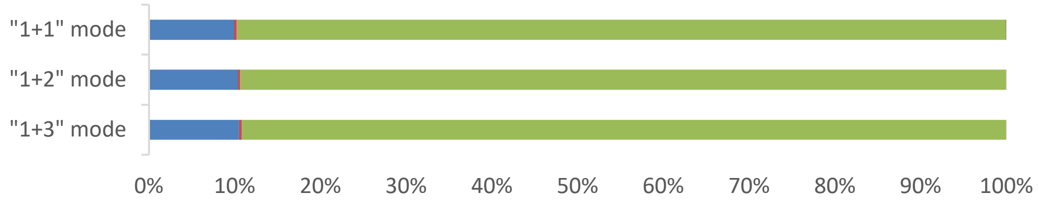
Based on the methodology, assumptions and calculation model described in this report, the greenhouse gas emissions in the life cycle are shown as Table 3 respectively. In terms of life cycle stages, it is clear in Figure 3 that the RMA and Production stage has the highest share of the total life cycle GHG emissions.



	"1+3" mode	"1+2" mode	"1+1" mode
RMA and Production	83.0%	79.7%	83.8%
Distribution	2.4%	2.1%	1.8%
Use	13.7%	17.4%	13.7%
End of Life	0.9%	0.8%	0.7%

Figure 3 Product Carbon footprint analysis by all life stages

Figure 4 shows the shares of total CO_2e emission for different parts or processes of RMA and production stage. Electronic parts has the largest share.



	"1+3" mode	"1+2" mode	"1+1" mode
Metal Parts	10.5%	10.3%	9.9%
Plastic Parts	0.4%	0.4%	0.4%
Electronic Parts	89.1%	89.3%	89.7%
Manufaturing of the Product	0.0%	0.0%	0.1%

Figure 4 Product Carbon footprint analysis by manufacturing process

4 Life Cycle Interpretation

The main interpretations and conclusions of this evaluation are described hereinafter:

The results for different stages and manufacturing process, please see section 3.

The highest impact of the the energy storage system GHG emission occurs from the RMA and Production stage (about 80% of the total life-cycle impact). The important contribution at this stage comes from the production of electronic components， such as printed circuit board, capacitors, ICs, inductors, etc. It can be reduced by minimizing material usage, using recycled or low-carbon materials when design the product， promoting suppliers to use energy-saving and environmentally friendly raw materials as much as possible in the components design stage, adopting advanced energy-saving production processes and technical equipment, strictly controlling the energy consumption of each process and improving the efficiency of energy use, shortening the transportation distance from raw materials to production sites, etc.

The second impact of the the energy storage system GHG emission occurs from the use stage. The GHG emission of use stage occurs from the loss of electric power, which is directly related to carbon emissions (see section 2.1.3). It can be reduced by improving the product energy efficiency. Considering the conversion power of the energy storage system, it will generate 163.5kg ("1+1" mode)/327.1kg ("1+2"/"1+3" mode)CO2e emissions during the 10 years of life, but the stored electrical energy can help reduce 4095.9kg("1+1" mode)/8191.7kg("1+2" mode)/12287.6kg("1+3" mode) CO_2e emissions.

The distribution stage and end of life stage have no significant impacts on GHG emission.