HUAWEI

Product Carbon Footprint Report

Product Name : Smart String ESS

Product Model : LUNA2000-200KWH-2H1

Report Number : SYBH(G-L)10210588

Reliability Laboratory of Huawei Technologies Co., Ltd.

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General information	
Report Number	SYBH(G-L)10210588
Report Traceability	First report
Applicant	Huawei Digital Power Technologies Co., Ltd
Address	Office 01, 39th Floor, Block A, Antuoshan Headquarters Towers, 33 Antuoshan 6th Road, Futian District, Shenzhen, 518043, P.R.C
Reference Standards	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
Product Name	Smart String ESS
Product Model	LUNA2000-200KWH-2H1
Product Description	The ESS consists of the power supply and distribution system, monitoring system, environment control system, and fire suppression system. It stores and releases electricity controlled by the Smart Rack Controller (also referred to as rack controller). The input and output ports of the ESS are high-voltage direct current (HVDC) ports. It features safety, reliability, fast deployment, low cost, high energy efficiency, and intelligent management.
Energy Capacity	193.5 kWh (nominal)
Weight	2.8 t (without packaging and extinguishing agent)
Refrigerant	HFC-134a
Extinguishing Agent	HFC-227ea
Functional Unit	The usage of one LUNA2000-200KWH-2H1 for 20 years
Product picture	
Boundary	Cradle to grave

Environmental Impact Categories	Climate Change (CC)
Cut off Criteria	Raw Materials which constitute <1% of product weight and >95% of product weight included
Software Tool	SimaPro 9.4
Database	ecoinvent 3.8
Assessment Method	IPCC 2021 GWP 100a
Abbreviations	EES: Energy Storage System CC: Climate Change GHG: Greenhouse Gas GWP: Global Warming Potential RMA: Raw Material Acquisition PCB: Printed Circuit Board PCBA: Printed Circuit Board Assembly IC: Integrated Circuit EoL: End-of-Life ESC: Europe Supply Center UK: United Kingdom AC: Air Conditioner
Reason for Carrying The Study	Market requirements
Target Audience(s)	Client

Result and Interpretation

Assumption Scenarios	**GHG Emissions**	**Identify Hot Spot**	**Proportion**
Scenario 1	1.39E+05 kg $CO_{2\ eq}$	Use stage	82.11%
Scenario 2	1.56E+05 kg $CO_{2\ eq}$	Use stage	84.01%
Scenario 3	2.54E+05 kg $CO_{2\ eq}$	Use stage	90.19%
Scenario 4	3.61E+05 kg $CO_{2\ eq}$	Use stage	93.08%

Note: The results of this report exemplify that the differences in application scenarios of ESS can have a high impact on the GHG emission results within its lifetime, especially the use stage. The results of the life cycle assessment of this product in several common hypothetical application scenarios are shown above, please see section 2.3.1 for more details about scenario 1~4.

Approved by Senior Engineer:	2023-01-17	Zhang Jiaojiao	Zhang Jiaojiao
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	Date	Name	Signature

Content

1 GOAL AND SCOPE DEFINITION

1.1 Goal Definition

Huawei Digital Power Technologies Co., Ltd aims to carry out a carbon footprint assessment on LUNA2000-200KWH-2H1. Through this Carbon Footprint assessment, the assessment results can be used to find out what the most important contributors are within the upstreaming, manufacturing and downstreaming process chain of LUNA2000-200KWH-2H1.

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

The goal of this report is to estimate an indicator for Climate Change (CC) mid-point impact category of LUNA2000-200KWH-2H1 used in Europe during its lifetime.

1.2 Scope Definition

1.2.1 Functional Unit

The applicable functional unit is the usage of one LUNA2000-200KWH-2H1 for 20 years. All results below are based on an estimated lifetime of 20 years.

1.2.2 System Boundary

This studied product system is one LUNA2000-200KWH-2H1 used in Europe. To evaluate the life cycle greenhouse gas (GHG) emissions in relative scale to Global warming potential (GWP100), in kilograms (kg) of carbon dioxide equivalents ($CO_{2\ eq}$) of LUNA2000-200KWH-2H1. The lifetime of the product is assumed to be 20 years. The product is transported from Dongguan, China to Europe.

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

The system boundary is shown in Figure 1.

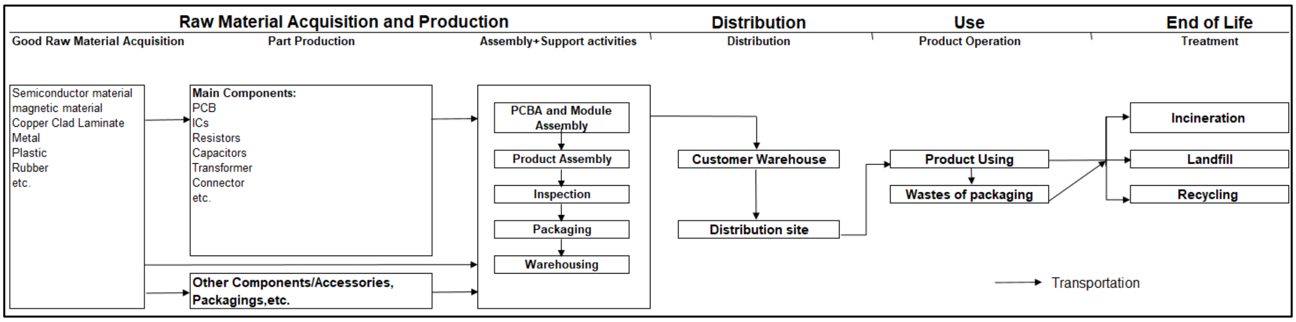

Figure 1 The Life Cycle Process Map of LUNA2000-200KWH-2H1

This product system boundary includes all of the life cycle stages of the product, including raw material acquisition (RMA), part production, assembly and support activities (including testing, warehousing, etc.), main distribution processes, use stage and end of life (recycling/ disposal) stage.

The capital goods (e.g. machinery equipment and buildings, used in the life cycle of products) that are not directly associated with the production of this product are excluded.

2 LIFE CYCLE INVENTORY

2.1 Data collection

2.1.1 Raw Material Acquisition and Production

The raw material acquisition and production stage mainly includes the acquisition of raw materials, production of parts/components, assembling and support activities of finished products, as follows.

The raw materials stage includes:
- Raw material (e.g. semiconductor material, magnetic material, copper clad laminate, metal, plastic, etc.) extraction of product component/part.
- Production/generation of energy used for raw materials manufacturing.
The packaging of raw materials is not included in the system boundary.

The production of component/part includes:
-Transportation of raw materials to manufacturing sites of component/part (e.g. electronic components, cable, etc.).
- Manufacturing of product component/part and the generation of associated process waste and its treatment.
- Production/generation of energy used for component/part manufacturing.
The packaging material of component/part is not included in the system boundary.

The assembling and support activities stage includes:
- Transportation of product component/part to product assembly.
- PCBA and Modules assembly, final product assembly and the generation of associated process waste and its treatment.
- Production/generation of energy used for product manufacturing.
The internal transportation and final product packaging are not included in the system boundary.

Most of the basic data required for the development of the assessment for the product were obtained from direct measurement of the size and mass of each component or technical data sheets of each component of the system. 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).

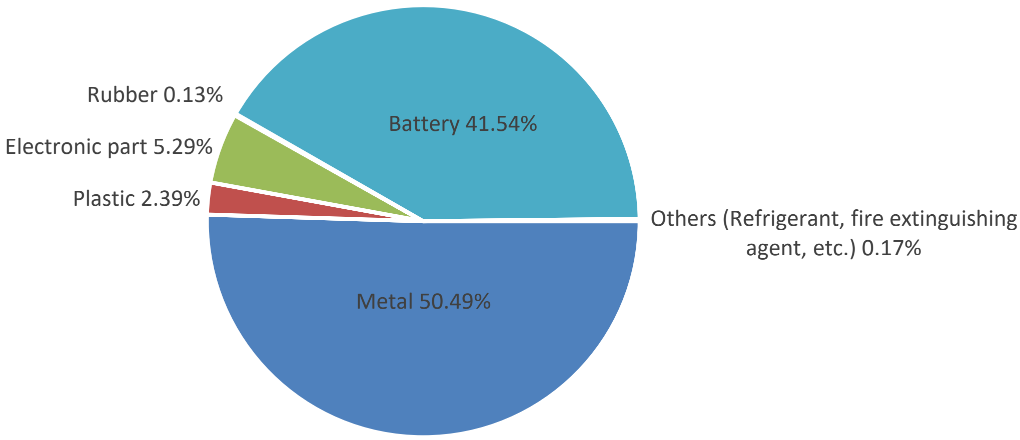

Figure 2 Main constitutive raw materials and parts of LUNA2000-200KWH-2H1

Note: The fire extinguishing agent is not filled in the fire extinguishing system before delivery and will be filled when the fire suppression system is installed.

Raw material GHG emission data for all electronic parts and electrical components, structural parts, including their packaging material, the process energy, waste treatment and transportation GHG emission data are collected from the latest applicable ecoinvent database.

2.1.2 Distribution

The distribution stage includes:
- The transportation process from the Dongguan assembly factory to the Shenzhen port. The distance is about 70 km by truck.
- The transportation process from Shenzhen port to Trieste port, Italy. The distance is about 14150 km by ship.
- The transportation process from Trieste port to the Budapest, Hungary (Huawei Europe Supply Center, ESC). The distance is about 550km by truck.
- The transportation process from ESC to Europe customer location. The distance referred to the average freight distance in EU is about 250 km by truck, as defined in section 7.14 of the EU Product Environmental Footprint Category Rules Guidance.

Secondary data collected from the latest applicable ecoinvent database embedded an average load factor and empty return trips is used for the transportation distance and the calculation of the GHG emissions. Land transportation distances data is from Google Maps. Maritime transportation distances data is obtained from http://www.searates.com/services/.

2.1.3 Use

This section refers to the use of LUNA2000-200KWH-2H1 by customers, excluding installation (assembled onsite and commissioning processes, e.g. transportation of installation personnel, the usage of auxiliary equipment and tools required for equipment installation, equipment debugging, etc.) and maintenance processes of product during the use stage. Considering that these processes are not under control of Huawei, and the environmental impact is relatively small compared with the all life cycle, these processes are cut off due to the limitation of activity data availability.

The ESS consists of the power supply and distribution system, monitoring system, environment control system, and fire suppression system. The GHG emissions during the use stage are comprised of two emissions categories: direct and indirect emissions. Indirect emissions are due to the electricity consumption, mainly form the battery system, inverters, air conditioners, monitoring system, lighting system and fire suppression system. The lighting system remains normally-off during the usage of the LUNA2000-200KWH-2H1 and only opens during the maintenance, which will lead to extremely few power consumption. Thus, this process is cut off due to the limitation of activity data availability. Direct emissions are comprised of the fugitive emissions from refrigerant leakage and fire extinguishing agent leakage.

It is worth mentioning that the product is available for a wide range of applications, such as photovoltaic system and other grid systems. Under various application scenarios, the differences of electricity sources and loading cycle times per day will correspond to different power grid emission factor and working duration, which will lead to multiple GHG emissions in the use stage.

In this report, four different usage scenarios are assumed considering the impact of working/standby duration and power source in the use stage, as shown in Table 1.

Table 1 Assumptions for application scenarios and technical specification

<table>
<tr><th colspan="2">Assumption scenarios</th><th>Scenario 1</th><th>Scenario 2</th><th>Scenario 3</th><th>Scenario 4</th></tr>
<tr><td rowspan="6">Battery system</td><td>Output power</td><td colspan="4">100 kW (Total)</td></tr>
<tr><td>charging & discharging efficiency</td><td colspan="4">96.3%</td></tr>
<tr><td>Standby power</td><td colspan="4">620 W (Total)</td></tr>
<tr><td>Electricity source</td><td>national power grid</td><td>national power grid</td><td>photovoltaic plant</td><td>photovoltaic plant</td></tr>
<tr><td>Working duration per day</td><td>2 h</td><td>4 h</td><td>2 h</td><td>4 h</td></tr>
<tr><td>Standby duration per day</td><td>22 h</td><td>20 h</td><td>22 h</td><td>20 h</td></tr>
<tr><td rowspan="4">Inverters</td><td>Output power</td><td colspan="4">100 kW (Total)</td></tr>
<tr><td>Efficiency</td><td colspan="4">92.5% (ESC360kw-F) and 96.6% (LUNA2000-100KTL-M1)</td></tr>
<tr><td>Electricity source</td><td>national power grid</td><td>national power grid</td><td>photovoltaic plant</td><td>photovoltaic plant</td></tr>
<tr><td>Working duration per day</td><td>4 h</td><td>8 h</td><td>4 h</td><td>8 h</td></tr>
<tr><td rowspan="3">Environment control system</td><td>Power</td><td colspan="4">860 W</td></tr>
<tr><td>Electricity source</td><td colspan="4">national power grid</td></tr>
<tr><td>Working duration</td><td colspan="4">7511 h (Refers to the Regulation (EU) N.206/2012)</td></tr>
</table>

	per year	
Monitoring system	Power	3 W
	Electricity source	national power grid
	Working duration per day	24 h
Fire suppression system	Power	5 W
	Electricity source	national power grid
	Working duration per day	24 h

As of the assessments date, there is no applicable PCR for reference. The use modelling assumption is established based on the use stage modelling requirements of EU Product Environmental Footprint Category Rules Guidance.

The amount of electricity used by the battery system can be calculated by the following equation:

$$\text{The Energy consumption} = \frac{\text{output power}}{\text{efficiency}} \times (1 - \text{efficiency}) \times \text{operating time per year} \times \text{life time} + \text{the standby power} \times \text{standby time per year} \times \text{life time}$$

The amount of electricity used by inverters can be calculated by the following equation:

$$\text{The Energy consumption} = \frac{\text{output power}}{\text{efficiency}} \times (1 - \text{efficiency}) \times \text{operating time per year} \times \text{life time}$$

To maintain the temperature and humidity environment required for system operation, LUNA2000-200KWH-2H1 is configured with two air conditioners, which operate at the temperature below 20℃ or above 25℃. The amount of electricity used by the air conditioners during life time can be calculated by the following equation. Where, the operating time per year of the air conditioner is assumed to be 7511 h/annum according to Regulation (EU) N.206/2012. The amount of electricity used by air conditioners, monitoring system and fire suppression system during its life time can be calculated by the following equation:

$$\text{The Energy consumption} = \text{the output power} \times \text{operating time per year} \times \text{life time}$$

- Basic parameters, such as power consumption and efficiency, are obtained from the Product User Manual.
- Life time of product is assumed to be 20 years.

The calculation results are summarized in the following table.

Table 2 Amount of electricity used by LUNA2000-200KTL-H1 (kWh)

Assumption scenarios	Amount of electricity consumption for each system					Total electricity consumption
	Battery system	Inverters	Environment control	Monitoring system	Fire suppression	

			system		system	
Scenario 1/3	1.56E+05	3.40E+05	3.23E+05	6.13E+02	8.76E+02	8.20E+05
Scenario 2/4	2.03E+05	6.79E+05	3.23E+05	6.13E+02	8.76E+02	1.21E+06

The evaluation model of the use stage is based on the assumption that the product is used in Europe, the electric emission factor (275 g $CO_{2\ eq}$/kWh) of EU power grid is obtained from European Environment Agency (EEA), and the electric emission factor (42.9 g $CO_{2\ eq}$/kWh) of EU photovoltaic plant is obtained from the report, PVPS Trend Report 2022, reported by International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS).

The installation and usage of air conditions may result in fugitive emissions of greenhouse gases due to refrigerant leakage. According to the product design manual and the manufacture technological process specification of Huawei's air-conditioning products, the annual leakage rate of air-conditioning refrigerant is ≤1 g/yr, and the leakage detection of the sealing system is 100%. It can be inferred that there is almost no leakage of refrigerant in the use stage, would have a negligible contribution of environmental impacts and is then cut off.

The initial filling quantity of extinguishing agent (HFC-227ea) is designed to be 28.5 kg. The extinguishing agent partially leaks over the life time. The leakage rate is 4%±2% in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Here we assume 4% leakage during the operation. The GWP value of HFC-227ea is obtained from IPCC assessment report (AR 6).

2.1.4 End-of-Life

The assumptions of waste treatment modes at EoL stage are as below:
- 90% of the metal parts of the product can be recycled and 10% are sent to landfills (Refer to IEC/TR 62635:2012 Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment).
- 60% of plastic parts can be recycled, and 40% incinerated (Refer to IEC/TR 62635:2012 Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment).
- 65% of the electronic parts (cable, etc.) are recycled, 10% are incinerated, and 25% are sent to landfills (This assumption is based on the minimum recovery targets referred to the directive 2012/19/EU (WEEE)).
- 100% of rubber is incinerated. (Refer to IEC/TR 62635:2012 Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment).
- 70% of batteries of the product can be recycled and 30% are sent to landfills (This assumption is based on the median recycling targets which is considering the diversity of batteries and referred to the directive 2013/56/EU on batteries).
- 15% of the refrigerant is lost during the recycling process and directly discharged into the atmosphere, 85% can be recycled (Refer to 2006 IPCC Guidelines for National

Greenhouse Gas Inventories and Impacts of Leakage from Refrigerants in Heat Pumps published by UK Department of Energy & Climate Change (DECC)).

Note: The GWP value of HFC-134a is from IPCC assessment report (AR 6).

- 100% of remaining extinguishing agent can be recycled (Refers to 2006 IPCC Guidelines for National Greenhouse Gas Inventories).

Note: The extinguishing agent EoL has a negligible contribution of environmental impacts and is then cut off.

- 65% of other materials are recycled, 10% are incinerated, and 25% are sent to landfills (This assumption is based on the minimum recovery targets referred to the directive 2012/19/EU (WEEE)).

The secondary data of the recycling, landfill and incineration models in ecoinvent are used to calculate the GHG emissions at EoL stage.

The mass of individual raw material (e.g. electronic part, metal and plastic, etc.) of EoL product under the corresponding treatment mode (recycling/landfill/incineration) is calculated by following formula in Simapro, and then the environmental impact of EoL scenarios are assigned to for each material categories automatically.

$$M_{ij}=R_{ij} * M_i$$

Where,

M_{ij} is the mass of the i^{th} raw material disposed by the j^{th} waste treatment method.

R_{ij} is the proportion of the i^{th} raw material disposed by the j^{th} waste treatment method.

M_i is the mass of the i^{th} raw material.

i represents the raw material categories of EoL product.

j represents the treatment method (recycling/landfill/incineration).

Note：The combined masses of materials are equal to the total mass of the product.

The cut-off approach in the database is used. All incineration processes are calculated without energy recovery. All recoverable wastes are disposed of through external company. For the material recycling in the end of life and manufacturing process, the scrap doesn't be considered as an input, all recyclable waste is disposed through open-loop recycling, and the recycling benefit is allocated to the production as recycled materials which may use produce other products instead of LUNA2000-200KWH-2H1.

2.2 Product Carbon Footprint Data Calculation

The collected primary data of the manufacturing of LUNA2000-200KWH-2H1 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 2023 with geographically representative and time-sensitive data in the database selected as far as possible. The secondary data used in the SimaPro 9.4 for the GHG emission calculation is from the ecoinvent database. The used datasets are selected timely and reflect consistent production data.

The life cycle model of the GHG emissions in SimaPro 9.4 is as follows.

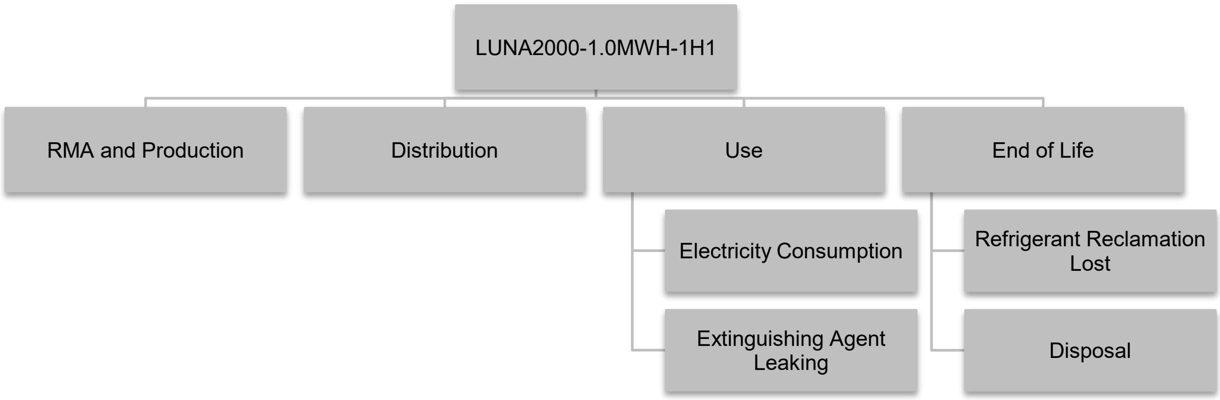

Figure 3 Life cycle model of the GHG emission calculation in SimaPro

Based on the methodology, assumptions and model mentioned above, the calculation results of GHG emissions are shown in Table 3.

Table 3 The calculation results of GHG emissions (kg $CO_{2\ eq}$)

Assumption scenarios	Scenario 1	Scenario 2	Scenario 3	Scenario 4
RMA and Production	**2.37E+04**	**2.37E+04**	**2.37E+04**	**2.37E+04**
Distribution	**5.89E+02**	**5.89E+02**	**5.89E+02**	**5.89E+02**
Use	**1.15E+05**	**1.31E+05**	**2.29E+05**	**3.36E+05**
Electricity Consumption	*1.10E+05*	*1.27E+05*	*2.25E+05*	*3.32E+05*
Extinguishing Agent Leaking	*4.03E+03*	*4.03E+03*	*4.03E+03*	*4.03E+03*
End of Life	**6.39E+02**	**6.39E+02**	**6.39E+02**	**6.39E+02**
Refrigerant Reclamation Lost	*3.21E+02*	*3.21E+02*	*3.21E+02*	*3.21E+02*
Disposal	*3.18E+02*	*3.18E+02*	*3.18E+02*	*3.18E+02*
Total	**1.39E+05**	**1.56E+05**	**2.54E+05**	**3.61E+05**

3 Life Cycle Impact Assessment

Based on the methodology, assumptions and model described in this report, the results of GHG emissions in relative scale to GWP 100a for LUNA2000-200KWH-2H1 see Table 3.

In terms of life cycle stages, the result can be shown as Figure 4. It shows that the highest emission stage is the use stage.

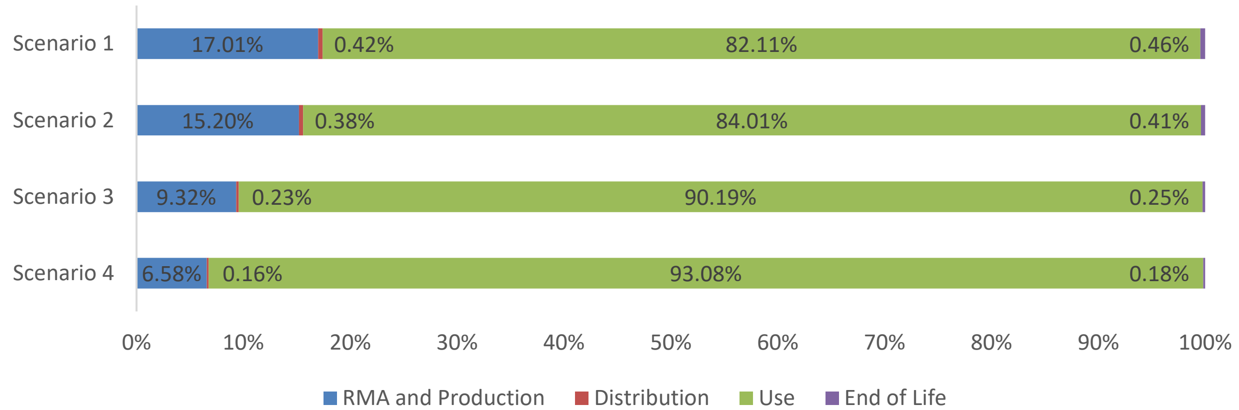

Figure 4 Product carbon footprint analysis by all life stages

Figure 5 shows the shares of total $CO_{2\ eq}$ emissions for different parts or processes of RMA and production stage. Metal parts, batteries and electronic parts have the major shares.

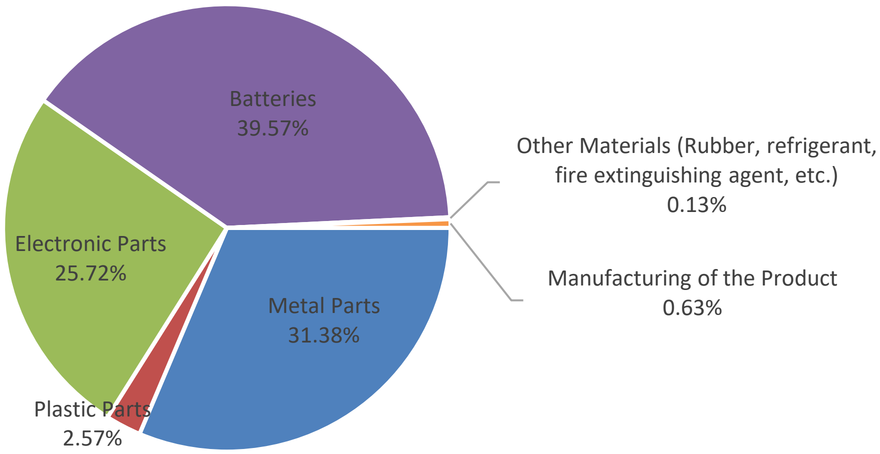

Figure 5 Product carbon footprint analysis by manufacturing process

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 LUNA2000-200KWH-2H1 GHG emissions occurs from the use stage (over 80% of the anticipated life cycle GHG emissions associated). For this stage, the GHG emissions are mainly caused by the electric energy consumption of the product and extinguishing agent leaking (details please see section 2.1.3), which is mainly affected by the electricity consumption of product. The GHG emissions can be reduced by improving the product energy efficiency or using new low-GWP extinguishing agent.

The second impact occurs from the RMA and production stage. As shown in figure 5, GHG emissions are mainly from metal parts and batteries due to the high mass proportion. For electronic parts, the impact per unit mass of these components is relatively high because of the high energy consumption, waste and emissions in the manufacturing process. The GHG emissions related to these parts can be reduced by minimizing material usage, using recycled materials or low-carbon materials and optimizing manufacturing processes when those parts are designed.

For distribution stage, minimizing material usage also contributes to reduce the GHG emissions. The GHG emissions in the end of life stage are mainly due to the leakage of refrigerant when disposed. The impacts can be mitigated by using new low-GWP refrigerants and optimizing recycling and destruction technologies.

Annex Ⅰ Configuration of Product

Parts list		
Part Name	Description	Qty.
Outdoor cabinet-FusionSolar-Energy storage battery cabinet	Cabinet-DKBA41036496-Outdoor cabinet-FusionSolar-Energy storage battery cabinet-Digital power-1810mm(W)-1200mm(D)-2135mm(H)	1
ESM51320AS1	Lithium Battery, ESM51320AS1, 442mm(W)*660(D)*307mm(H), 51.2V, 320Ah	12
ESC360kw-F	Inverter, ESC360kw-F	1
LUNA2000-100KTL-M1	Inverter, LUNA2000-100KTL-M1, Smart PCS-Grid connected and off grid operation-LAB	1
PC3000D-3	Cabinet Air Conditioner, Air Cooled, 3000W, downflow, -42VDC~-58VDC, heating, R134A, EC fan, C Environmental Applications	2
Rack Mounted Fire extinguishing system	Fire extinguishing system, , Rack Mounted Fire extinguishing system, FK-5-1-12, 3KG, English	1