Medium Voltage Power Station (MVPS-4600-S2-10)

Product Carbon Footprint

Content

1. Preface

For over 40 years, the SMA Group has been driving the transformation toward climate-friendly power supply based on renewable energy sources in collaboration with its business partners worldwide. Our products and solutions are used by households and companies on every continent for sustainable and efficient power generation, storage, and usage. From the very beginning, we have been firmly convinced: it is not enough to develop innovative technologies for climate-friendly energy generation. It is equally important to uphold high environmental, social, and governance standards throughout the entire value chain. To achieve this, we work closely with our stakeholders. For us, sustainable business means combining long-term economic success with environmental protection, ethical conduct, and social responsibility. A responsible and respectful approach to people, environment, and resources – alongside the increasing use of renewable energy throughout the entire value chain – is the foundation for this.

To assess the environmental impact of our products across their life cycle phases, derive measures from this, and improve product sustainability, we use Product Carbon Footprints (PCF), among other tools. These are prepared by external experts from the Fraunhofer Institute for Building Physics IBP. The PCF is based on internationally recognized standards ISO 14067, ISO 14040, and ISO 14044. It measures the total direct and indirect greenhouse gas emissions of a product and thus its impact on climate change over its entire life cycle in CO_2-equivalents (CO_2e).

In this white paper, we summarize the methodology used to create the PCF for the SMA Medium Voltage Power Station (MVPS) and present the key findings and results.

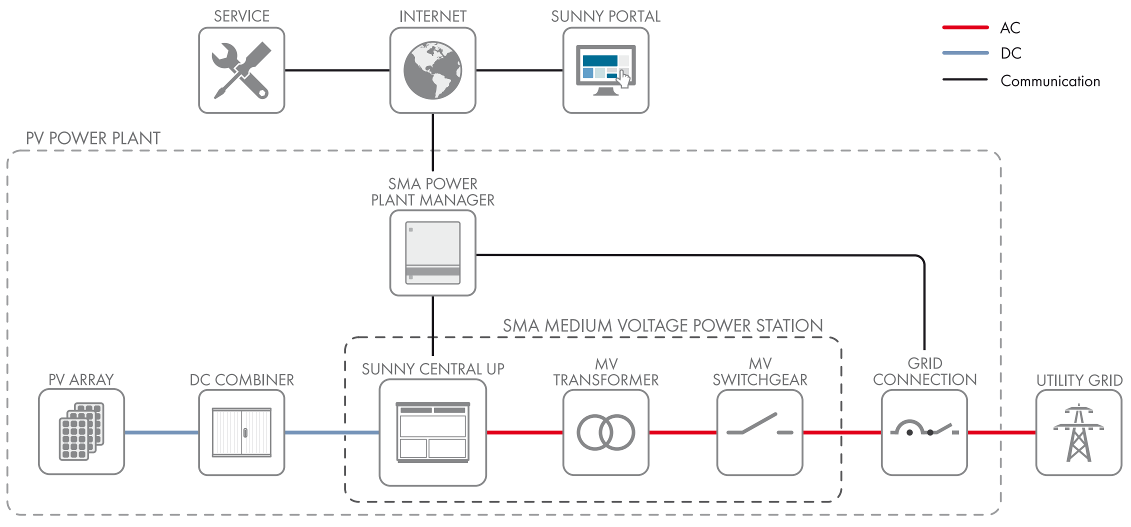
2. Life Cycle Inventory Analysis

2.1 System analyzed

The SMA Medium Voltage Power Station (MVPS) offers maximum power density in a plug-and-play design and is used in PV and energy storage power plants with 1500 V DC. The pre-configured 20-foot skid solution can be easily transported and quickly commissioned. The MVPS ensures maximum system reliability and energy yield for PV and energy storage power plants while minimizing logistics and operational risks.

To achieve this, it combines a central inverter (Sunny Central UP or Sunny Central Storage UP), a transformer, and a switchgear into a compact system. In the system considered below, a Sunny Central 4600 UP is used.

Structure of an SMA Medium Voltage Power Station for PV Applications



2.2 Life cycle phases analyzed

The data collection for the creation of the PCF for the MVPS covers the entire life cycle (cradle-to-grave) and is therefore compliant with DIN EN 15804+A2 as well as the modules outlined below:

A1-A3 Raw material extraction, supply chain transports, core processes on production site of MVPS components, transports to final assembly of the MVPS

A4-A5 Distribution transports to utilization site, packaging and transport protection, reinforced concrete foundation

B1, B4 Efficiency losses of MVPS components, electricity consumption from local grid, leakage of SF6 gas (Assumption: 1 percent per operation year), in the case of considering a 40-year service life, B4 includes the replacement of the central inverter

C-D End-of-Life stage including transports, potential environmental credits from material recycling and energy recovery from incineration using the avoided burden approach

2.3 Data Quality

To ensure the most comprehensive data collection as well as very high data quality and transparency throughout the entire life cycle of the MVPS, SMA provided a detailed bill of materials (BOM) for the installed Sunny Central 4600 UP. The remaining aspects were modeled based on secondary data. Company-specific data for the other MVPS components were provided by suppliers in the form of Environmental Product Declarations (EPD, switchgear), Product Carbon Footprints (PCF, transformer), material lists, and supply chain information (20-foot container). Based on this information, LCI models for the production and end-of-life phases were created using the LCA-FE software and the CUP2023.1 database. The created models were then validated for plausibility using the information provided by the suppliers. All further assumptions are summarized in the following table:

Production
- During production, an additional 3 percent was added to the calculated greenhouse gas emissions (CO_2e) for the core processes at the suppliers' sites
- The environmental impact of the production of the transformer oil are based on estimated greenhouse gas emissions (CO_2e) from the manufacturer

Packaging
- Packaging includes wooden pallets and plastic foils used to transport MVPS components from manufacture to the assembly site, as well as transport protection parts and plastic foil for distribution to utilization site.

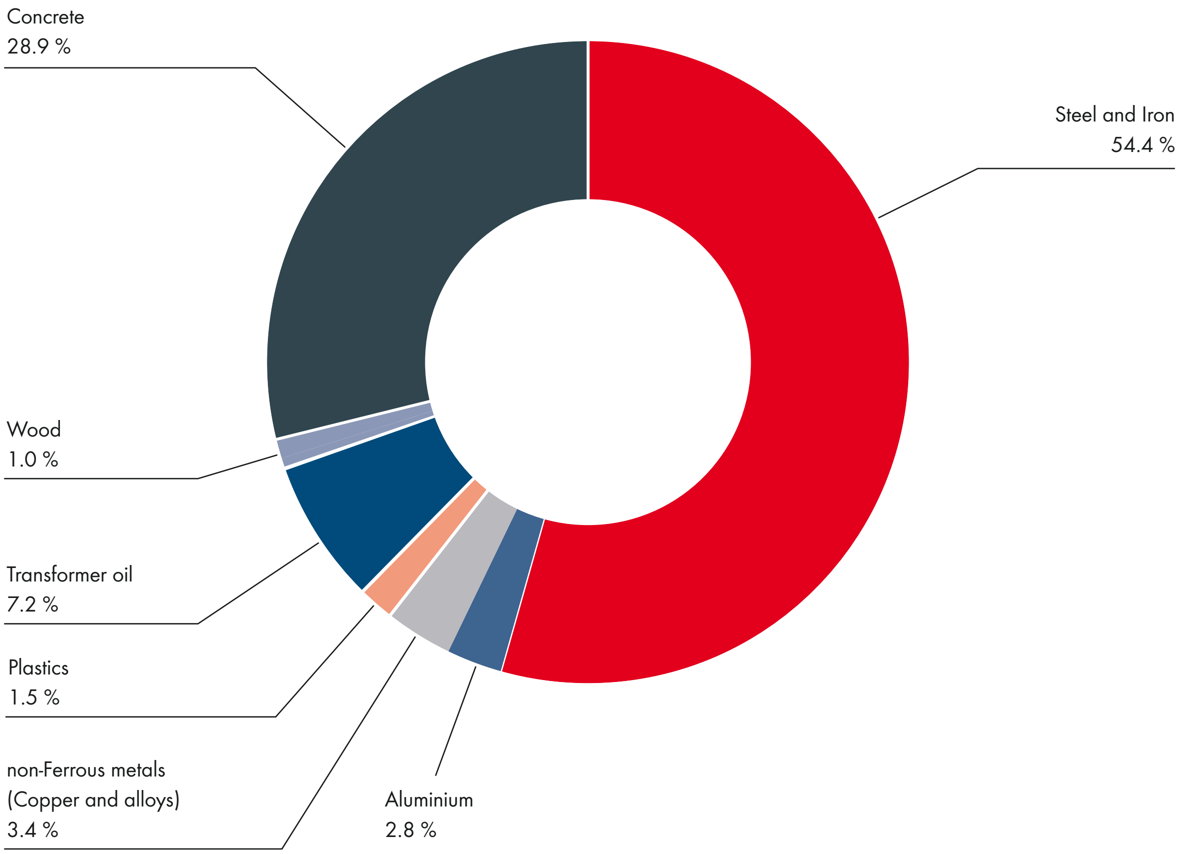
Use phase
- Five use case scenarios at different locations are considered.
- The MVPS is operated with a rated power of 4,600 kVA.
- System operation lifetime: 40 years, central Inverter lifetime: 20 years, hence two inverter life cycles are considered in the PCF assessment. The lifetime of the other system components is 40 years.
- Central inverter efficiency: 98.4 percent
- System efficiency: 97.77 percent

End-of-Life
- A collection rate of 90 mass-percent and a process efficiency of material recycling and incineration of 95 mass-percent is assumed for modelling End-of-Life impacts and potential credits

3. Results

3.1 Material composition of MVPS

The MVPS under consideration weighs approximately 23.4 tonnes. 17 percent is attributed to the inverter, 50 percent to the other MVPS components, 1 percent to packaging, and 32 percent to the concrete foundation. In total, around 12.7 tonnes, equivalent to 54.4 percent, consist of steel and iron, followed by concrete (28.9 percent). Other relevant materials include transformer oil (7.2 percent), as well as aluminum and non-ferrous metals such as copper and alloys, each accounting for approximately 3 percent.



Percentage by mass of individual materials and components in an MVPS, total weight approximately 23.4 tonnes (including packaging and concrete foundation)

3.2 Product Carbon Footprint

The product carbon footprint of the MVPS varies depending on the use case. The absolute results are summarized in the following table for service live of 20 and 40 years.

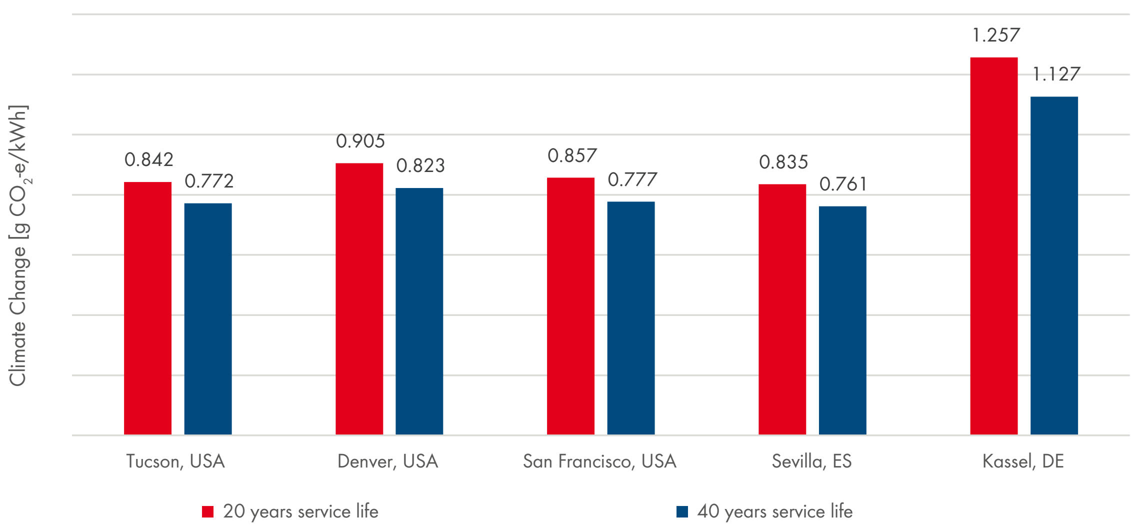
Service life MVPS	**20 years**	**40 years**	
Production (A1-A3)	60.5	76.0	t CO_2e
Transports and packaging (A4)	3.1 – 4.1	3.8 – 5.1	t CO_2e
Concrete foundation (A5)	1.6	1.6	t CO_2e
Use phase (B1)	123.5 – 164.5	247.0 – 328.9	t CO_2e
End-of-Life-phase (C-D)	-20.6	-27.1	t CO_2e

For a 20-year service life the production of the MVPS components results in approximately 60.5 tonnes of CO_2-equivalent. For a 40-year service life, the carbon footprint for production increases to 76 tonnes of CO_2-equivalent due to the replacement of the central inverter after 20 years. The results for transport and packaging vary depending on the installation site (transport mix and distance). The use phase accounts for the largest share of the total CO_2-equivalent emissions in both the 20- and 40-year scenario (73.5 to 78.6 percent), primarily driven by efficiency losses of the MVPS.

At the End-of-life, proper recycling of all MVPS components and the consideration of burdens and credits beyond the system boundary (life cycle stages C + D) allow for credits of between 20.6 and 27.1 tonnes of CO_2-equivalent. Depending on the usage scenario (installation site), the total carbon footprint ranges from 168.1 to 209.3 tonnes of CO_2-equivalent (20-year service life) or from 301 to 383.5 tonnes of CO_2-equivalent (40-year service life).

To correctly interpret and compare the results of the PCF, it is important to understand that installation sites with higher solar irradiation show higher absolute greenhouse gas emissions (CO_2e) in the use phase, as more usable solar electricity is converted over the service life (20 or 40 years). Accordingly, efficiency losses are higher. Therefore, comparisons should always be based on the functional unit (1 kWh of AC electricity at the inverter output). This is illustrated in the following graphic.

Results of the PCF in g CO_2-equivalent per functional unit



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