



Medium Voltage Power Station (MVPS-9200-S4-10)

Product Carbon Footprint



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1. Preface

The SMA Group develops, produces and distributes systems and solutions for the generation, storage and use of solar energy worldwide. These include PV and battery inverters, monitoring systems for photovoltaic plants, charging solutions for electric vehicles, as well as intelligent energy management systems and digital services for future energy supply. Extensive services, along with medium-voltage technology and power supplies for hydrogen production, round off the offering. Furthermore, the SMA Group operates successfully as a system integrator for complex power plant solutions and is involved in the development of Battery Energy Storage System (BESS), as well as the turnkey delivery of BESS projects as an EPC (engineering, procurement, construction) contractor.

To assess the environmental impact of our products across their life cycle phases and enhance transparency for our customers, 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 CO₂-equivalents (CO₂e).

In this white paper, we summarize the methodology used to create the PCF for the SMA Medium Voltage Power Station (MVPS-9200-S4-10) and present the key findings and results for a 20-year usage scenario.

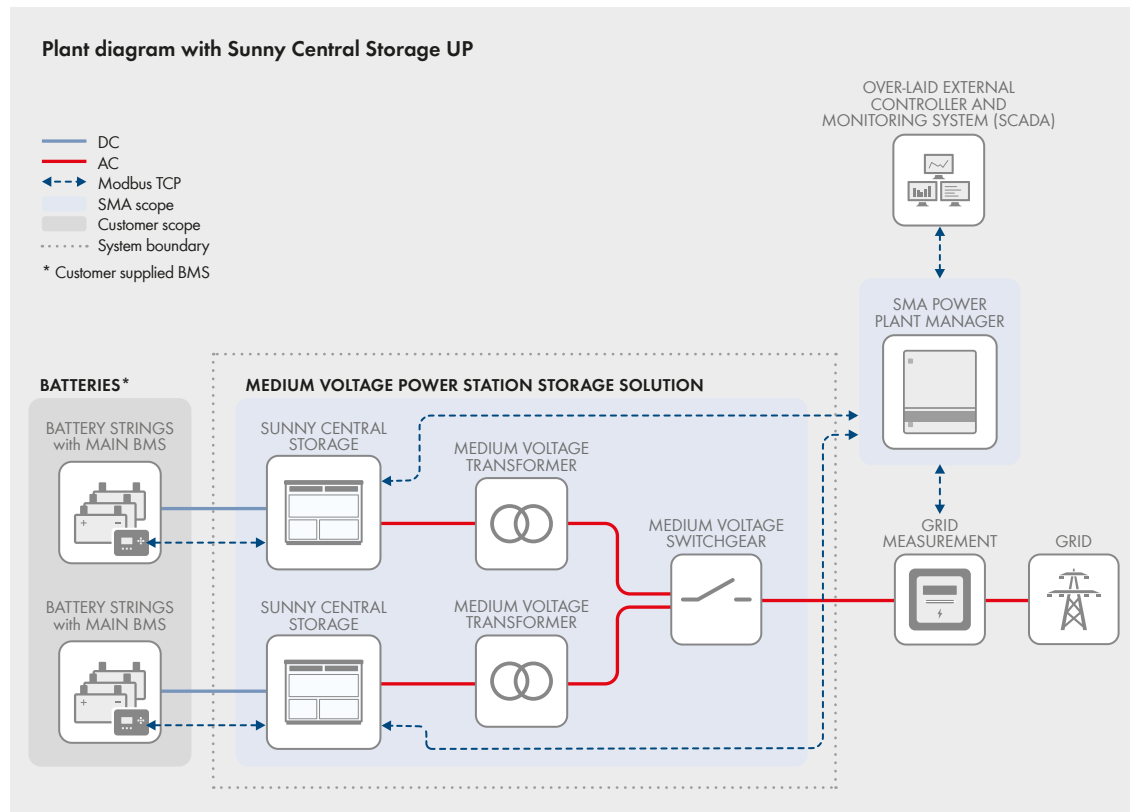
2. Life Cycle Inventory Analysis

2.1 System analyzed

The SMA Medium Voltage Power Station (MVPS) offers high 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 40-foot skid solution can be easily transported and quickly commissioned. The MVPS offers high system reliability and energy yield for PV and energy storage power plants while lowering logistics and operational risks.

To achieve this, the MVPS 9200 combines two Sunny Central Storage 4600 UP-S central inverters, two transformers, and a switchgear into a compact system.

Considered MVPS components within the system boundary



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 at the production sites of the MVPS components, transports to final assembly
- A4-A5 Distribution transports to the utilization site, packaging and transport protection, concrete foundation
- B1, B4 Efficiency losses of MVPS components for storage and grid feed-in, and electricity consumption from local grid, SF₆ leakage (assumption: 1% per year)
- C-D End-of-Life phase 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-S. 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), mate-

rial lists, and supply chain information (40-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% was added to the calculated greenhouse gas emissions (CO₂-equivalent) for the core processes at the suppliers' sites.
- The environmental impacts of transformer oil production are based on CO₂-equivalent emissions estimated by 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 the utilization site.

Use phase

- Five use case scenarios at different locations are considered.
- The use case scenarios consider the storage and grid feed-in of surplus renewable energy from photovoltaics and wind power.
- A daily charging and discharging time of four full-load hours each and operation at 75% of the rated power of 9,200 kVA (6,900 kVA) are assumed.
- The service life is 20 years¹⁾.
- System efficiency (inverter at 75% and 1,300 V):
 - When charging the battery: 99.09%; MVPS: 98.45%
 - When discharging/feeding into the grid: 99.12%; MVPS: 98.48%

End-of-Life

- A collection rate of 90 mass-percent and a process efficiency of material recycling and incineration of 95 mass-percent are assumed for modeling End-of-Life impacts.

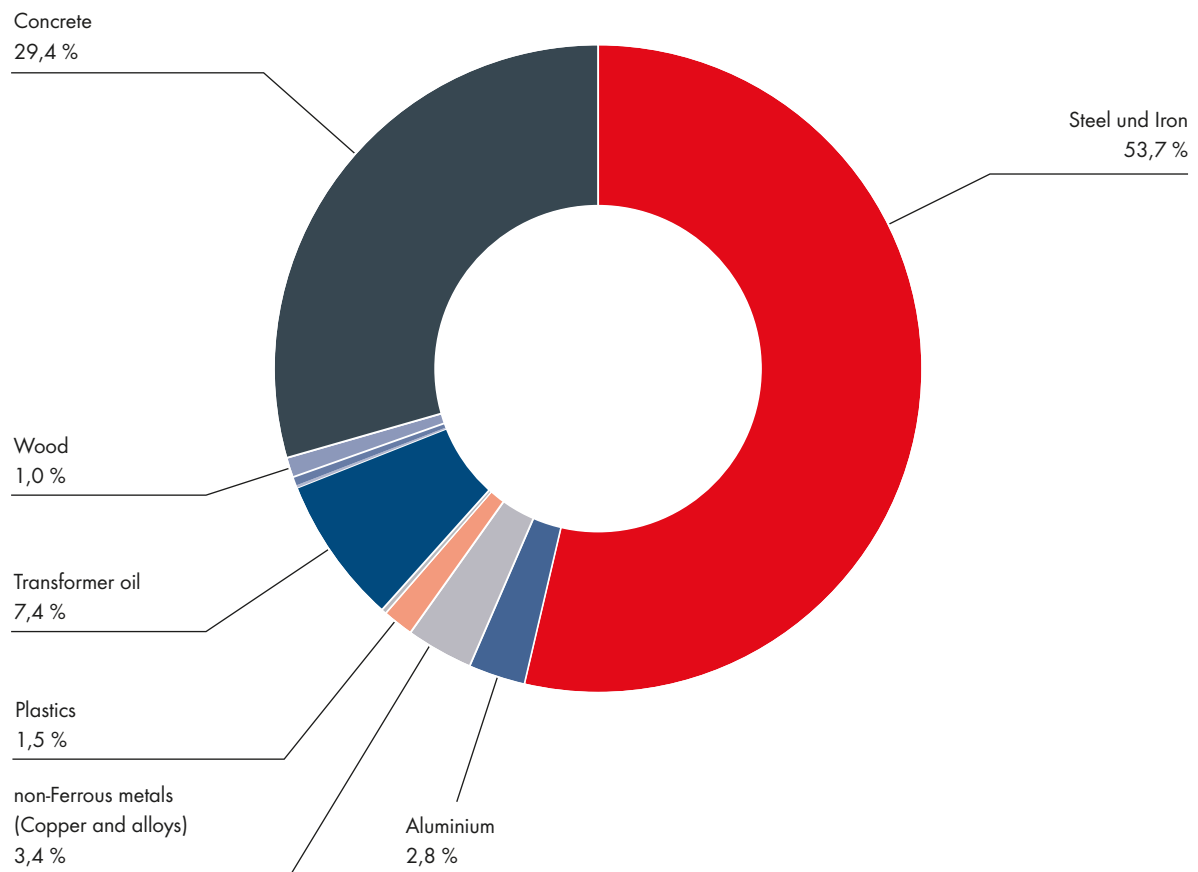
¹⁾ 20 years is the expected typical service life of battery storage systems. When installed and operated correctly, the individual system components can have a longer service life. For example, the Sunny Central Storage 4600 UP-S inverter is designed to last 25 years, while transformers and switchgear can last up to 40 years.

3. Results

3.1 Material composition of the MVPS

The MVPS under consideration weighs approximately 45.9 tonnes, including packaging and the concrete foundation. 17% is attributed to the inverter, 49% to the other MVPS components, 1% to packaging, and 33% to the concrete foundation. In total, around 24.6 tonnes, equivalent to 53.7%, consist of steel and iron, followed by concrete at

29.4%. Other relevant materials include transformer oil at 7.4% , as well as aluminum and non-ferrous metals such as copper and alloys, each accounting for approximately 3%.



Percentage by mass of individual materials and components in an MVPS, total weight approximately 45.9 tonnes (including packaging and concrete foundation)

3.2 Product Carbon Footprint

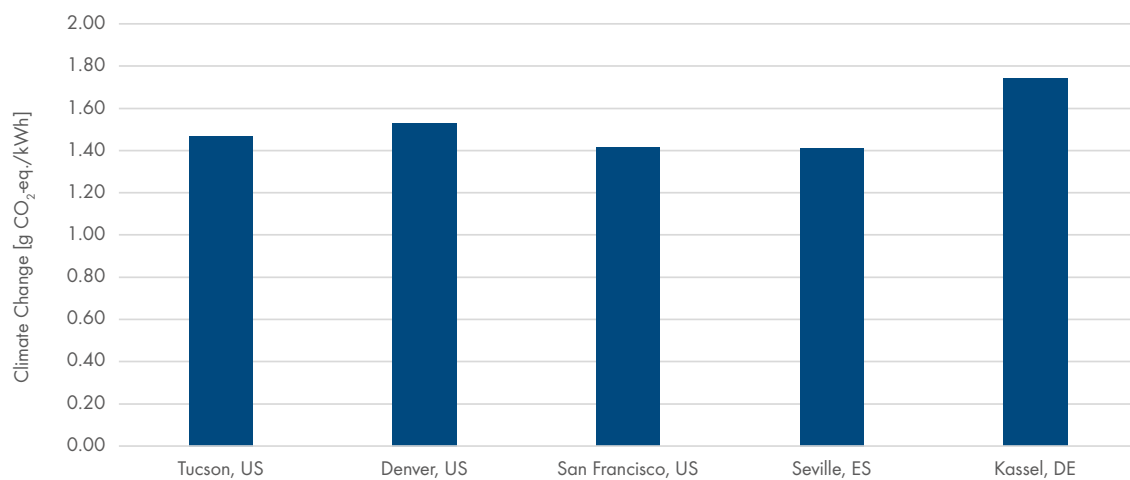
The absolute product carbon footprint results for the MVPS, expressed in tonnes of CO₂e, are summarized in the following table.

Production (A1-A3)	117.6	t CO ₂ e
Transports and packaging (A4)	6.0 – 8.0	t CO ₂ e
Concrete foundation (A5)	3.2	t CO ₂ e
Use phase (B1)	188.0 – 253.9	t CO ₂ e
End-of-Life-phase (C-D)	-40.7	t CO ₂ e

For a 20-year service life, the production of the MVPS components results in approximately 117.6 tonnes of CO₂e. 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 absolute CO₂e emissions (68 to 75%), primarily driven by efficiency losses of the MVPS. At end of life, proper recycling of all MVPS components and the consideration of burdens and credits beyond the system boundary (life cycle stage C+D) allow for credits of approximately 41 tonnes of CO₂e. Depending on the use case scenario (installation site), the absolute carbon footprint ranges from 276.2 to 340.0 tonnes of CO₂e.

To correctly interpret and compare the product carbon footprint results, it is important to understand that installation sites with higher solar irradiation show higher absolute CO₂e emissions in the use phase, as more usable solar electricity is converted over the service life at these locations. Accordingly, efficiency losses are higher. Therefore, comparisons should always be based on the functional unit (1 kWh of AC electricity at the MVPS output). This is illustrated in the following graphic.

Product carbon footprint results in g CO₂e per functional unit (scenario: surplus PV electricity)



3.3 Interpretation

The following key aspects are central to the interpretation of the results:

1. The use and production phases have the greatest impact on the PCF. Recycling at the end of life or the use of secondary raw materials in production could further reduce the PCF.
2. The impacts of the use phase are calculated at 75% of the nominal peak power and 1,300 V. The most significant impacts of the use phase on the PCF are associated with efficiency losses, followed by standby electricity consumption from the local grid. The PCF in relation to the functional unit can be further reduced by operating at 100% of the nominal peak power.
3. This report considers a scenario involving an AC-coupled energy storage application. The PCF is expected to be lower for a DC-coupled application because the battery energy storage system (BESS) is charged directly by the solar generator.
4. This report considers a scenario with an MVPS service life of 20 years. Because the individual system components can achieve longer service lives, for example 25 years for the inverter or up to 40 years for the transformer or switchgear, the PCF could be further reduced by extending the service life to 40 years, for example by replacing the inverter. This measure could reduce the relative share of the production phase in the overall PCF results of the MVPS.



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