



SOPHIA

Sustainable Off-grid solutions for Pharmacies and Hospitals In Africa

Aims to improve quality of life of populations through better treatment & working conditions in rural and remote health facilities in Africa

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By providing:

- 🚰 Safe, clean drinking water and deionized water for medical purposes
- 🔥 Hot water and steam production for hospital thermal requirements
- ⚡ Emergency electricity supply for surgical and intensive care units
- 🧊 Ultra-low temperature storage of sensitive medication at -70°C
- 🧊 Low temperature storage of blood plasma at -30°C
- ❄️ Cooling of medicines and food at $+5^{\circ}\text{C}$

Life Cycle Assessment of a Sustainable Cooling, Heating and Clean Water System: SophiA Concept

The SophiA system fulfils multiple functions by continuously providing various hospitals in Africa with renewable off-grid refrigeration, without disruption or power outages, and at different temperature levels ($+5^{\circ}\text{C}$, -30°C , -70°C). It uses a cascaded cooling system including ice storage, steam at 150°C using high temperature thermal energy storage - the PVsteamCube system, and freshly cooled clean drinking water at 20°C using the water treatment system. A Life Cycle Assessment (LCA) of these SophiA system outputs was carried out to assess their environmental performance.

The LCA was carried out by SPF Institute for Solar Technology in collaboration with Makerere University for all the technologies involved in the production of refrigeration, heat and clean water by the SophiA system for 25 years, with a system boundary as shown in [Figure 1](#). The main objective was to investigate the environmental impacts associated with the raw material extraction, manufacturing processes, use and end-of-life phases of the SophiA system. Moreover, we wanted to know to what extent the SophiA system, powered 100% by renewable energy, performs better from an environmental point of view than a system powered by fossil fuels or the electricity grid.

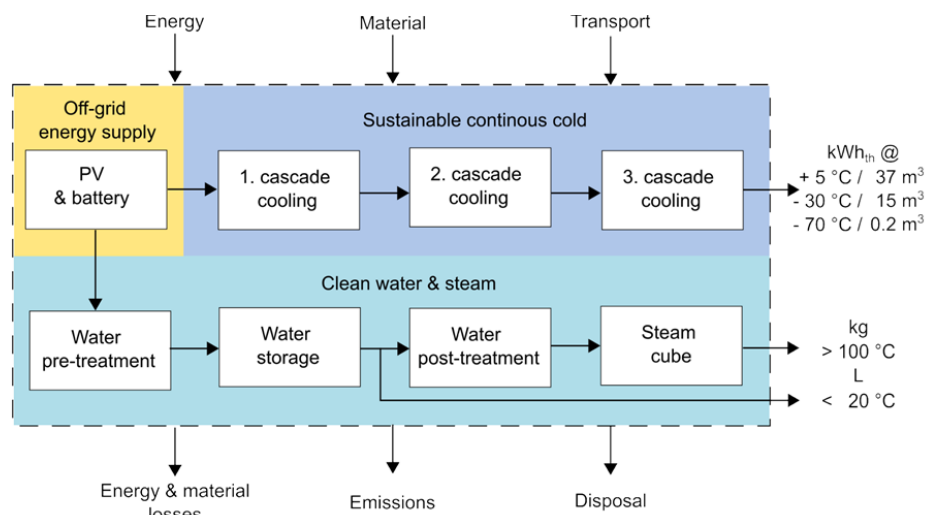


Figure 1 System boundary of the SophiA system including its two-container providing sustainable continuous cold, heat, and clean water

To carry out the LCA for SophiA system outputs, the inventory analysis for material and energy inputs was prepared using the Ecoinvent database and data collected from different SophiA partners involved in the design and manufacture of different SophiA technologies. The Life Cycle Inventory (LCI) of different SophiA technologies was imported to SimaPro to perform calculations for Life Cycle Impact Assessment (LCIA). The impact assessment was carried out using the IPCC 2021 GWP 100a and Environmental Footprint 3.1 methodologies with a geographical focus on the African region.



The environmental impact (Figure 2) according to the IPCC 2021 GWP 100a methodology for the different SophiA system outputs is:

- 100.7 g CO₂ -eq for +5 °C (1 kWh_{th} for a total cooling volume of 37 m³ at +5 °C)
- 126.6 g CO₂ -eq for -30 °C (1 kWh_{th} for a total cooling volume of 15 m³ at - 30 °C)
- 62.3 g CO₂ -eq for -70 °C (1 kWh_{th} for a total cooling volume of 0.2 m³ at -70 °C)
- 0.2 g CO₂ -eq (1 L of clean drinking water at 20 °C)
- 51.1 g CO₂ -eq for 1 kg of steam at 150 °C with PVsteamCube Iron
- 50.9 g CO₂ -eq for 1 kg of steam at 150 °C using PVsteamCube Aluminium

The LCIA using the EF 3.1 methodology shows that the highest impacts are observed in the impact categories of resource use (metals and minerals) followed by human toxicity non-cancer, eutrophication of fresh water, ecotoxicity of fresh water, acidification, and human toxicity cancer.

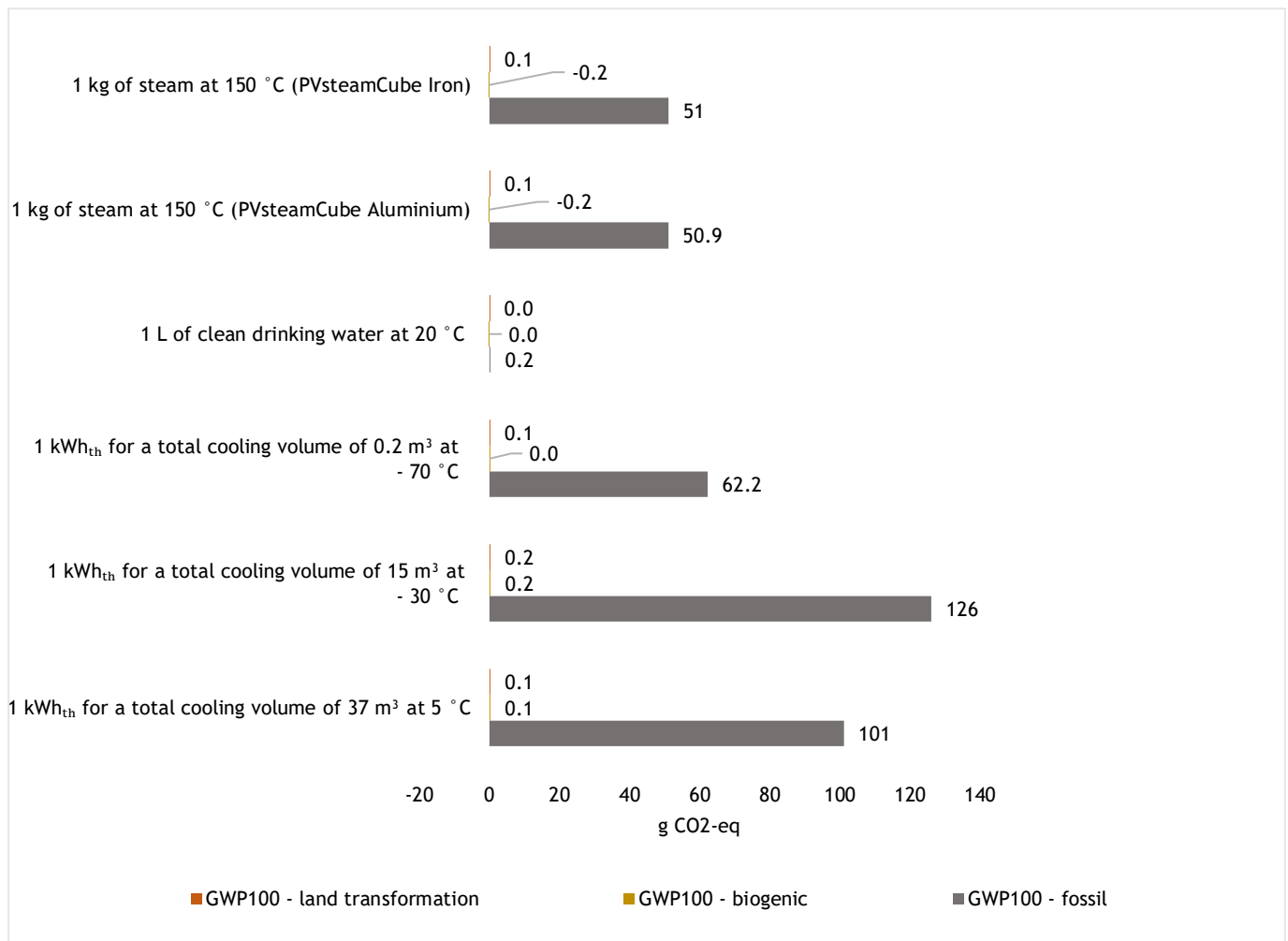


Figure 2 Comparison of the environmental impact of all outputs of the SophiA system according to the IPCC 2021 GWP 100a methodology

The SophiA system is an off-grid system powered by 100% renewable energy supply and it is important to know how well the system performs compared to different alternative energy supplies. The environmental impact of the SophiA system is found to be quite low when compared to the 100% on-grid diesel backup supply and 48% grid electricity with on-grid diesel backup. The environmental impact of the SophiA system outputs is reduced by about 28% to 69% compared to 100% on-grid diesel backup supply and reduced by about 56% to 87% compared to grid electricity with on-grid diesel backup scenario.

The results of the LCA assessment of the SophiA system outputs were presented as a poster during the ISEC- International Sustainable Energy Conference in Graz, Austria in April 2024. The poster was awarded as the best poster out of 92 contributions presented during the conference. To learn more about this event and read the related news article on the SophiA website, [click here](#).

