



# SOPHIA

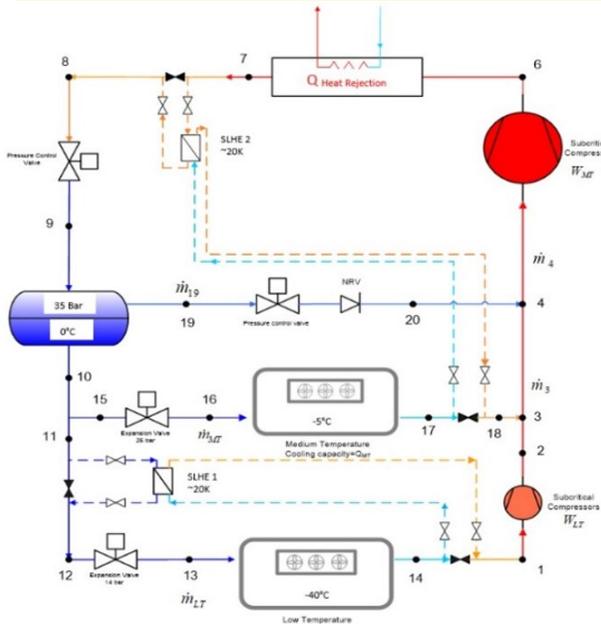
Sustainable Off-grid solutions for Pharmacies and Hospitals In Africa

# Potential applications of CO<sub>2</sub> systems in developing countries with high ambient temperature

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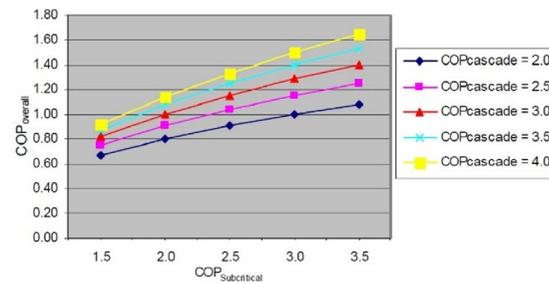
## SOFACT N° 1

To overcome the drawbacks of transcritical operation at high ambient temperatures, cascaded solutions are a viable, well-proven and energy-efficient solution in which the CO<sub>2</sub> system operates as the lower stage of a cascade refrigeration system, allowing CO<sub>2</sub> condensation at temperatures well below the critical temperature, i.e. 31 °C. The COP of the system can be improved by rejecting excess heat to the ground, instead of using a secondary refrigerant.



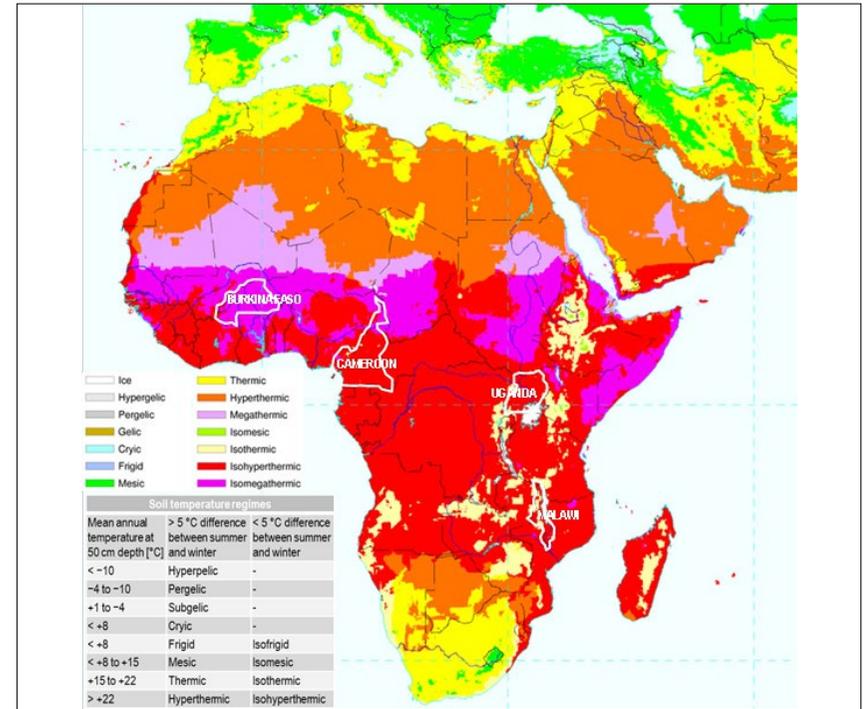
Proposed CO<sub>2</sub> LT and MT booster system using low temperature heat sinks.

A typical subcritical CO<sub>2</sub> booster refrigeration system providing low temperature (LT) for the cold room and medium temperature (MT) for the chilled food cabinet has been modelled in Engineering Equation Solve (EES) software. The purpose is to simulate when operating in subcritical mode, the high discharge temperature (HT) in subcritical mode will be cooled by the low temperature ground temperature.



Effect of subcritical and cascade systems COPs on overall COP

The MT /LT subcritical CO<sub>2</sub> booster refrigeration system modelled in this paper has been in fact built and installed at the LSBU facilities which was funded by the UK EPSRC.



Soil temperature regimes in Africa by USDA, by Kettler (2019)

**Ground temperatures in SophiA project implementation countries**  
 In deepest ground (more than 200 cm) in Ouagadougou (Burkina Faso) and Douala (Cameroon), the ground temperature is above 26 °C during the cooling seasons. At a depth of 40-50 cm, average ground temperature in Malawi is 26-27 °C while in Uganda, monthly measures in the forest are between 20 °C and 22 °C.

To operate with a ground-coupled heat exchanger, the ground temperature should be below the critical point of CO<sub>2</sub>, at a temperature range of 26-21 °C (considering a ΔTCM of about 5-10 °C).

In Southern Africa, Equatorial Africa (Forest zone) and in locations close to lakes and rivers, ground temperatures are low enough to favour the use of soil as a heat sink for a subcritical CO<sub>2</sub> refrigeration cycle.

