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An integrated renewable energy system for the de-fossilization of a commercial swine nursery barn

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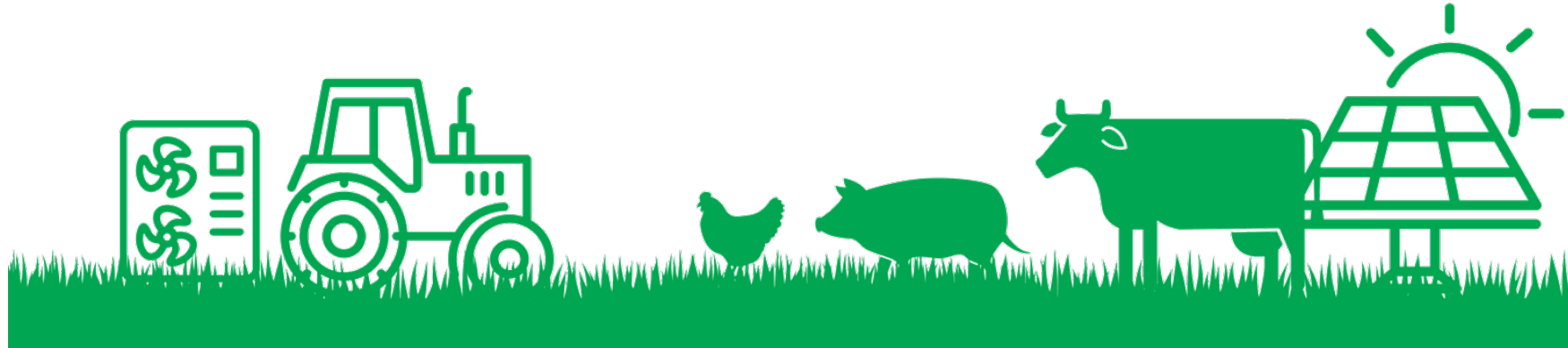
RES4LIVE Italian pilot farm

- Farrow-to-Nursery Swine Farm
- 500 sows, 2500 weaners
- De-fossilization of nursery barn

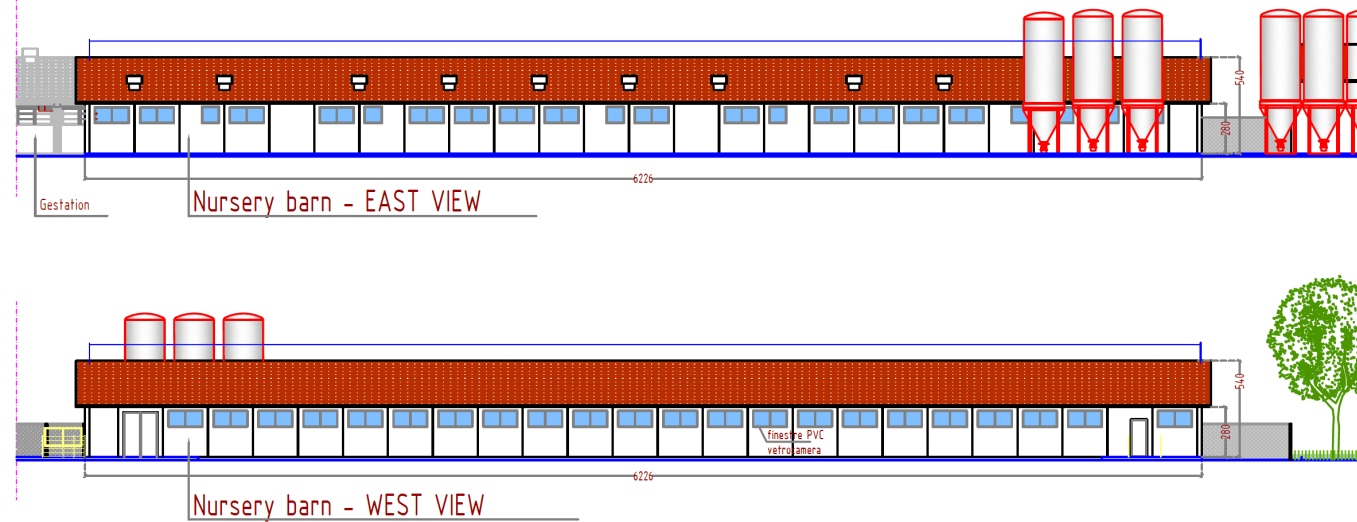


Objectives

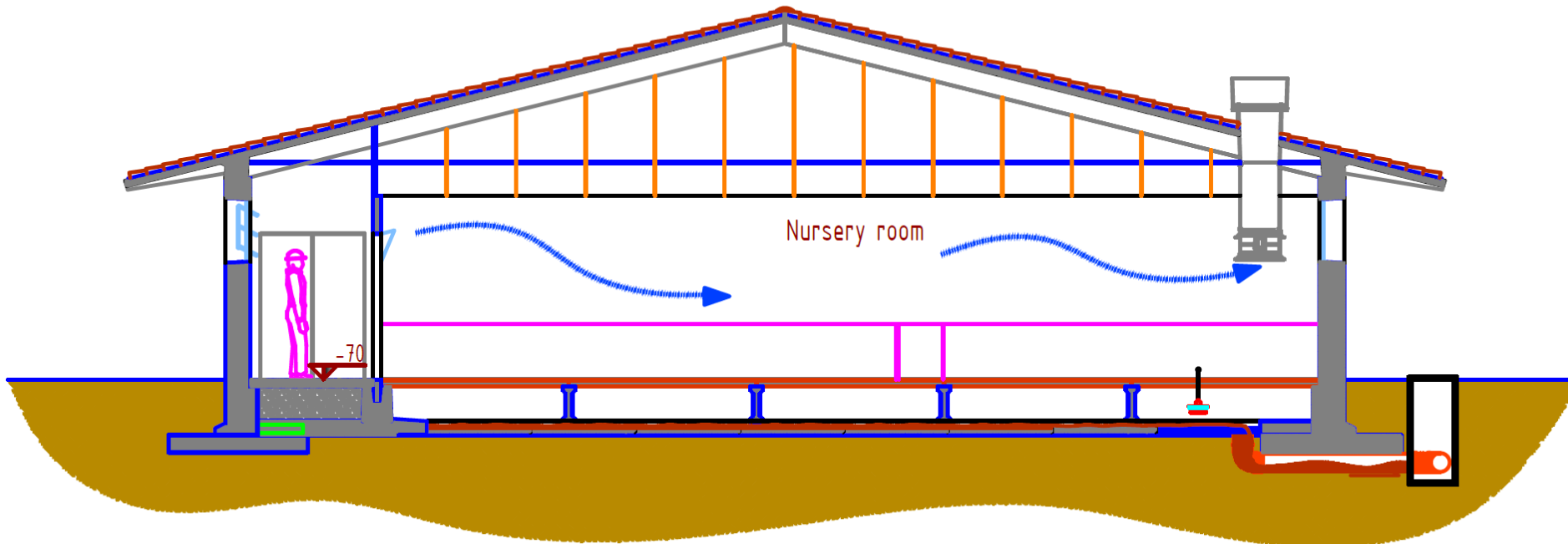
- Development and installation of an integrated RES system combining
 - a photovoltaic-thermal plant,
 - a geothermal storage, and
 - a modular heat pump.
- Smart control system for environment monitoring and energy management
- Smart control system to monitor underground temperatures



Nursery barn



Hallway along the western side allows to access the nursery rooms and also represents a zone for pre-treatment of the clean air conveyed inside the nursery rooms.



Integrated RES system

- 35 kW medium temperature heat pump,
- 8 kW_{el} and 25 kW_{th} PVT system with a solar station, to provide electricity for the heat pump operation and the electric needs of the nursery barn, and thermal energy
- Borehole Thermal Energy Storage (BTES) system that exploits both solar thermal energy and underground heat capacity to increase the heat pump efficiency by storing the excess heat from PVT, and
- Smart control system.



Installation of geothermal storage: 8 boreholes with double U pipes, 30 m deep



BTES field

- The area is fully accessible again
- The connections can be inspected
- Works by Golinelli
- UNIBO keeps on measuring underground T, every m down to 25m



System monitoring

Circulation of the vector fluid (water and propylene glycol) among PVT and BTES controlled by solar station through RESOL VBus



Process Diagram



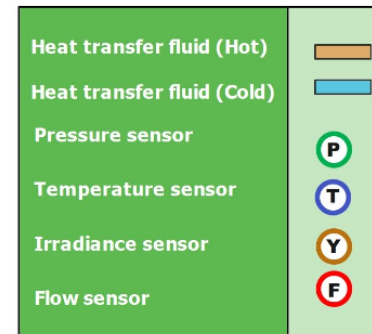
Powered by RESOL
VBus.net
Online Status
02.09.2024 15:30:28



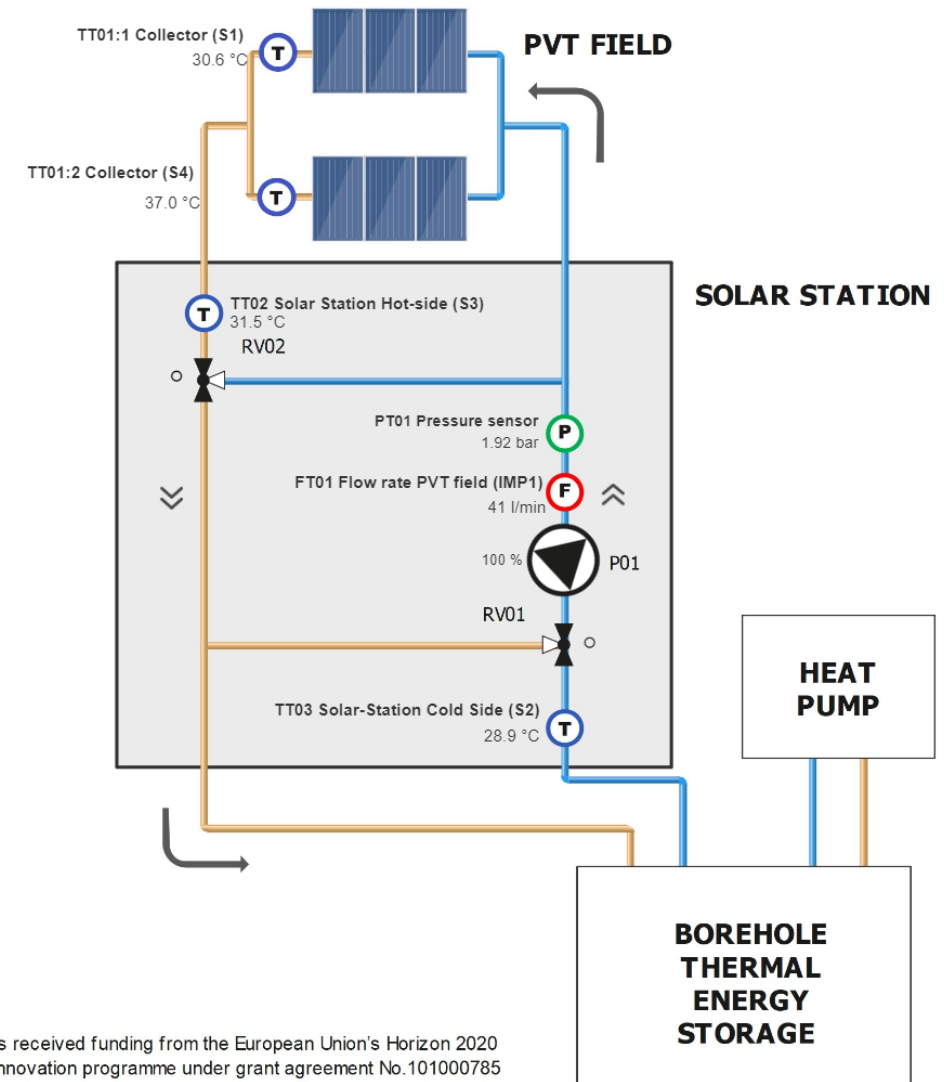
Humidity 52 %
Pressure 1012 hPa
Wind 1.68 m/s



TT15 Ambient Temperature (S5) 35.4 °C
YT01 Irradiance sensor (CS10) 490 W/m²



Power 7.0 kW
Heat quantity today 70 kWh
Heat quantity week 70 kWh
Heat quantity month 0.2 MWh



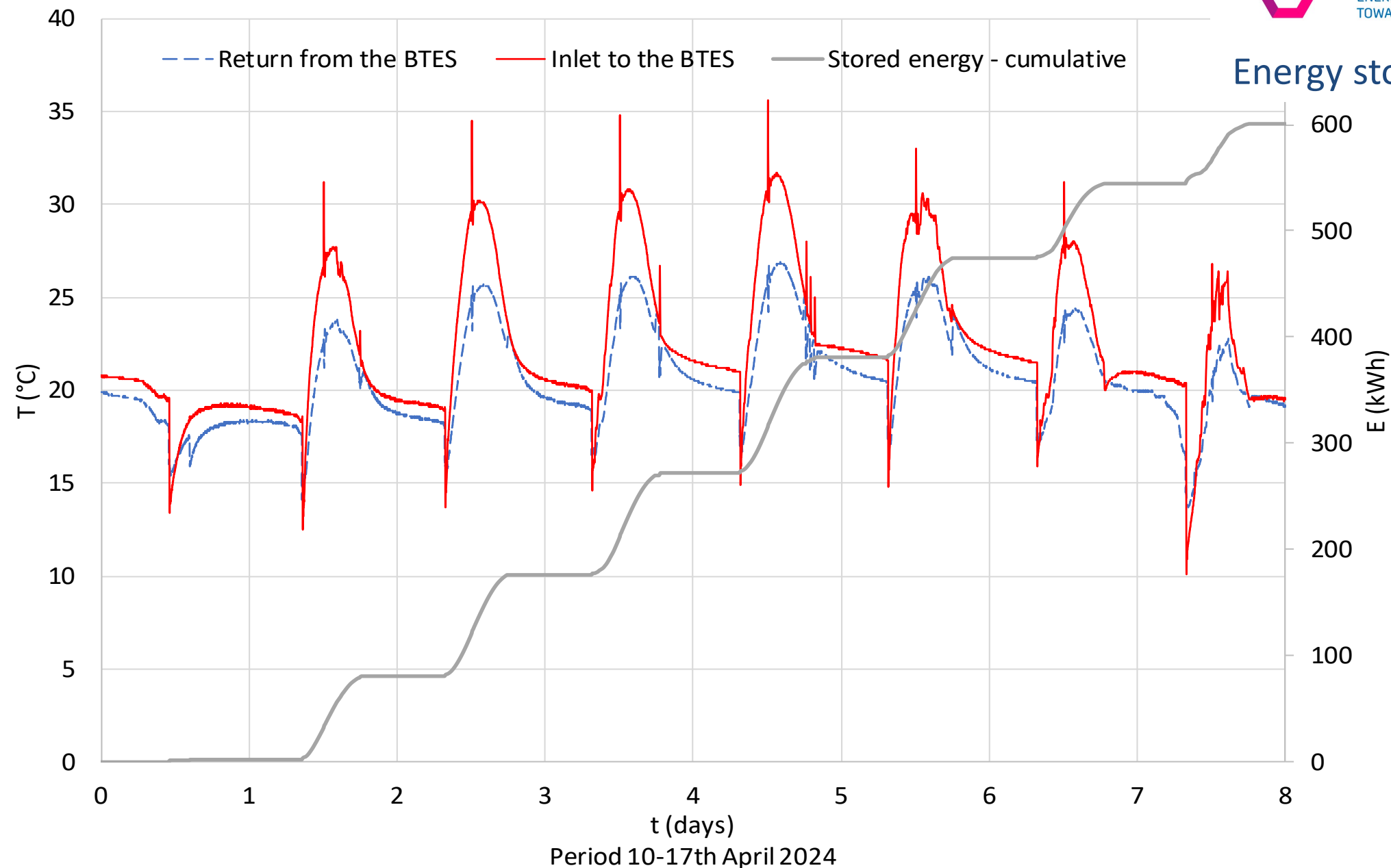
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.101000785

CO₂ emission saving

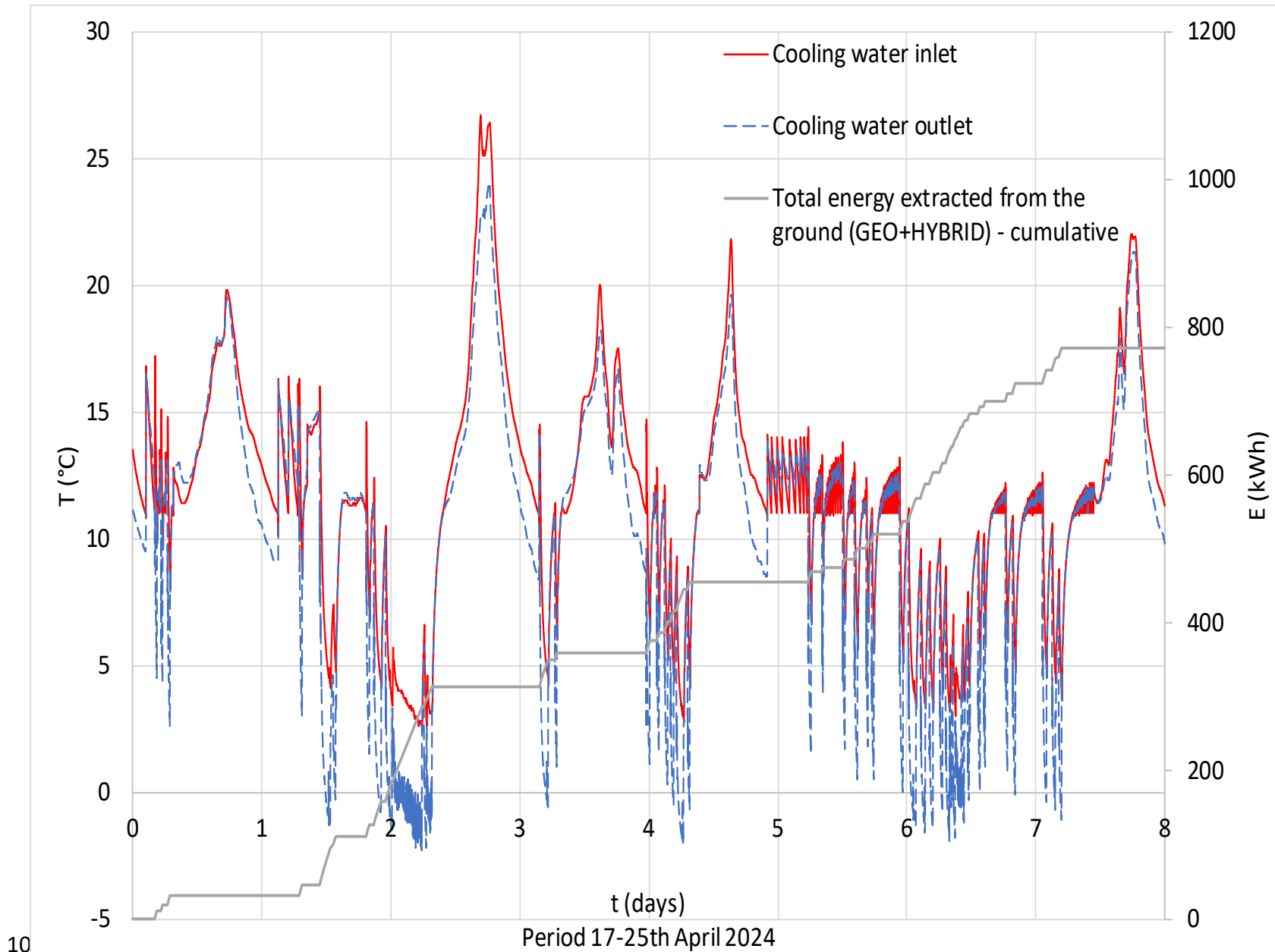
		May	June
EF for heat generation (tCO ₂ /TJ)	64.35		
Thermal energy produced (kWh)		1807	2220
Equivalent CO ₂ emissions saved (kg)		418.6	514.3
EF for electricity generation (tCO ₂ /TJ)	74.4		
Electrical energy produced (kWh)		860	1110
Equivalent CO ₂ emissions saved (kg)		230.3	297.3

Based on the heat and electricity production assessed **yearly: 8621 kgCO₂**.

Energy analysis: measured data



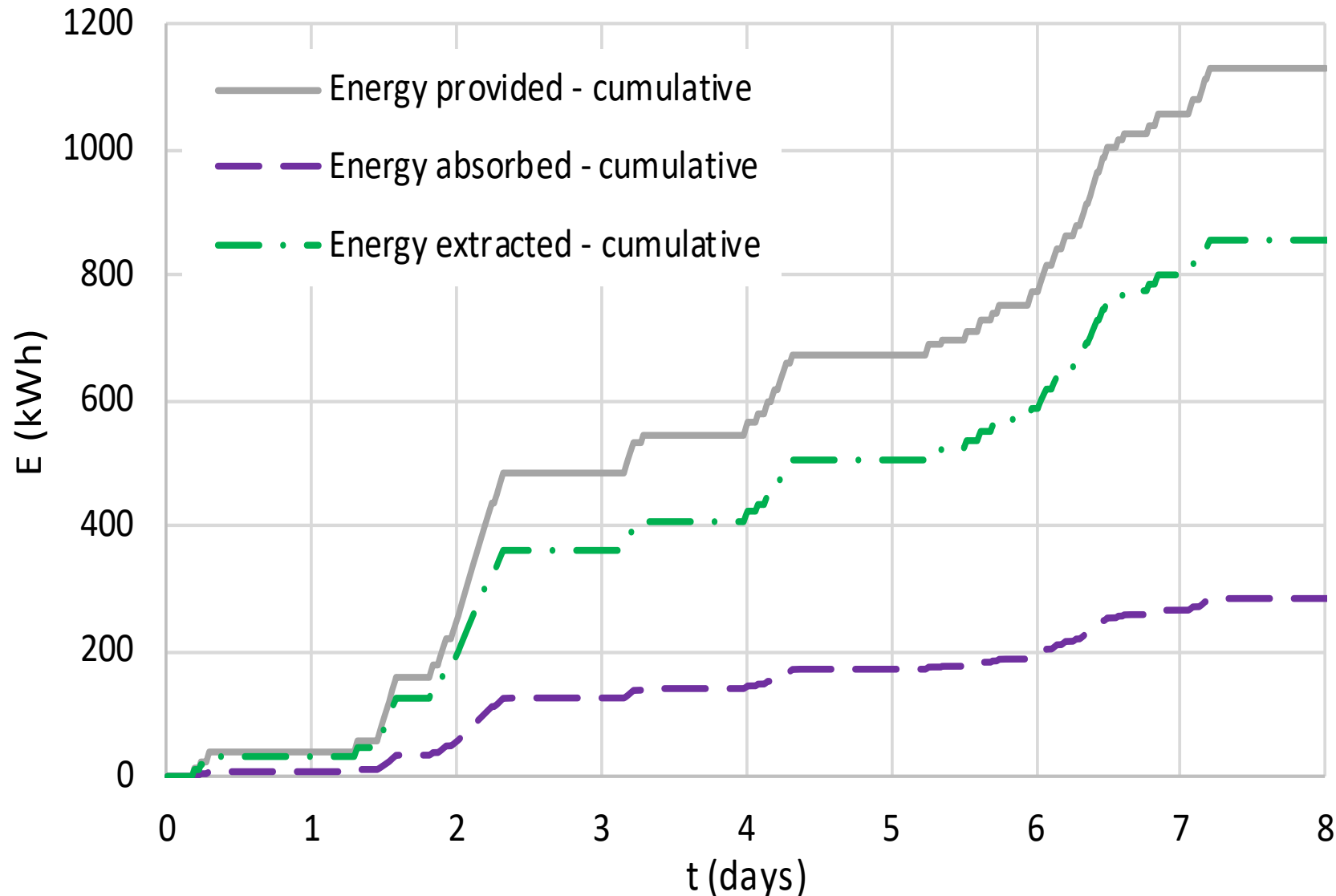
System performance – Extracted geothermal water



Total energy extracted from the ground: 800 kWh

Minimum temperature: -2°C

System performance – Cumulative energy



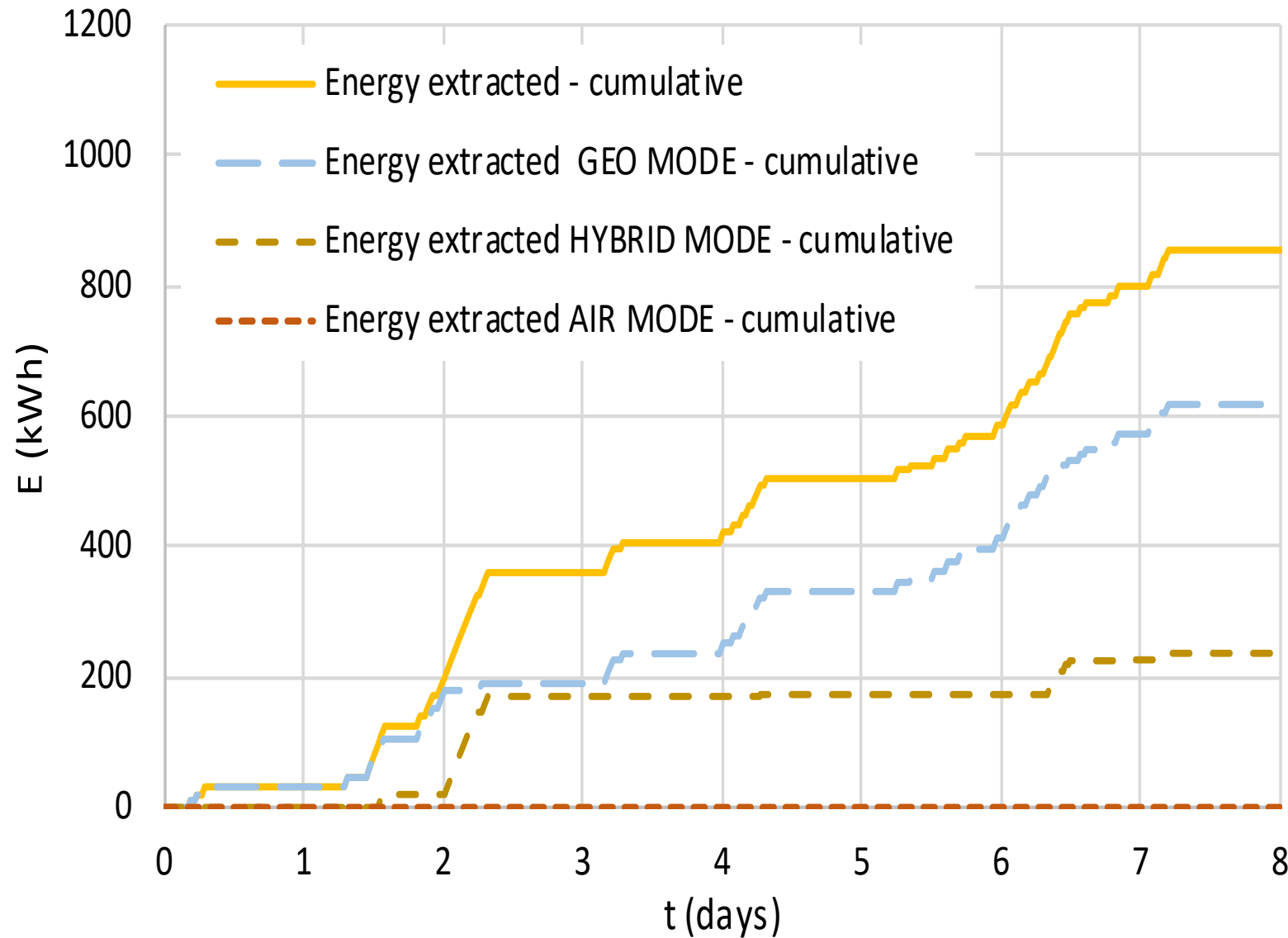
Period 17-25th April 2024

Energy provided: 1100 kWh

Energy extracted: 850 kWh

Energy absorbed: 250 kWh

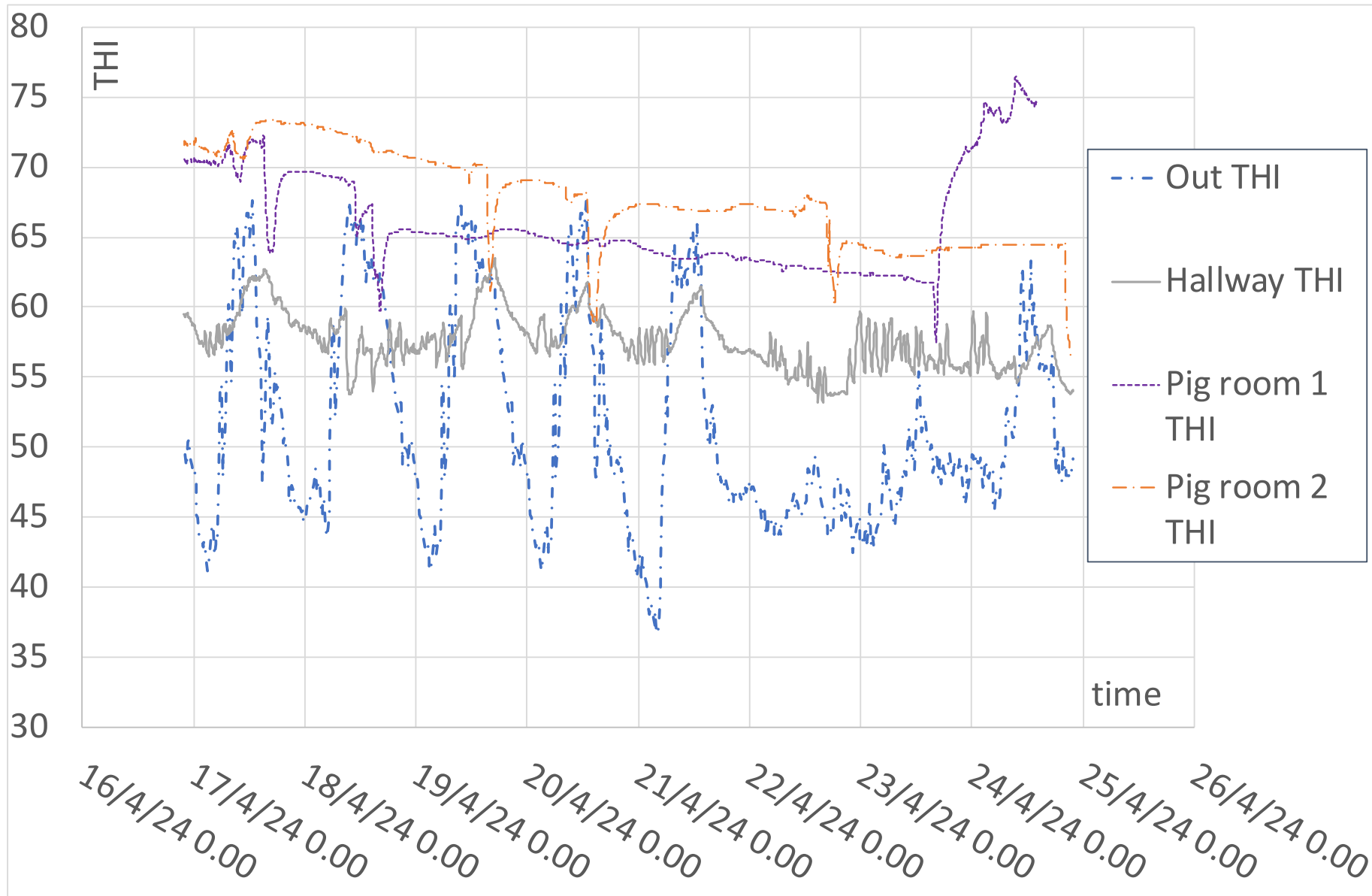
System performance – Energy sources



Period 17-25th April 2024

	Average COP
GROUND mode	4.67
AIR mode	No activation
HYBRID mode	3.50
TOTAL	4.34

System performance: THI control



In cold season, THI trends in the weaners' rooms is substantially kept within the range 60-75, corresponding to animal welfare



BTES technical data

Storage capacity of solar thermal energy	40%		(Ratio of the solar radiant energy over the PVT area to the heat stored underground) 8 BHEs of 30 m depth coupled with a PVT plant of 25 kW _{th}
Maximum injectable temperature	35	°C	Safety in order not to damage the plastic pipes and for environmental protection of the aquifer
Minimum temperature in the BTES	-2	°C	Using glycol during the heat extraction with DHSP
Temperature increase of the ground due to storage	5	K	Ground temperature rise from 15 (natural state) to 20°C (after a season of heat injection).
Max heat extraction capacity	26.8	kW	8 BHEs of 30 m depth, providing peak power to the DSHP 34 kW, after summer heat injection, with peak COP = 4.7. No use of air.
Average heat extraction capacity	13	kW	8 BHEs of 30 m depth providing average power to the DSHP 34 kW, in the middle of winter and using glycol, exploiting half of the power (17 kW) with peak COP = 4.7. The remaining power is provided by hybrid use with air, reducing the total COP to 4.3
Standard temperature difference between inlet and outlet during extraction	3	K	
Standard temperature difference between inlet and outlet during injection	5	K	

Conclusions



- An integrated system with PVT, Borehole Thermal Energy Storage (BTES) and Dual Source Heat Pump (DSHP) was designed and installed; under monitoring.
- An effective solution calls for monitoring the temperatures of the components, and environmental parameters outdoor and indoor.
- Underground areas of farmyards can be effectively exploited to install BTES, to store excessive heat produced by RES system, such PVT or biogas.
- A mix of RES can be specifically designed for a livestock farm, to exploit the renewable resources available.
- The system effectively managed indoor temperatures of a swine nursery barn without reliance on fossil sources



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