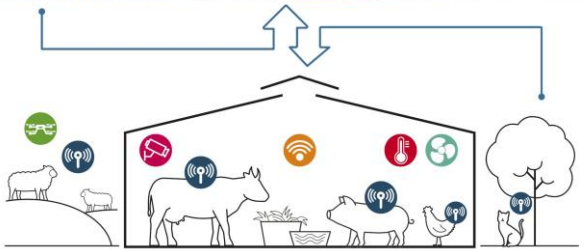

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RES4LIVE
ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

Control of the environmental conditions in a nursery barn through a smart heating system and renewable energy sources

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Introduction

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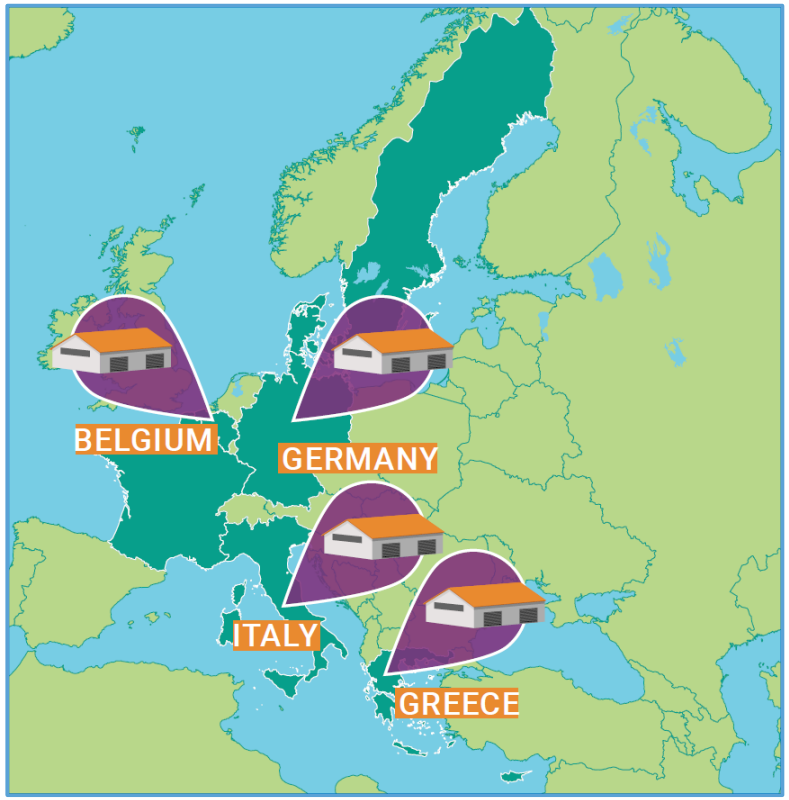
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

The study was developed within the project RES4LIVE "Energy Smart Livestock Farming towards Zero Fossil Fuel Consumption" (H2020, IA, 2020-2024)

- Sustainable livestock production and de-fossilising energy needs in husbandry facilities emerge as crucial aspects
- 4 pilot farms



More sustainable livestock production and de-fossilising energy needs in husbandry facilities emerge as **crucial aspects within EU**

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RES4LIVE Italian pilot farm

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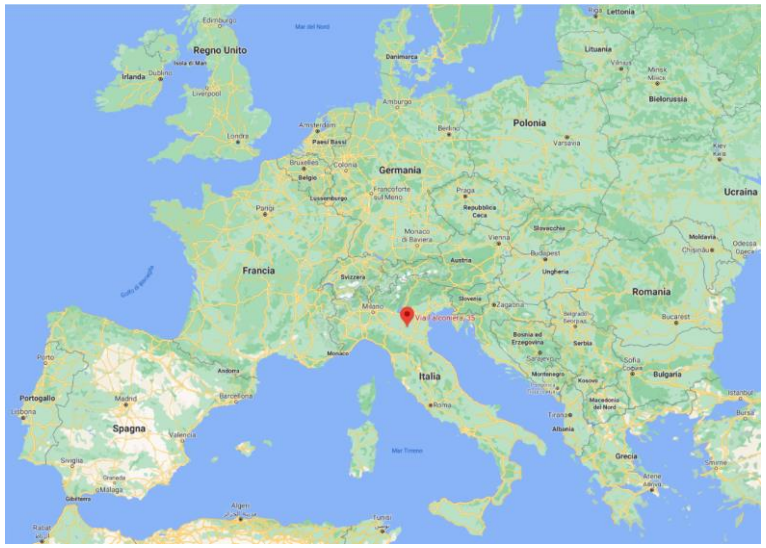
- Farrow-to-Nursery Swine Farm
- 500 sows, 2500 weaners
- De-fossilization of nursery barn



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Objectives

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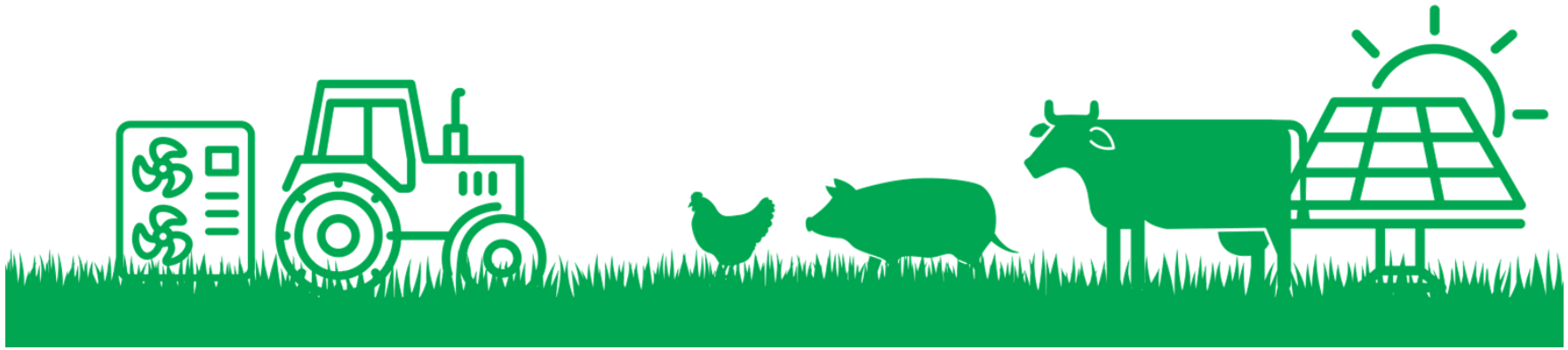
- Development and installation of an integrated RES system combining
  - a photovoltaic-thermal plant,
  - a geothermal storage, and
  - a modular heat pump.
- Smart control system for environment monitoring and energy management
- Smart control system to monitor underground temperatures



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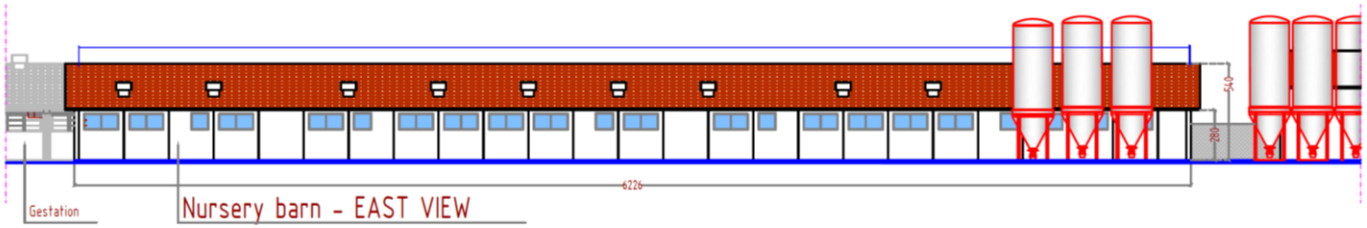
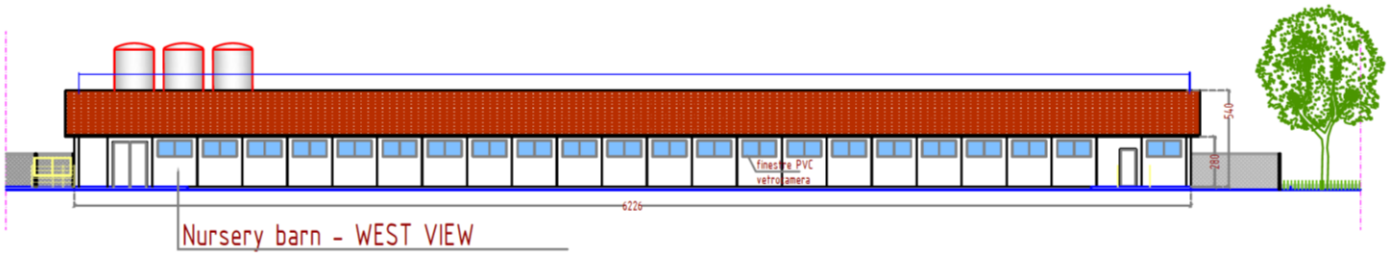
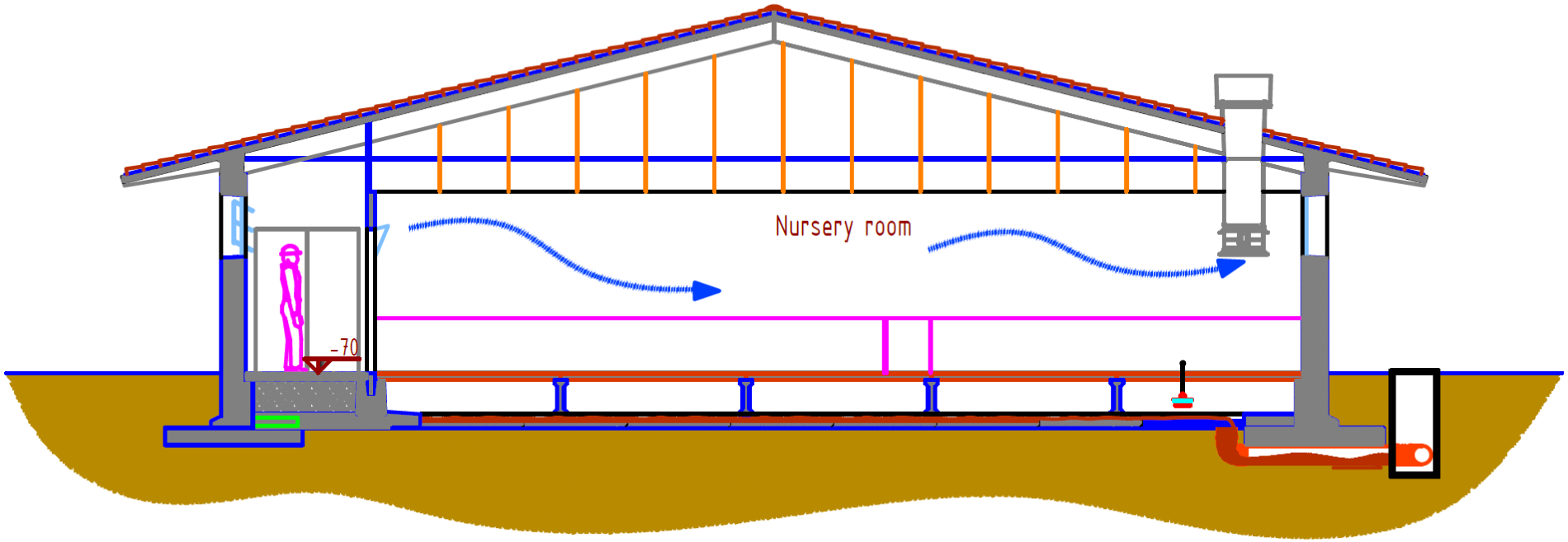
Nursery barn





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 kWel and 25 kWth 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.

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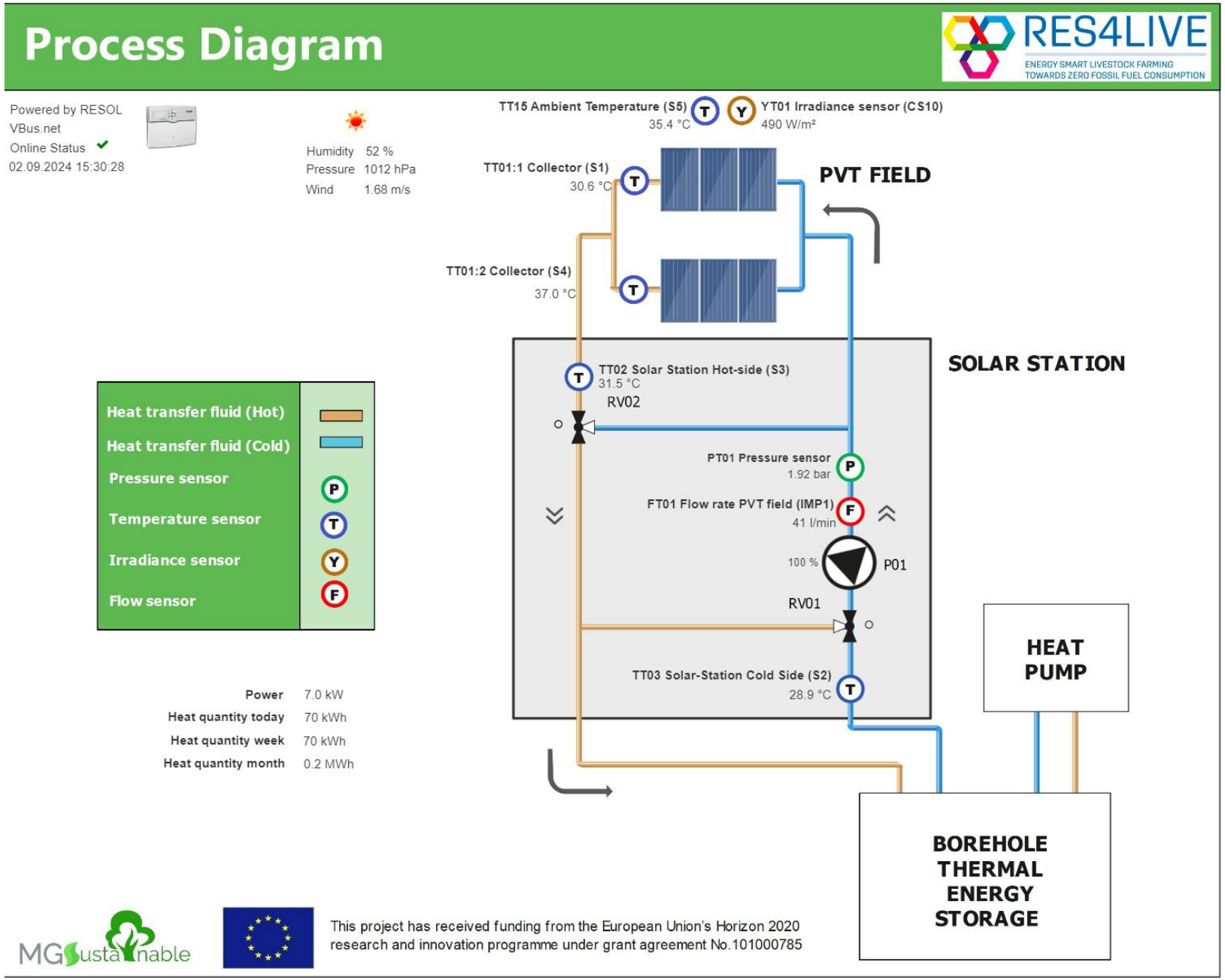
Installation of geothermal storage: 8 boreholes with double U pipes, 30 m deep

- 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



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Energy analysis: measured data

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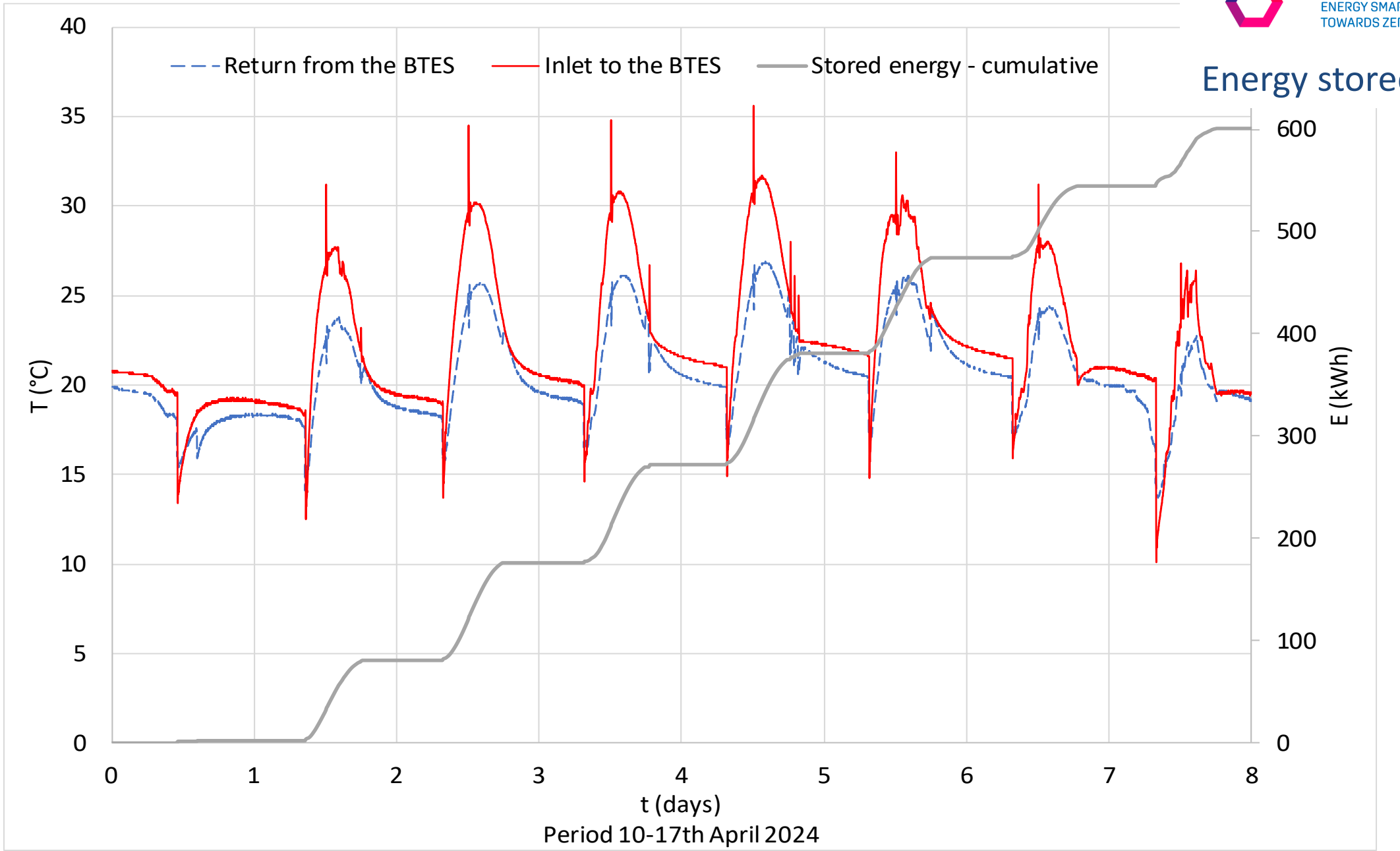
Energy stored: 600 kWh



Period 10-17th April 2024

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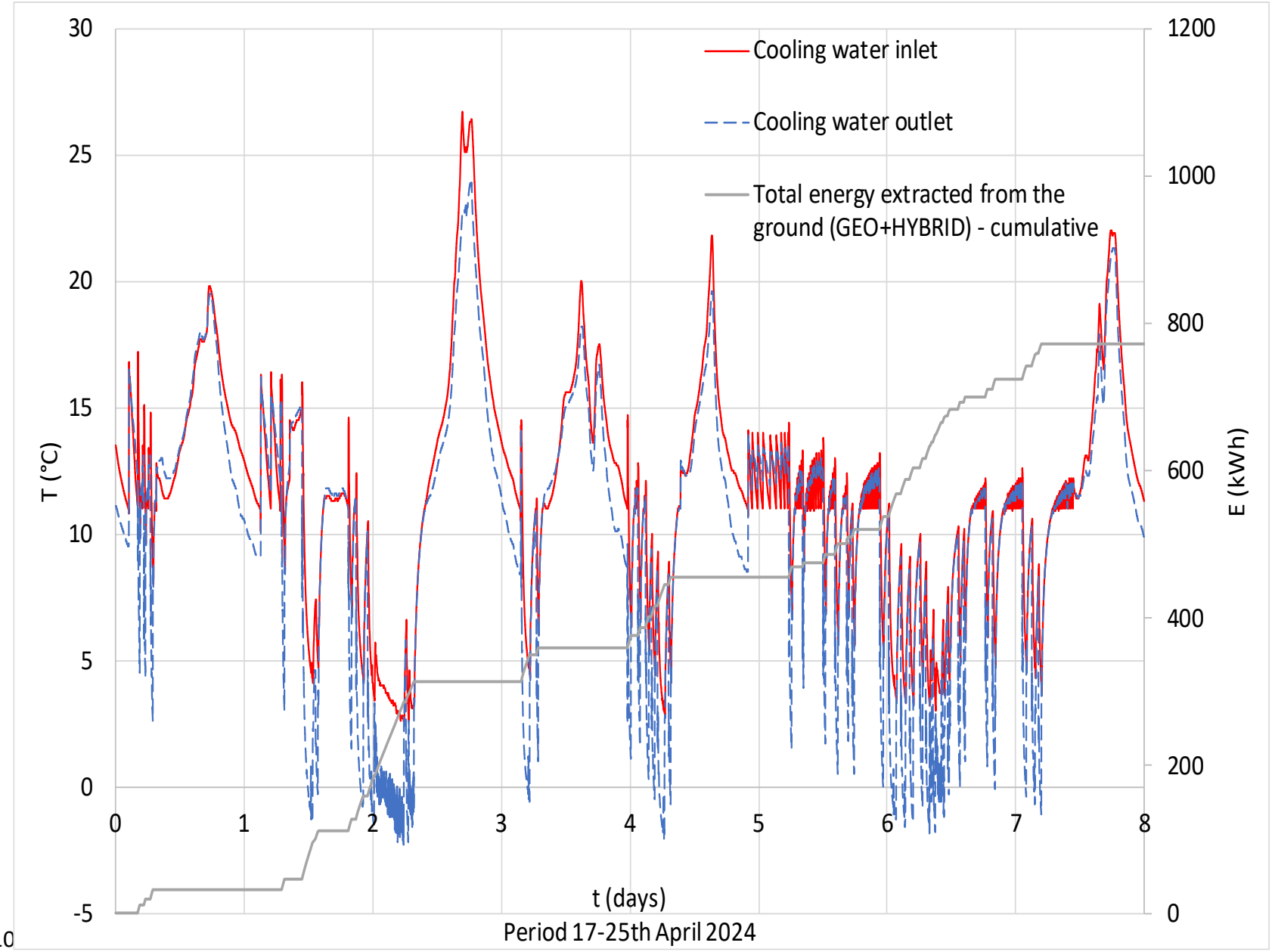
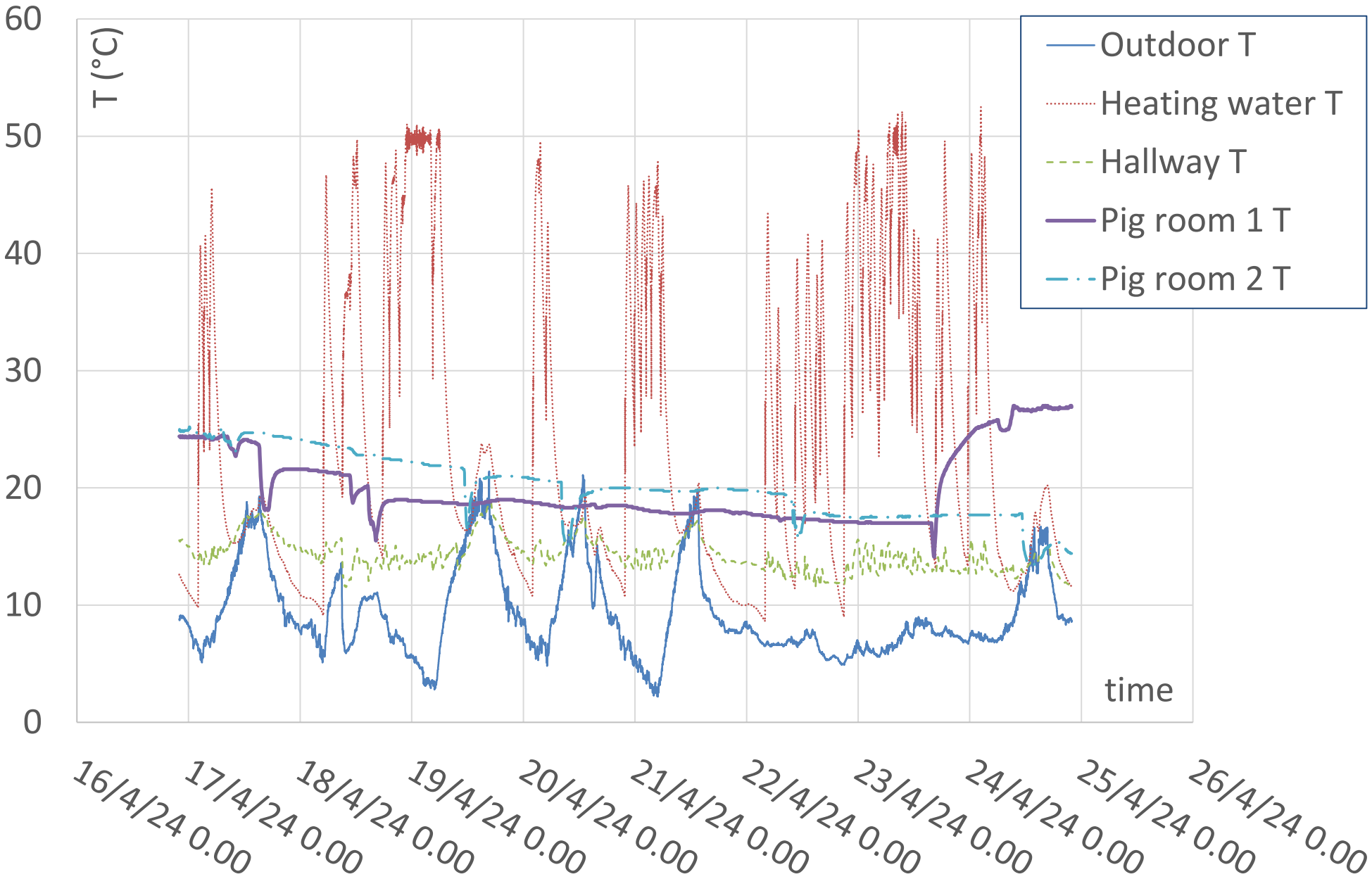
System performance – Extracted geothermal water



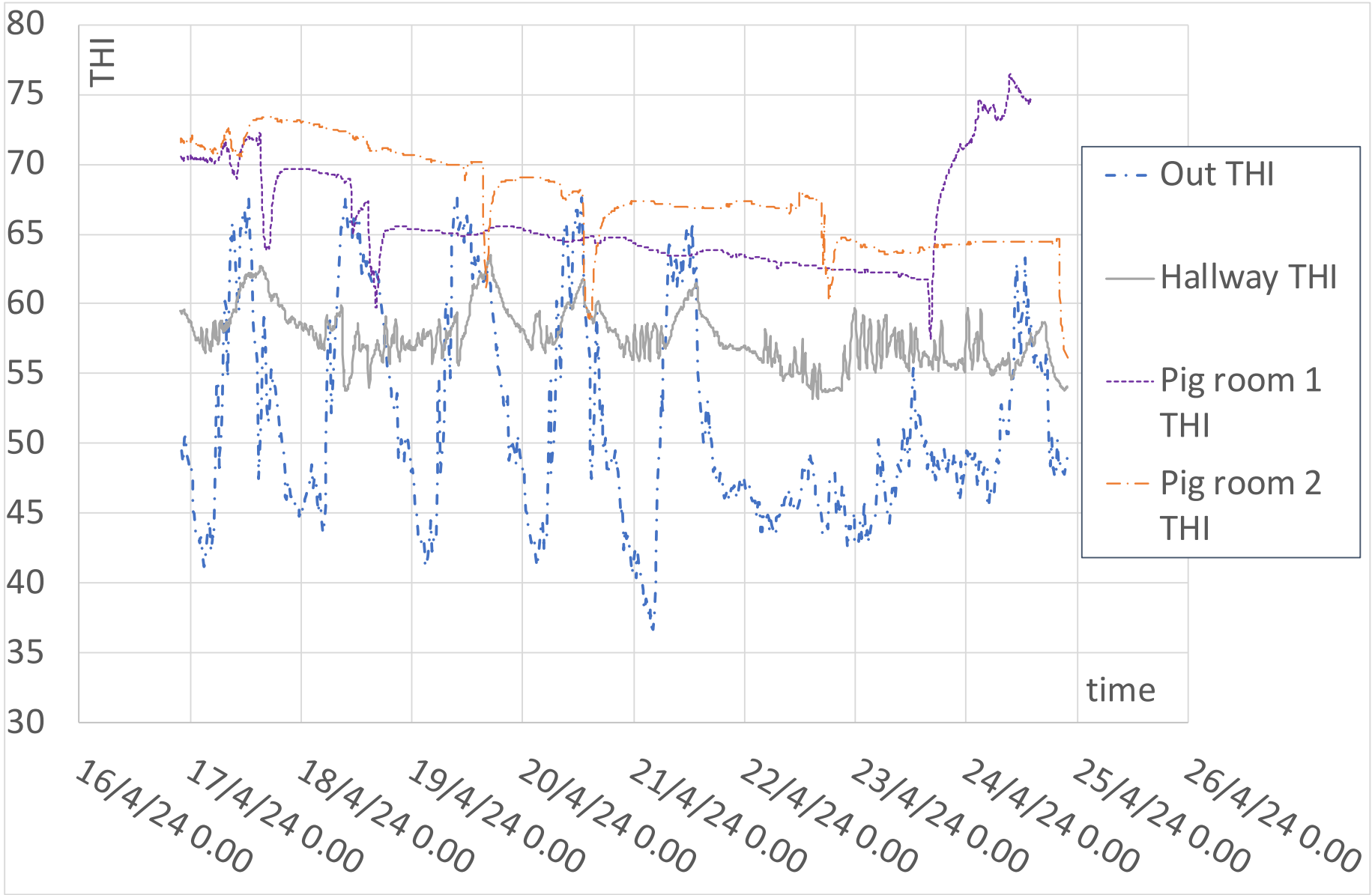
Total energy extracted from the ground: 800 kWh

Minimum temperature: -2°C

System performance: T control

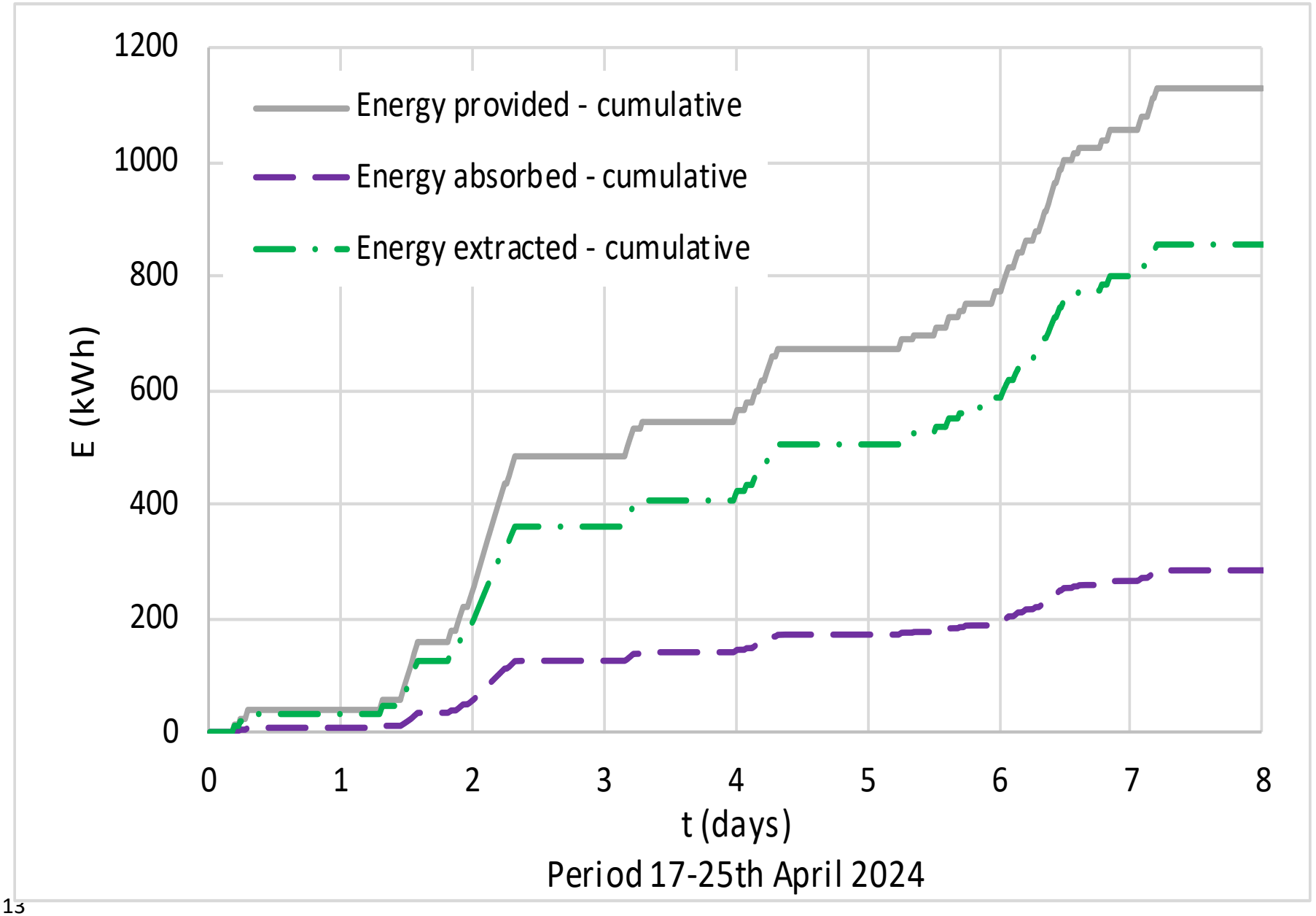


System performance: THI control



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

System performance – Cumulative energy



Energy provided: 1100 kWh

Energy extracted: 850 kWh

Energy absorbed: 250 kWh

System performance – Energy sources

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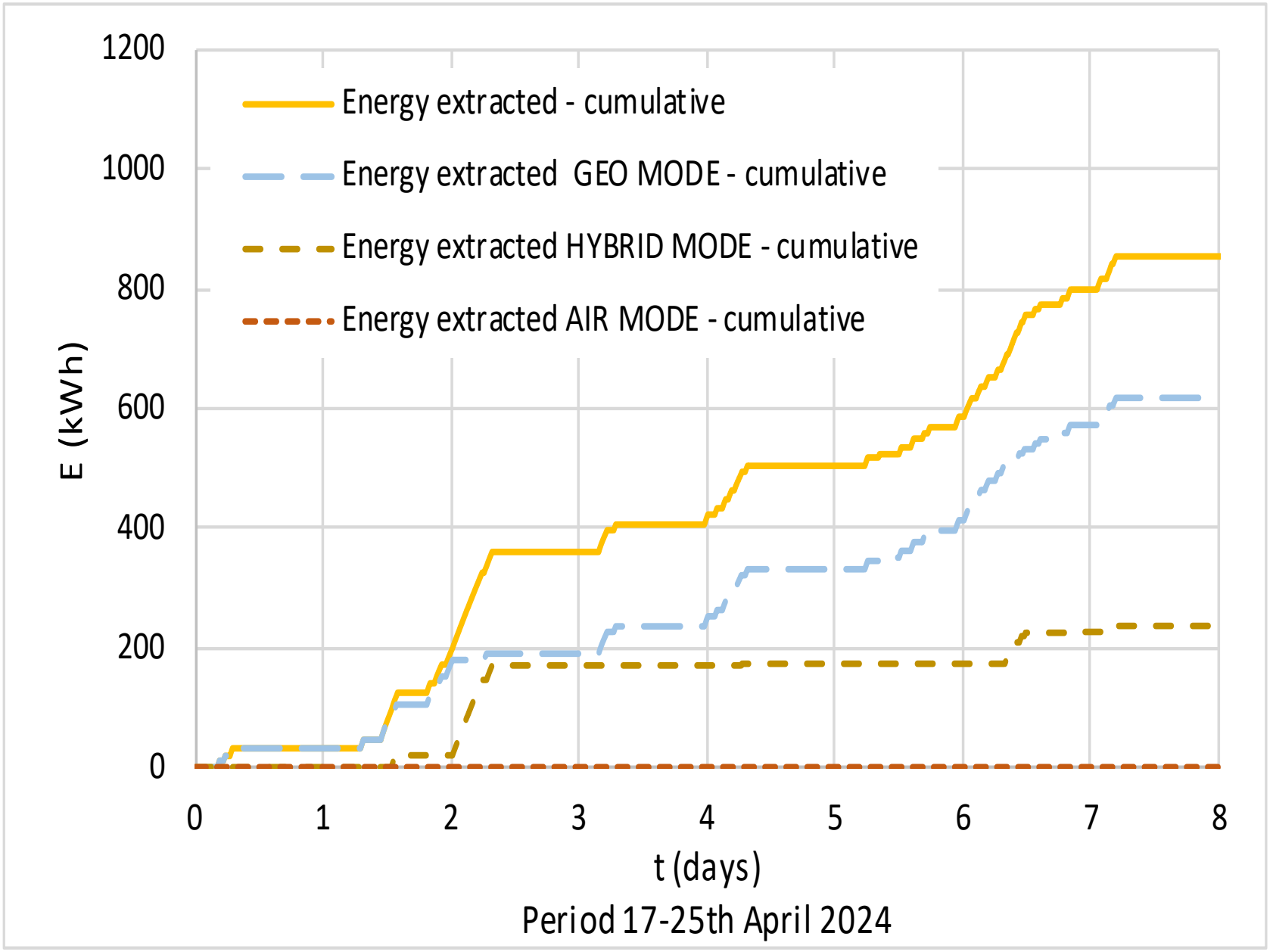

	Average COP
GROUND mode	4.67
AIR mode	No activation
HYBRID mode	3.50
TOTAL	4.34

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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	
CO2 emission saving	8621	kgCO2	Based on the heat and electricity production assessed yearly

Conclusions

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- 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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