RES4LIVE
ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

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Renewable Sources and Energy Retrofitting Solutions for Microclimatic Control in Pig Barns

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Pilot case

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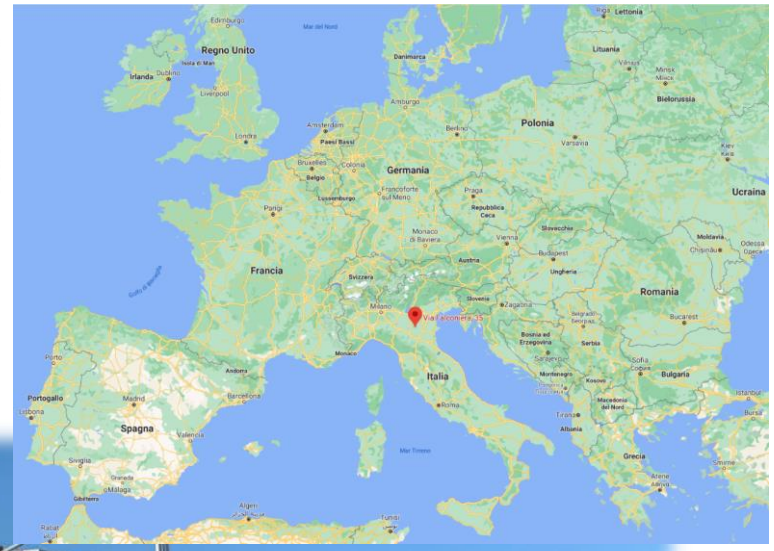
- Farrow-to-Nursery Swine Farm
- 500 sows, 2500 weaners
- De-fossilization of nursery barn
- Retrofitting of hog barn

GOLINELLI
AZIENDA AGRICOLA



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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
- Retrofitting of old pig barn to increase energy efficiency

Integrated RES system

- 35 kW medium temperature heat pump,
- 8 kW_{el} PVT system with solar station, to provide electricity for the heat pump and the nursery barn, and thermal energy (24 kW_{th})
- 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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Preliminary design - Energy loads

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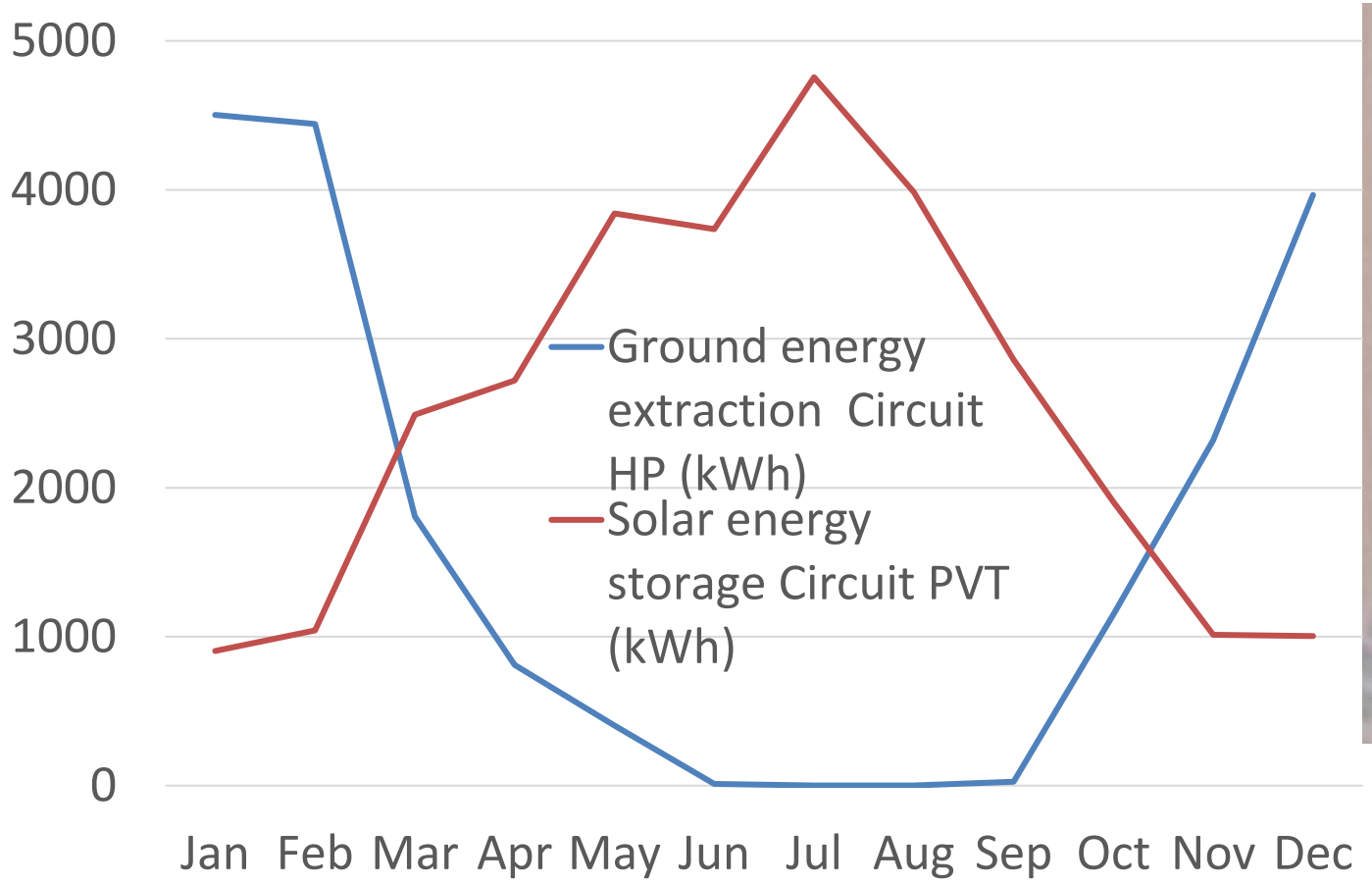

- 8 Boreholes 30 m
- 2 piezometers

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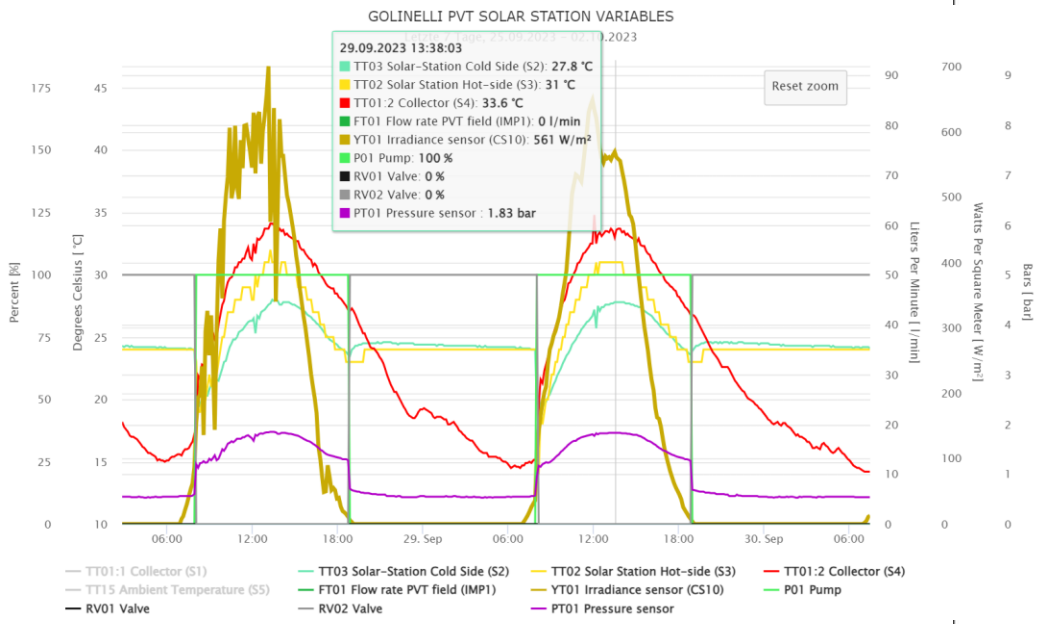
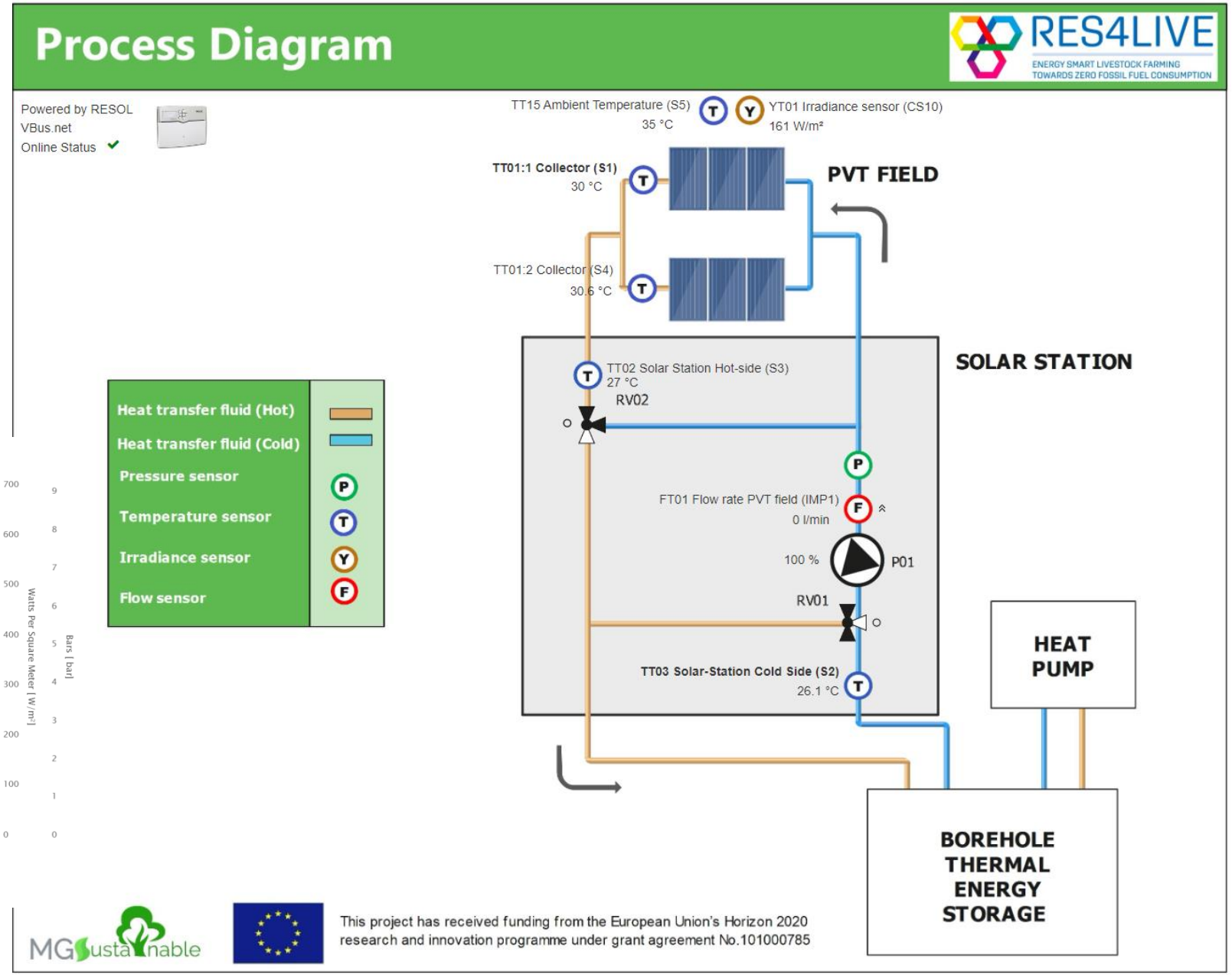
Installation of geothermal storage: 8 boreholes with double U pipes, 30 m deep

- 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





Measurement of boreholes temperature

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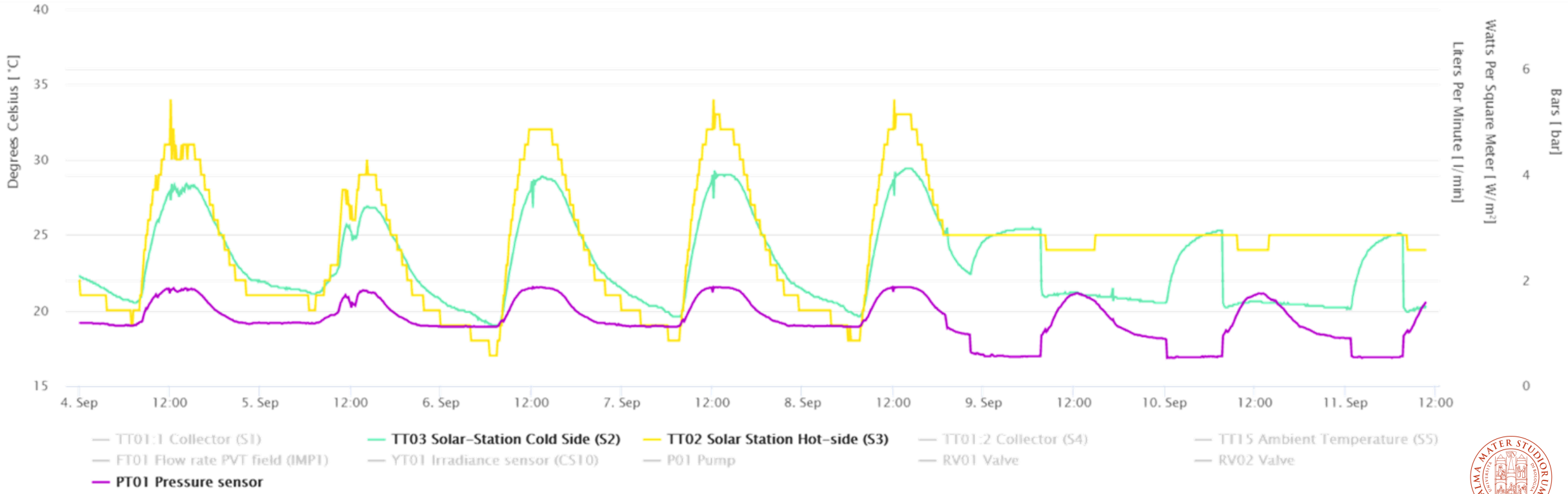
- Average Temperature in 30m borehole in March 2023: 15.9°C (before installation)
- Average Temperature in 30m boreholes on 10 Sep 2023: 20.5 °C
- Increase in TC temperature due to solar heat injection from May to August 2023: 4.6°C



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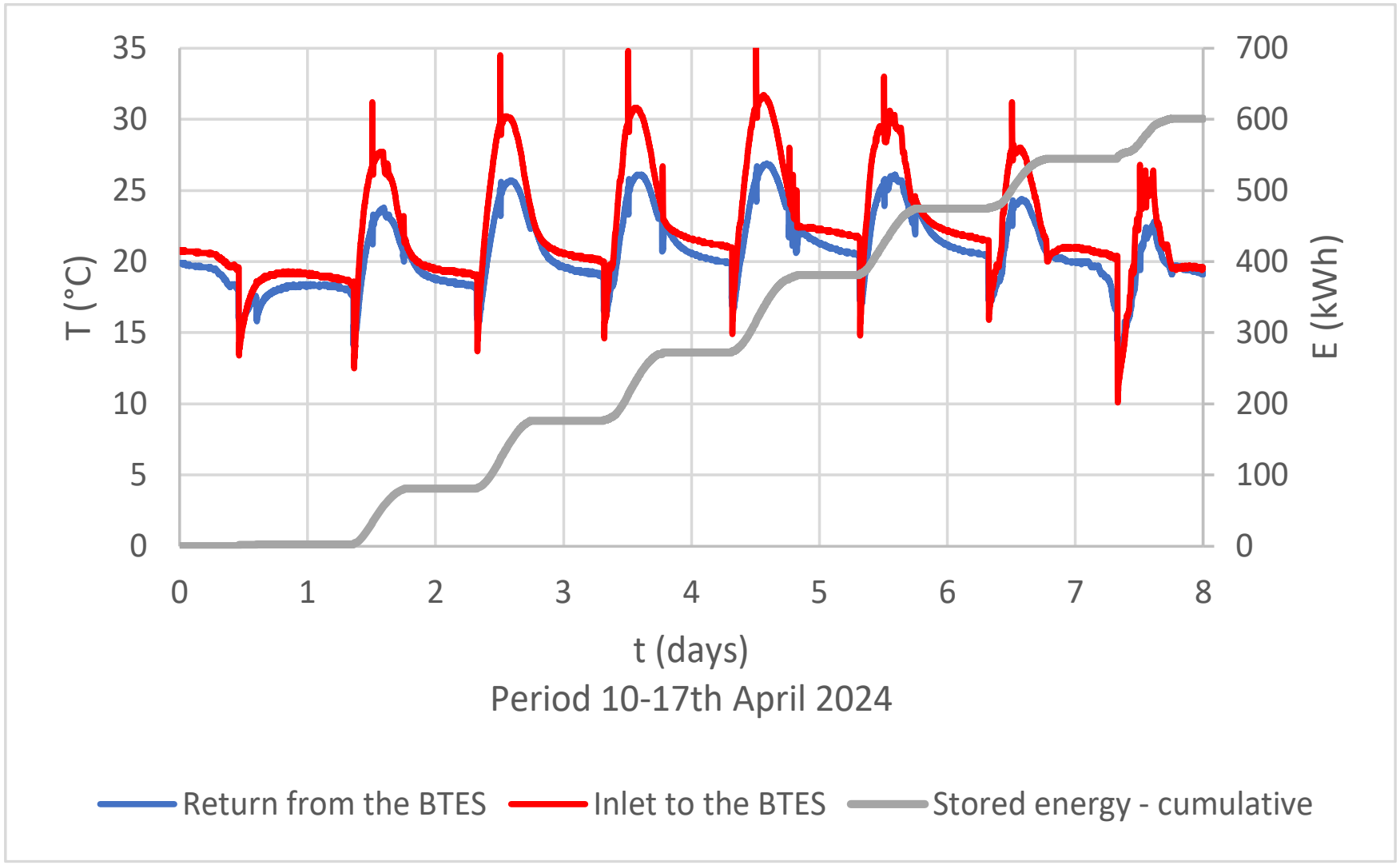
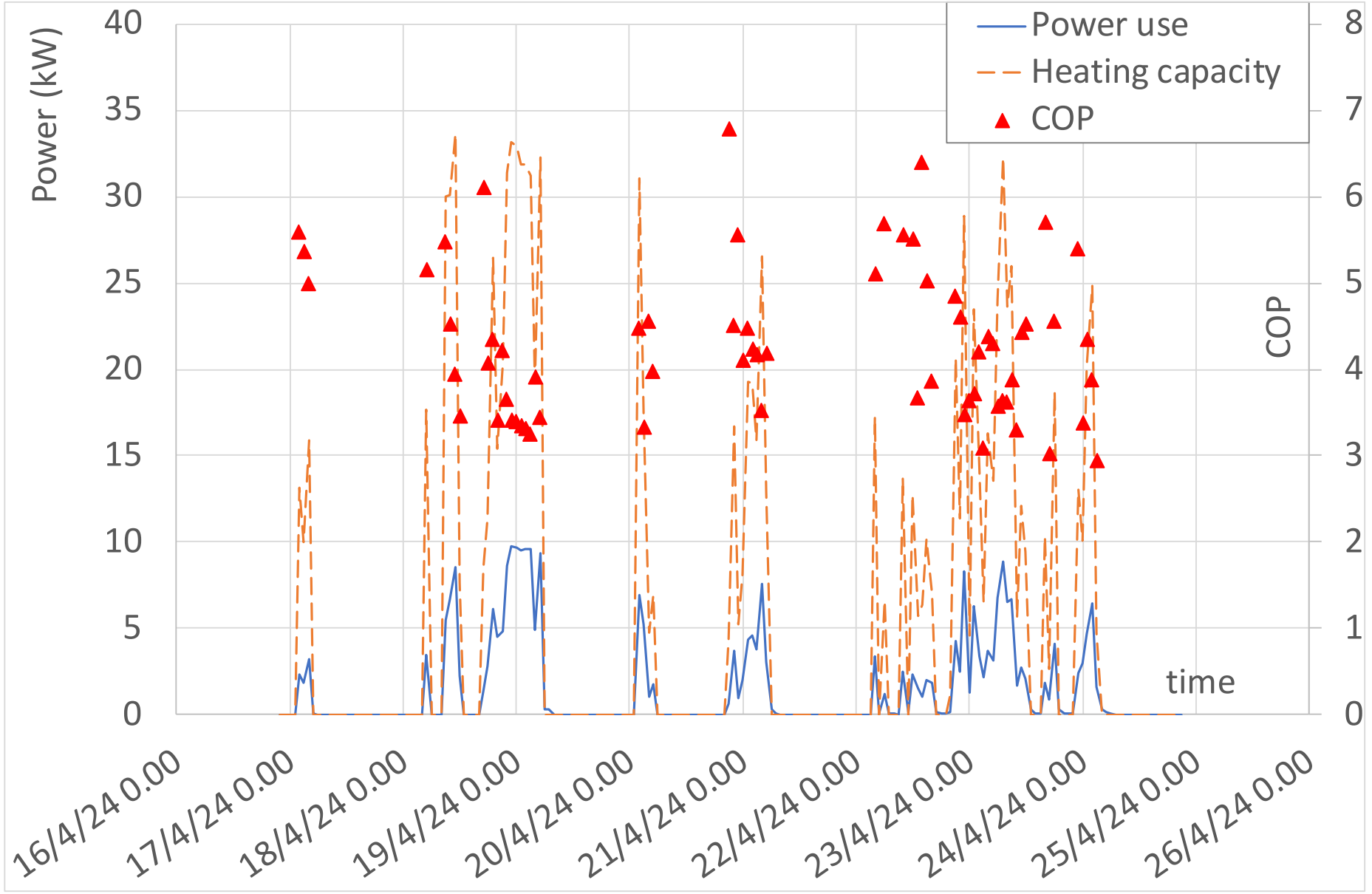
BTES System performance – temperature and heat injected



Energy stored: 600 kWh

System performance



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

Energy retrofitting of hog barn

Initial state

- 34 windows of 2.8 m x 0.8 m, with steel single-layer frames and 4 mm thick glass surfaces.
- thermal transmittance assessed 5.9 W/m^{2}K

Retrofitting solution

- windows with frame in tubular stainless steel, transparent infill in 16mm thick double chamber alveolar polycarbonate
- thermal transmittance of 2 W/m^{2}K
- environmental sensors and actuators
- automatic openings based on temperature and air quality

Effect of retrofitting on indoor temperature and humidity

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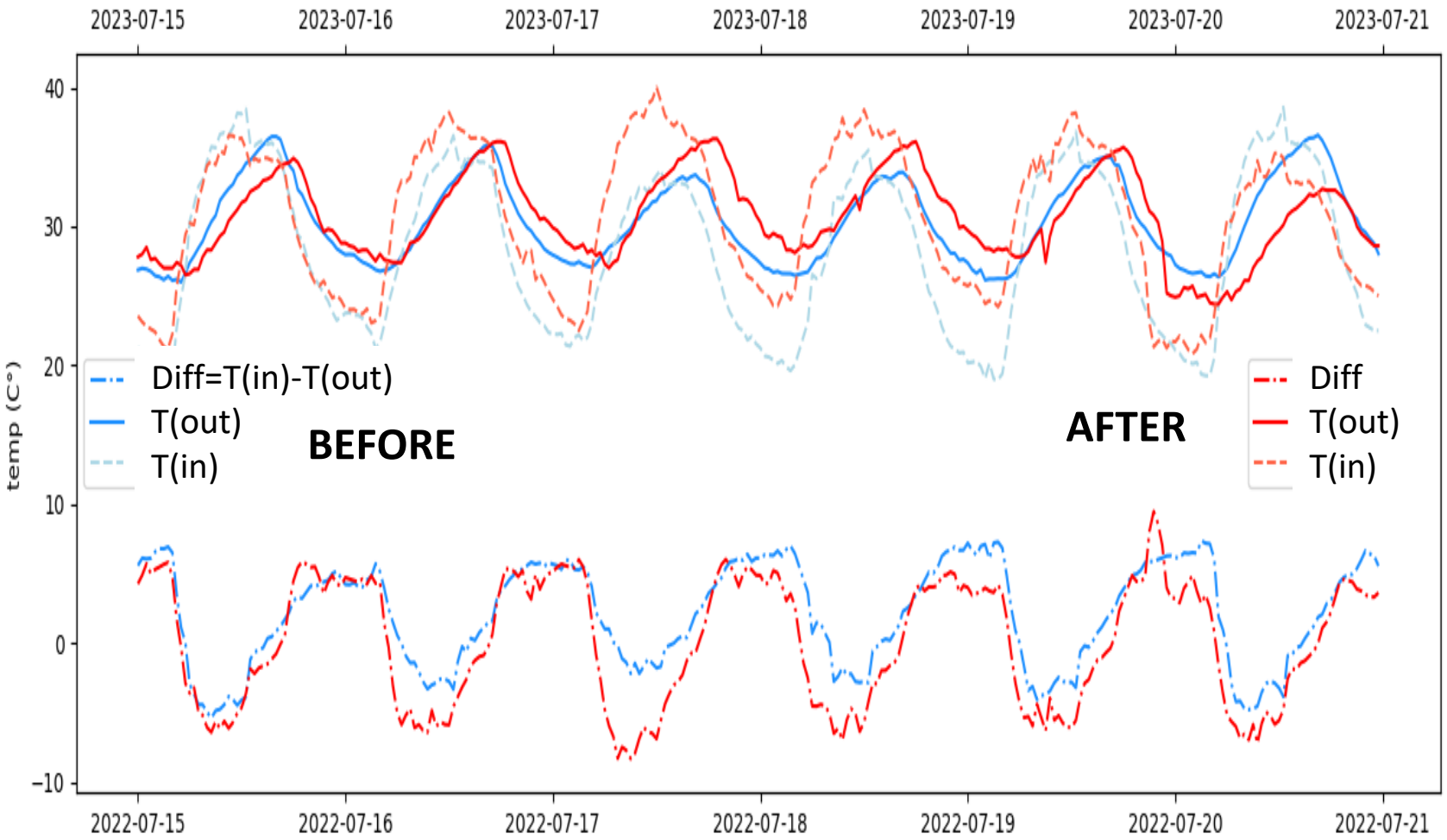

- August 2022: ΔTHI(in-out) = +1.94 (daily avg)
- August 2023: ΔTHI(in-out) = -2.38
- Reduction of daily avg indoor THI = -4.32

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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.
- Energy efficiency of existing hog barn was increased through retrofitting
- Underground areas of farmyards can be effectively exploited to install BTES, to store excessive heat produced by RES system, such PVT or biogas.
- An effective solution requires monitoring the temperatures of the components, and environmental parameters outdoor and indoor.
- Smart monitoring systems have been developed. Data about energy usages were analyzed to assess efficiency.
- Data collection proved fundamental for the definition of technical solutions of retrofitting, to increase the energy efficiency of existing livestock barns
- Targeted retrofitting can significantly enhance the sustainability livestock farming.

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