RES4LIVE – Progress on Pilot Systems for Energy Smart Livestock Farming towards Zero Fossil Fuel Consumption

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Session 11: Fossil-free livestock farming
Tuesday, 2nd July 2024
Conference Auditorium

AgEng 2024

RES4LIVE
ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

- Introduction
- General Information
- Proposed Solution
- Pilot Farms & Interventions
- Expected Impact

Introduction

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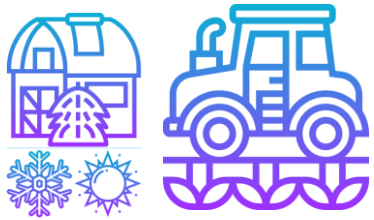
ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

- Current direct (on-farm) energy use accounts for 3.2% of the EU's total energy consumption and is dominated by energy from fossil sources. (Eurostat, 2022)
- Agriculture accounts for 10.3% of the EU's greenhouse gas emissions, with the livestock sector alone accounting for around 70% of all GHG emissions. (European Court of Auditors, 2021)

Intensive Livestock Farming is one of the most **energy consuming** sub-sectors of agriculture, mainly based on fossil fuels use

While…

Electricity and thermal energy is required to cover strongly diversified energy demand



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Introduction

RES4LIVE
ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

- Current direct (on-farm) energy use accounts for 3.2% of the EU's total energy consumption and is dominated by energy from fossil sources. (Eurostat, 2022)
- Agriculture accounts for 10.3% of the EU's greenhouse gas emissions, with the livestock sector alone accounting for around 70% of all GHG emissions. (European Court of Auditors, 2021)

…thus:

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

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General Information

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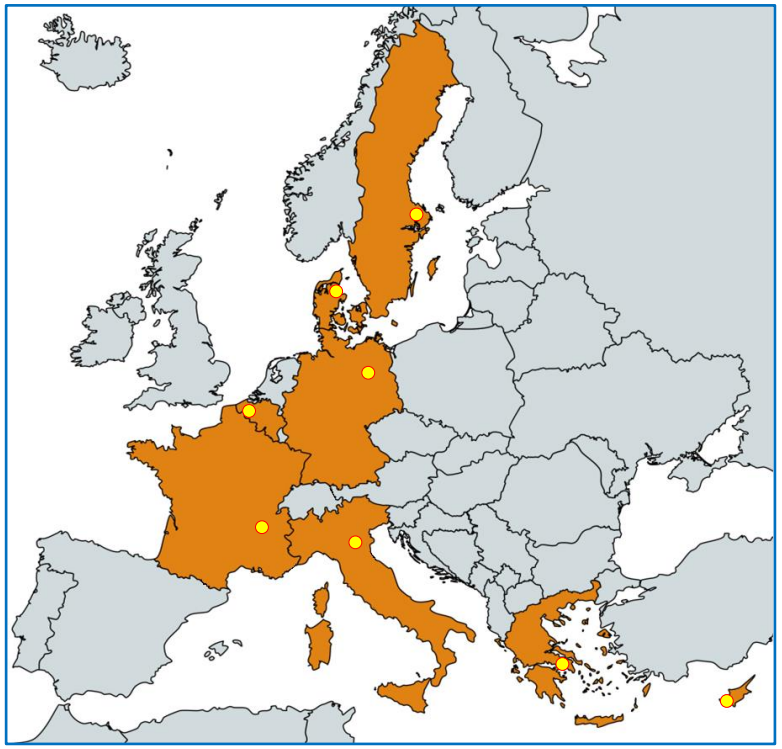
Horizon 2020

01/10/2020 – 30/09/2024

17 Partners from 8 EU countries



Consortium

Agricultural University of Athens · Aarhus University · Alma Mater Studiorum Università di Bologna · ATB · CERTH Centre for Research & Technology Hellas · CETRI Center for Technology Research & Innovation · CRMT Powertrain R&D · EAAP European Federation of Animal Science · EUREC The Association of European Renewable Energy Research Centres · Ghent University · Golinelli Azienda Agricola · ILVO Institute for Agricultural and Fisheries Research · MGsustainable · Pleg.ma Labs · Psyctotherm · TerraEnergy The Alternative Solution

Project Coordinator

Agricultural University of Athens (AUA)

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Proposed Solution

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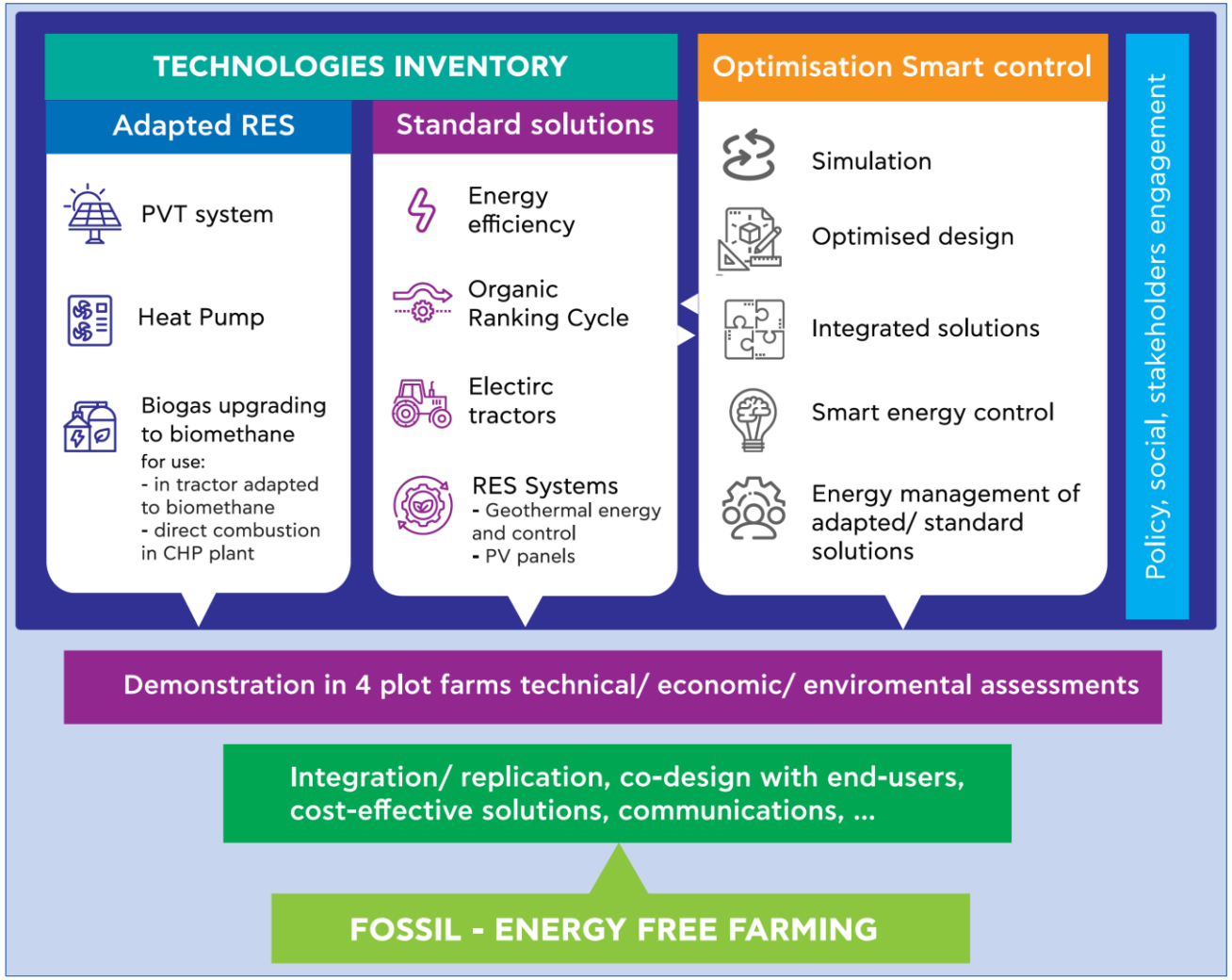
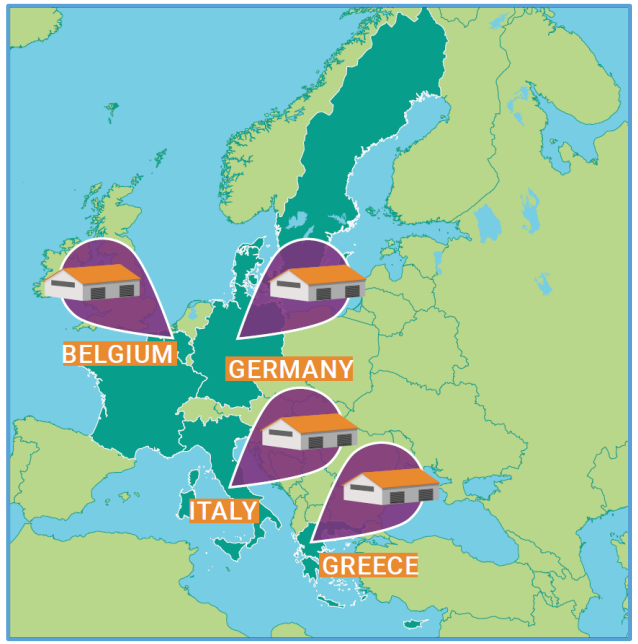


- **Replacement of fossil energy use,** utilizing Renewable Energy Sources (RES)
- A **combination of technologies and solutions** will be installed and evaluated in 4 livestock farms



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Proposed Solution

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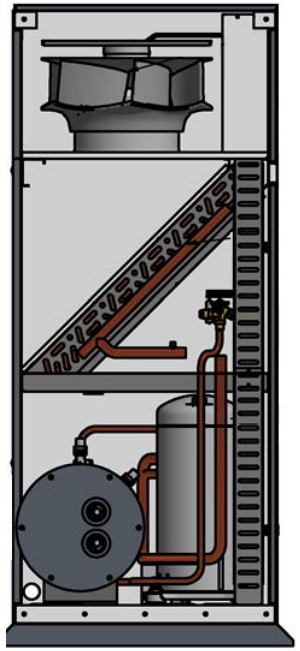
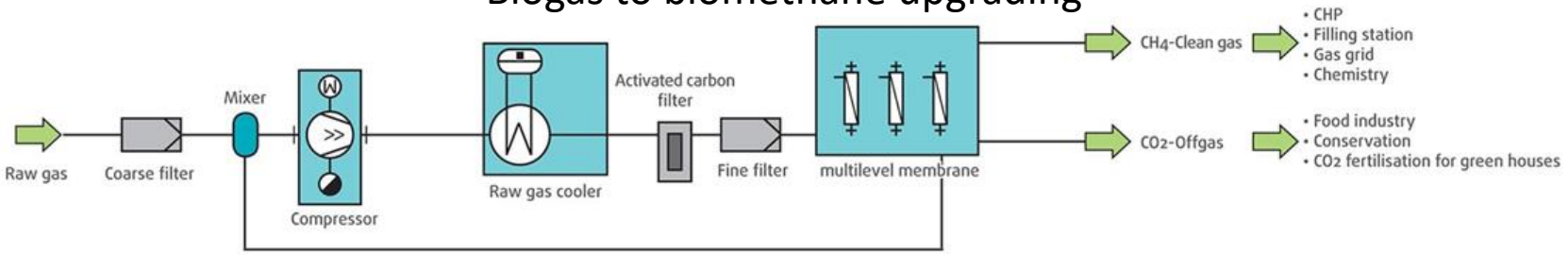
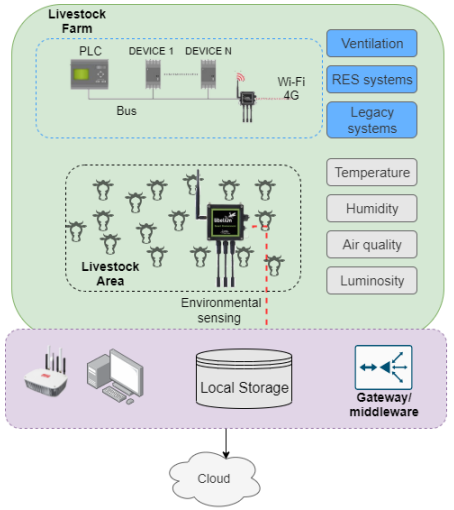
Heat pump



Biogas to biomethane upgrading

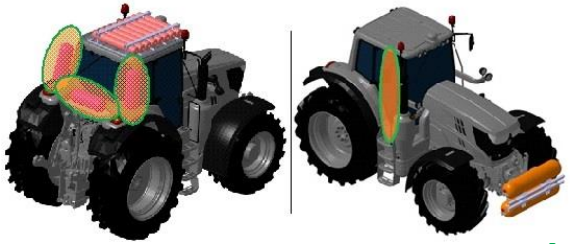


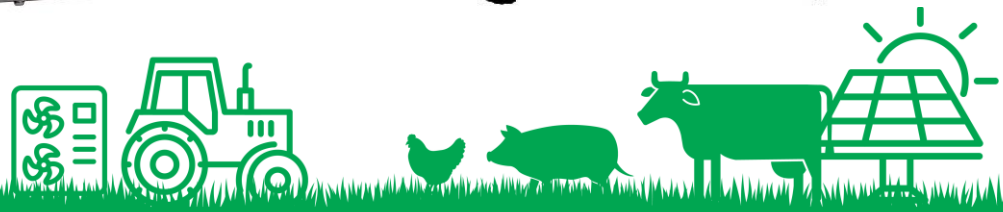
Smart control



Thermal Photovoltaics

Biomethane tractor





Market integrated, cost-effective & case-sensitive
Renewable Energy Sources solutions towards fossil-free livestock farming

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Pilot Farms and Interventions

Demonstration in 4 different farms

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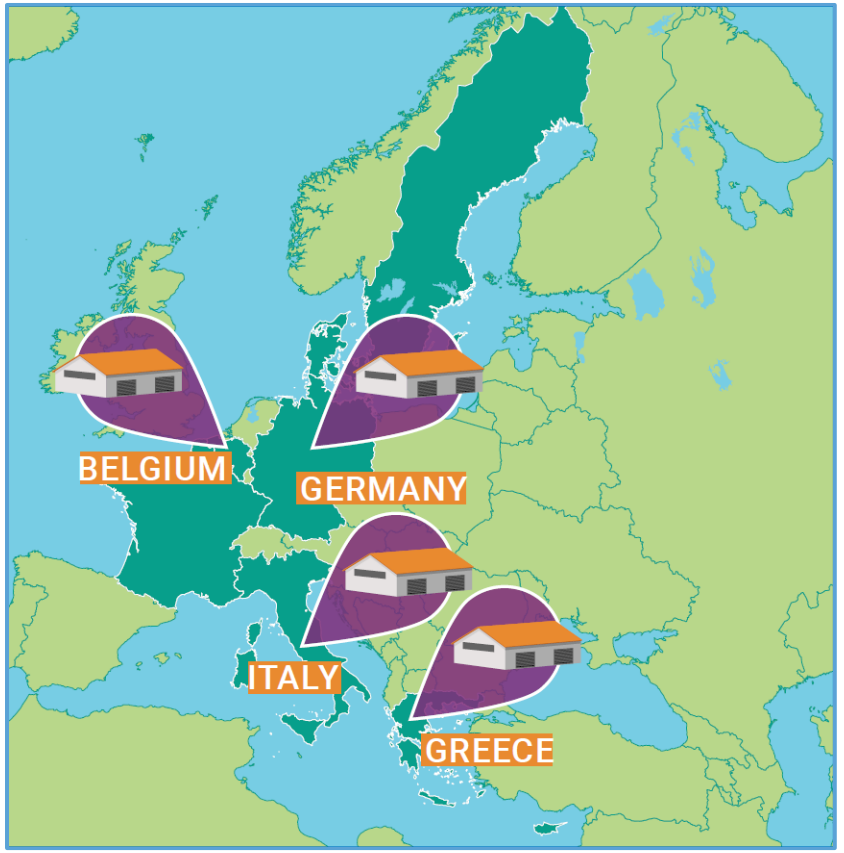
1. Experimental swine farm - EV ILVO (Belgium)
2. Commercial swine farm - Golinelli Farm (Italy)
3. Experimental egg production poultry farm - Agricultural University of Athens (Greece)
4. Experimental dairy cattle farm - LVAT (Germany)



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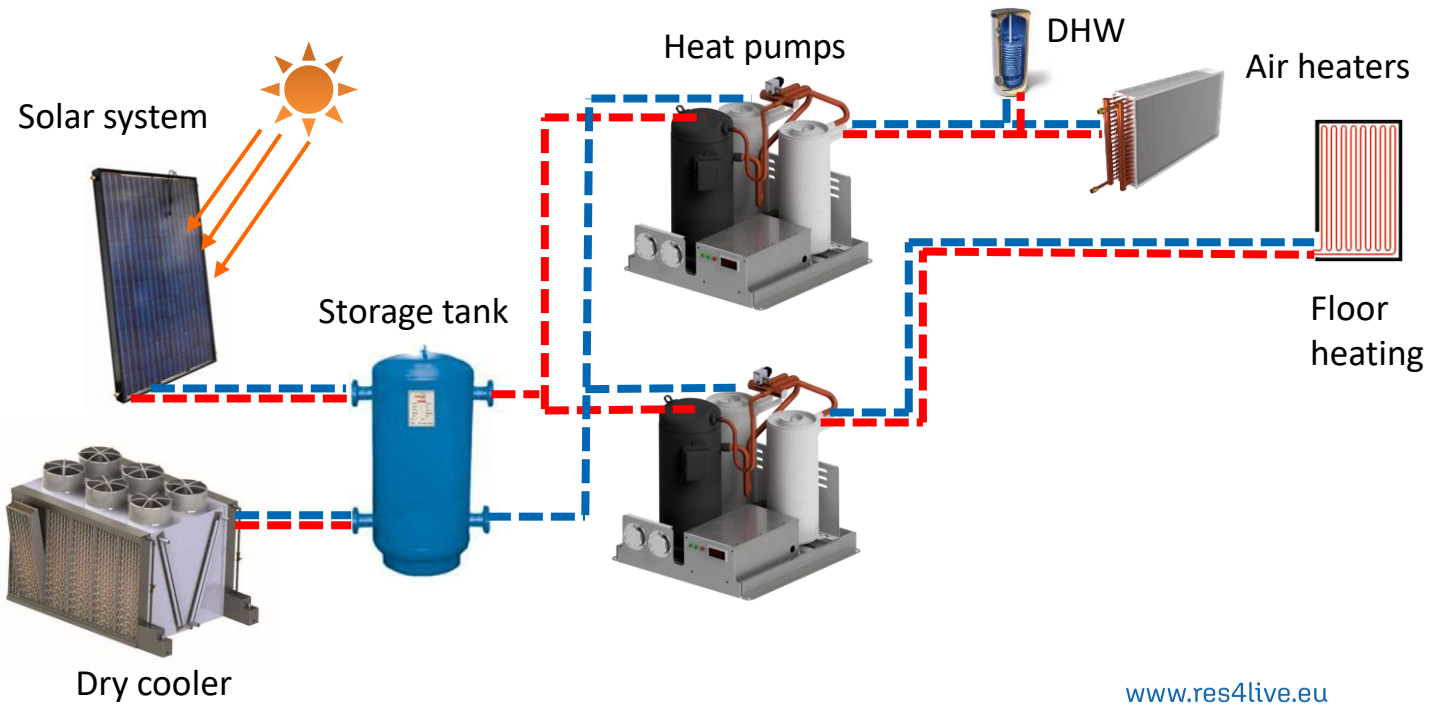
Experimental swine farm - EV ILVO (Belgium)

- Two (2) interconnected buildings, total area of 2,550 sq.m
- 105 sows, 600 piglets, 750 fattening pigs
- Gas heater & mechanical ventilation
- No cooling system



- 2-in-1 heat pump to cover the necessary thermal loads
- PVT system to partially cover the energy needs of the farm

- High temperature heat pump
- Low temperature heat pump
- Thermal photovoltaics
- Smart control

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Experimental swine farm - EV ILVO (Belgium)

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- High-temperature heat pump (40 kW - 60°C) provides sanitary hot water and air heating

- Low-temperature heat pump (25 kW - 42°C) is connected to the underfloor heating system used for piglets

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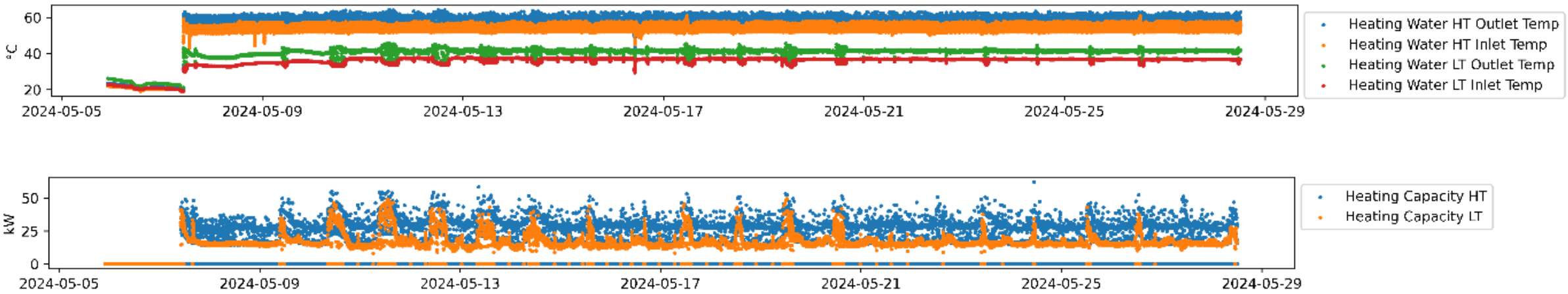
Experimental swine farm - EV ILVO (Belgium)



- When the temperature of the thermal storage tank (TES) is above 37°C, the heat pumps operate as water-to-water.
- Until the temperature drops below 17°C.
- The dry cooler serves as a heat source for the heat pumps (air-to-water) using either 1 or 2 fans depending on the heat demand.

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Experimental swine farm - EV ILVO (Belgium)

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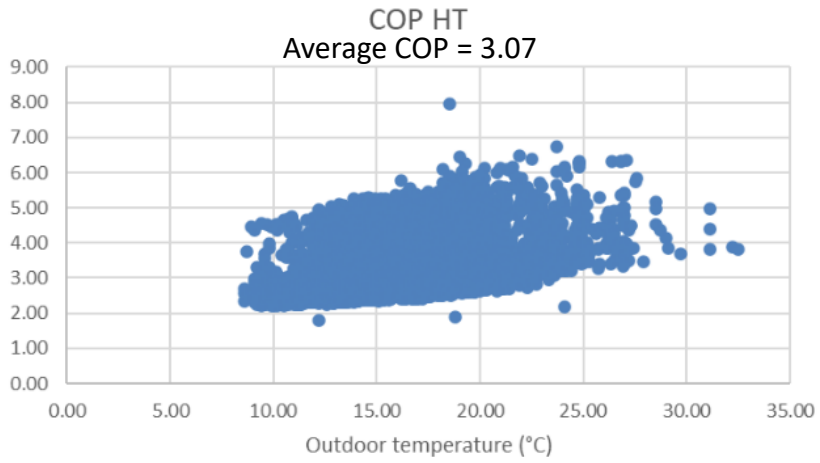

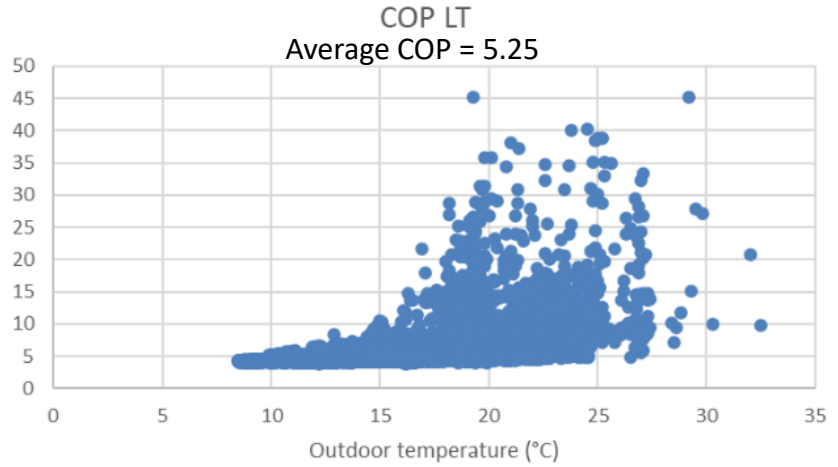

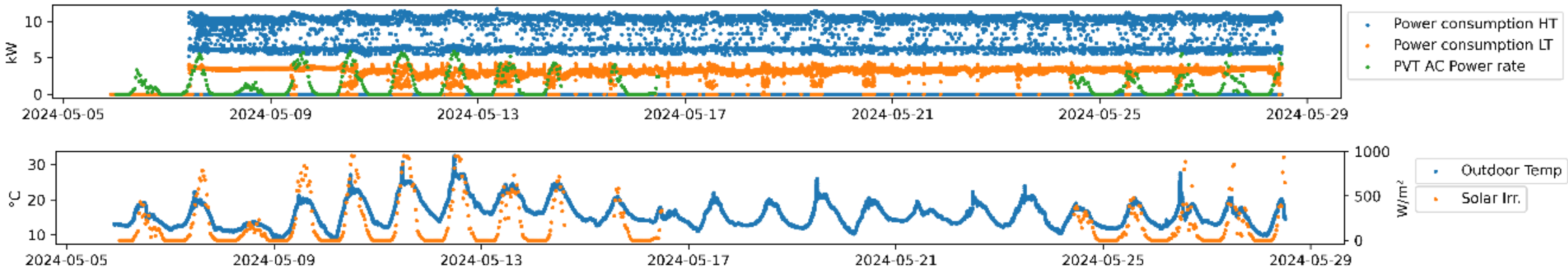

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Commercial swine farm - Golinelli Farm (Italy)

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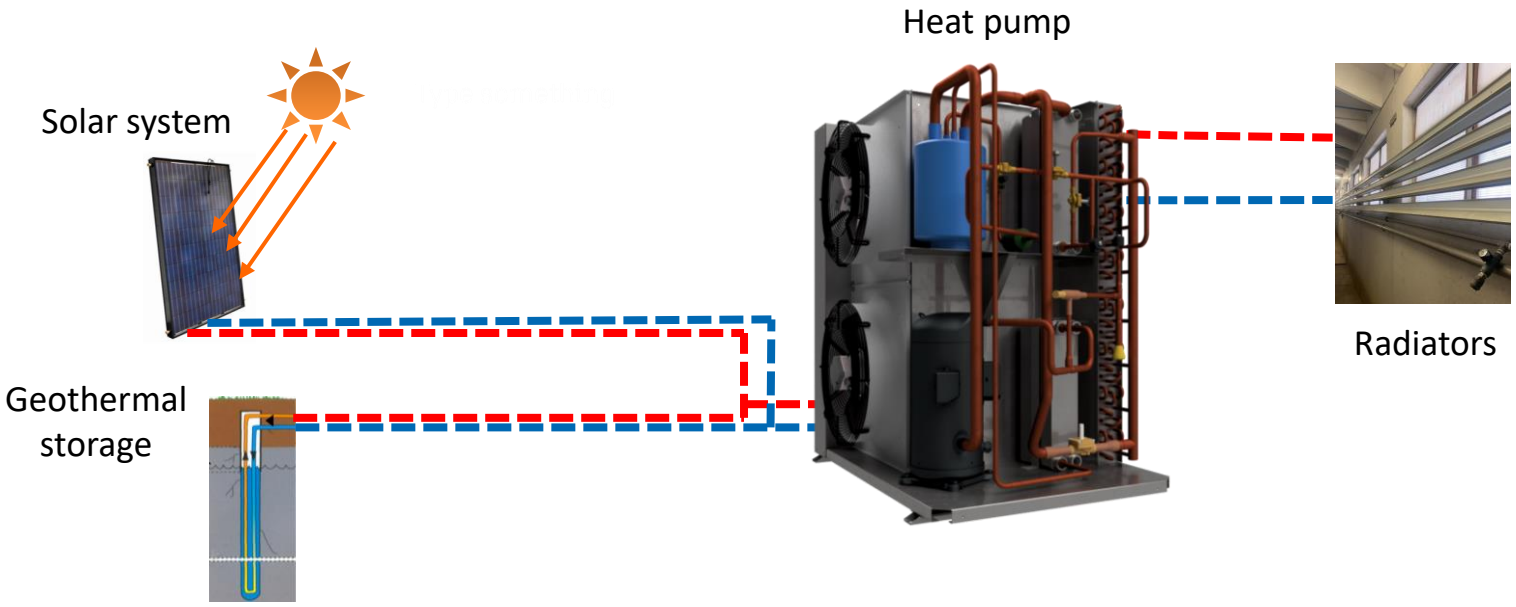
GOLINELLI
AZIENDA AGRICOLA

- Interventions in two (2) of the farm's buildings (nursery & hog barn)
- 2500 weaners in a 1,000 sq.m.
- 500 sows & a variable number of hogs



-Replacement of LPG boiler with a heat pump to cover thermal energy needs
- Increased heat pump COP utilizing PVTs and geothermal storage

- Heat pump
- Thermal photovoltaics
- Geothermal energy storage
- Smart control
- Energy efficiency measures

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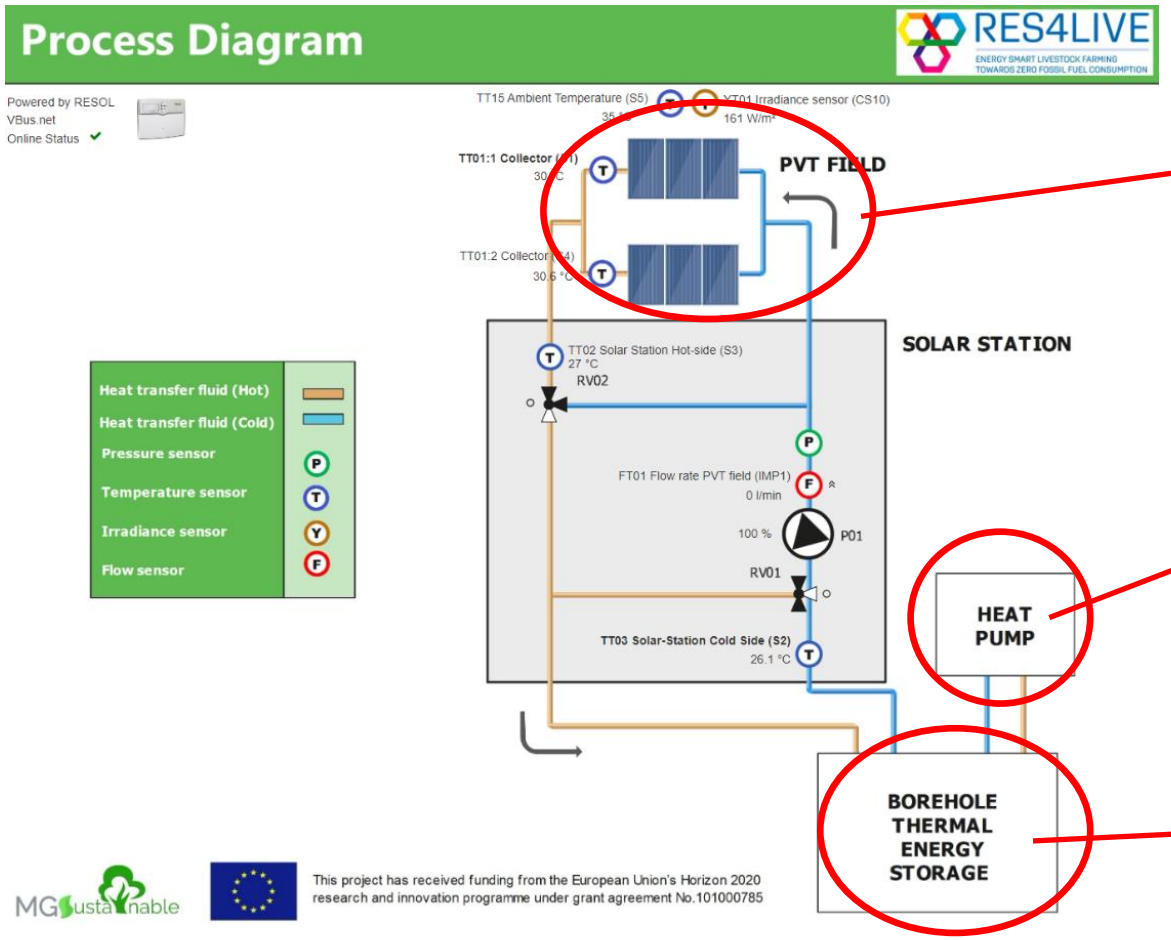
Commercial swine farm - Golinelli Farm (Italy)

- PVT/ BTES/ Heat pump integrated system



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Commercial swine farm - Golinelli Farm (Italy)

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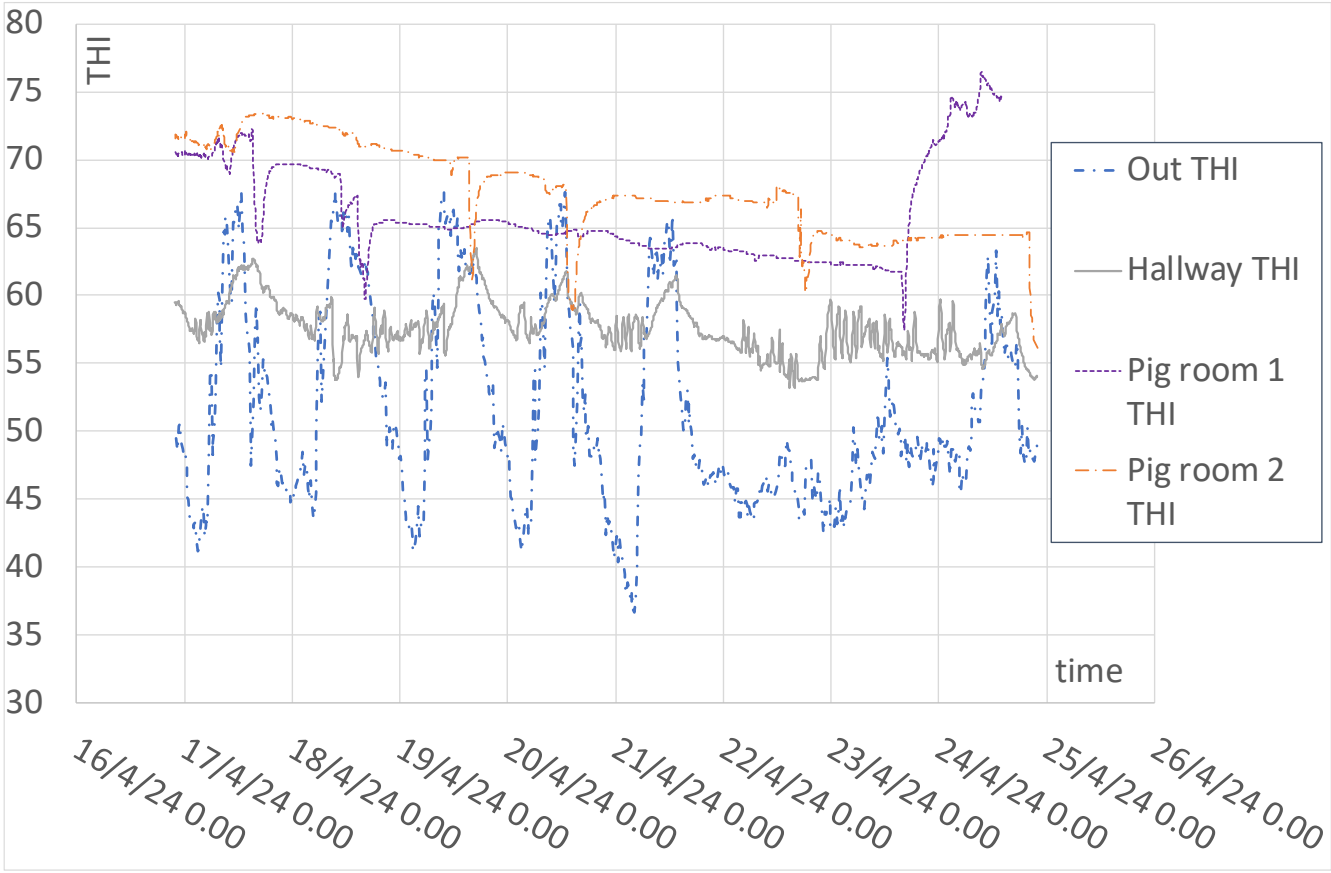
- PVT/ BTES/ Heat pump integrated system

THI measured in the monitored indoor spaces (substantially kept below the alert threshold of 75) and outside the barn



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Commercial swine farm - Golinelli Farm (Italy)

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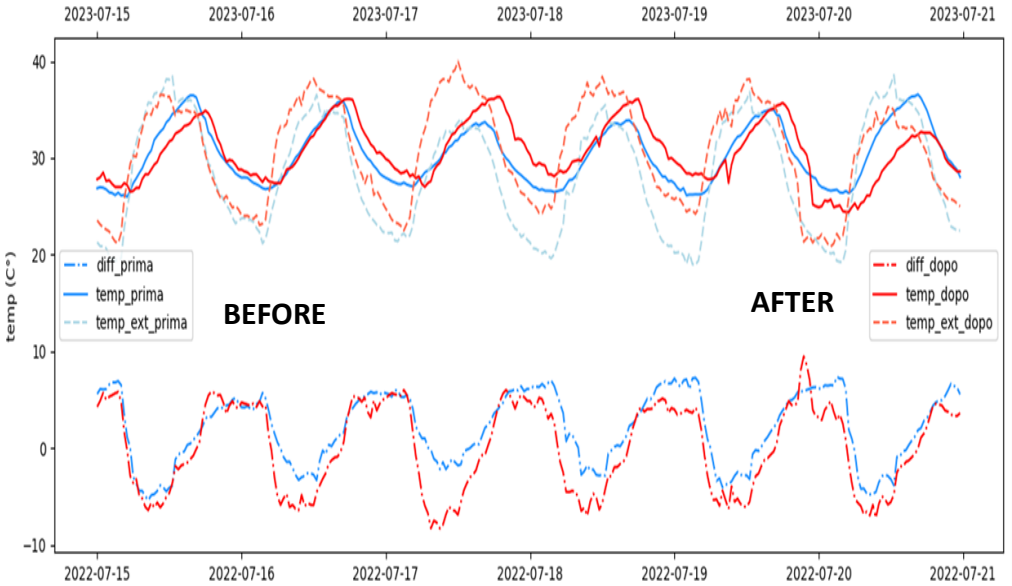
- Retrofitting of the hog barn



- Windows with frame in tubular stainless steel
- Transparent infill in 16mm thick double chamber alveolar polycarbonate
- Thermal transmittance of 2 W/m2K (≈ 1/3)
- 6 gearmotors with limit switch for the mechanical opening

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

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Experimental egg production poultry farm - Agricultural University of Athens (Greece)

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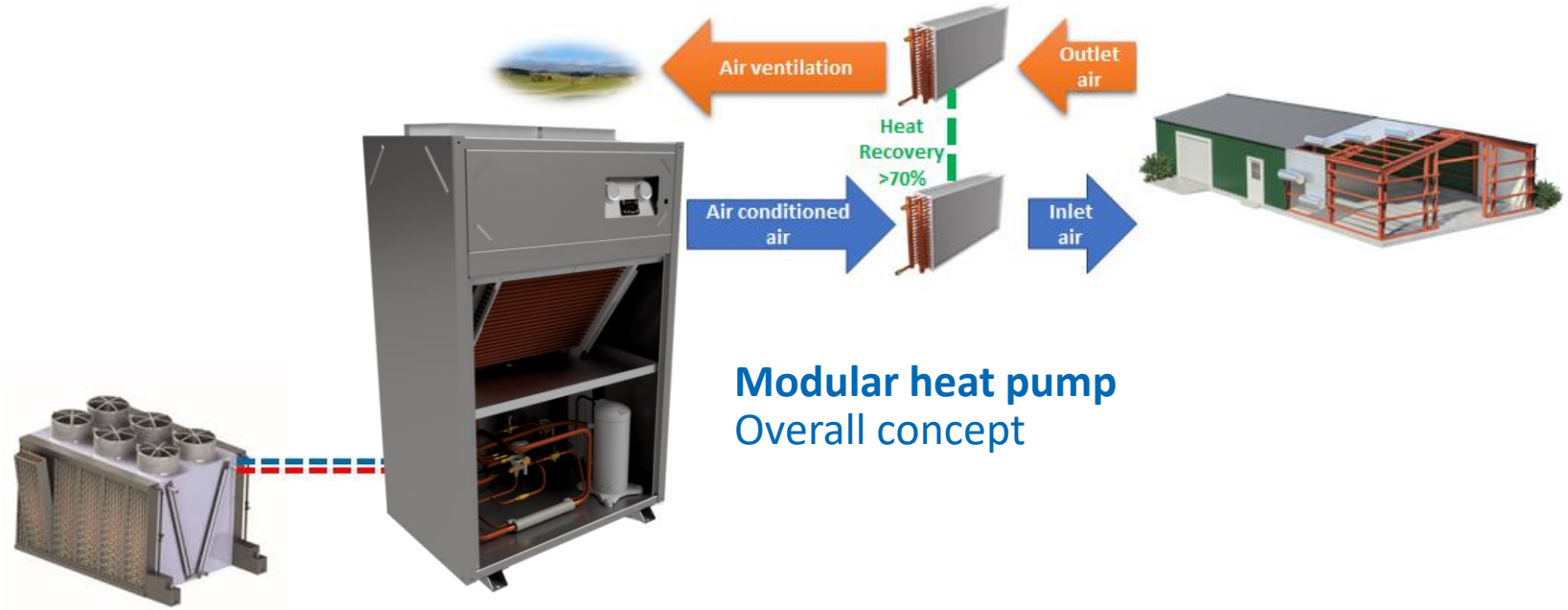
ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
AGRICULTURAL UNIVERSITY OF ATHENS

- Two space 90 sq.m. building - 450 pullets & 400 hens
- Forced ventilation for removing the thermal loads
- Thermal lambs



Modular heat pump
Overall concept

- Heat pump to regulate indoor space conditions
- Cover part of the total energy need from PV production

- Heat Pump
- Photovoltaics
- LEDs
- Smart control

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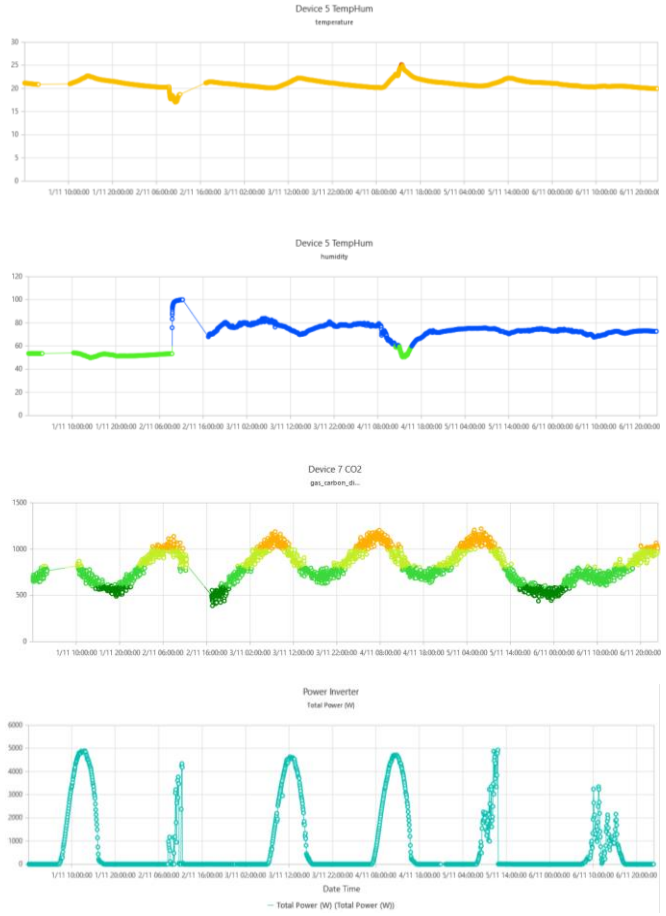
- Heat pump and PV system

Main systems installed at the AUA pilot farm and acquired data



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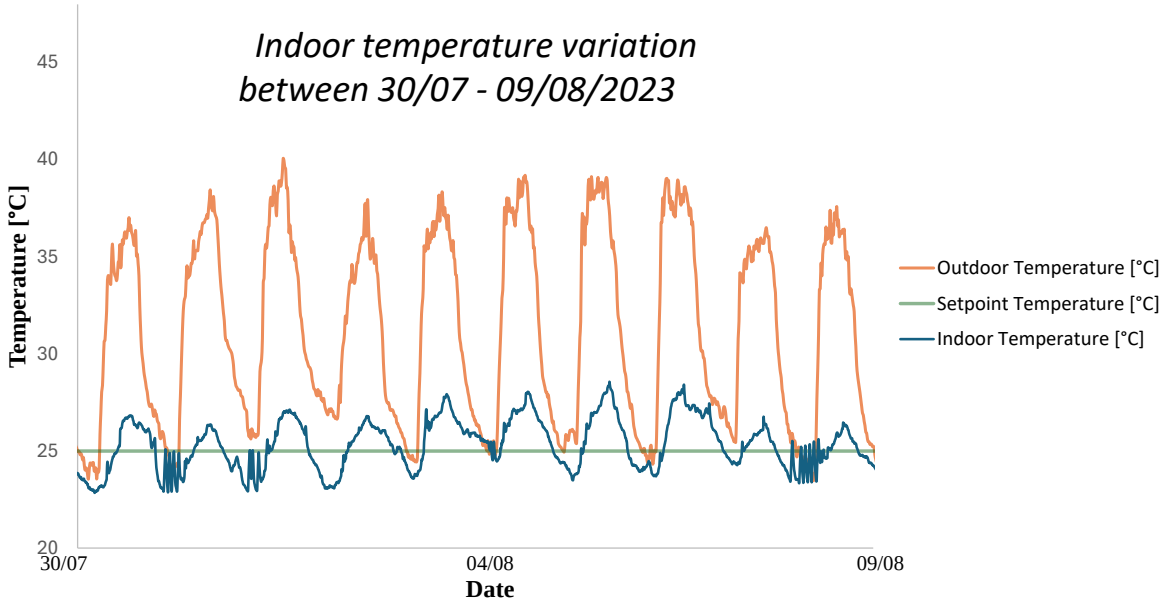

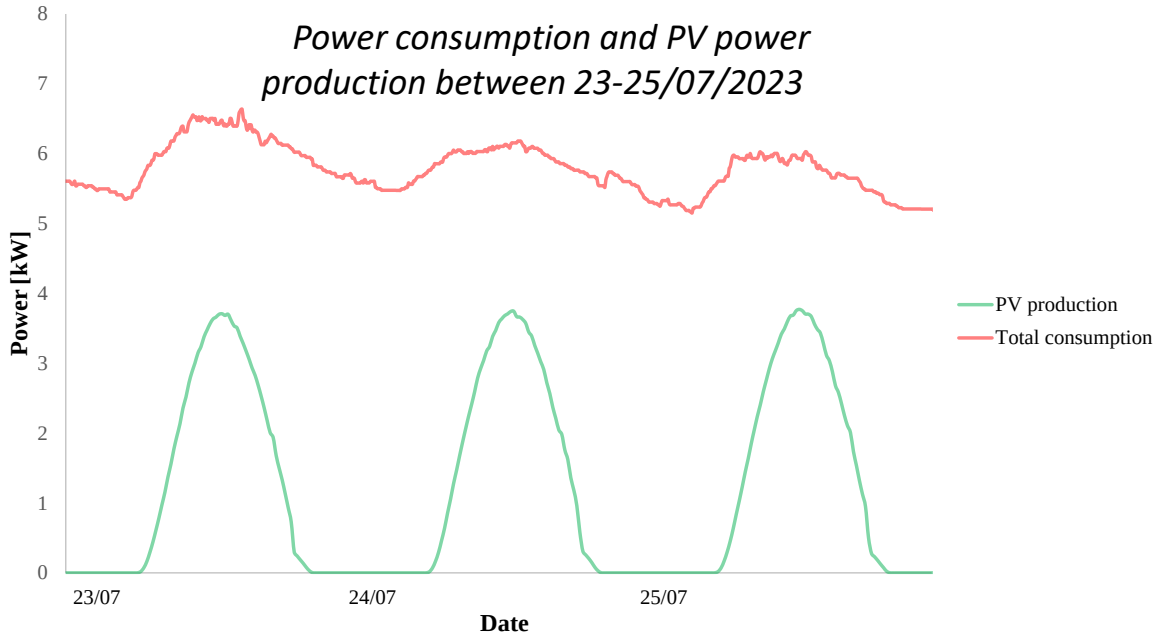

Energy consumption and PV production between summer and winter.

Period (mode)	Total electricity used (kWh)	Total electricity produced (kWh)	Self-Sufficiency (%)	Self-Consumption (%)
Summer (cooling)	4,031.23	908.50	22.54	99.70
Winter (heating)	2,389.51	482.71	20.20	85.60

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Experimental dairy cattle farm - LVAT (Germany)

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- Main barn: 2,240 sq.m. ~150 animals
- Welfare barn: 630 sq.m. ~70 animals
- Young cattle barn: 1,080 sq.m. – 130 animals

- Operational biogas CHP plant
- Milk cooling systems (heat recovery)

Utilization of produced biomethane and PVTs production to reduce energy consumption

- Biomethane upgrading unit
- Biomethane tractor
- Thermal photovoltaics
- Smart control
- Electric tractor

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Experimental dairy cattle farm - LVAT (Germany)

- Biogas to biomethane upgrading plant

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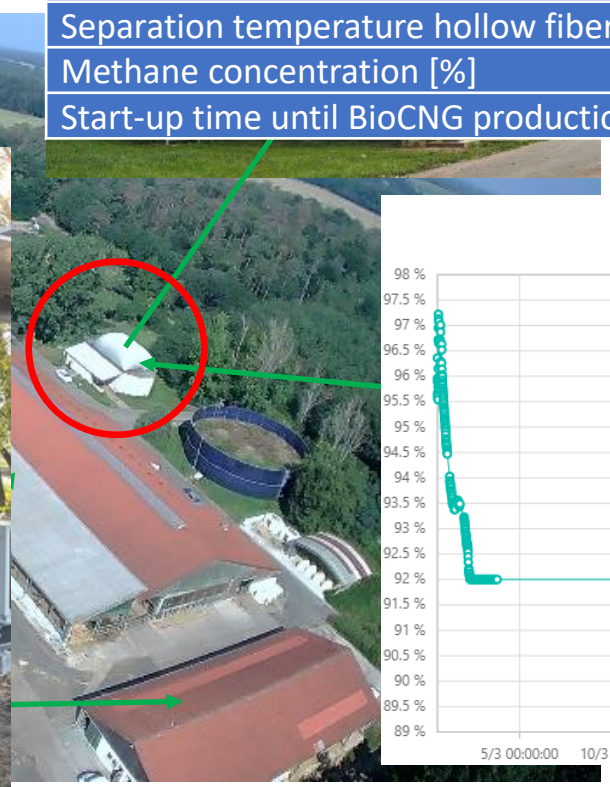
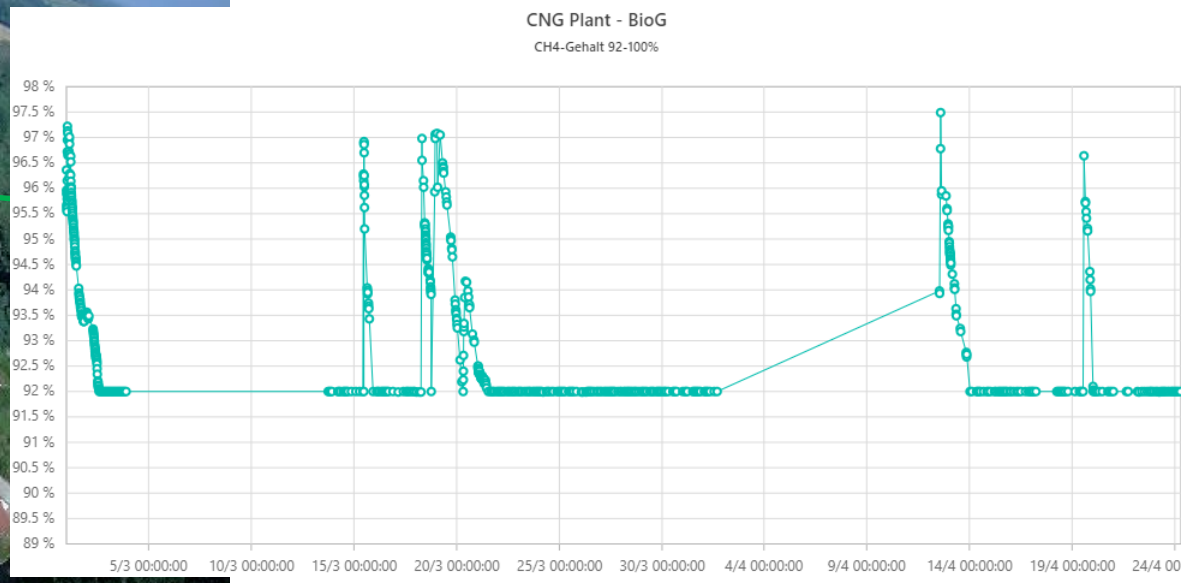
Main dairy cow barn:

- Integration of a PVT system with heat storage in the heat recovery system
- Implementation of energy meters

Performance indicator	Average
Specific energy consumption [kWh_{el} Nm^{-3} BioCNG]	0,94
Separation pressure hollow fiber membrane [bar]	7,83
Separation temperature hollow fiber membrane [°C]	57,44
Methane concentration [%]	96,75
Start-up time until BioCNG production [min]	26,78

BioCNG unit





Methane concentration

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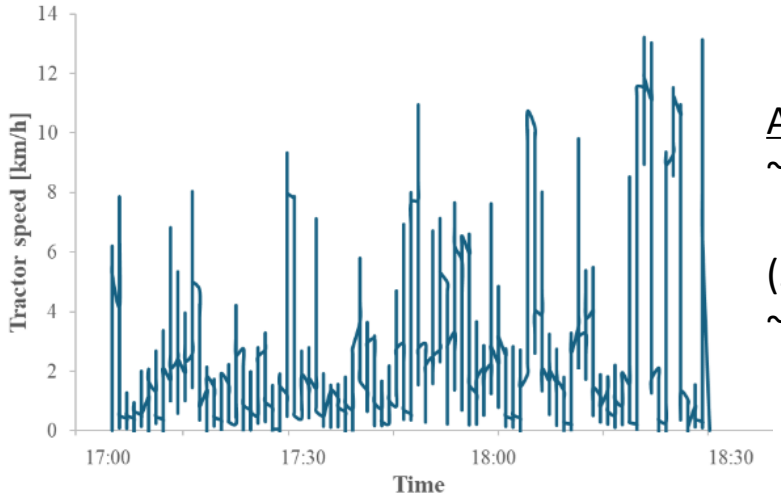
- Adapted tractor for biomethane use

The adapted tractor

Tractor speed during the first tests at LVAT premises



<u>Average fuel consumption</u>
~ 4.5 kg BioCNG/ hour

(5.75 kg BioCNG daily, for
~ 3.5 hours of operation)

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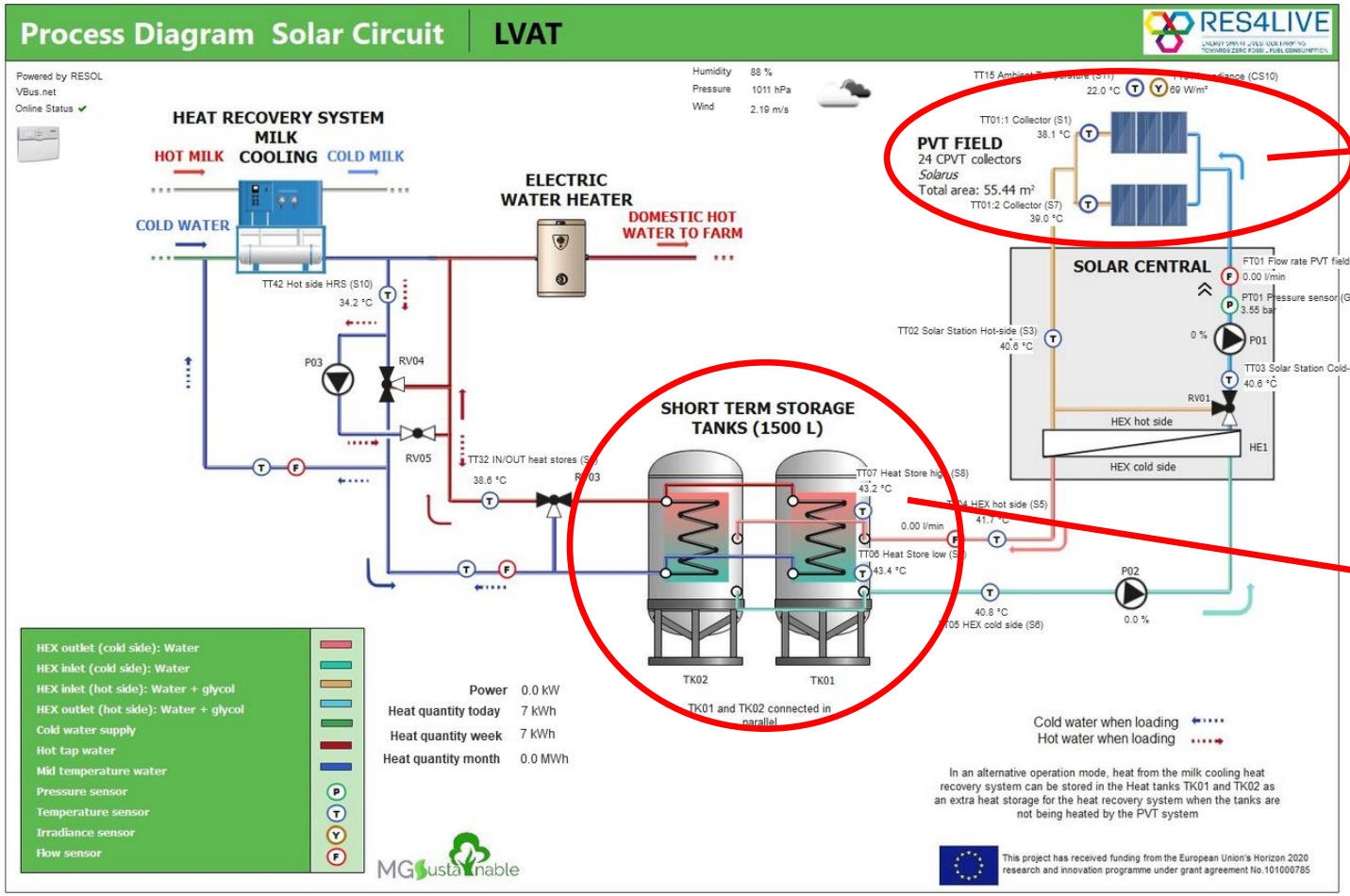
Experimental dairy cattle farm - LVAT (Germany)

- Integration of the heat storage tanks with the Heat Recovery System



PVT system

Short-term heat storage

Experimental dairy cattle farm - LVAT (Germany)

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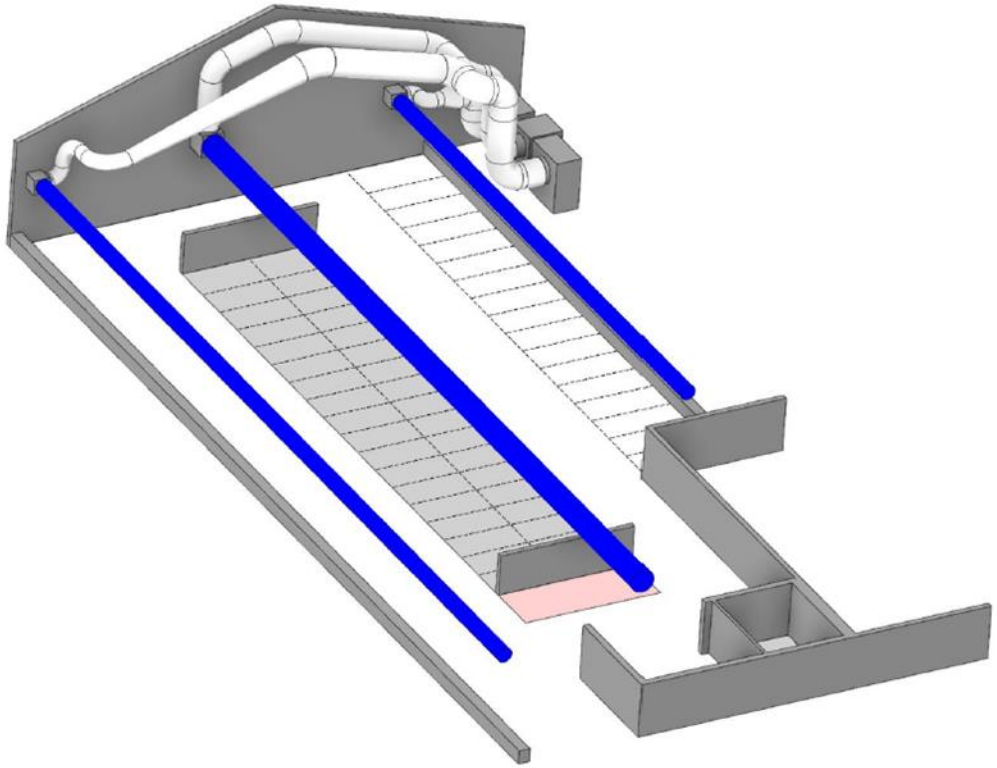
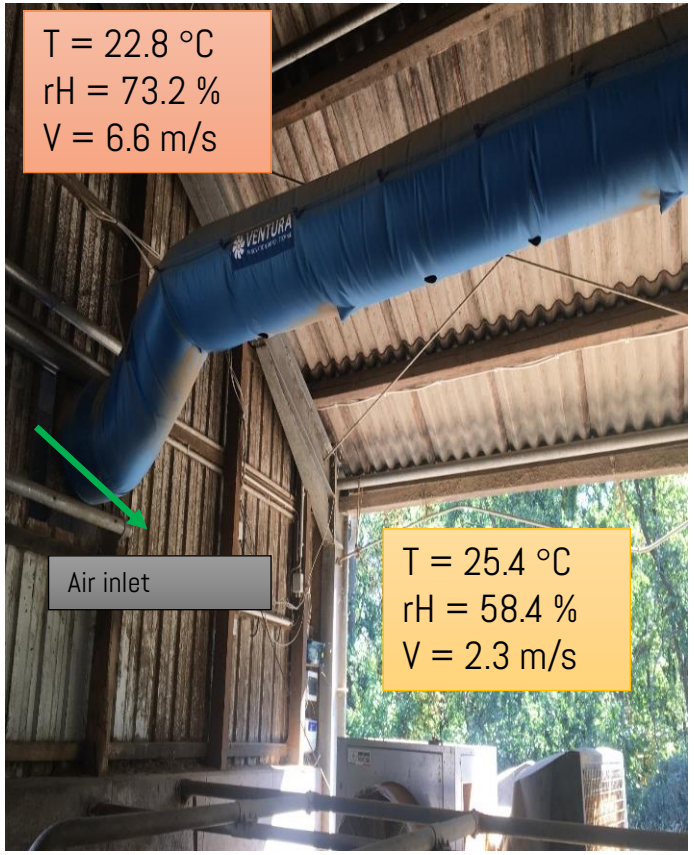
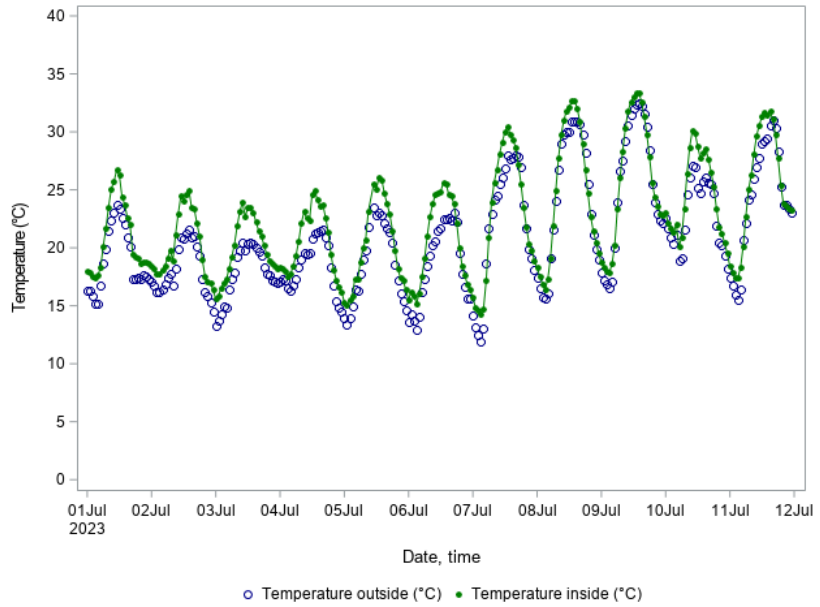
- New smart barn ventilation system



Integration of evaporative coolers (upper right corner) into the ventilation system (blue tubes) of the barn.





Temperatures inside and outside the welfare barn during July '23.

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Expected Impact

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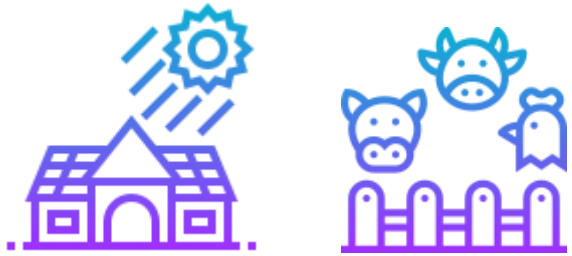
- **Advanced and cost-effective** technologies
- **Sustainability** of the farms' operation
- Superior **thermal comfort** of the animals



- **Increased productivity with minimum climate change impact**
- Creating **forefront knowledge** in the deployment of RES in livestock sector

- **Job growth & competitiveness** in the EU livestock industry
- Improving EU citizens' **quality of life**

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Thank you!

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RES4LIVE Project

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RES4LIVE HORIZON2020

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

RES4LIVE – Progress on Pilot Systems for Energy Smart Livestock Farming towards Zero Fossil Fuel Consumption

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Session 11: Fossil-free livestock farming
Tuesday, 2nd July 2024
Conference Auditorium