



RES4LIVE

ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

Il contributo degli allevamenti all'indipendenza energetica e alla decarbonizzazione

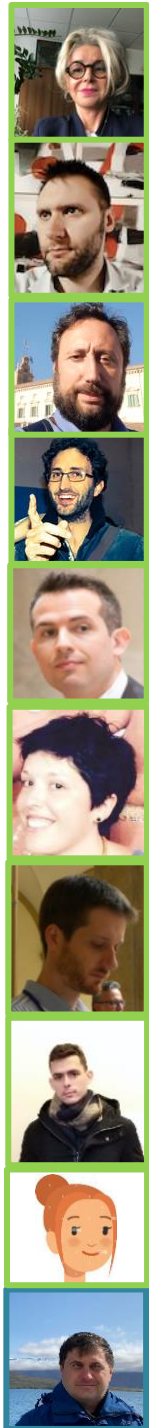
Incontro di co-progettazione fra stakeholder

Bologna, 9 Settembre 2024 ore 14.30-16.30

Palazzo della Cultura e dei Congressi - Piazza della Costituzione, 4/a



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



Patrizia Tassinari	Full Professor
Daniele Torreggiani	Full Professor
Stefano Benni	Associate Professor
Alberto Barbaresi	Assistant Professor
Marco Bovo	Assistant Professor
Enrica Santolini	Assistant Professor
Giovanni Pollicino	Technician
Carlos A. Perez Garcia	PhD Student
Claudia Giannone	PhD Student
Francesco Tinti (DICAM)	Assistant Professor

The Research Team

The **Structures and Environment group** of the **Agricultural and biosystems engineering sector (DISTAL)** focuses mainly on:

- **Design**, modelling and monitoring of **smart agri-food structures and systems** to improve **sustainability, traceability** and **safety** (greenhouses, animal housing, food processing, etc.)
- **Energy modelling** and **renewable energy** in **agrifood and livestock systems**
- Smart farming and **Precision livestock farming**
- **Machine learning** and **big data** in the **agri-food sector**
- **Planning of rural** areas and **nature based solutions**

Georesources and geothermal sector (DICAM):

- Development and use of geothermal energy
- Low enthalpy geothermal energy
- Thermal Response Test





RES4LIVE

ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

Project Overview



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

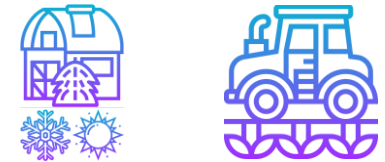
Project Overview – Introduction



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



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



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



www.res4live.eu

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



Project Overview – Introduction

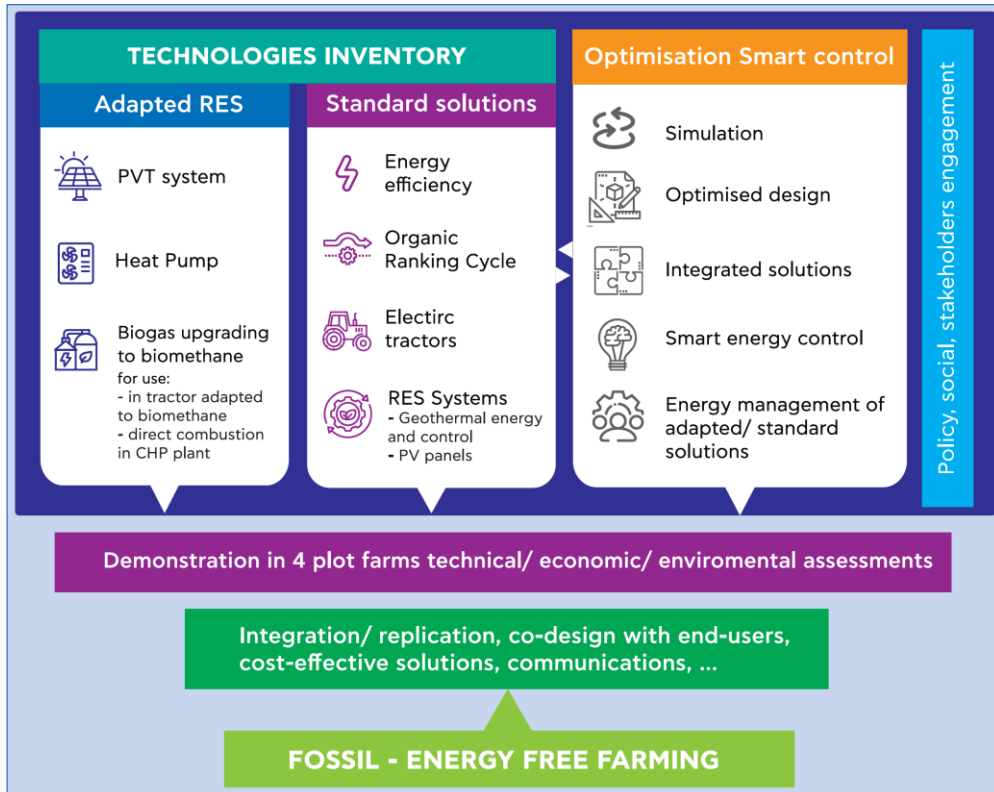


ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
AGRICULTURAL UNIVERSITY OF ATHENS



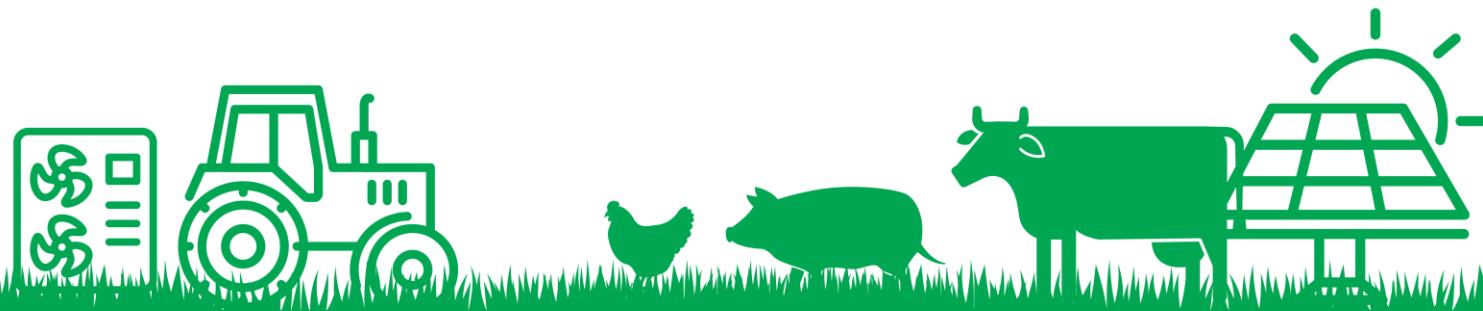
RES4LIVE

ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION



- **100% replacement of fossil energy in intensive livestock farming sector** utilizing Renewable Energy Sources (RES)
- **A combination of technologies and solutions** will be installed and evaluated in 4 livestock farms

Market integrated, cost-effective & case-sensitive RES solutions towards fossil-free livestock farming

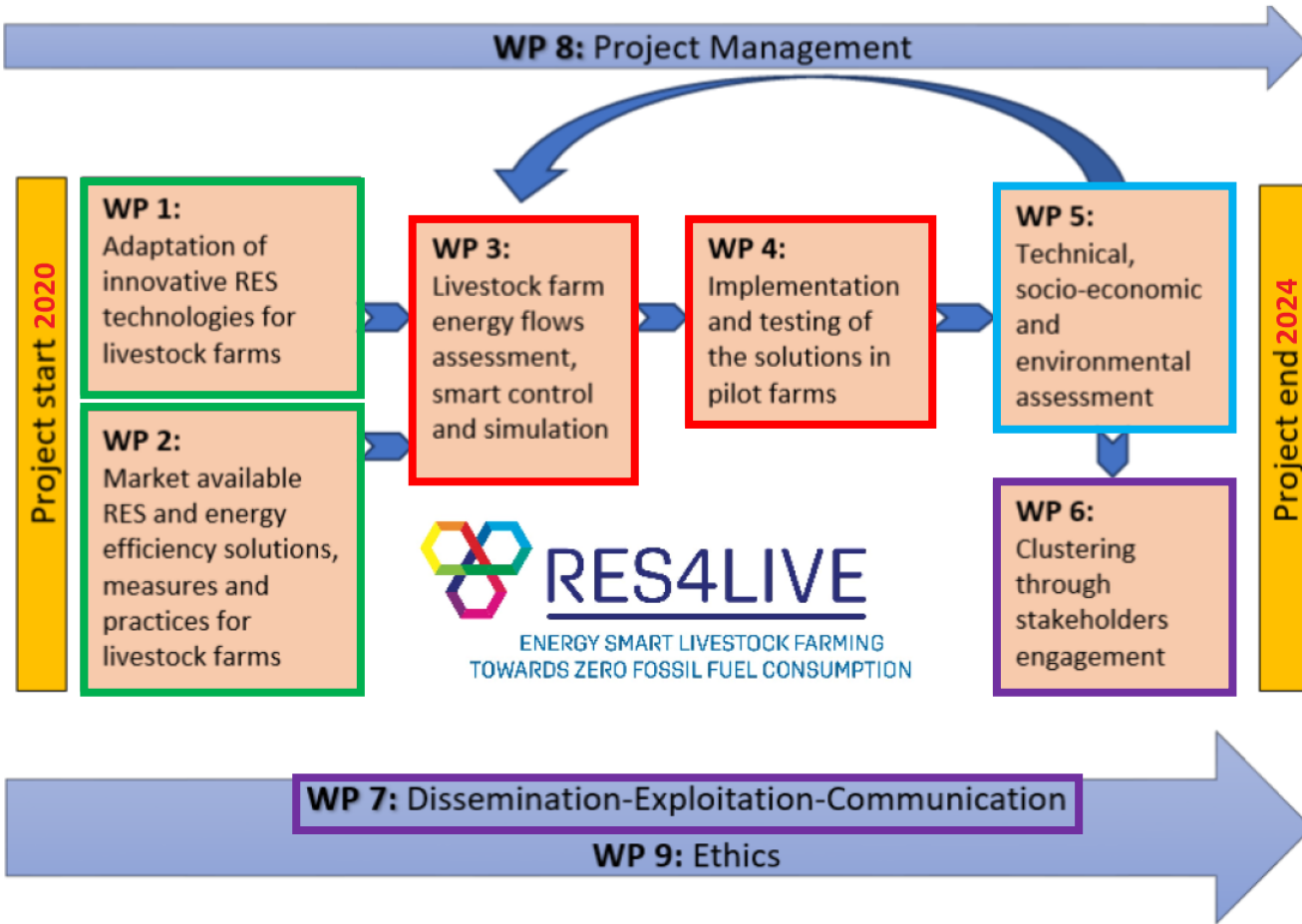


www.res4live.eu

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



Project Overview – Next steps



WP1 & WP2 – Completed

WP3 – Completed (TBD)

WP4 – Testing and monitoring of solutions

WP5 – Continue with LCA/ LCC models
Focus on Technical assessment
Fill out social assessment questionnaires

WP6 – Policy recommendations
Complete Workshops
Case studies and Best practices

WP7 – Cluster expansion, PAs
Exploitation, Innovation management



ILVO pig farm (9090 MELLE)



Farrow – to – finish farm

- 105 sows, 600 piglets, 750 fattening pigs

Current:

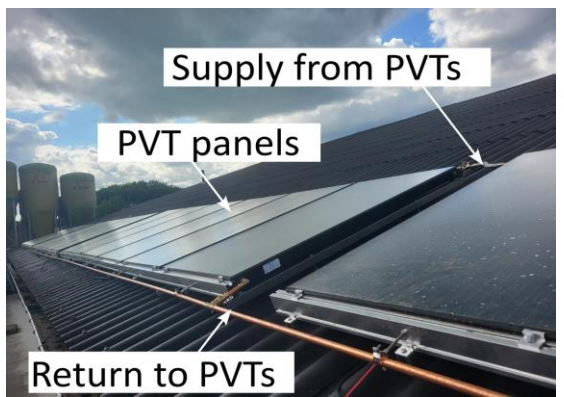
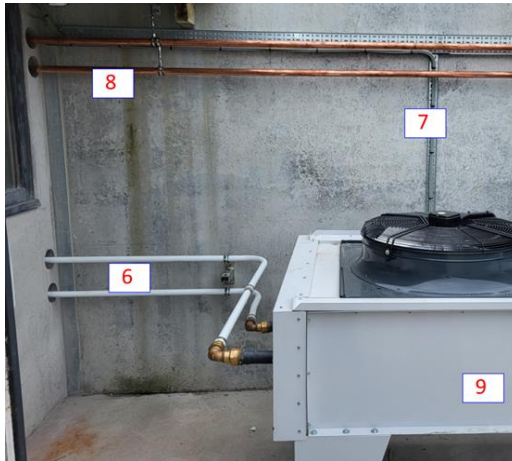
- 60kW gas heater with gas consumption ~220MWh/year
- No cooling system
- Hotraco mechanical ventilation system controlled via temperature (together with heating)
- Gas cannon

RES4LIVE:

- Smart energy & ventilation control (1 comp.)
- 2 modular heat pumps of each 30kW or 1 cascade HP
- PVT collectors for cold side of heat pump



Renewable energy sources installed at the pig farm



27/06/2024



www.res4live.eu

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



Monitoring & performance evaluation hybrid solar system

Heat transfer fluid (HTF) = 35 % glycol + 65 % water mixture

$$Q_{th} = \dot{m} \rho c_p \Delta T$$

Q_{th} = Heat gain from the PVT [W]

\dot{m} = mass flow rate (1 or 2) $\left[\frac{kg}{s} \right]$

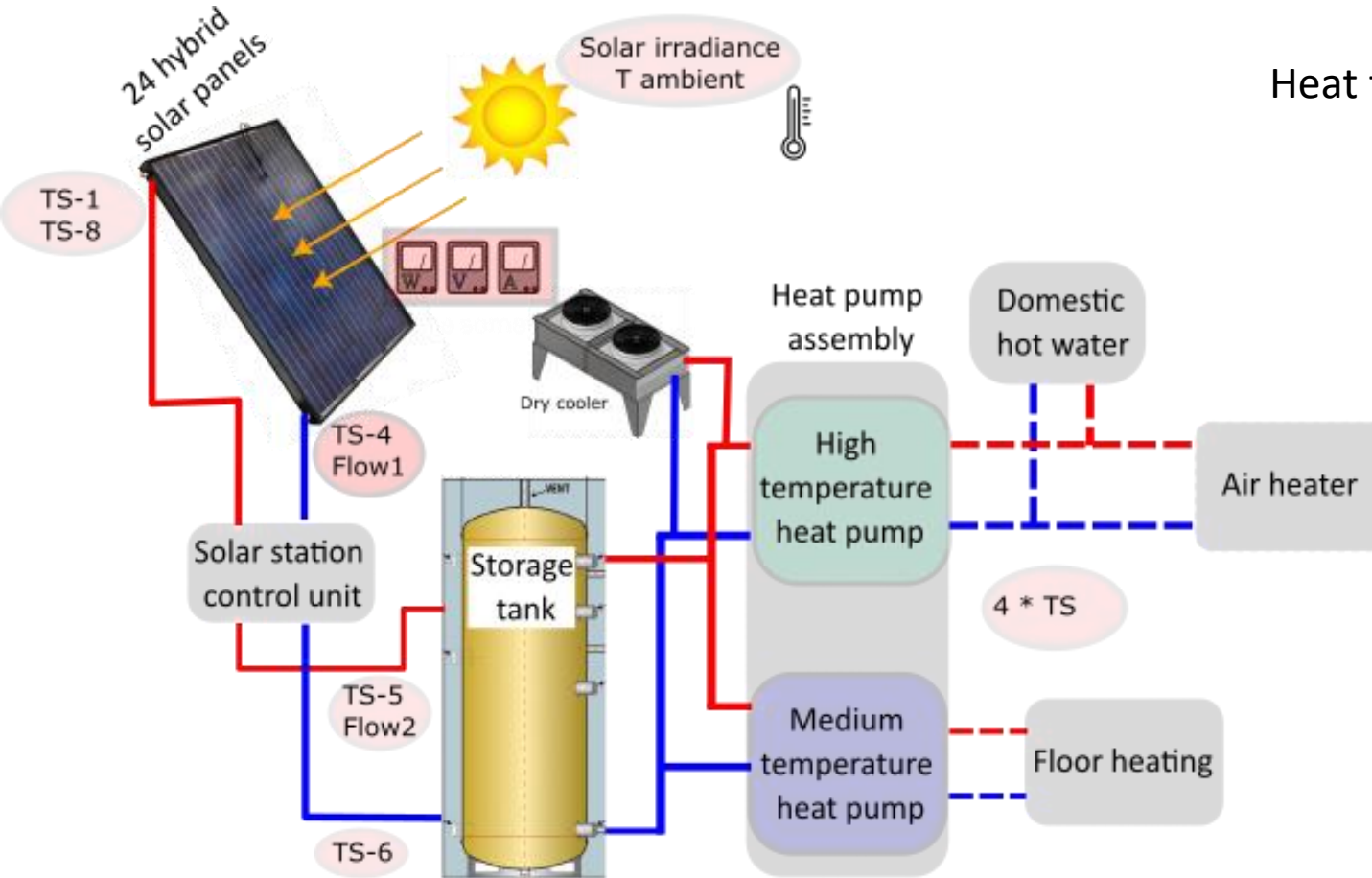
ρ = density HTF $\left[\frac{kg}{m^3} \right]$

c_p = specific heat capacity HTF $\left[\frac{J}{kgK} \right]$

ΔT = temperature difference [K]

$$\Delta T_1 = \left[\frac{TS1 + TS8}{2} - TS4 \right]$$

$$\Delta T_2 = [TS5 - TS6]$$

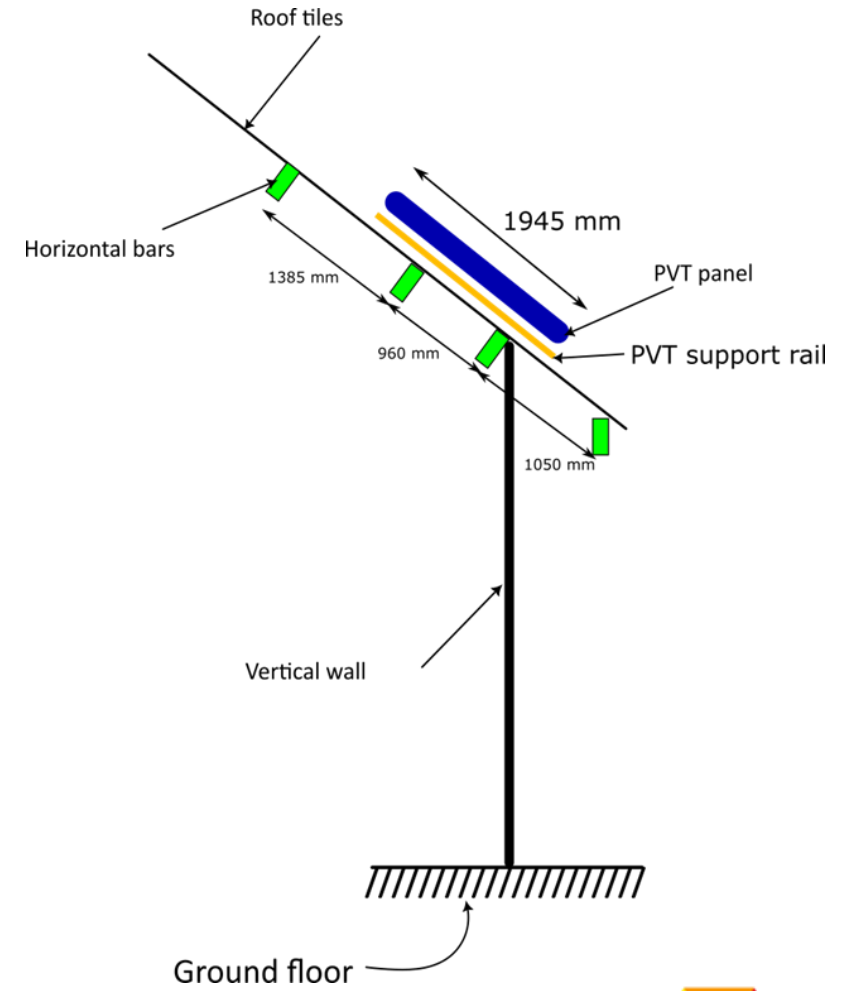
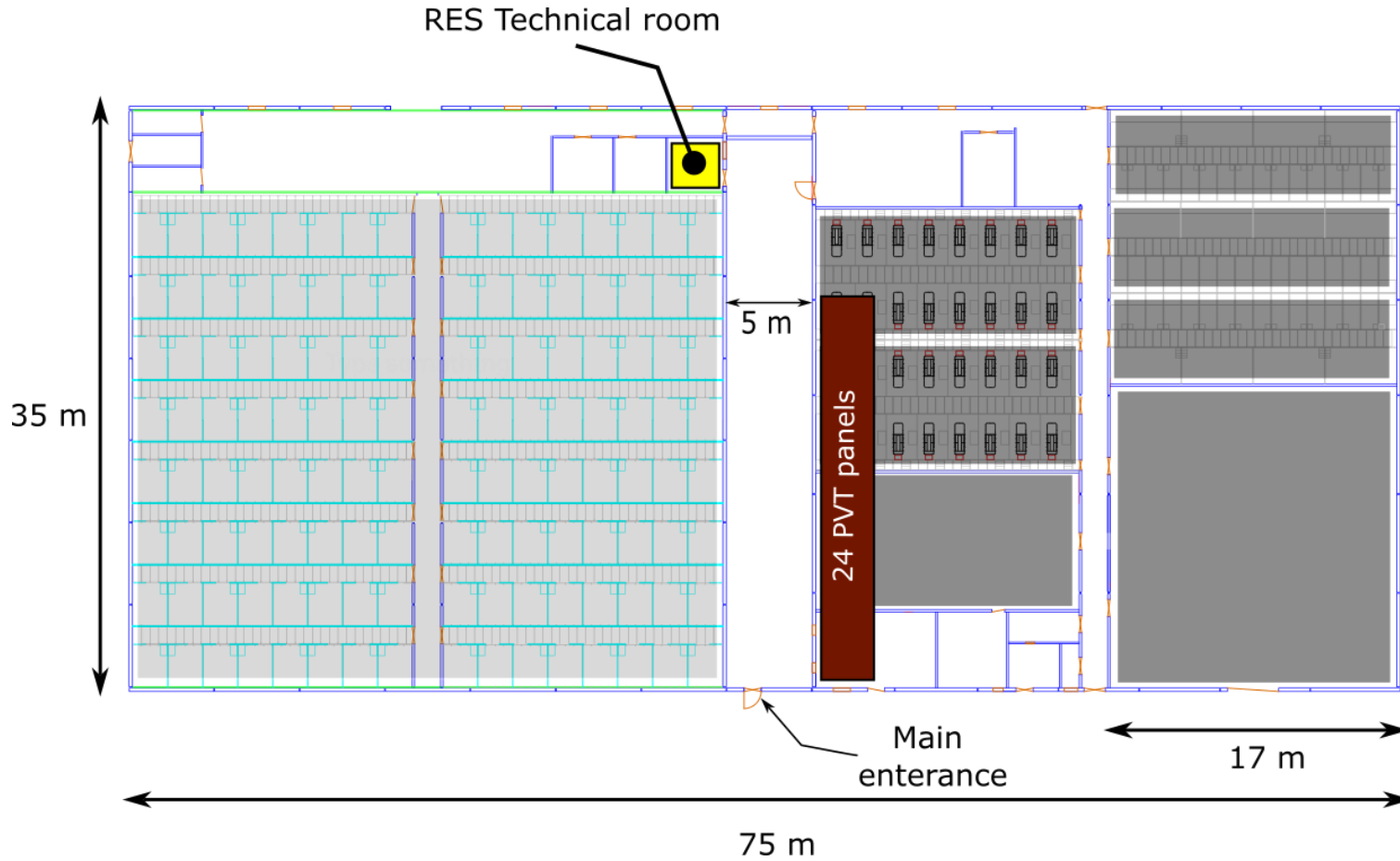


Test runs: Heat pump

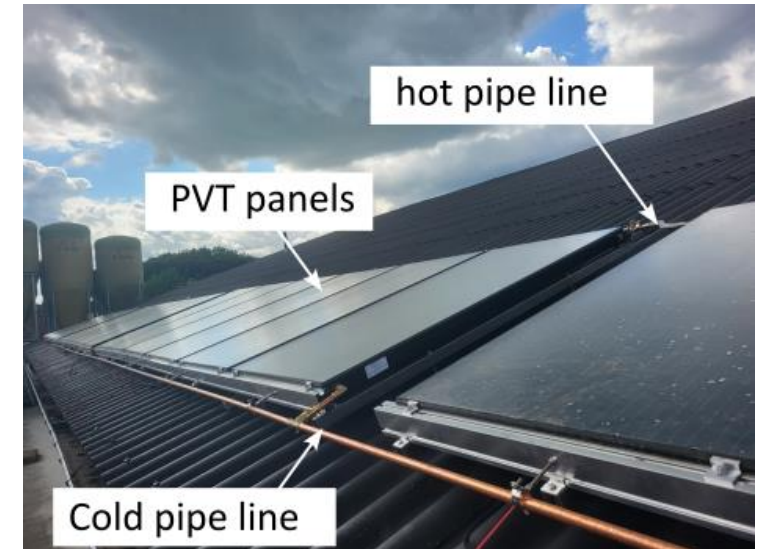
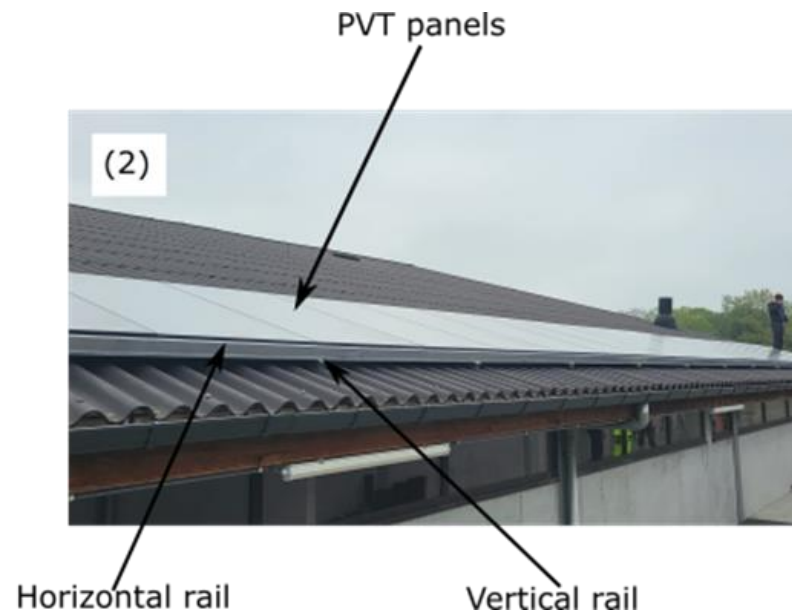
- **Many short runs (for 7 hours max)**
- **Long runs**
 - 28/11/2023 to 01/12/2023 (defrost)
 - 29/01/2024 to 07/02/2024 (fuse + relay)
 - 07/03/2024 to 19/03/2024 (Noise)
 - 07/05/2024 to present (OK)



PVT panels at ILVO

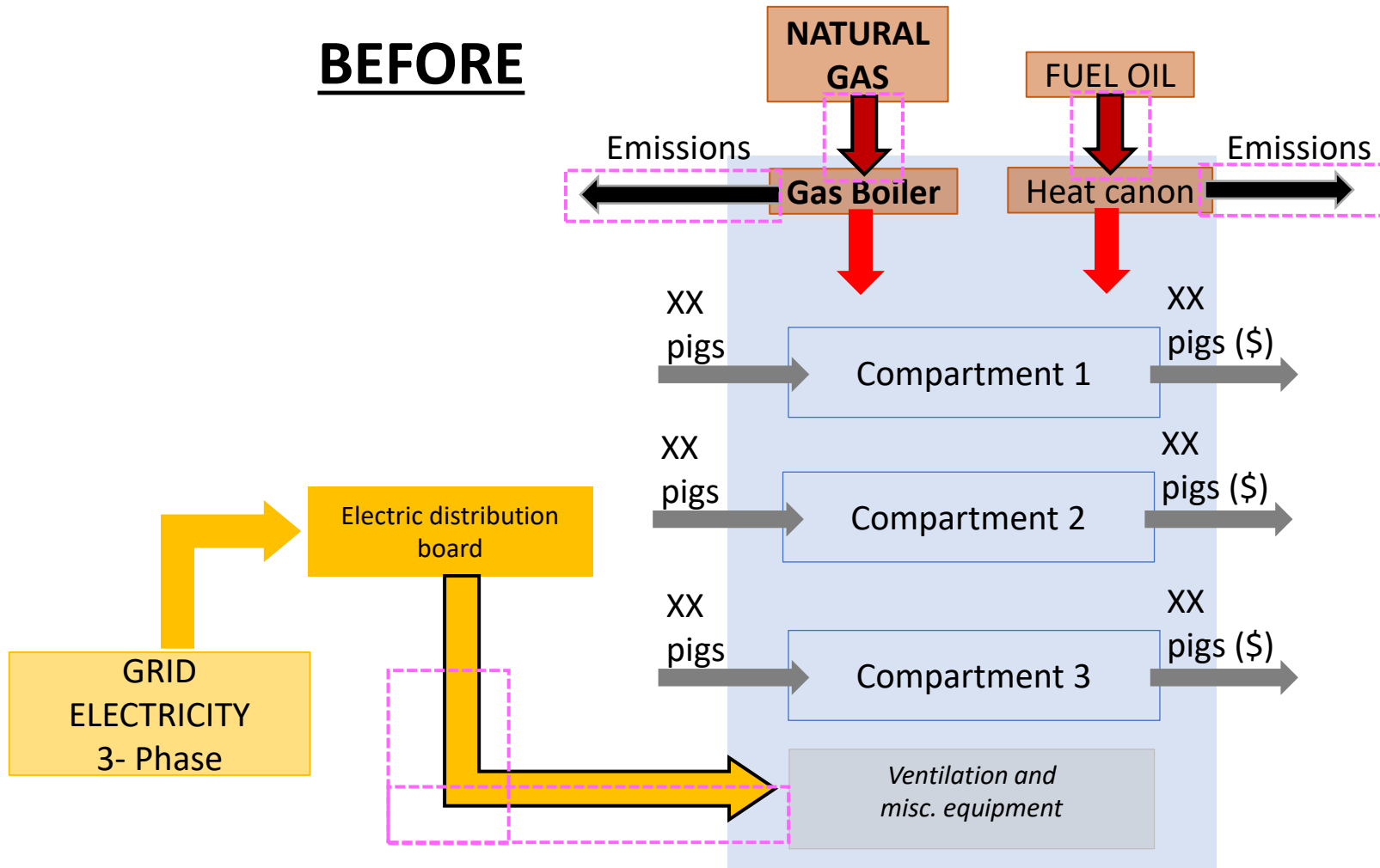


PVT panels at ILVO



3. EV ILVO // Swine – Belgium (1)

BEFORE

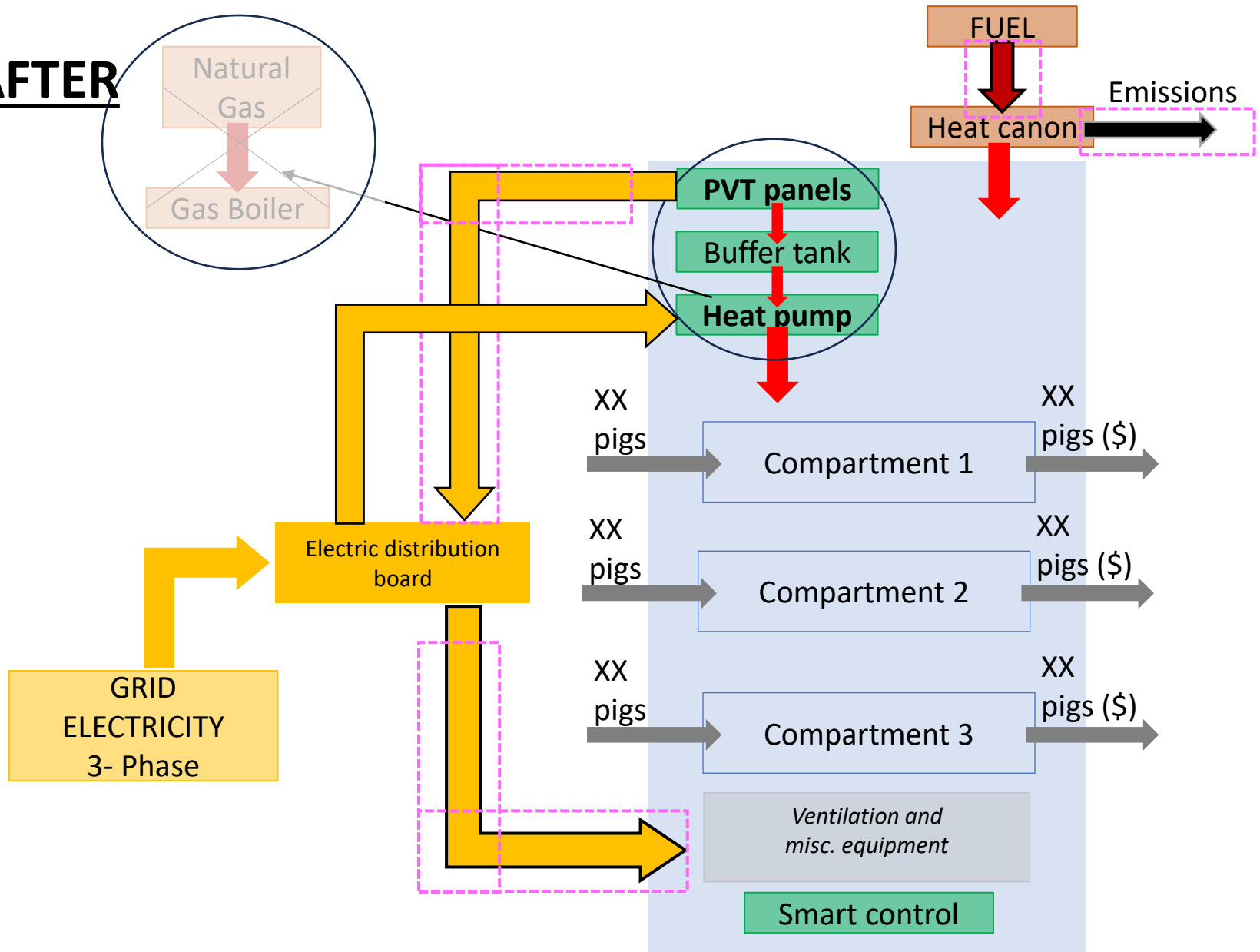


Legend

- 1. System boundaries
- 2. New (RES) system
- 3. Existing equipment (or a part of it)
- 4. Product flow
- 5. Electrical energy flow
- 6. Thermal energy
- 7. Electrical energy flow of interest (consumed or produced by our systems)
- 8. Fuel flow
- 9. On-farm emissions
- 10. Fuel, energy, or emission flow to be calculated or measured

3. EV ILVO // Swine – Belgium (2)

AFTER



Legend

1. System boundaries
2. New (RES) system
3. Existing equipment (or a part of it)
4. Product flow
5. Electrical energy flow
6. Thermal energy
7. Electrical energy flow of interest (consumed or produced by our systems)
8. Fuel flow
9. On-farm emissions
10. Fuel, energy, or emission flow to be calculated or measured

LVAT Dairy Farm, Germany



www.res4live.eu

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



LVAT Dairy Farm, Germany

Overview of interventions on the farm

Main dairy cow barn:

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



Biogas plant:

- Implementation of gas composition sensors
- Novel farm-scale CNG filling station
- Operation of a CNG-fueled tractor



Welfare dairy cow barn:

- Installation of a tube ventilation system with smart climate control
- Fusion of sensor data from animal-specific and environmental traits to predict heat stress

www.res4live.eu

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



LVAT Dairy Farm, Germany

CNG conversion plant, filling station and CNG tractor

- **Activities and outcome**

- Both the CNG conversion plant with filling station and the tractor retrofitted for CNG usage have been established on the LVAT farm and work as intended
- Data monitoring is ongoing

- **Challenges and deviations**

- Final position of the CNG conversion plant in the farm had to be changed to have more distance to the biogas plant
- Process of approval by local authorities took longer than expected

- **Next steps**

- Address items missing for final approval (fire safety)
- Continue monitoring and optimizing BioCNG production
- Measure BioCNG consumption for different tasks with the CNG tractor



Ongoing matters with the CNG plant (1)

- **First key figure from data:**
 - ca. 1 kWh electricity consumption per Nm³/h Bio-CNG for gas separation and compression to 240 bar
 - (corresponds to ~ 9-10% individual energy requirement)
- **This performance value (kWh) is tried to be optimized in the demonstration period**



*BioG exhibiting the second pilot plant (35 m³)
at the Karpfham trade fair*

LVAT Dairy Farm, Germany

PVT System

- **Activities and outcome**
 - The PVT system was installed and connected to the LVAT farm by MG
- **Challenges and deviations**
 - No deviations
 - It was difficult to find local craftsmen to assist in the installation of the PVT system, which delayed the installation process
- **Next steps**
 - Connecting the power line to the farm grid
 - Continue monitoring the production of electrical power and warm water



www.res4live.eu

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



LVAT Dairy Farm, Germany

Finished installation of the PVT system (LVAT)



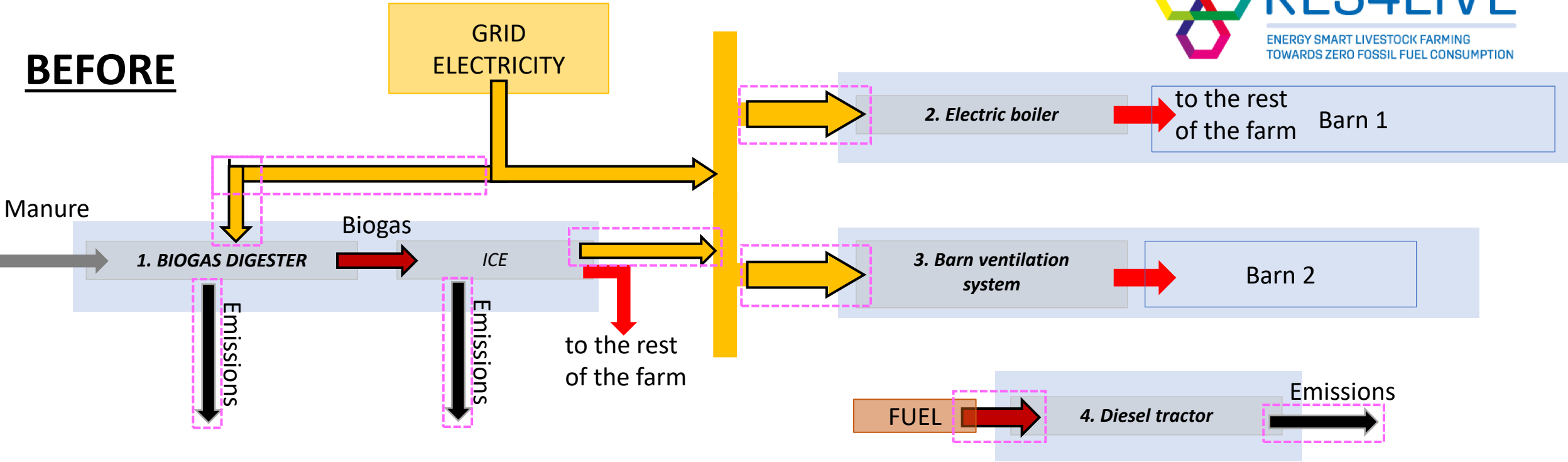
www.res4live.eu

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



4. LVAT // Dairy cows – Germany (1)

BEFORE



Legend

1. System boundaries

2. New (RES) system

3. Existing equipment (or a part of it)

4. Product flow

5. Electrical energy flow

6. Thermal energy

7. Electrical energy flow of interest (consumed or produced by our systems)

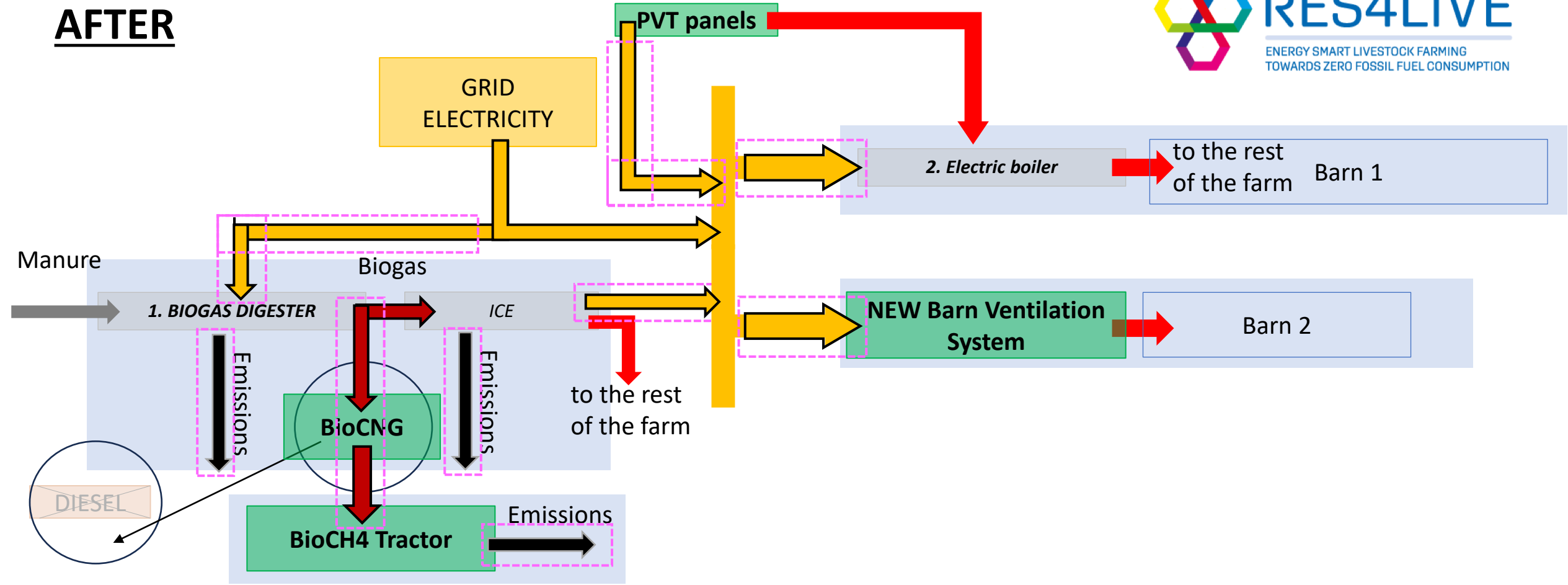
8. Fuel flow

9. On-farm emissions

10. Fuel, energy, or emission flow to be calculated or measured

4. LVAT // Dairy cows – Germany (2)

AFTER



Legend

- 1. System boundaries
- 2. New (RES) system
- 3. Existing equipment (or a part of it)
- 4. Product flow
- 5. Electrical energy flow
- 6. Thermal energy
- 7. Electrical energy flow of interest (consumed or produced by our systems)
- 8. Fuel flow
- 9. On-farm emissions
- 10. Fuel, energy, or emission flow to be calculated or measured



RES4LIVE

ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

WP4: AUA pilot farm



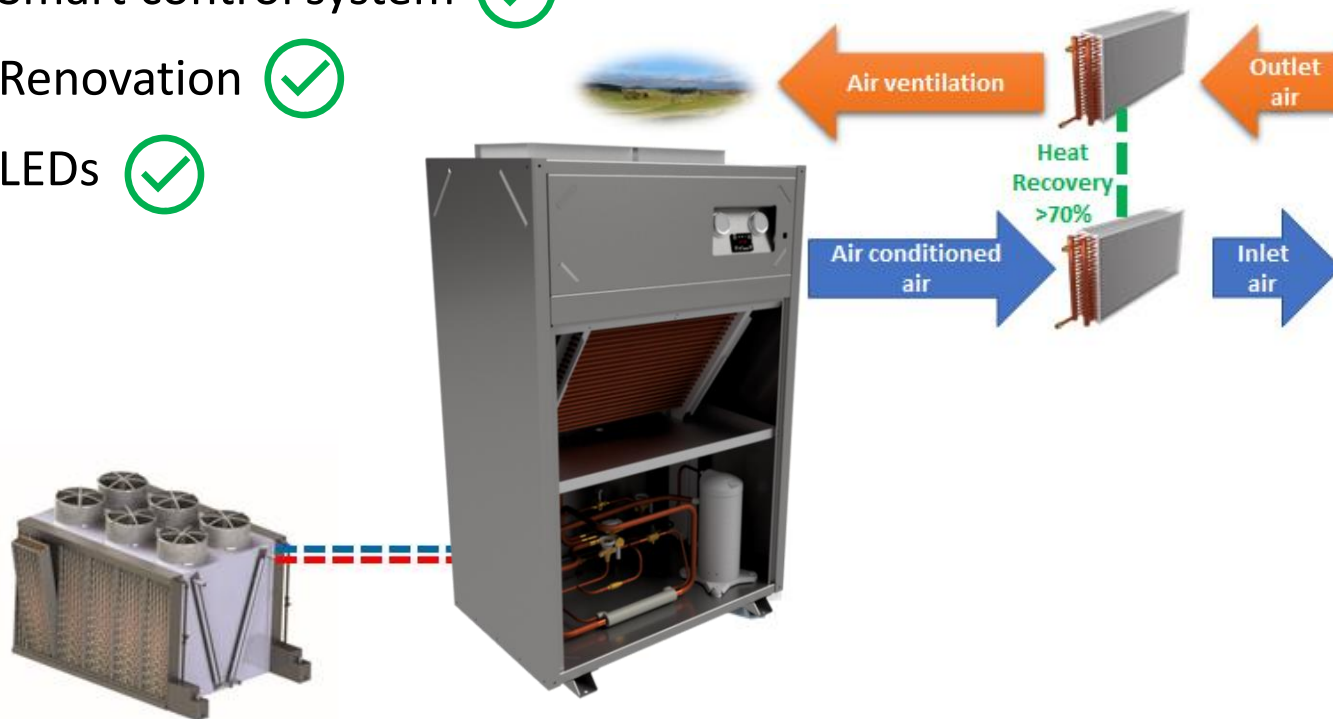
ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
AGRICULTURAL UNIVERSITY OF ATHENS



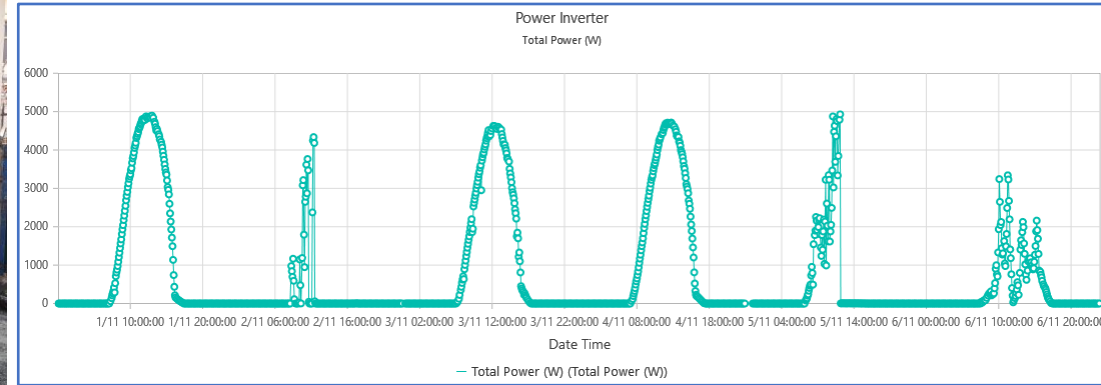
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.101000785

Progress in AUA's Poultry House

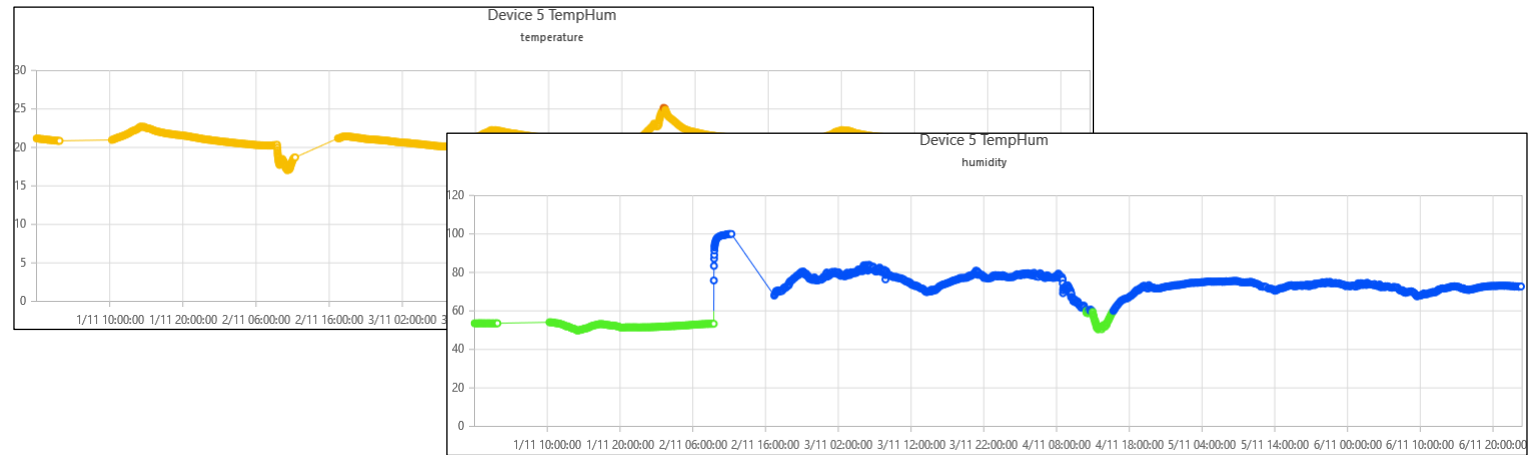
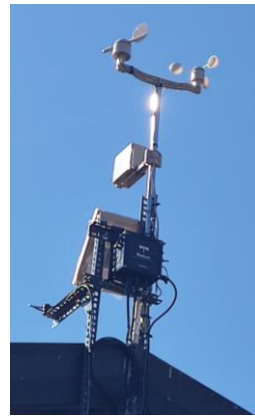
- Photovoltaics ✓
- Heat pump ✓
- Smart control system ✓
- Renovation ✓
- LEDs ✓



Photovoltaics



Smart Control



28/26/2023



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



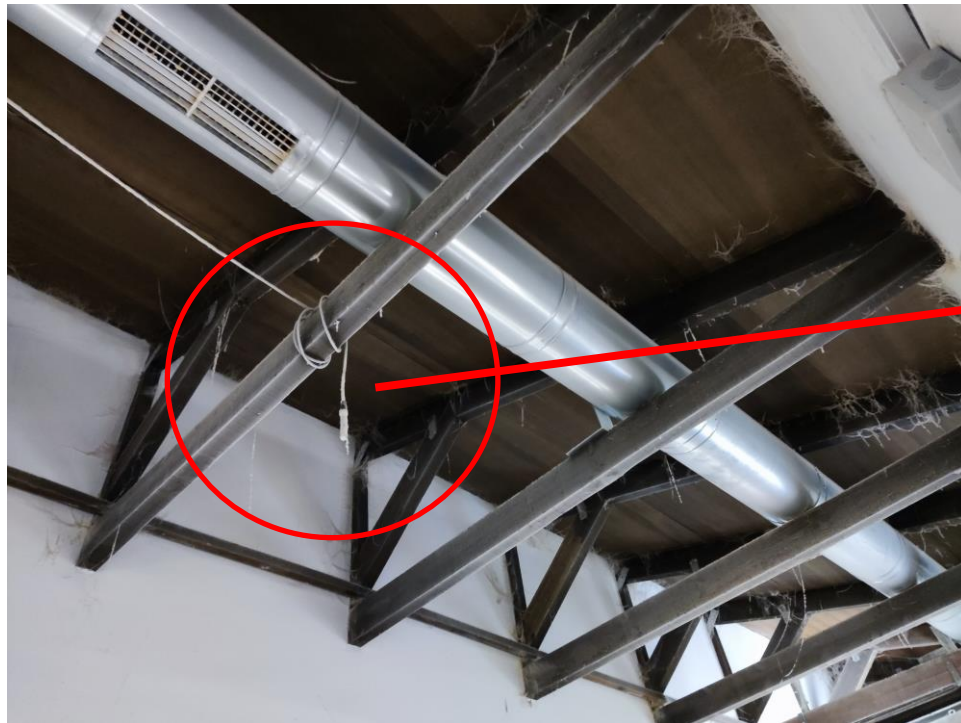
Heat Pump and Ventilation



Heat Pump and Ventilation

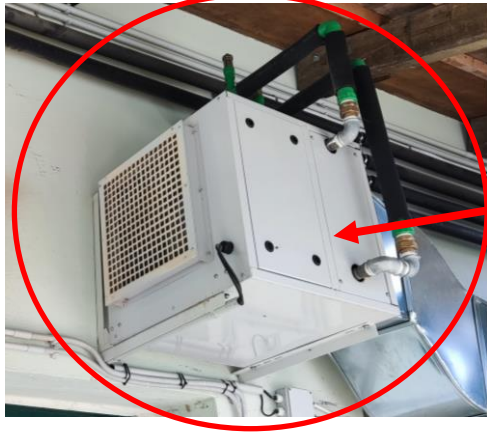
Setback

- More dust that initially expected due to minimum ACH approach



Heat Pump and Ventilation

Additional centrifugal fan in series



Heat Pump and Ventilation

Additional centrifugal fan in series



Heat Pump and Ventilation

New axial fan



Pullets
(West)



Heat Pump and Ventilation

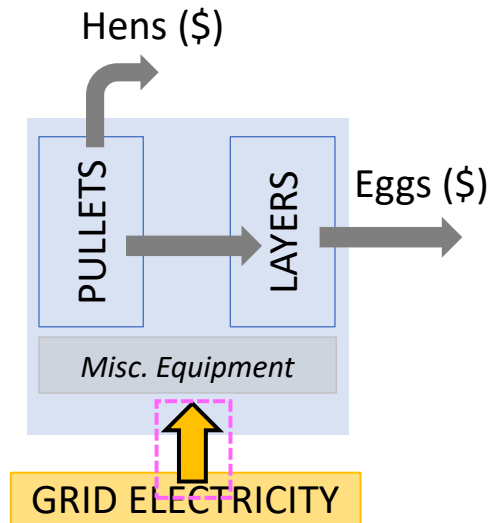
New axial fan

Munters EM36

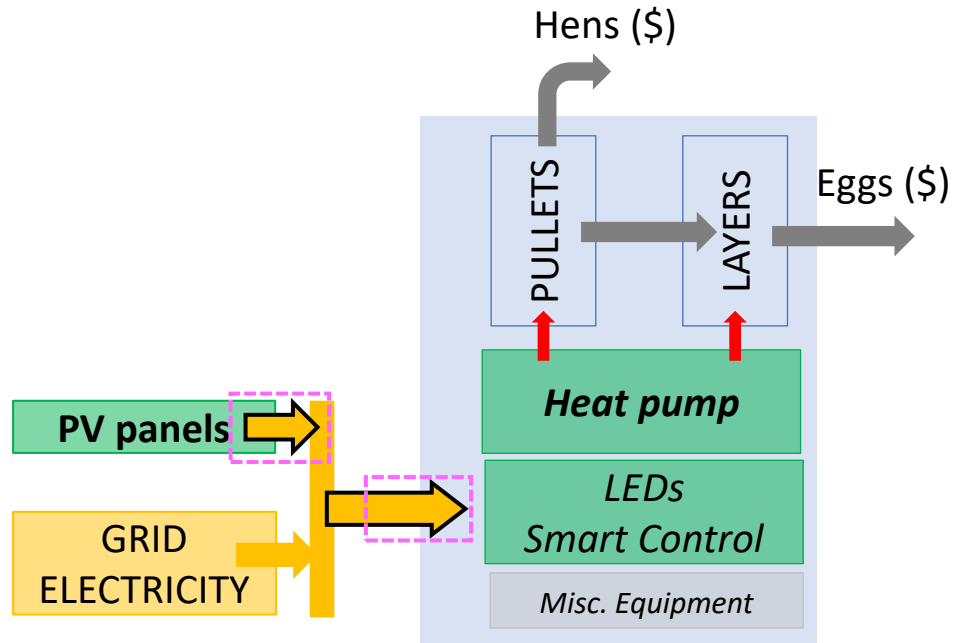


1. AUA // Laying hens – Greece

BEFORE



AFTER



Legend

1. System boundaries
2. New (RES) system
3. Existing equipment (or a part of it)
4. Product flow
5. Electrical energy flow
6. Thermal energy
7. Electrical energy flow of interest (consumed or produced by our systems)
8. Fuel flow
9. On-farm emissions
10. Fuel, energy, or emission flow to be calculated or measured



RES4LIVE

ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

Clustering through stakeholders engagement



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

Task 6.2 Co-design process towards energy smart agriculture - Next steps



	Greece	Germany	Belgium	Italy
Partners	AUA	ATB/LVAT	ILVO/UGent	UNIBO/GOLINELLI
1st Round	28 September 2022 - Agricultural University of Athens	30 April 2024 on CNG filling station	25 January 2023 - Agri Flanders Expo 1 February 2023 - Interwaas	22 October 2022 - national Agricultural and Livestock Exhibition
2nd Round	14 December 2023	8 June 2024 Landpartie in Brandenburg	18 June 2024 Cool Energy, in collaboration with “coolpigas” and coolchickens”	21 February 2024 Bologna
3rd Round	April - July 2024	In progress	18 June 2024	9 September 2024

www.res4live.eu

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



Dissemination and Communication Plan and Activities

Participation at international events & conferences



EVENT		
12th Conference of Hellenic Association of Agricultural Engineers - presentation	21-22 October 2021	AUA
ISES Solar World Congress	25-29 October 2021	MG Sustainable Engineering Ab
Workshop on the implementation of Green Deal and Farm-to-Fork Strategy in the agri-food sector - presentation	10 December 2021	AUA
1 st AREA ZERO: Alliance for Renewable Energy in Agriculture and Zero Fossil Energy Webinar	24 March 2022	AUA
3rd Greek AgroFossilFree Lab (in Greek)	12 May 2022	AUA
1st AgroFossilFree Transnational Innovation Workshop for Greenhouses	14 June 2022	AUA
Geosciences for a sustainable future	19-21 September 2022	UNIBO
EUSEW Extended Programme	19-23 September 2022	EUREC, AUA
AgEng-LandTechnik2022	22-23 November 2022	AUA, UNIBO
The XX CIGR World Congress 2022	5-9 December 2022	AUA, UNIBO
Zootechnia 2023	4 February 2023	AUA
Inauguration of Forez Energy methanization site	3 March 2023	CMRT
SolarPACES	10-13 October 2023	MG Sustainable Engineering Ab
Ecomondo's Faie	7 November 2023	AUA
IEEE International Workshop on Metrology for Agriculture and Forestry- MetroAgriFor, Pisa	6-8 November 2023	UNIBO
ISES Solar World Congress	30 October 2023 – 4 November 2023	MG Sustainable Engineering AB
PorciForum, LLeida	March 2024	UNIBO
CIGR South Corea	May 2024	UNIBO
AgEng Athens	June 2024	All
EAAP Florence	September 2024	All

National Workshops



www.res4live.eu

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



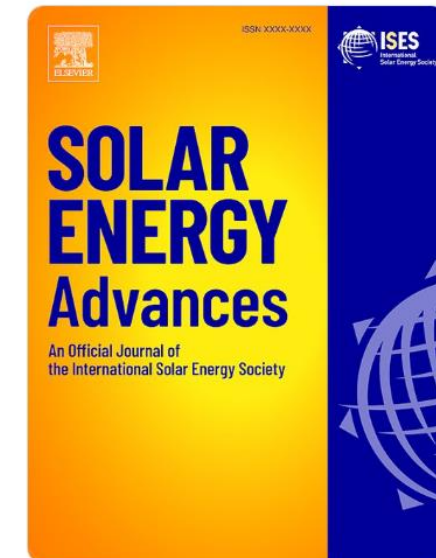
T7.1: Dissemination and Communication Plan and Activities

Publications

Experimental assessment of a solar photovoltaic-thermal system in a livestock farm in Italy	Peer-reviewed, published 2023	MG Sustainable Engineering AB
Evaluation of a solar photovoltaic thermal (PVT) system in a dairy farm in Germany	Peer-reviewed, published 2023	MG Sustainable Engineering AB
Thermodynamic assessment of heat stress in dairy cattle: lessons from human biometeorology	Peer-reviewed, published 2022	ATB
Energy Use in the EU Livestock Sector: A Review Recommending Energy Efficiency Measures and Renewable Energy Sources Adoption	Peer-reviewed, published 2022	AUA, CERTH
Evaluation of the Use of Concentrated Solar Photovoltaic Thermal Collectors (CPVT) in a Dairy and Swine Farm in Europe	Peer-reviewed, published 2021	MG Sustainable Engineering AB
Perché sui tetti delle stalle gli impianti fotovoltaici.	Not peer-reviewed	UNIBO
RES4LIVE: Energy Smart Livestock Farming Towards Zero Fossil Fuel Consumption	Not peer-reviewed (website article)	AUA

RES4LIVE @RES4LIVE · Feb 16, 2023

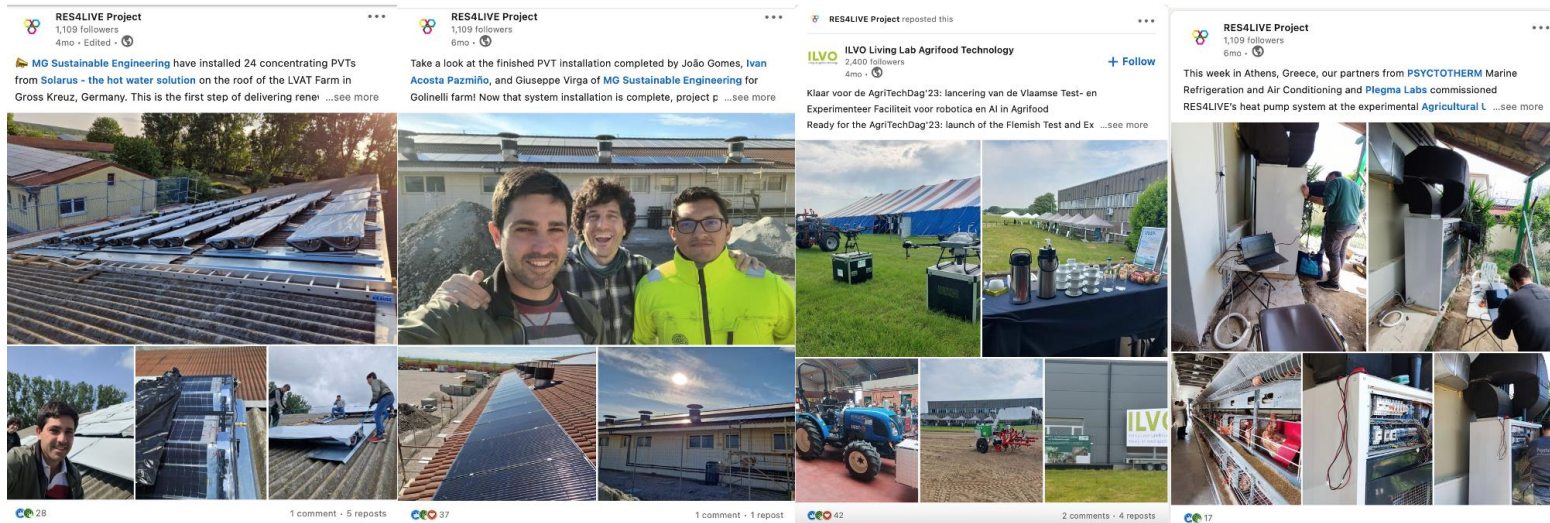
New RES4LIVE Publication! 📄
Our project partners MG Sustainable Engineering published a scientific article in the journal Solar Energy Advances. ☀️
Read the article "Evaluation of a solar photovoltaic thermal (PVT) system in a dairy farm in Germany" 📄
[sciencedirect.com/science/articl...](https://www.sciencedirect.com/science/article/...)



T7.1: Dissemination and Communication Plan and Activities



Posts for Farms' installations



www.res4live.eu

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



3rd Workshop in Belgium

- final Belgian workshop “Cool Energy” took place at ILVO in collaboration with the Agritechdag 2024. About 130 people registered, including researchers, policy makers, financiers, contractors, and farmers. The participants were informed on how to heat and cool livestock farms in a sustainable and/or renewable way. During noon, a technology market was organised in which the contractors explained their services. In the afternoon, participants had the opportunity to visit the RES4LIVE installation in the Varkenscampus.



National CNG Workshop at ATB and LVAT, Germany

The workshop took place on Tuesday, 30 April 2024, on the premises of the ATB and at the LVAT. Among the 40 participants were: researcher, consultants, industry, policy makers, business representatives of alternative fuels.

- Topic: technical and economical aspects of the BioCNG refuelling station, potentials of CNG to self-sufficiency and fossil free agriculture, market availability of the CNG and biogas tractors, costs of refitting diesel engines, existing barriers for market development, ...
- Main outcome: synergy problems solved (tractors and fueling station available on the market), technical and economic feasibility is demonstrated, main obstacle: approval procedures → simplification for micro fueling station and standardization of approval procedures.



EmiMod & Res4Live WS at ATB, LVAT, BAUA, Germany

The EmiMod project meeting took place on 5 and 6 June at ATB Potsdam, LVAT Groß Kreutz, and BAUA Berlin. Among the 37 participants were members of main research facilities & universities, industry, and consulting in livestock with focus on emission mitigation.

- Topic: Emission reduction from livestock farming systems, possibilities for defossilisation in livestock farming, in particular the CNG filling station and renewable energy for barn ventilation and cooling.
- Main outcome: in-depth studies required for economic feasibility; especially for defossilisation measures, even more in-depth life cycle and economy analyses are required to assess the overall environmental impact and also the social acceptance.



Brandenburger Landpartie

The Brandenburger Landpartie took place on 8 and 9 June 2024 on the premises of LVAT. ATB was represented on 8 June 2024. Among the 700 participants were people from society and politics – all stakeholders (biogas, science, consulting).

- Topic: Agriculture of the future: agriculture, renewable energy (e.g. biogas), milk production/processing, animal husbandry
- Main outcome: Social acceptance and the desire for defossilised livestock systems is high.



16.09.2024



Thank you!



www.res4live.eu

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

