Heat Pump HVAC System as Part of an Integrated RES System for the Indoor Climate Control of a Laying Hen House

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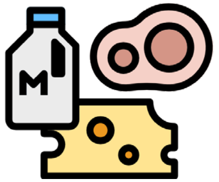
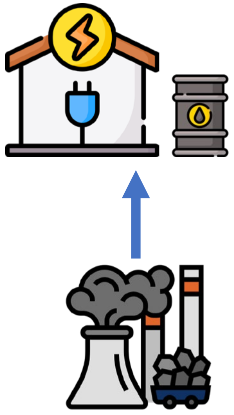
Problem: Energy Use in Livestock Buildings

Intensive Livestock Systems


- EU citizen consumes annually 22 kg of animal-based proteins[1]
- The annual egg production is approximately **6.7 million tonnes**[2]



Direct - on-farm - energy use accounts for 3.2% of the EU's total energy consumption[3]



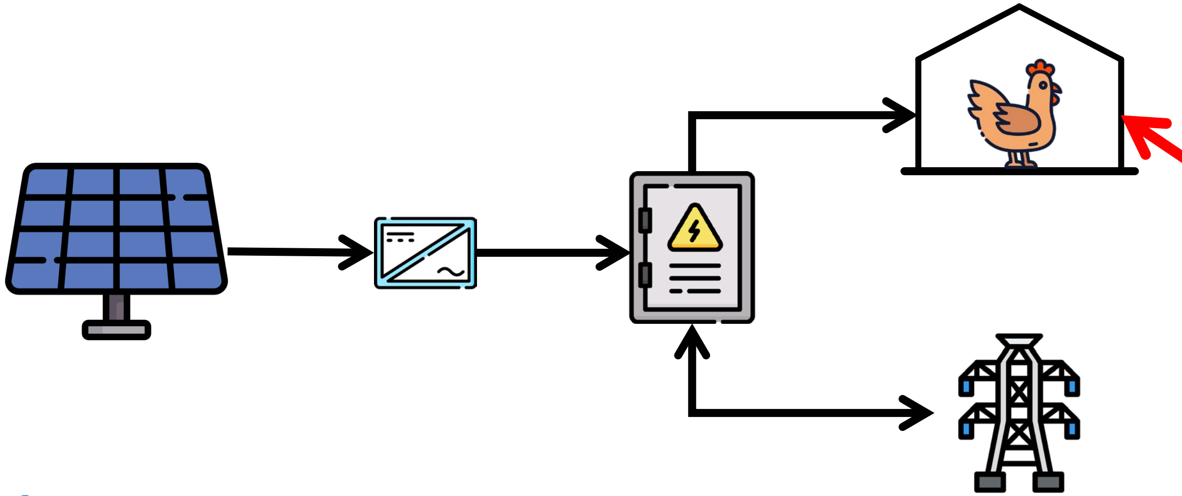
Targets for sustainable food production

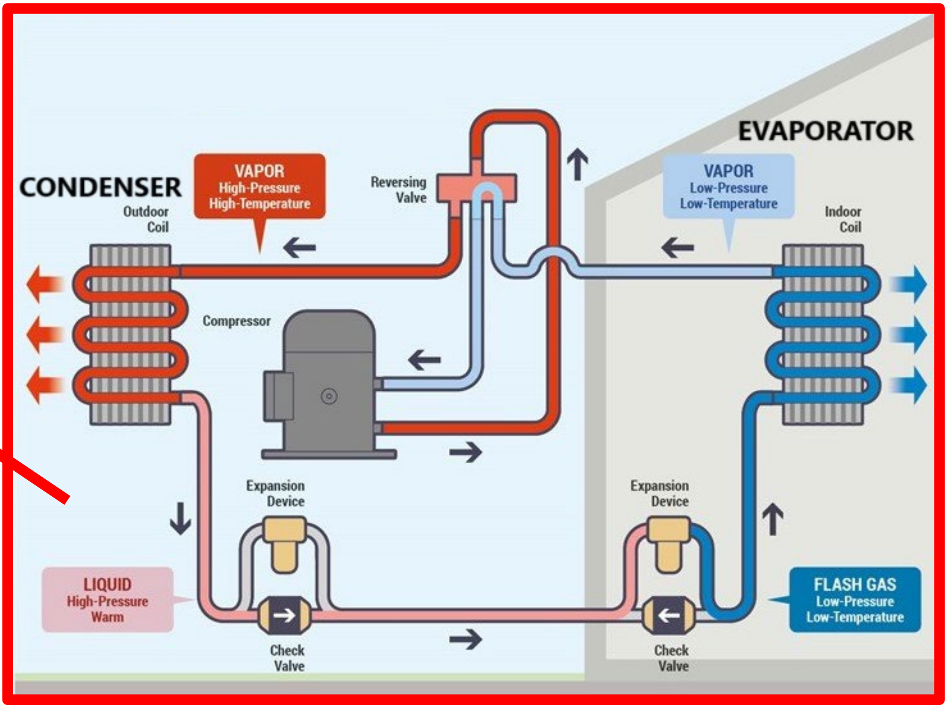
- Decarbonization
- Improved animal welfare
- Higher energy efficiency
- Climate resilience

[1] *FAOSTAT, 2018*
[2] *European Commission, 2023*
[3] *Eurostat, 2022*

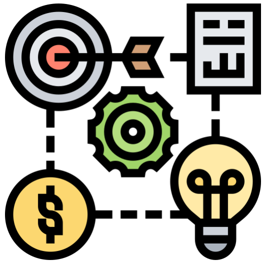
Proposed Solution: The H2020 RES4LIVE project

Use of heat pumps as part of an integrated RES system for the indoor climate control of a lying hen house





Objective



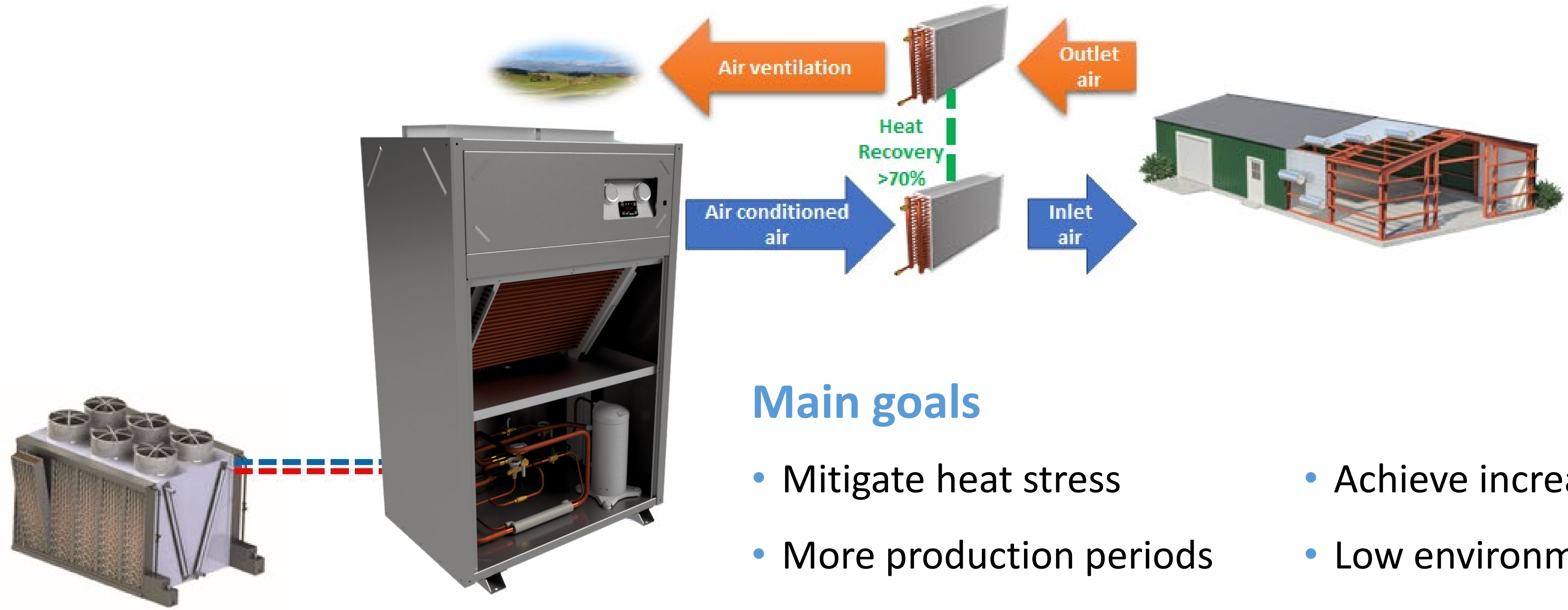
- Analyze the performance of a heat pump integrated in a livestock environment for two typical periods
- Understand its potential to enhance the sustainability of livestock systems

Case Study: Innovative Heat Pump (HP) in AUA

The hen house of Agricultural University of Athens (AUA)

- 45 m^2 of floor area / Capacity for ~400 hens
- 3-tier enriched colonies

- Heat pump to regulate indoor space conditions (heating, cooling & dehumidification)
- PVs to cover part of the total energy needs



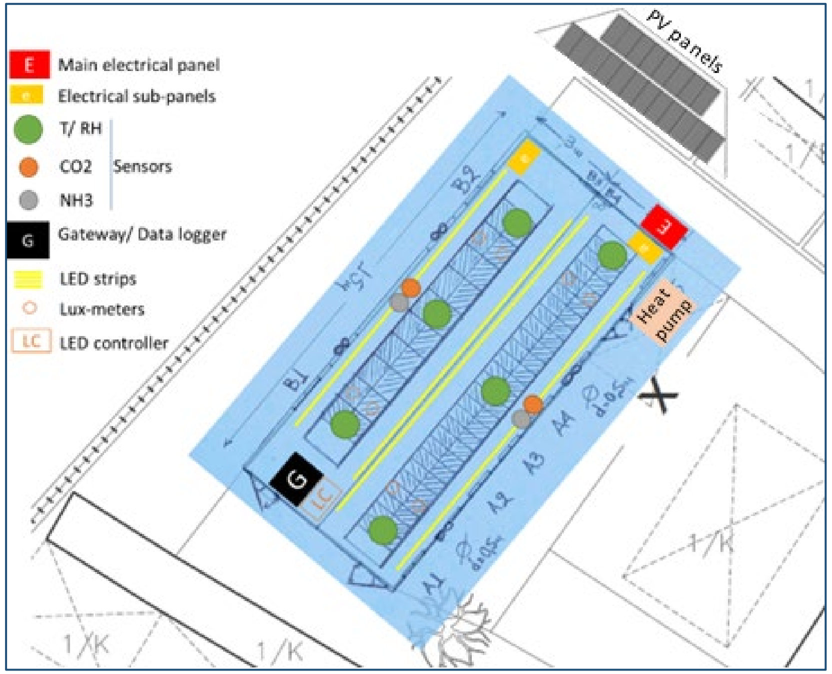
Main goals

- Mitigate heat stress
- More production periods
- Achieve increased production
- Low environmental impact

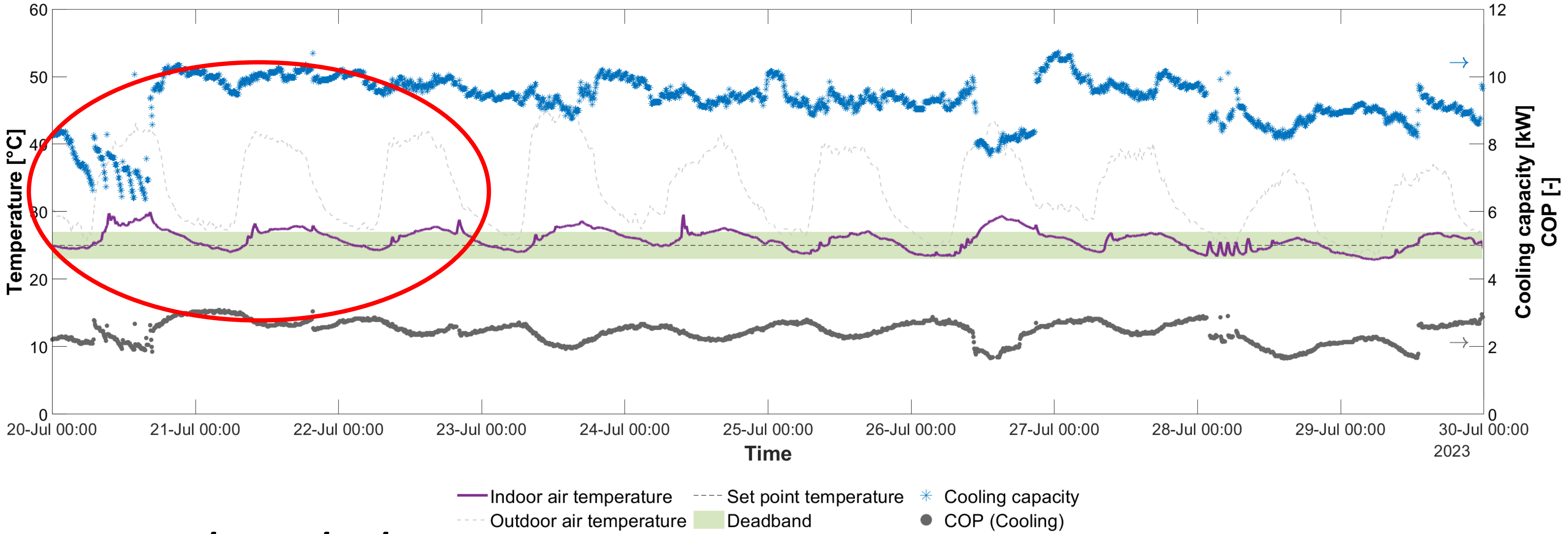
Case Study: Innovative Heat Pump (HP)

Main features of the HP system

- Air-to-air HP - Screw-type compressor
- 10 kW of nominal cooling capacity (R407C)
- Heat recovery system
- Auxiliary fans & water pumps



Results: Temperature in Summer (Cooling Mode)



<u>Between 20/07-19/08/2023</u>

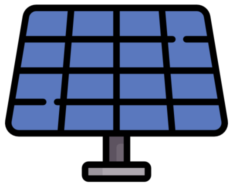
- Acceptable indoor air temperature even during heat waves (θ_{in}= 28 °C when θ_{out} = 45 °C)
- Cooling capacity not enough only due to extreme weather and higher ventilation rates

Results: Energy Consumption and Performance in Sumer (Cooling Mode)

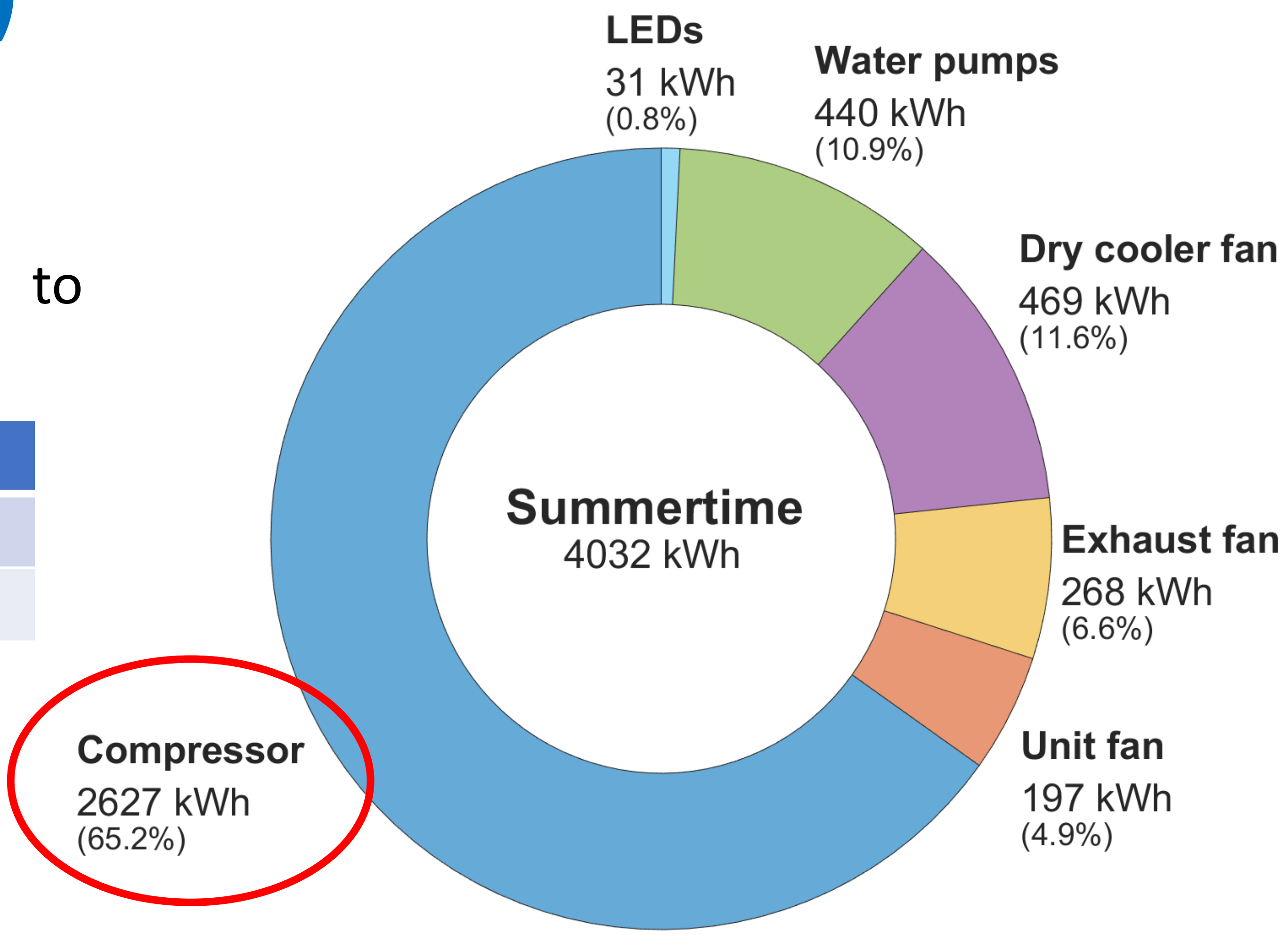
<u>Between 20/07-19/08/2023</u>

- Energy consumption: 90 $kWh_e\ m^{-2}$
- Energy consumption mainly due to compressor operation

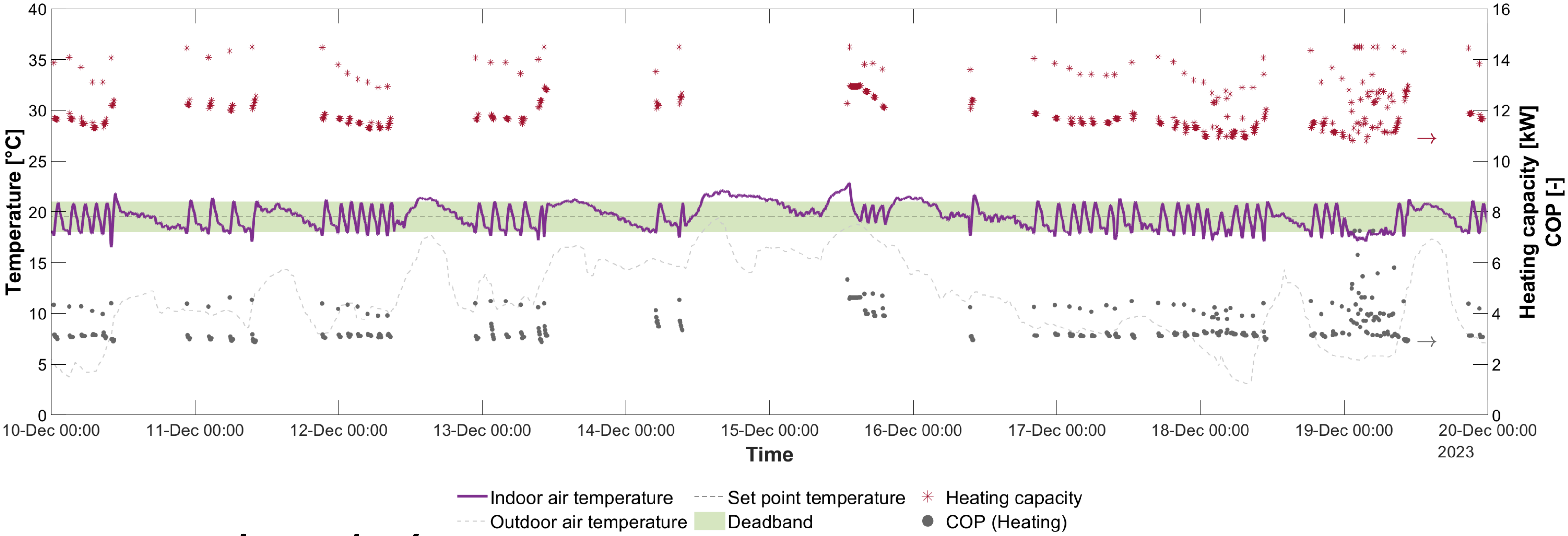
Mode (period)	Seasonal COP
Cooling (summer)	2.42
Cooling (year)	3.12



- 909 kWh generated
- 22.5% of Self-Sufficiency



Results: Temperature in Winter (Heating Mode)



Between 01/12-30/12/2023

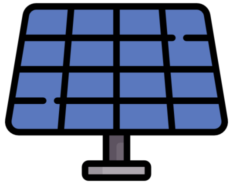
- Indoor air temperature mostly within the limits set
- COP always exceeded 3, even for even higher ventilation rates

Results: Energy Consumption and Performance in Winter (Cooling Mode)

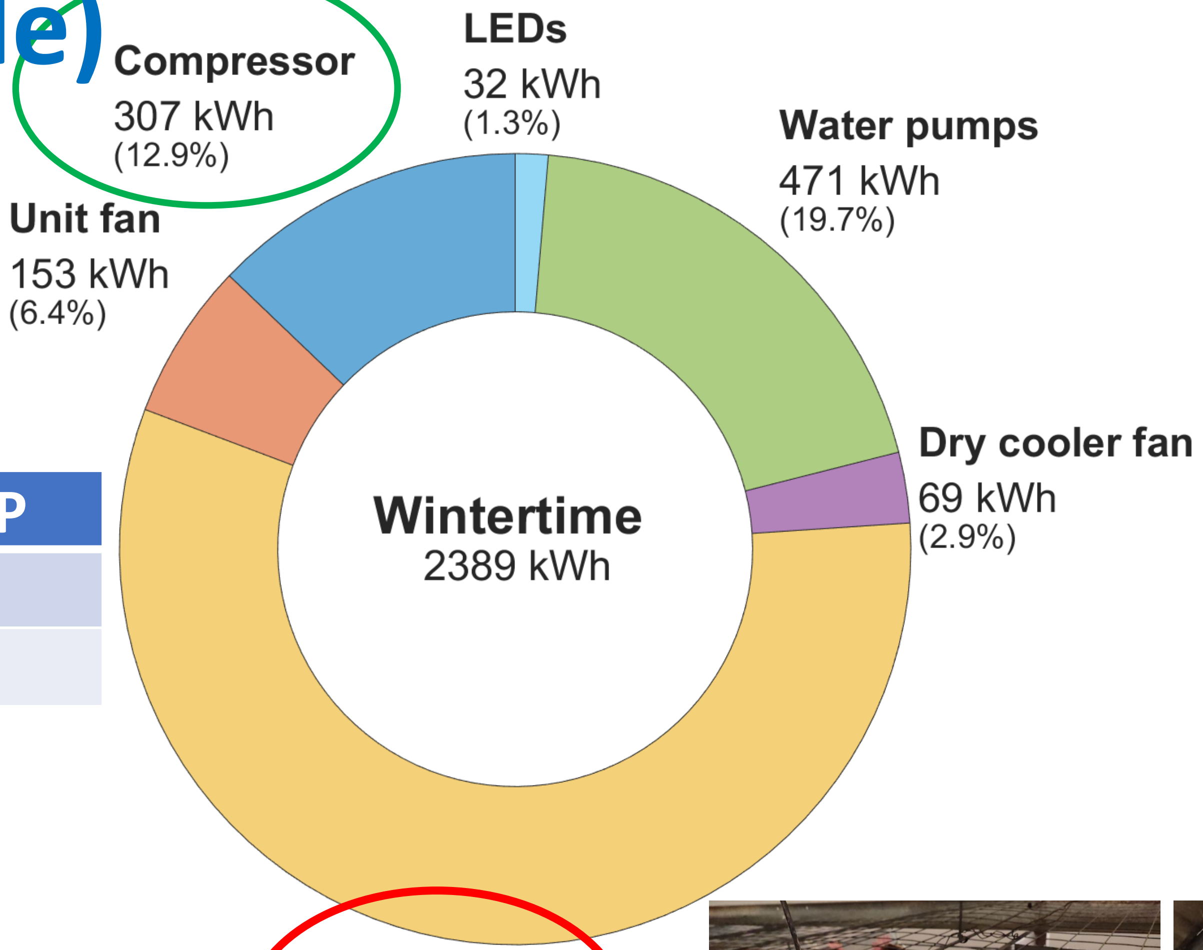
<u>Between 01/12-30/12/2023</u>

- Energy consumption: 53 $kWh_e\ m^{-2}$
- Bigger exhaust fan installed to mitigate dust build-up

Mode (period)	Seasonal COP
Heating (winter)	3.65
Heating (year)	3.77



- 483 kWh generated
- 20.2% of Self-Sufficiency



Conclusions

The heat pump maintained the adequate indoor air temperature, even during **heat waves**

The heat pump operation was satisfactory, with a **SCOP** 3.12 for cooling, and 3.77 for heating

The integration with a PV system let to avoided emissions of approximately **5,096 kg CO2-eq**

Room for improvement in the ventilation control approach.

A special attention should be paid to the **design stage.**

THANK YOU FOR YOUR ATTENTION

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