ECPLF 2024

Heating Strategies in Farrowing Compartments: Exploring Configurational Options and the Feasibility of Solar Systems Integration

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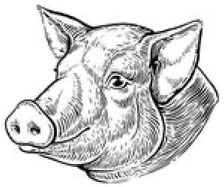
RES4LIVE
ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

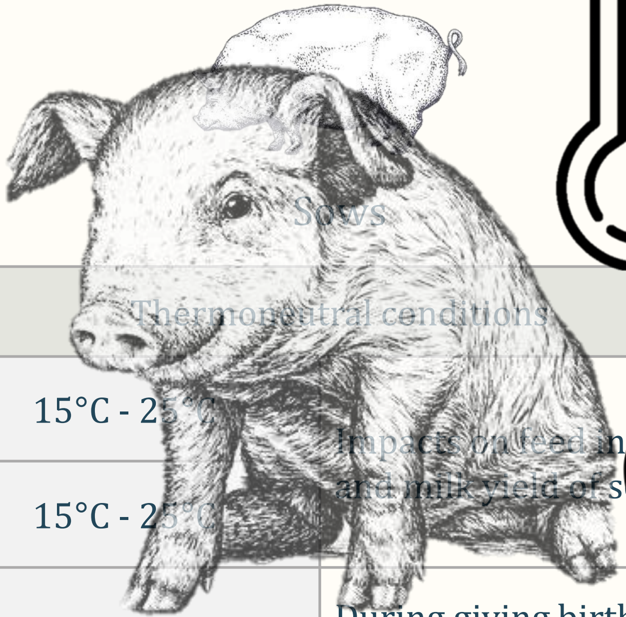


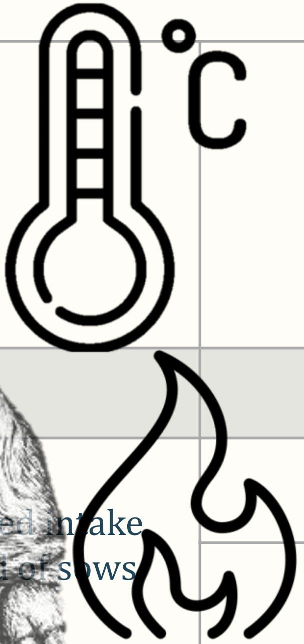
Kathy Oi In Put

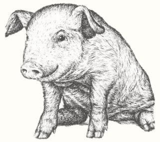
Research Team Sustainable Thermo-Fluid Energy Systems, UGent
Precision Livestock Farming team, ILVO

INTRODUCTION

Thermoneutral Zone







	Sows		Piglets	
Researches	Thermoneutral conditions		Thermoneutral conditions	
Bjerg et al. (2020)	15°C - 25°C	Impacts on feed intake and milk yield of sows	-	-
Malmkvist et al. (2012)	15°C - 25°C		-	-
Hörtenhuber et al. (2020)	19°C - 22°C	During giving birth and lactation.	18°C - 35°C	Vary from different stage of piglets.
Smith, Ramirez, and Hoff (2021)	Around 18°C	-	32°C - 35°C	For new-born piglets

INTRODUCTION

Heating Devices

Heat lamp with dimmer

Floor heating

Covering/ creep area

Controlled heat lamp with covering

RESEARCH GOALS

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Compare new heating configuration with the existing system

1. Comfort condition
2. Energy efficiency
3. Energy cost

GOALS 1

Feasibility of transiting to solar and storage system in conjunction with various heating systems

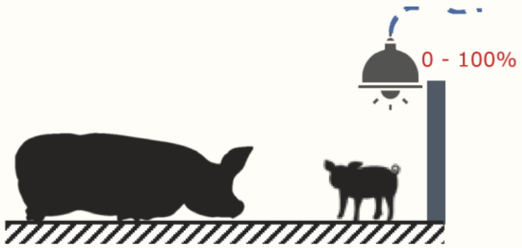
Business Model:
CAPEX, OPEX, ROI, payback time, etc.

GOALS 2

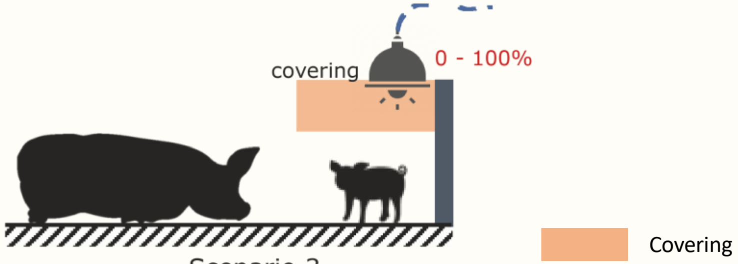
EXPERIMENT
METHODOLOGY

Experimental set-up

Scenario 1 (Standard)



Scenario 2



Scenario 3

- Scenario 1 (S1): Floor heating & manual heat lamp (ON, half-power, OFF)
- Scenario 2 (S2): Controlled heat lamp (Automatic power adjustment from 0% to 100%)
- Scenario 3 (S3): Controlled heat lamp & covering

EXPERIMENT
METHODOLOGY
Materials and Equipment

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Comfort conditions

Temperature sensors

- Ambient temperature of sows & piglets

Energy consumption

Energy meter

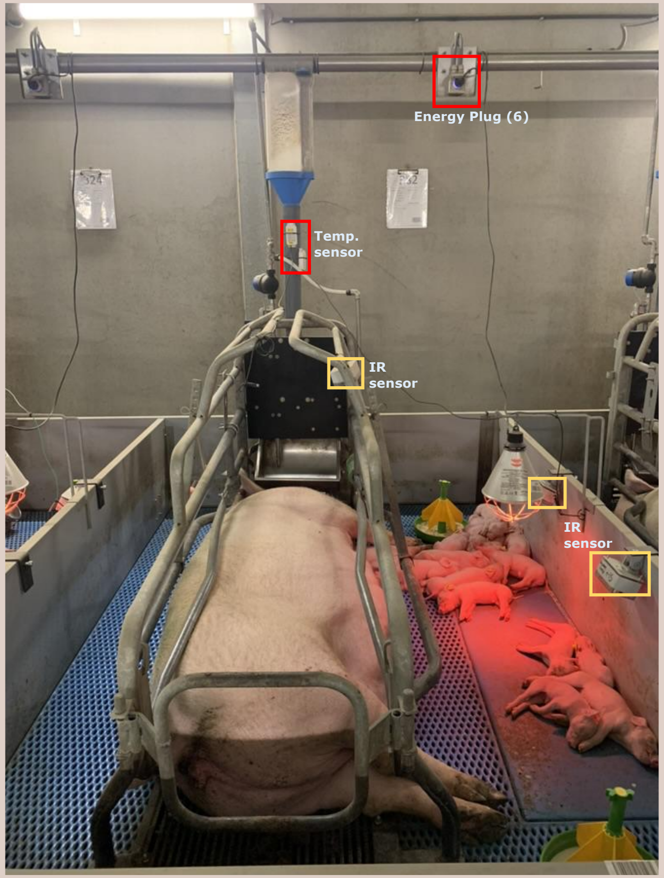
- Electricity consumption from the heat lamps

Flow rate meter

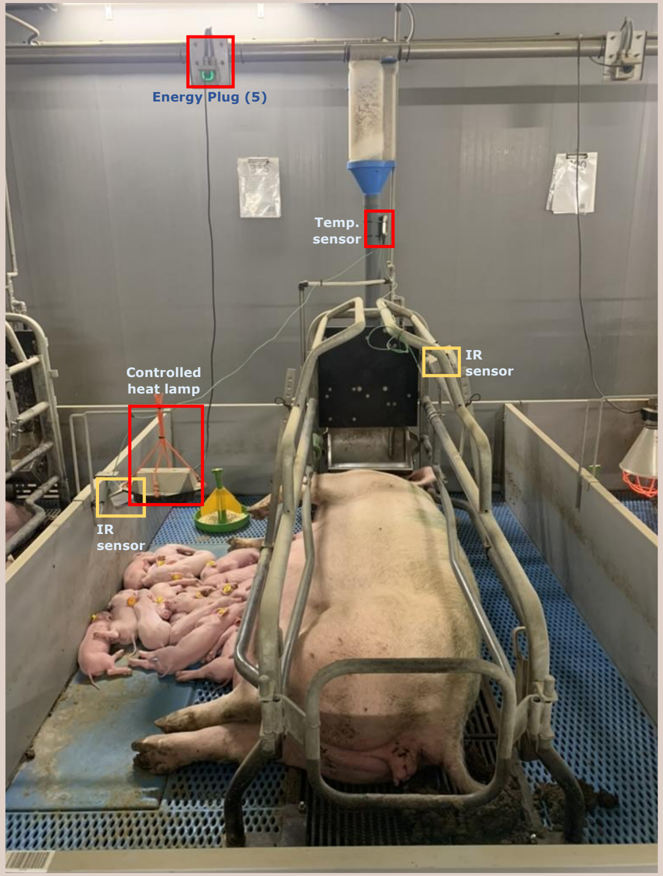
- Energy consumption from floor heating

EXPERIMENT
METHODOLOGY

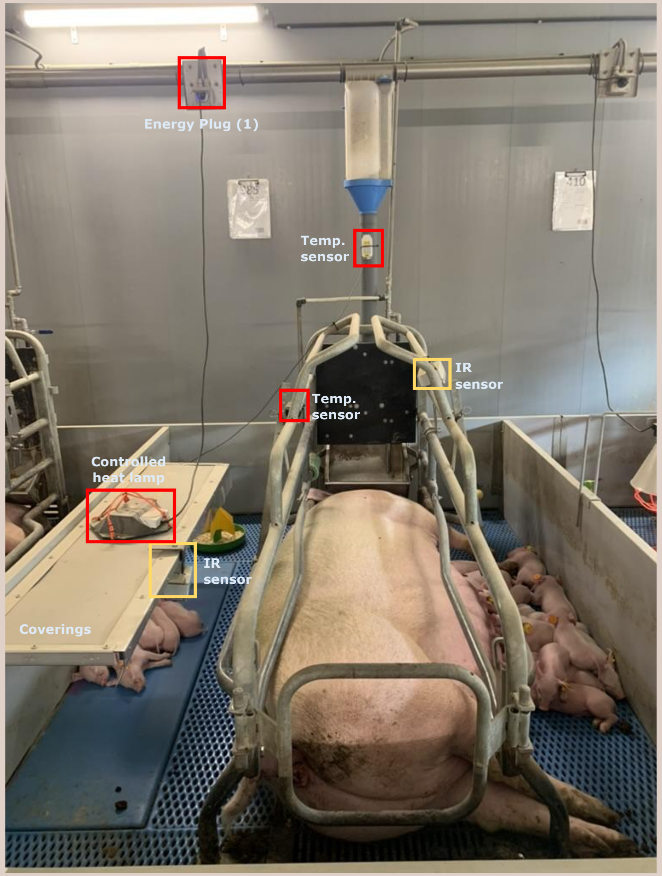
S1



S2

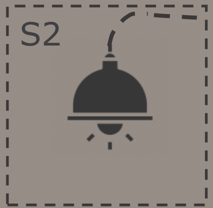


S3



EXPERIMENT
RESULTS & DISCUSSION
Comfort Condition

- Similar temperature trends
- Able to create a localised heating environment for piglets



- Relative low temperature
- Heat loss

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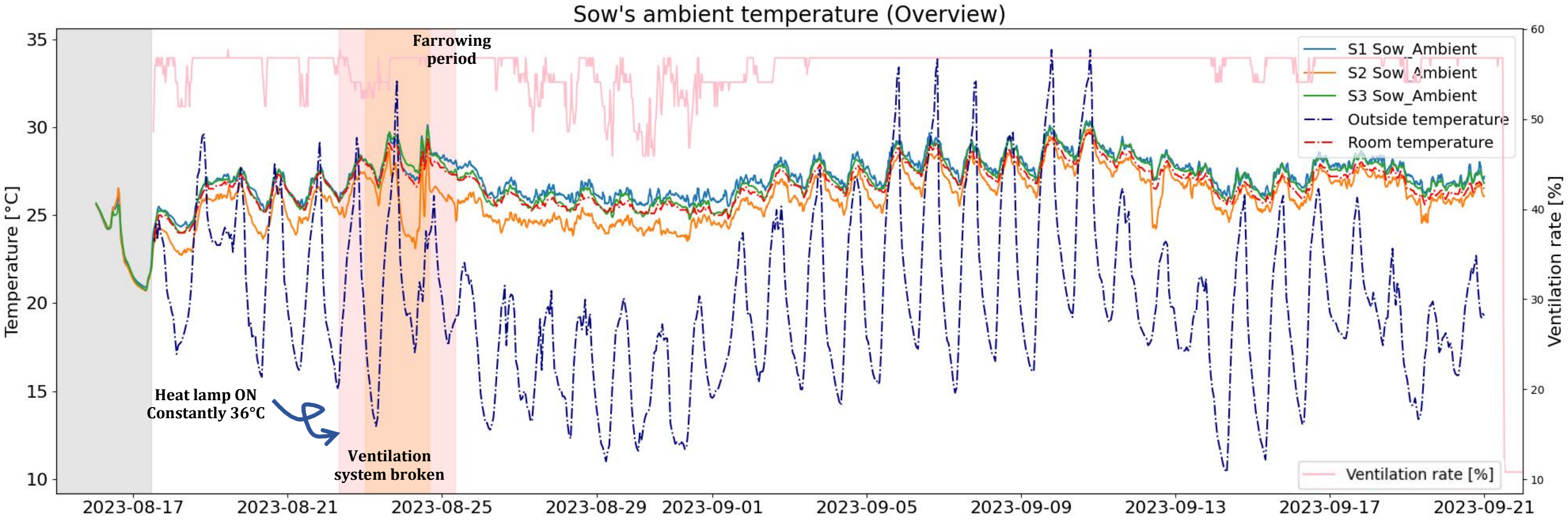
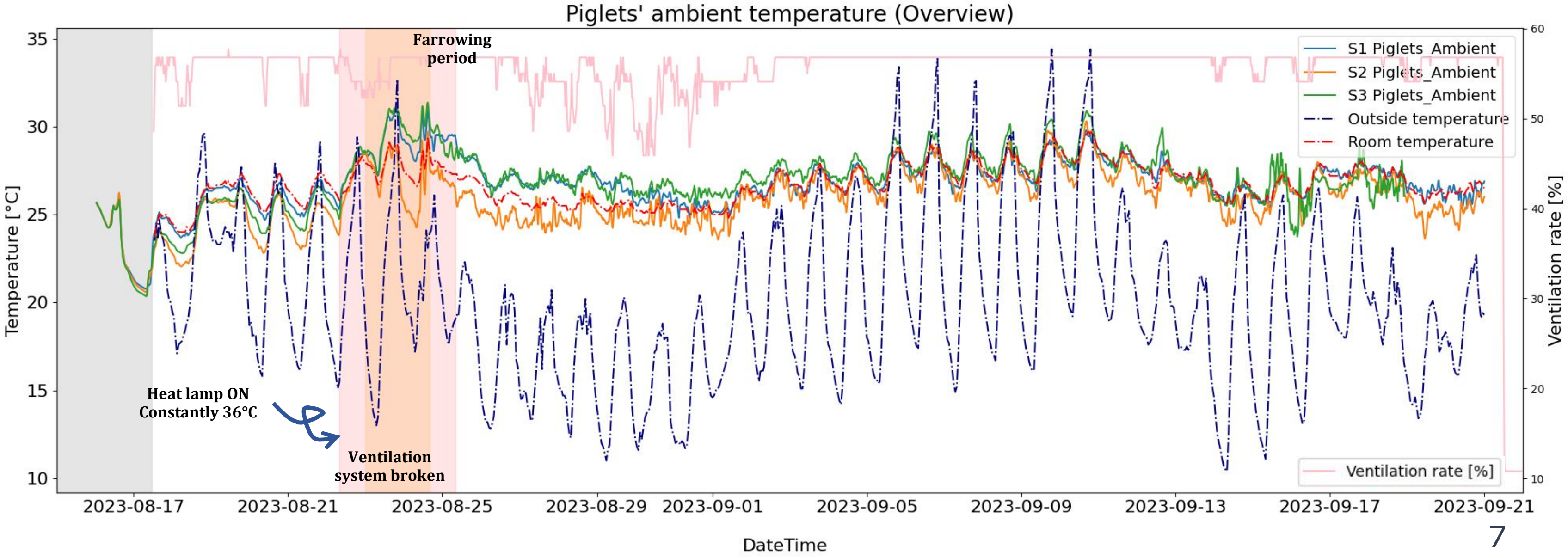
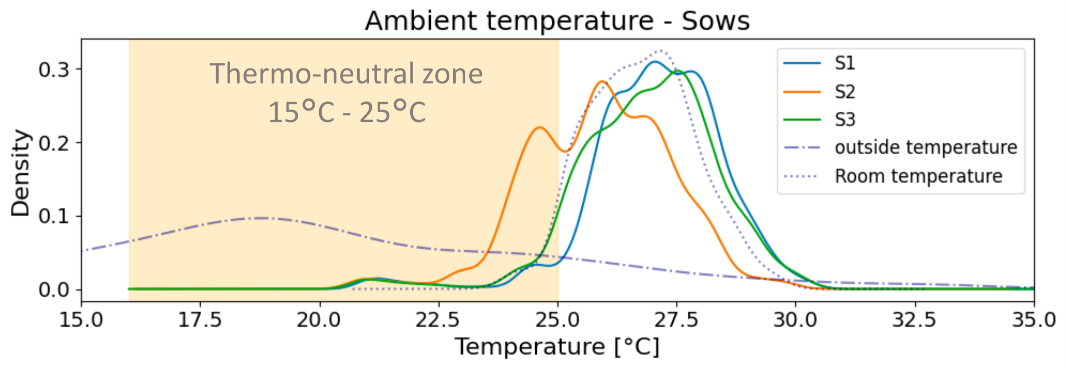
SOWS

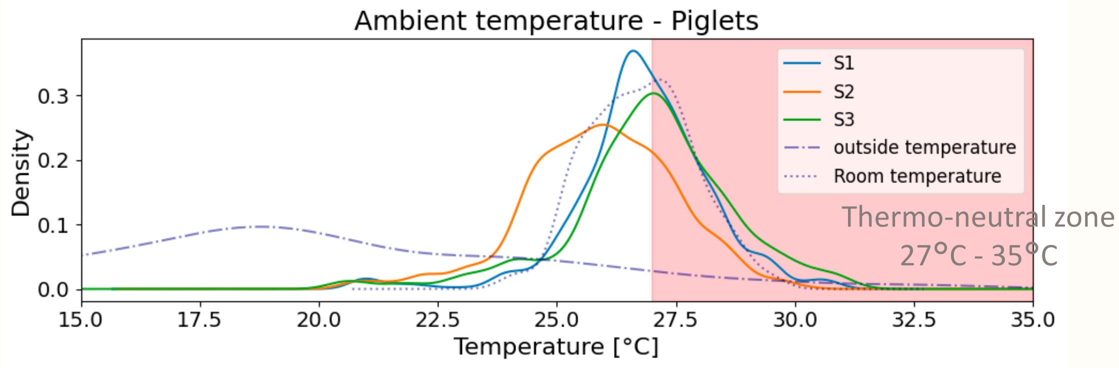


PIGLETS



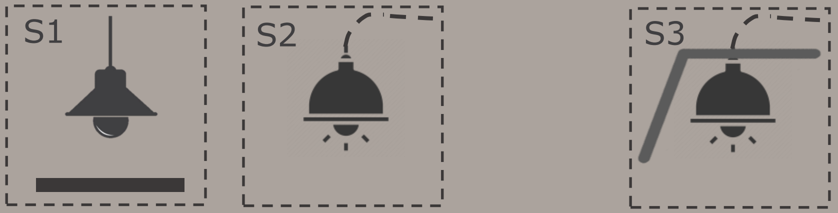
EXPERIMENT
RESULTS & DISCUSSION
Comfort Condition





SOWS

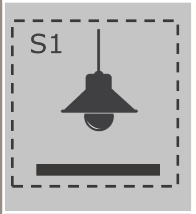
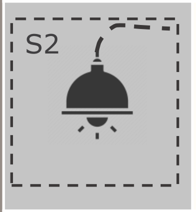
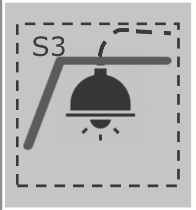
PIGLETS



- Multiple peaks: greater variability in temperature.
- Unimodal curve: less variability in temperature.

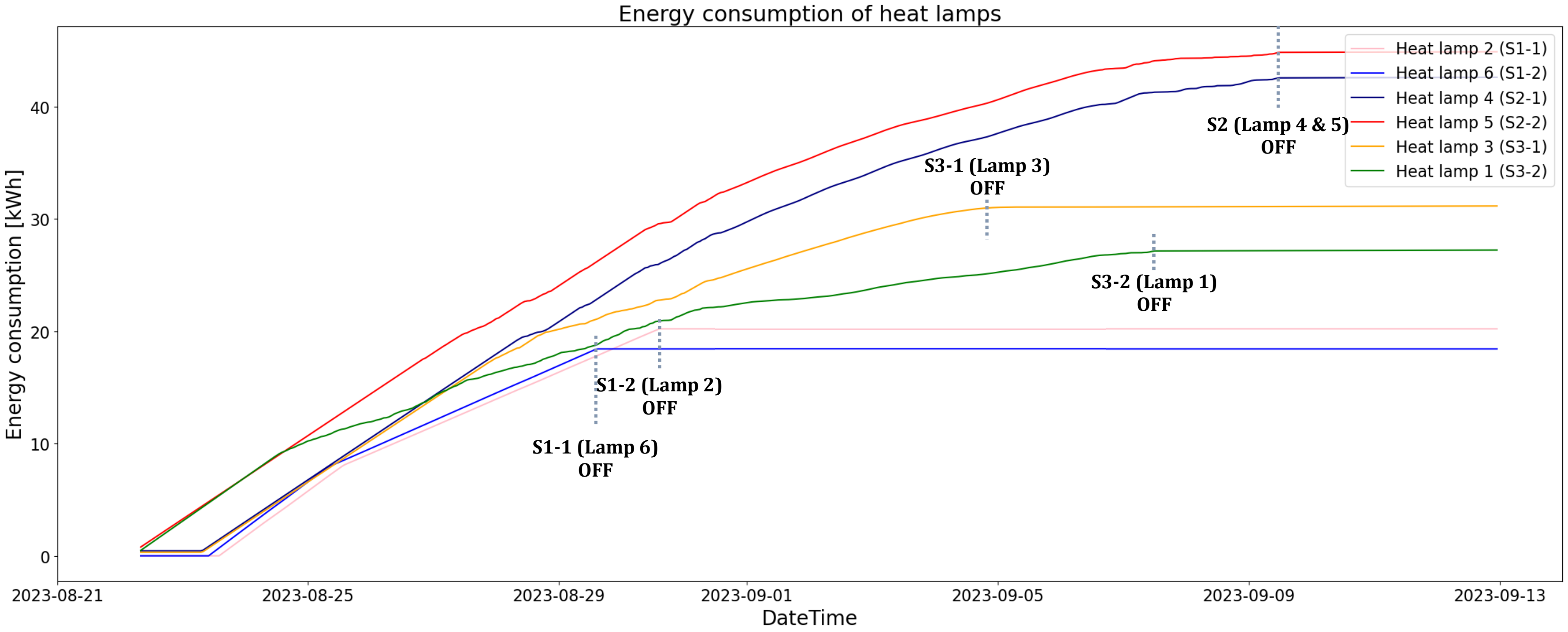
- Unimodal distribution: less variability in temperature.

EXPERIMENT
RESULTS & DISCUSSION
Energy consumption

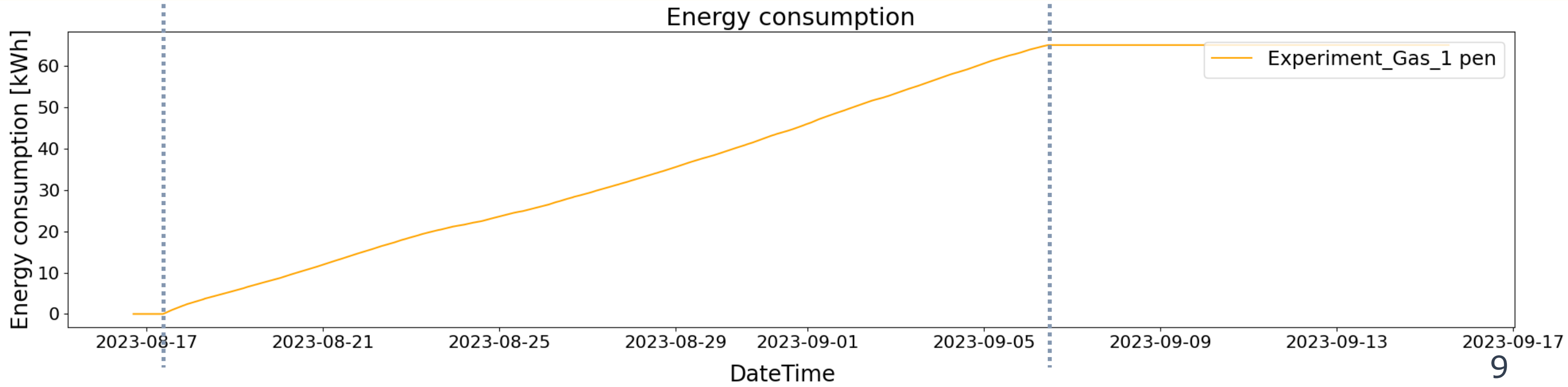
Scenarios	Electricity [kWh]	Gas [kWh]	Total energy cost for one compartment [€]
S1 	19.32	65.07	219.62
S2 	43.74	-	251.38
S3 	29.19	-	167.76

Over a 5-week cycle

HEAT LAMPS

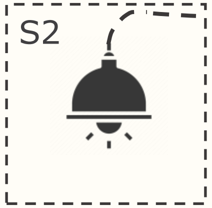


FLOOR HEATING

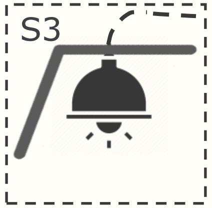


CONCLUSION (EXPERIMENT)

- The standard setup.
- Suitable heat for piglet.



- Higher heat loss, less energy efficient.
- Higher energy cost.



- Ability in creating localized heating for piglets while minimizing impact on sows.
- 25% more cost-effective than S1.

RESEARCH GOALS

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Exploring the feasibility renewables transition:

PVT/PV system

Storage system

Feasibility of transiting to solar and storage system in conjunction with various heating systems

Business Model:
CAPEX, OPEX, NPV, etc.

GOALS 2

MODELLING
METHODOLOGY

- DesignBuilder

Simulating yearly profile:
Temperature and energy consumption

- **Experimental data:**
  ✓ CO_2 and heat generation (Sows)
  ✓ Farrowing schedule
  ✓ Energy consumption pattern
  ✓ Ventilation rate, etc.

- **External factors:**
  ✓ Weather conditions
  ✓ Building materials & thermal properties
  ✓ occupancy density, etc.

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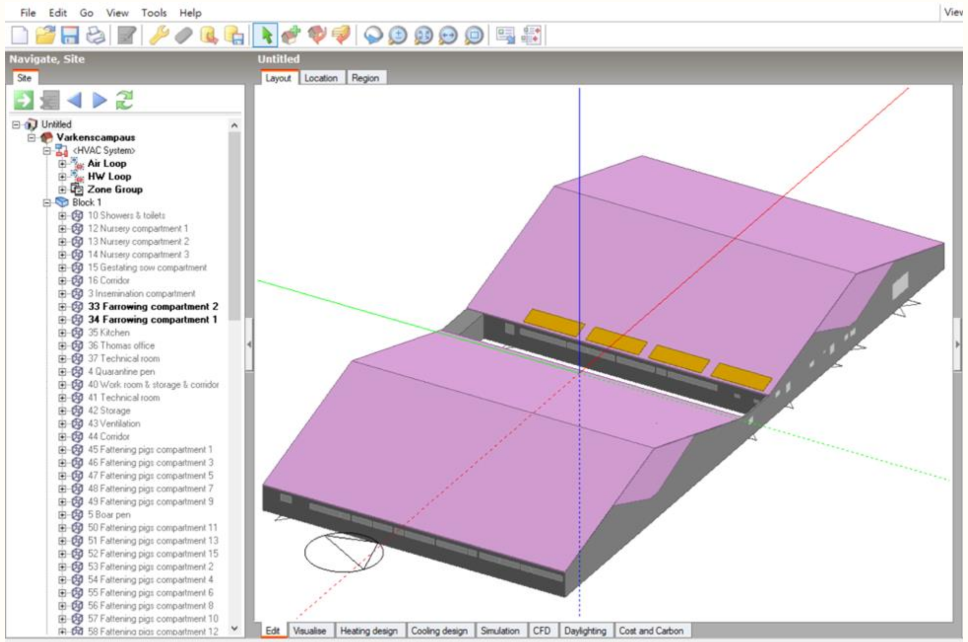
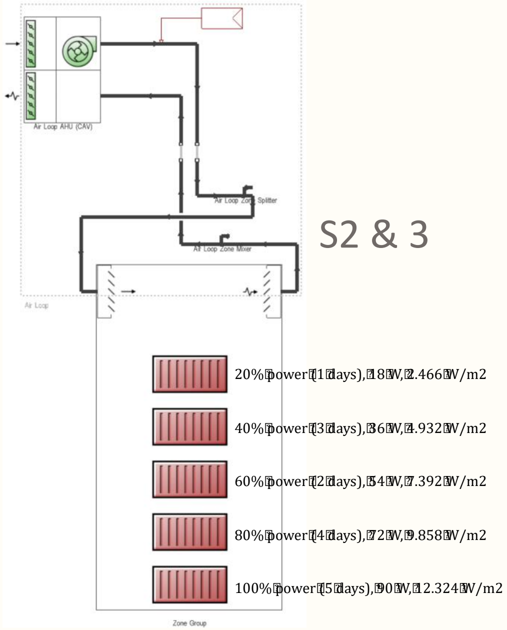
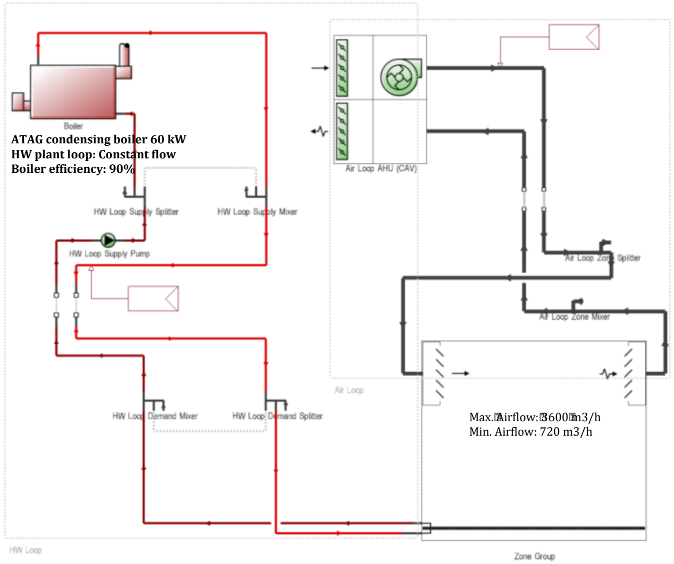


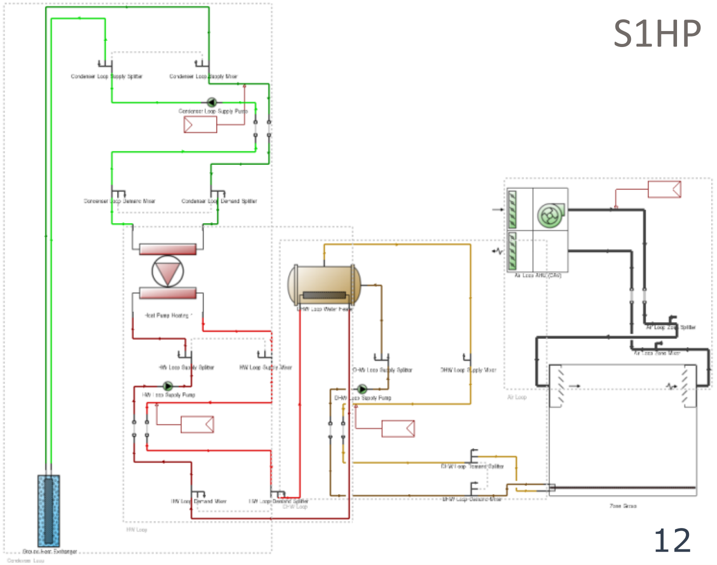
S2 & 3





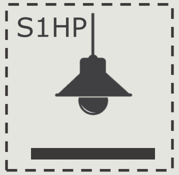
S1

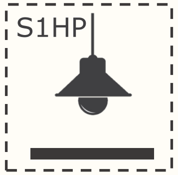
S1HP



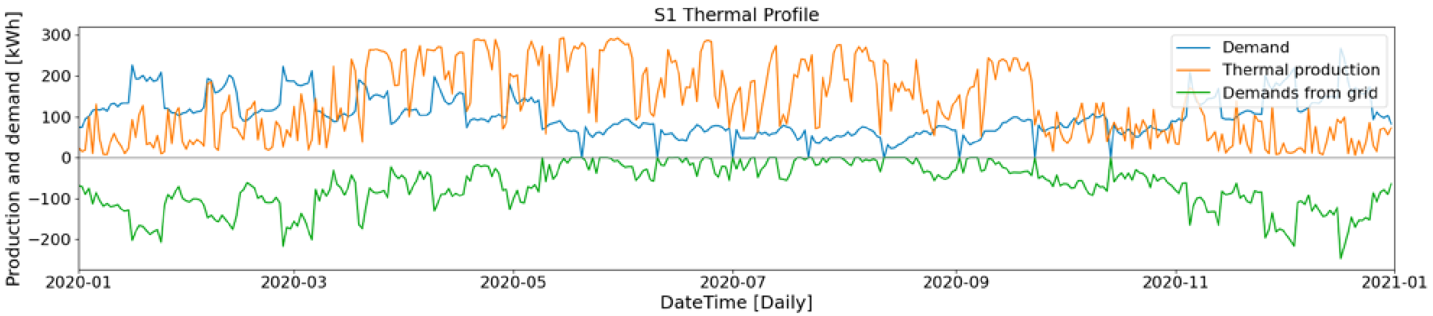
MODELLING

BUSINESS MODEL

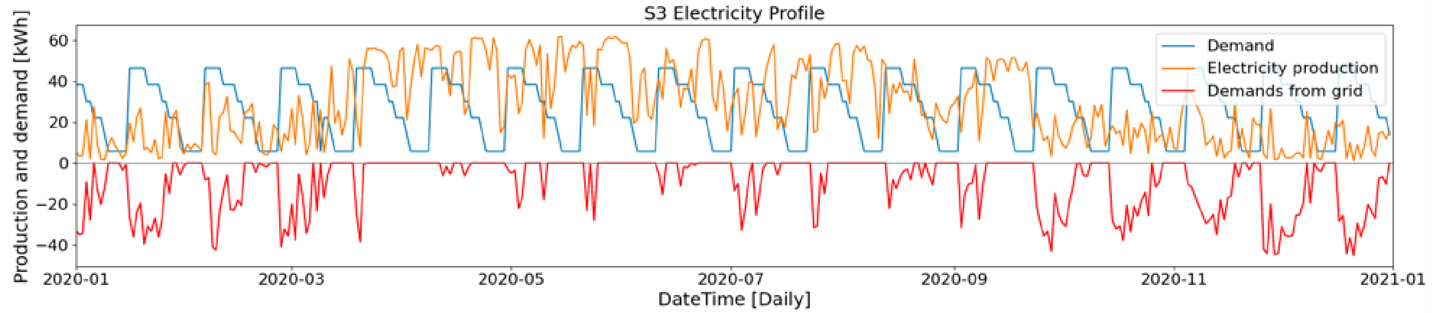
Yearly profile	 S1HP		 S3	
Number of panels	45	panels	23	panels
Electricity use	19842.97	kWh	9762.96	kWh
Total production	19842.97	kWh	9762.96	kWh
Electricity demand from the grid	13031.34	kWh	6264.99	kWh
Self-consumption percentage	34.17	%	35.32	%
Self-sufficiency percentage	34.17	%	35.32	%



Scenario 1HP. Electricity (heat lamps & floor heating): 45 PV panels



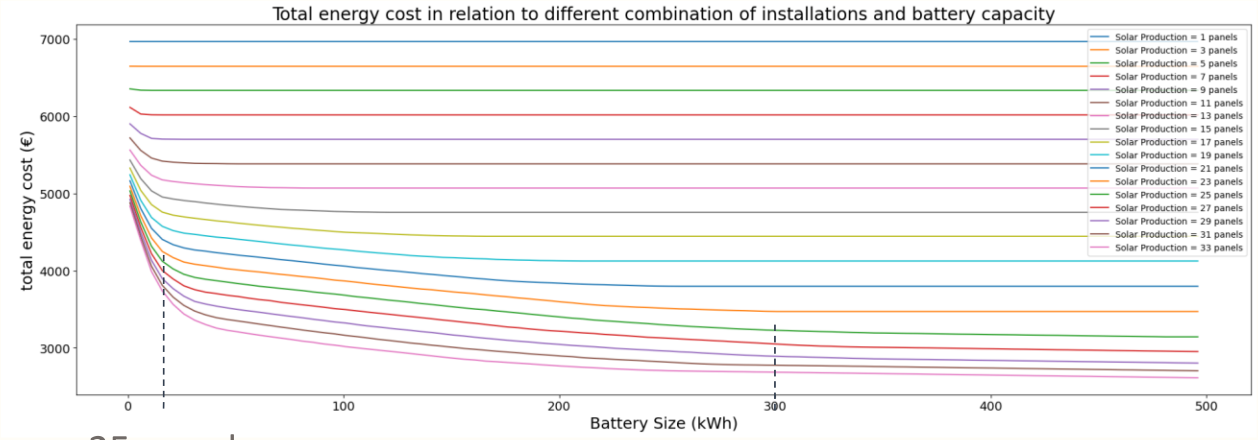
Scenario 3. Electricity (heat lamps): 23 panels



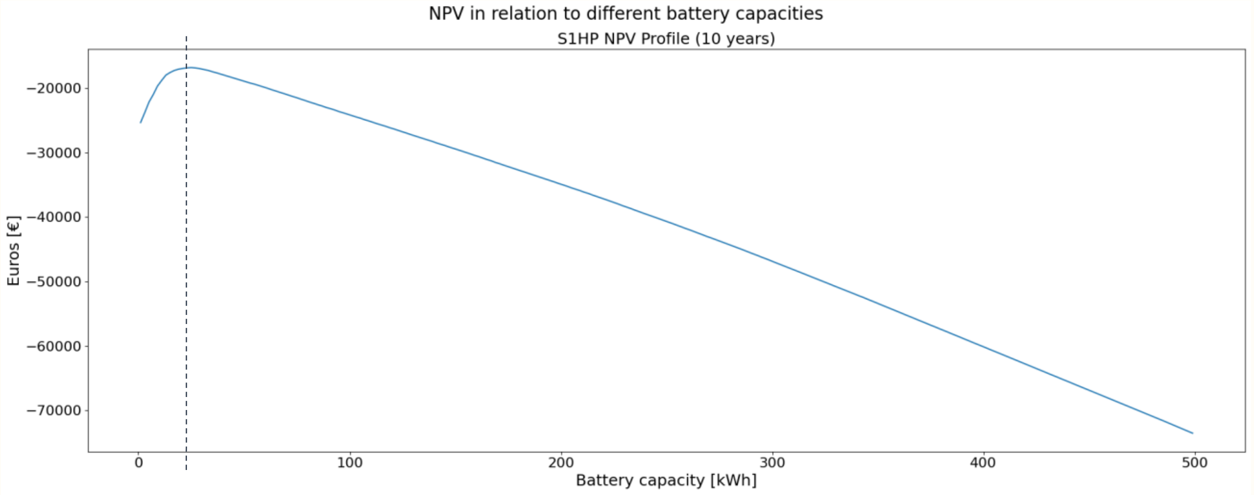
MODELLING

BUSINESS MODEL

S1HP

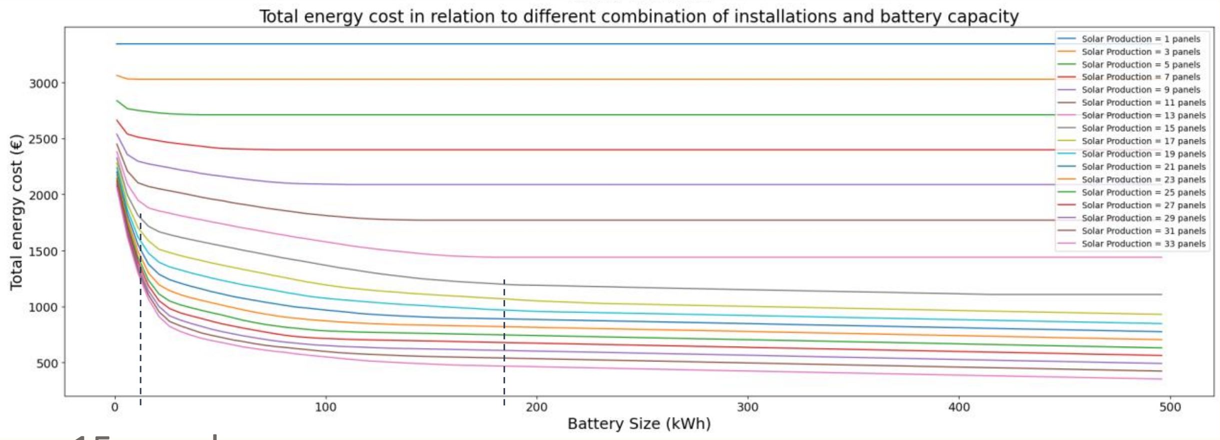


25 panels

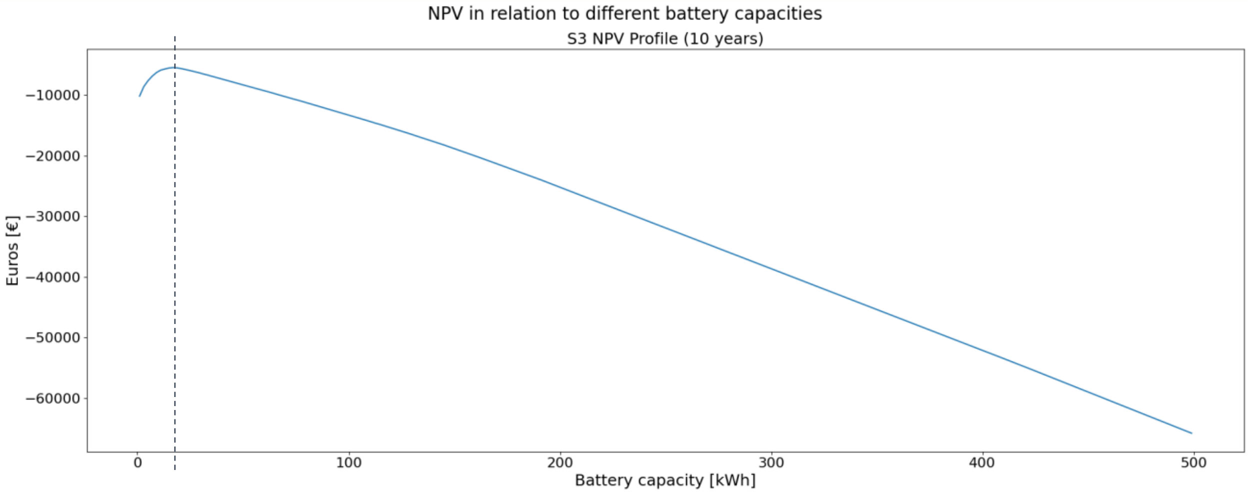


25 kWh

S3

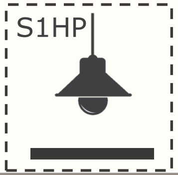


15 panels



17 kWh

CONCLUSION (MODELLING)



- The need for stable renewable systems.
- Explore combination with the solar systems and others.

Future Works

- Experimental scope for diverse heating configurations.
- More experiments to enhance the database for improved design of sustainable heating solutions for pig farming.

Yearly profile	S1 HP		S3	
Yearly electricity consumption	19,842.97	kWh	9,762.96	kWh
Before installing the storage system (Max. solar installation)				
Number of panels	45	panels	23	panels
Total production	19,842.97	kWh	9,762.96	kWh
Electricity demand from the grid	13,031.34	kWh	6,264.99	kWh
Own consumption	6,780.95	kWh	3,448.36	kWh
Self-consumption ratio	34.17	%	35.32	%
Self-sufficiency ratio	34.17	%	35.32	%
Net present value (NPV)	-16,605.64	€	-8,008.36	€
Payback time	47.30	years	36.69	years
After installing the storage system				
Number of panels	25	panels	15	panels
Size of battery	25	kWh	17	kWh
Total production	11,223.47	kWh	6,734.08	kWh
Electricity demand from grid	11,026.65	kWh Reduced 2004.69 kWh	4,733.47	kWh Reduced 1531.52 kWh
Own consumption	8,816.32	kWh	5,029.49	kWh
Self-consumption ratio	78.55	%	74.69	%
Self-sufficiency ratio	44.43	%	51.52	%
Net present value (NPV)	-16,831.60	€	-5,466.87	€

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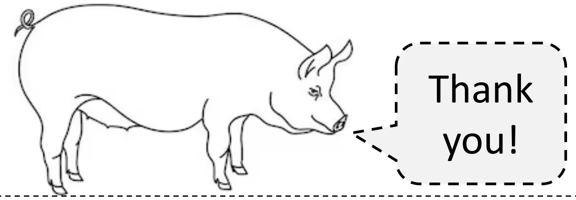

Contact

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