Life Cycle Impact Assessment of an Integrated PVT-BTES-Heat Pump System for a Commercial Swine Farm in Italy

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RES4LIVE
ENERGY SMART LIVESTOCK FARMING TOWARDS ZERO FOSSIL FUEL CONSUMPTION

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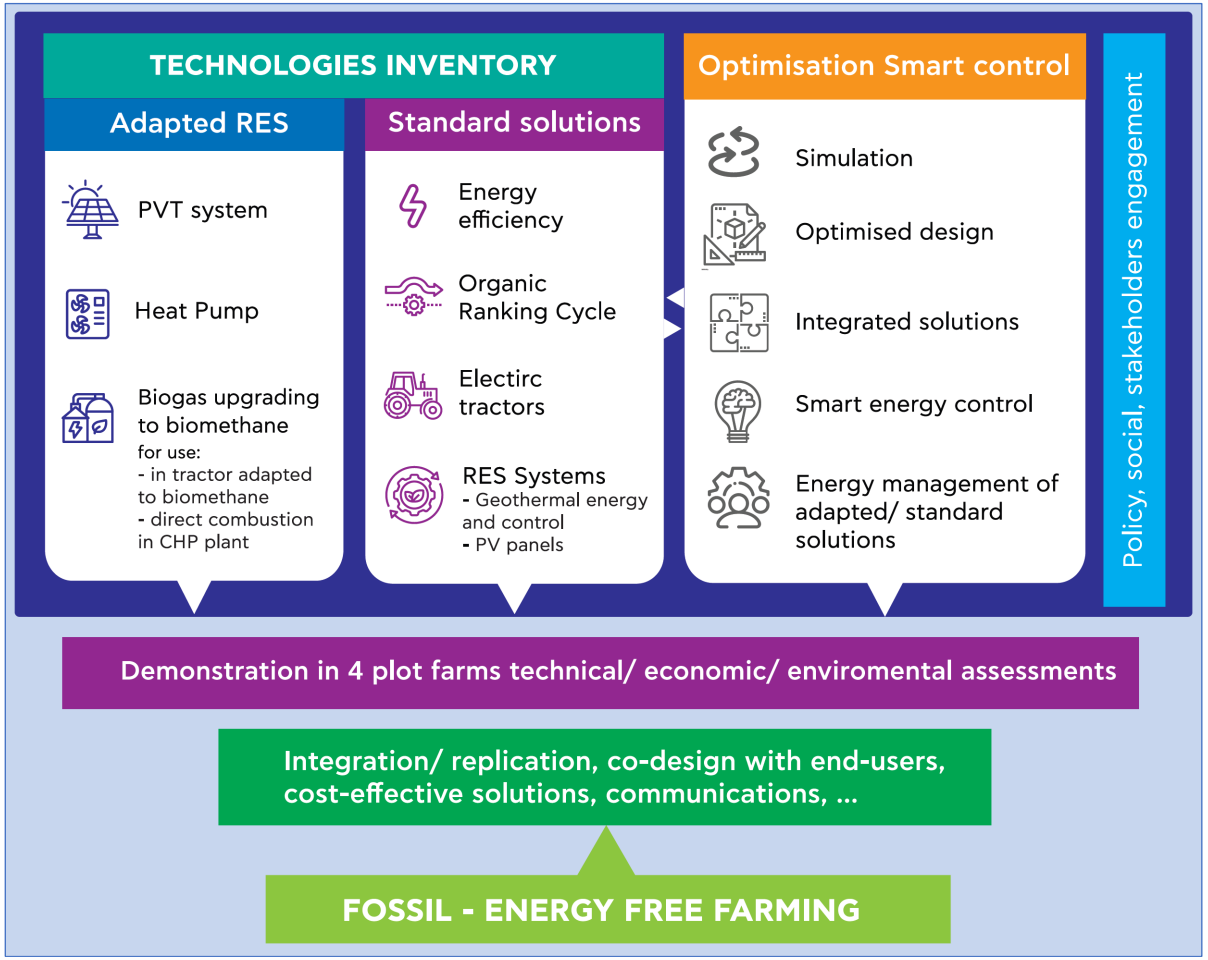
Introduction (1/2)

RES4LIVE Proposed Solutions



RES4LIVE
ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

- Replacement of fossil energy use, utilizing Renewable Energy Sources (RES)

Environmental Impact Assessment of RES Systems in Livestock Production

- Ensure the transition to renewable energy is both effective and sustainable
- Evaluate trade-offs so that the RES implementations have a net positive impact.
- Stakeholders can devise strategies that promote sustainability
- Insights into a less-studied area of the literature

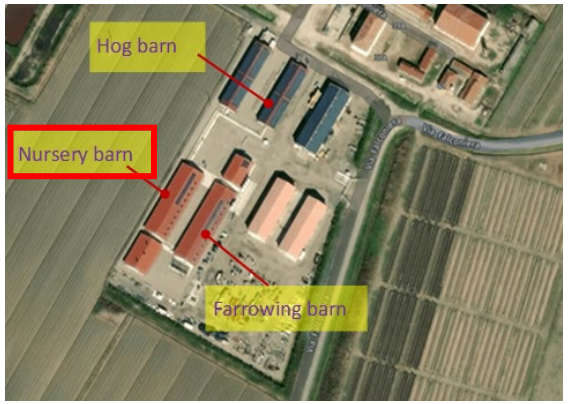
Introduction (2/2)

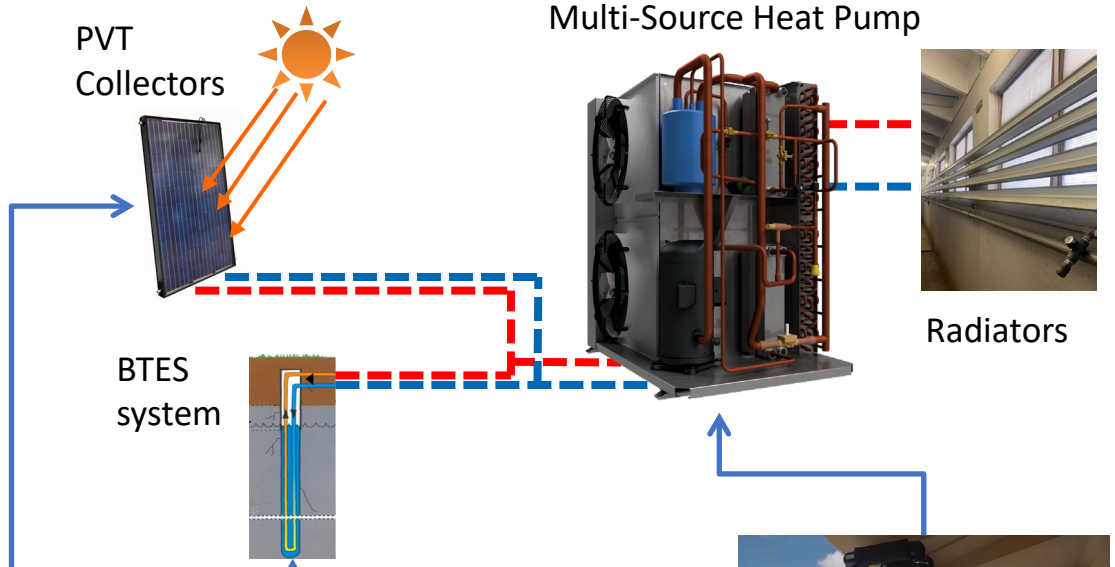
Case Study

- GOLINELLI pig farm Modena province (northern Italy)
- Consists of a farrowing, a nursery, a gestation and a hog barn with gestation sector

Interventions in nursery barn (13,500 weaners annually)

- Multi-Source Heat pump (HP)
- Photovoltaic-Thermal Collectors (PVT)
- Borehole Therma Energy Storage (BTES) system
- Smart control





Objectives (1/1)

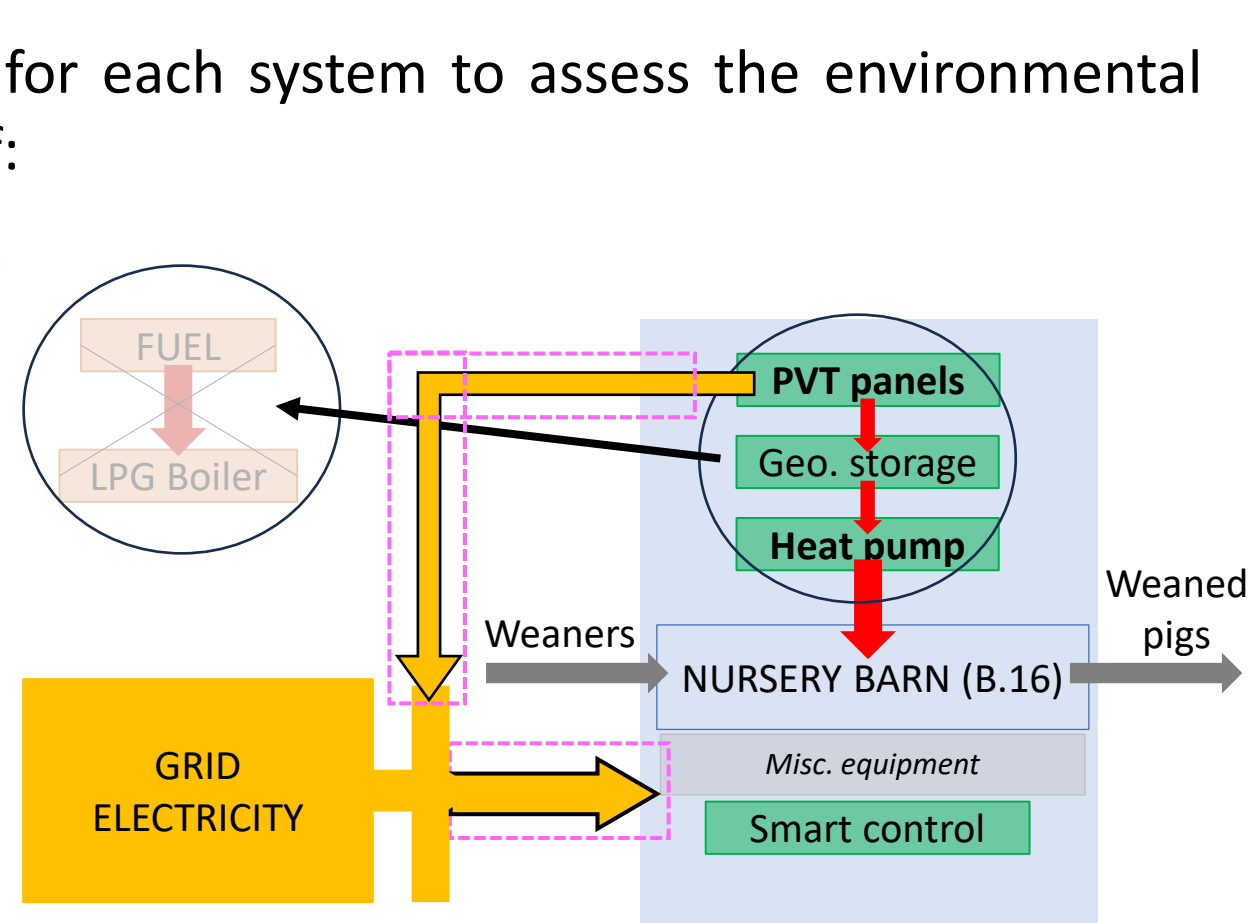
- Assess the **environmental performance an innovative energy system** deployed at a commercial swine farm in Italy
- Applying the **Environmental Life Cycle Assessment (eLCA) methodology**
- **Highly focused on the integrated RES system components:**
  - Multi-Source HP
  - BTES
  - PVT system
- Estimate the environmental performance using **indicators in accordance with EU-PEF 3.1 method**

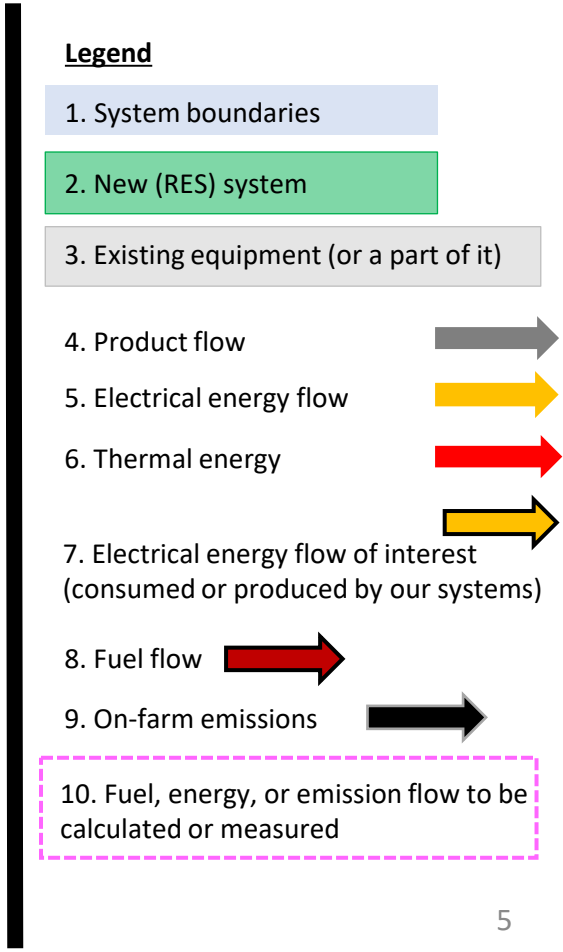
Materials and Methods (1/3)

System Boundaries and Functional Unit

- Cradle-to-farm-gate eLCA with functional unit 1 kg of weaned piglets at the gate of the nursery barn.
- The inventory created for each system to assess the environmental impact contributions of:

i. Raw materials extraction and transformation
ii. Assembly
iii. Transportation and installation to the farm





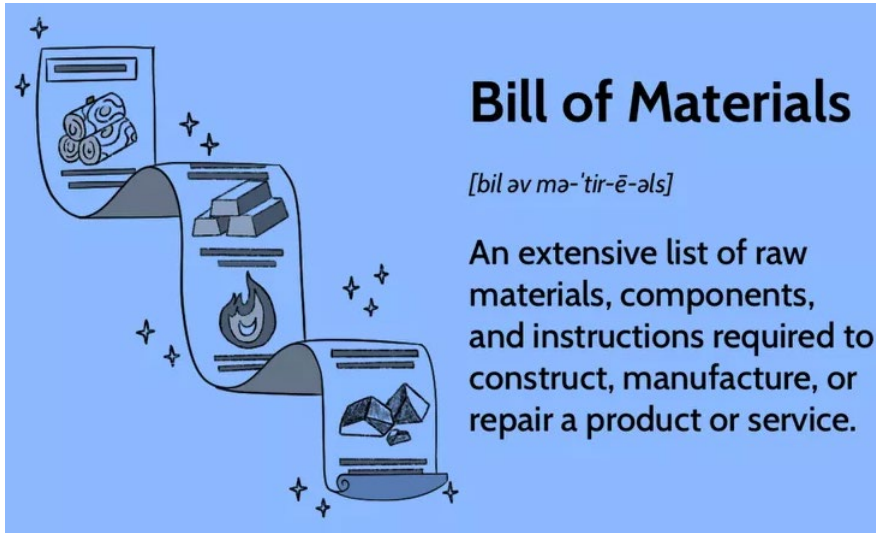
Materials and Methods (2/3)

Modelling Approach

- Development of the **LCA models in SimaPro software** (version 9.5PhD)

- Use of **attributional modeling approach** to estimate the environmental burden of the integrated RES system per kg of weaned piglets

- Elaboration of a detailed Bill of Materials (BoM) and relevant data processing for inventorying the RES technologies installed on GOLINELLI farm.



Materials and Methods (3/3)

Development of LCA Models – BOM-based Inventory Analysis for RES Technologies

Heat Pump

Resources			
Materials/fuels			
Reinforcing steel {GLO}| market for reinforcing steel | Cut-off, U	65	kg	Housing of heat pump
Metal working, average for steel product manufacturing {RER}| metal working, average for steel product manufacturing | Cut-off, U	65	kg	Housing of heat pump
Cast iron {GLO}| market for cast iron | Cut-off, U	48.8	kg	Digital Scroll Compressor
Steel, chromium steel 18/8 {GLO}| market for steel, chromium steel 18/8 | Cut-off, U	10.37	kg	Digital Scroll Compressor
Polyphenylene sulfide {GLO}| market for polyphenylene sulfide | Cut-off, U	1.22	kg	Digital Scroll Compressor
Steel, unalloyed {GLO}| market for steel, unalloyed | Cut-off, U	0.61	kg	Digital Scroll Compressor
Refrigerant R134a {GLO}| market for refrigerant R134a | Cut-off, U	3.64	kg	Digital Scroll Compressor
Refrigerant R125 {GLO-CN}| market for refrigerant R125 | Cut-off, U	1.75	kg	Digital Scroll Compressor
Refrigerant R32 {GLO-CN}| market for refrigerant R32 | Cut-off, U	2.24	kg	Digital Scroll Compressor
Lubricating oil {RoW}| market for lubricating oil | Cut-off, U	3.175	kg	Digital Scroll Compressor
Electricity/heat			
Electricity, medium voltage {IT}| market for electricity, medium voltage | Cut-off, U	83.76	kWh	For digital scroll compressor
Electricity, medium voltage {IT}| market for electricity, medium voltage | Cut-off, U	5.833	MJ	For evaporator (HEX)
Electricity, medium voltage {IT}| market for electricity, medium voltage | Cut-off, U	0.709	MJ	For evaporator (HEX)
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off, U	5.833	MJ	For evaporator (HEX)

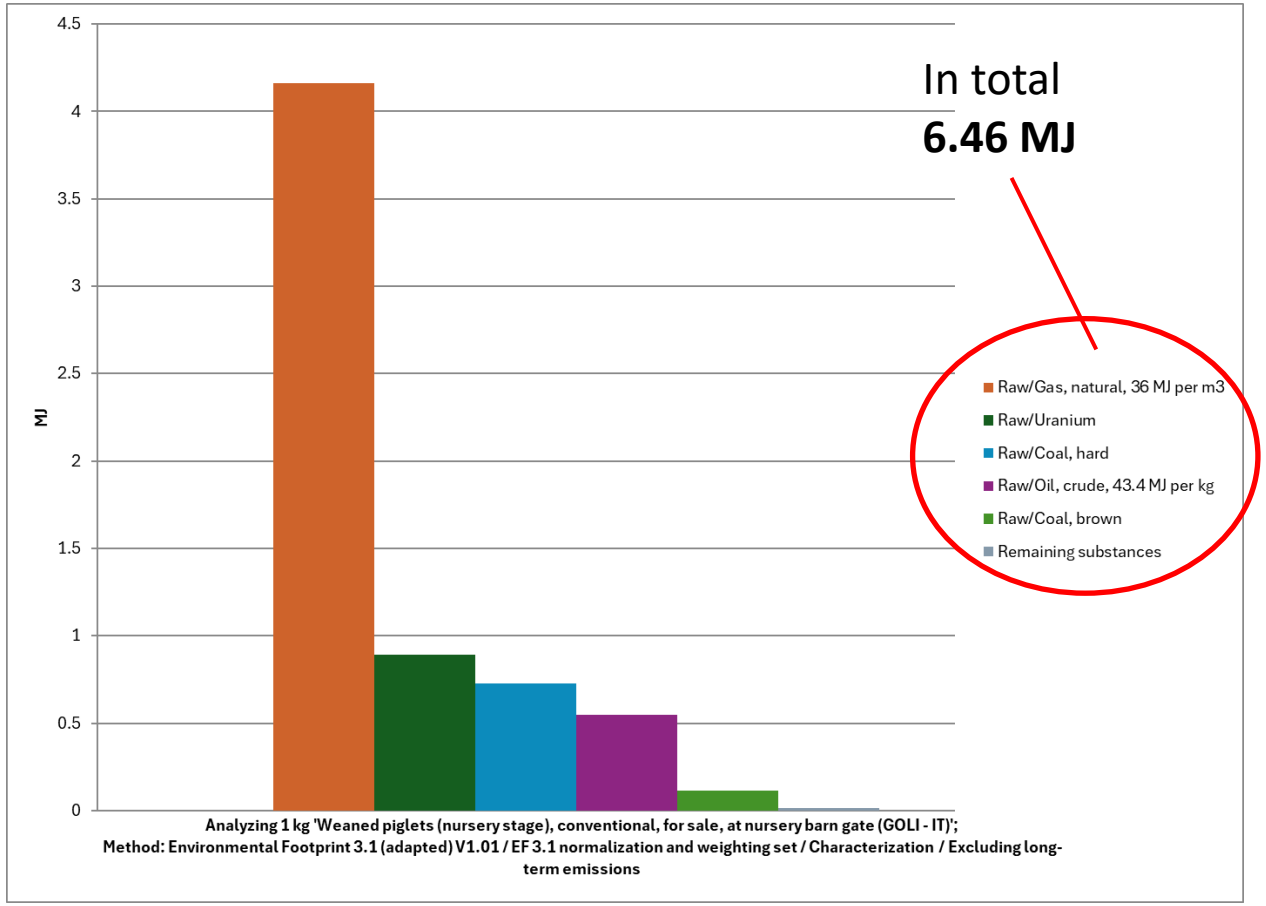
Data sources, for both materials and processes

1. Technology developers
2. Manufacturers
3. PhD theses/ journal articles

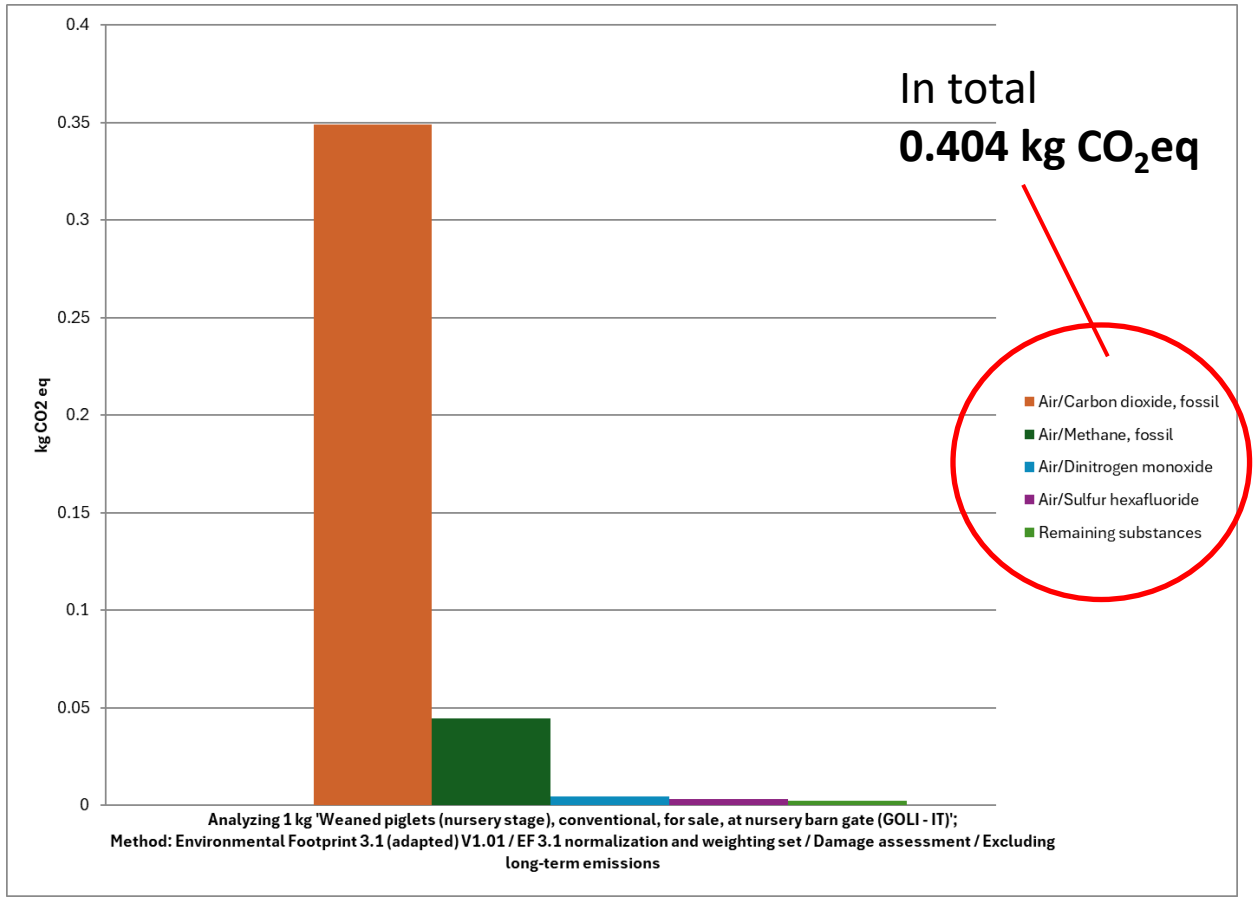
Results (1/4)

e-LCA Results before Interventions - Electricity

Impacts in terms of Resource Use, Fossil (RUF) and Climate Change (CC) - Annual per kg of weaned piglets



RUF due to electricity input - before

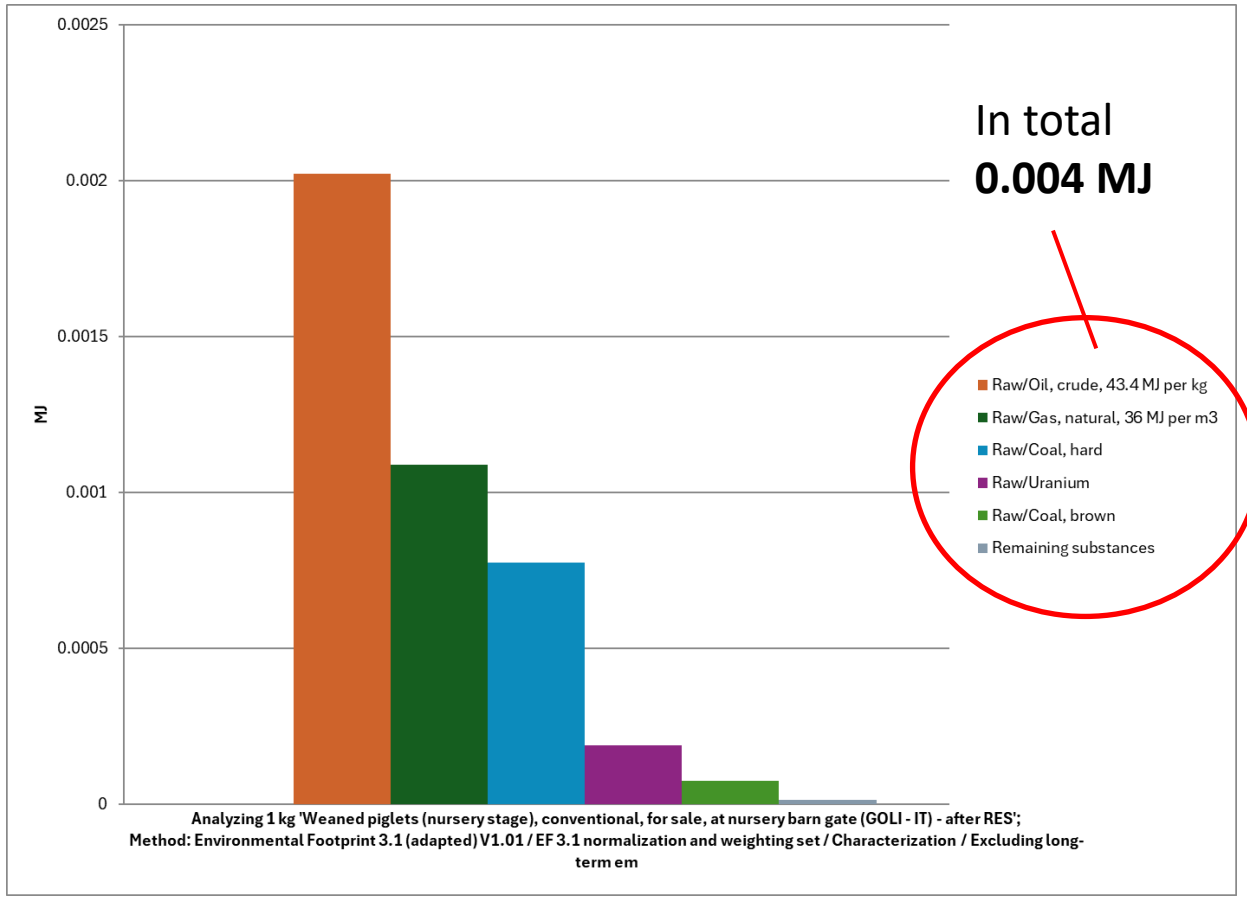


GHG emissions due to electricity input - before

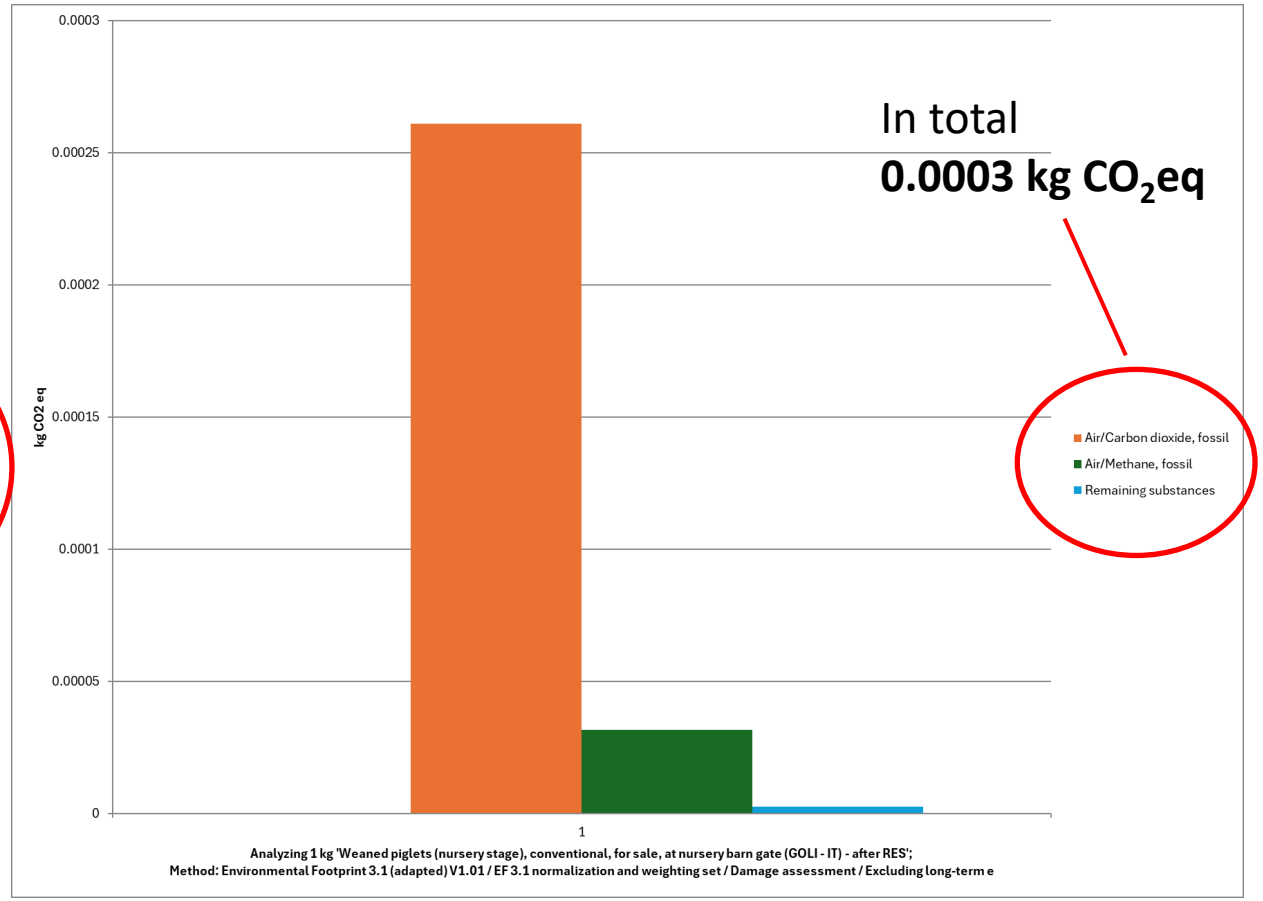
Results (2/4)

e-LCA Results for the Installed RES Technologies – Borehole Thermal Energy Storage

Impacts in terms of Resource Use, Fossil (RUF) and Climate Change (CC) - Annual per kg of weaned piglets



RUF – BTES input

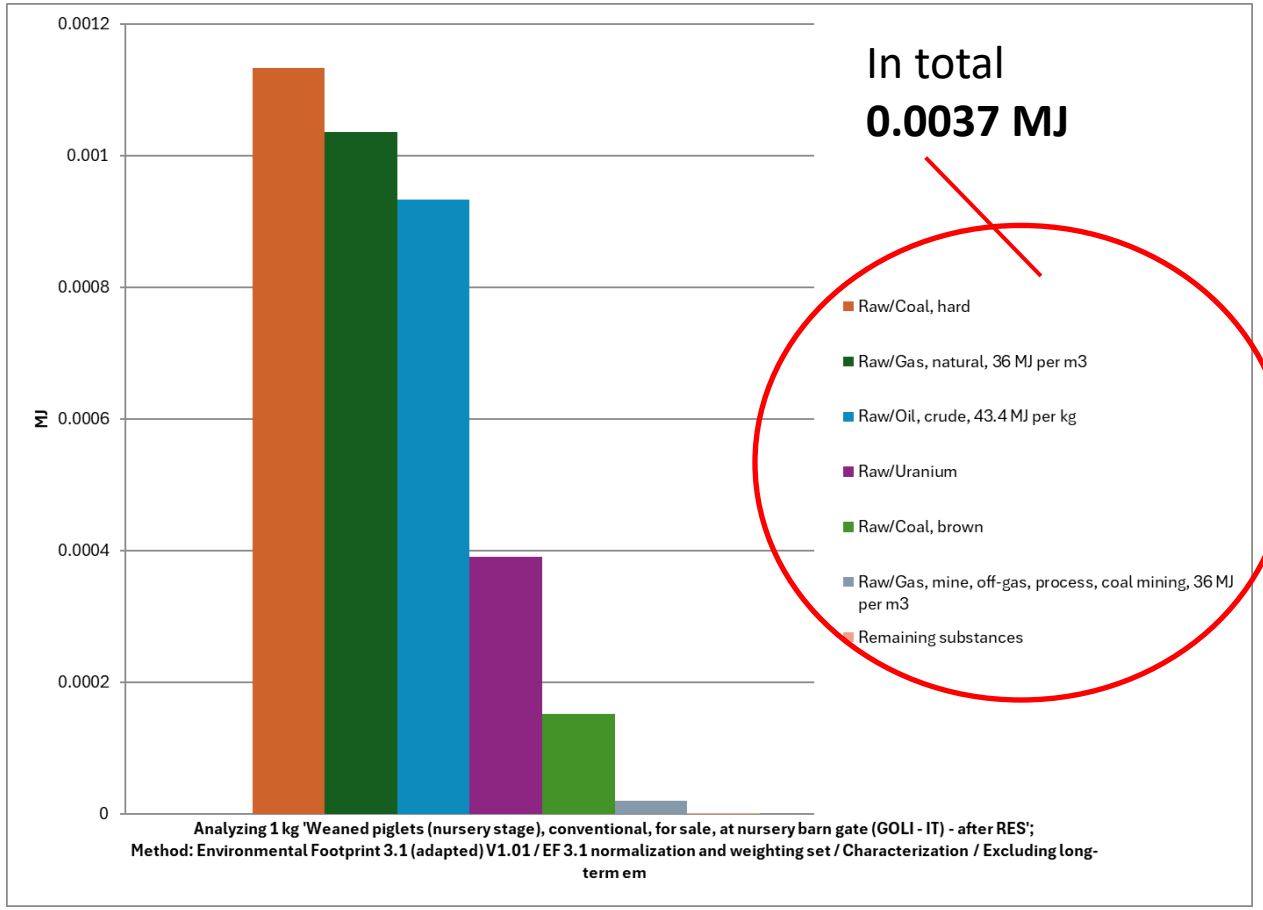


GHG emissions – BTES input

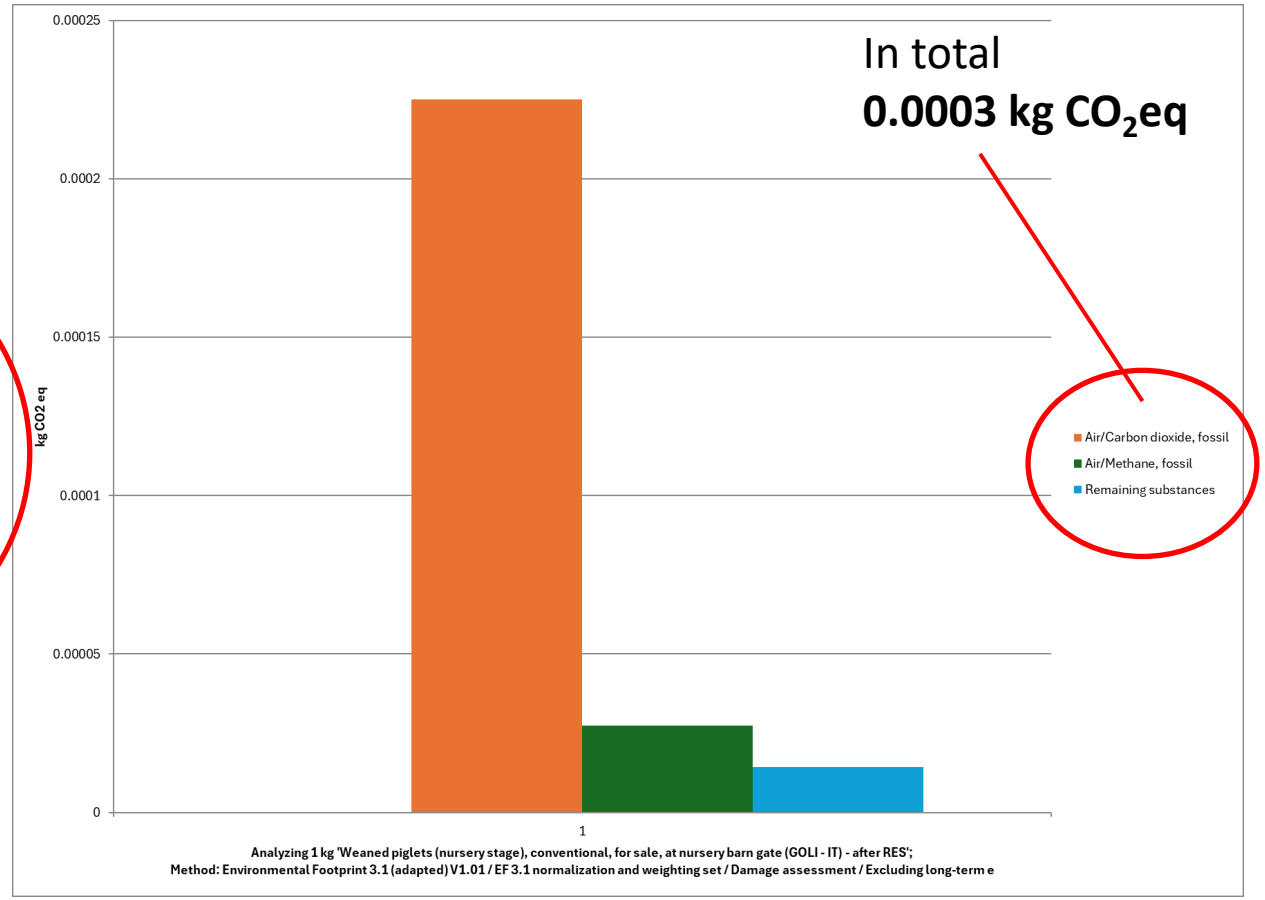
Results (3/4)

e-LCA Results for the Installed RES Technologies – Multi-Source Heat Pump

Impacts in terms of Resource Use, Fossil (RUF) and Climate Change (CC) - Annual per kg of weaned piglets



RUF – HP input

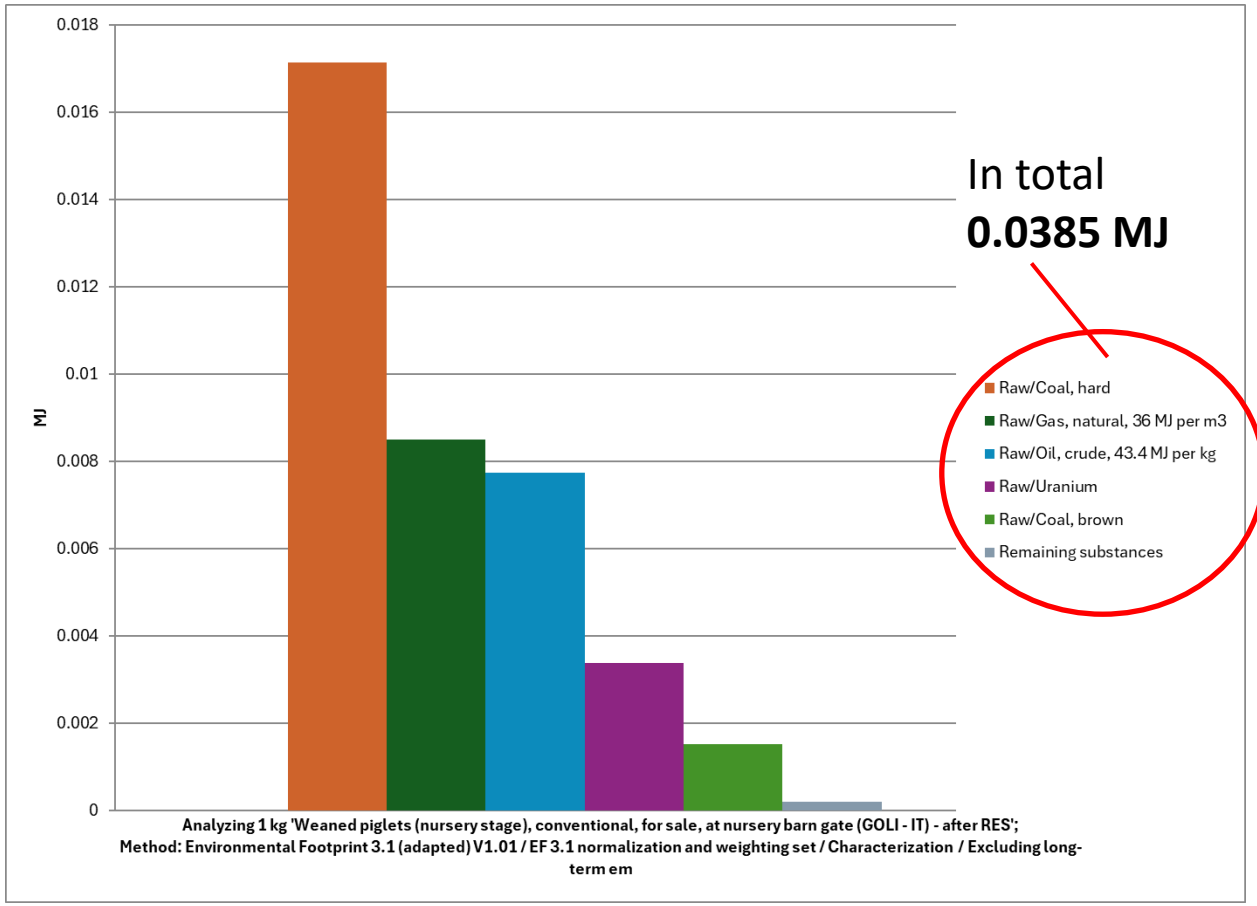


GHG emissions – HP input

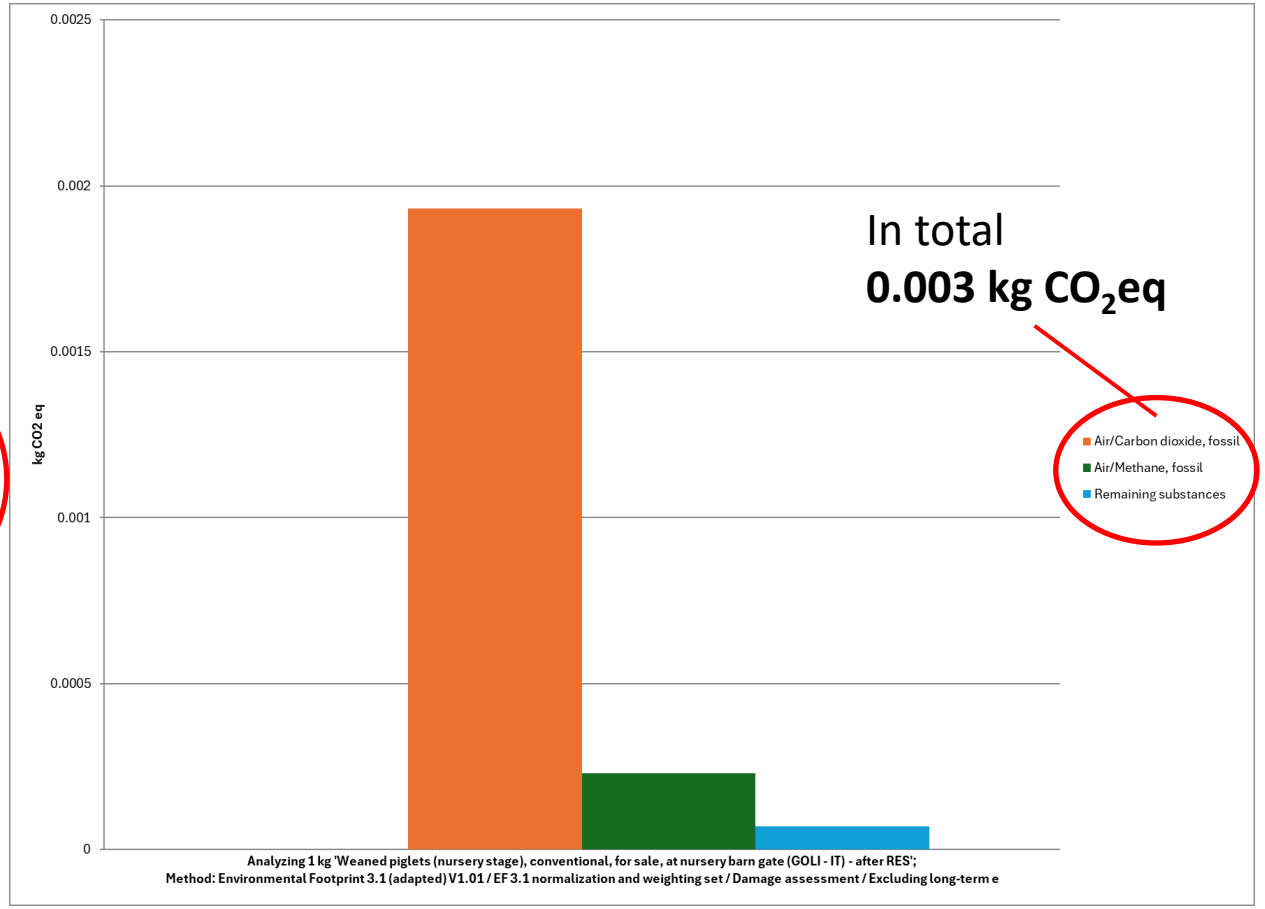
Results (4/4)

e-LCA Results for the Installed RES Technologies – PVT System

Impacts in terms of Resource Use, Fossil (RUF) and Climate Change (CC) - Annual per kg of weaned piglets



RUF – PVT input



GHG emissions – PVT input

Conclusions (1/2)

The **use of fossil fuels (RUF)** and **climate change (CC)** were identified within the impact categories connected with higher indicator estimates per kg of weaned piglets at the farm gate for all technologies:

Technology	Impact Category	Component (Contribution)
BTES	RUF	High-density polyethylene (33%)
	CC	Cement (23%)
HP	RUF	Aluminium (24%)
	CC	Aluminium (26.4)
PVT	RUF	Solar panels and mounting system (69%)
	CC	Solar panels and mounting system (68.6%)

Conclusions (2/2)

- The RES equipment contributes very low to the annual environmental footprint of weaned piglet at the nursery barn gate in comparison to the GHG emissions from the electricity input before the installation of these technologies

- These results will be used to investigate the potential environmental performance improvement of weaned piglet production which is associated with the installation and operation of this integrated RES system

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THANK YOU FOR YOUR ATTENTION

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