MG Sustainable Engineering

Evaluation of a solar photovoltaic thermal (PVT) system in a dairy farm in Germany

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Introduction

Livestock farms are a major contributor to CO_2 emissions. The use of renewable energy sources (RES) is a important step in order to mitigate emissions from the farms [1]. This study develops and evaluates a market integrated, cost-effective and case sensitive RES solutions for livestock farms. For this purpose, the dairy farm at LVAT-ATB in Germany (includes three barns for milk production with a total area of 3950 m²) was considered. A solar Photovoltaic thermal (PVT) system is designed in order to most effectively use the heat recovery of the milk coolers and to use the thermal heat from the PVT system to lift the inlet temperature of E-Boiler and reduce grid electricity consumption. The performance and monthly thermal output of designed PVT system is evaluated using two different collectors (Solarus and Dual Sun). A preliminary analysis was performed in order to obtain an indication on PVT collector selection highly suitable for livestock farms.

Livestock farming: recent trends, future prospects

Problem Statement:

- Fossil fuel use in the agricultural domain has negative effects becoming a major source of greenhouse gas (GHG) emissions, with significant contributions to global climate change and the risk of food security.
- The main energy demands in dairy farms include electricity for pumps, refrigeration, storage, control, separation, lighting and thermal energy for pasteurization, evaporation, drying, cleaning.

Future Prospects:

- With declining costs and improvement of reliability and performance of key RES technologies, the opportunities for farmers to engage in RES production are increasing.
- In situations where area is limited and particularly for both heat and electricity production **PVT collectors** provide an attractive option and can be installed on rooftops without occupying agricultural land.

RES4LIVE
ENERGY SMART LIVESTOCK FARMING
TOWARDS ZERO FOSSIL FUEL CONSUMPTION

- The strategic objective of RES4LIVE is to develop and bring into the market integrated, cost-effective and case sensitive RES solutions towards achieving fossil-free livestock farming.
- RES4LIVE is adapting and testing promising RES technologies in energy-intensive livestock farming (swine, dairy and poultry) for greatly reducing the fossil energy that is the main source to cover the energy demand.

Dairy farm at LVAT-ATB in Germany

- 3 barns for milk production
- Total barn area of 3950 m² ,Overall number of 445 cows and calves
  - Barn **A** houses 150 cows on an area of 2240 m²
  - Barn **B** houses 70 cows on an area of 630 m²
  - Barn **C** houses 140 cows on an area of 1080 m²

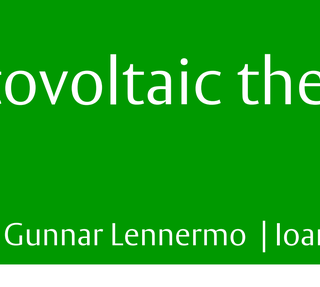


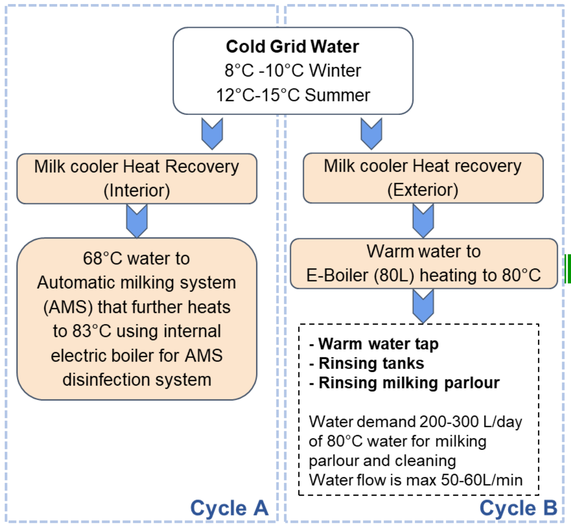
Figure 1. Dairy farm at LVAT-ATB in Germany

- Overall, the farm has an electricity consumption of about 201000 kWh/year for the milk production. The cows are milked with automatic milking systems (AMS), consuming electricity of 152 kWh/day.
- For heating the working areas related to milk production, the farm has a LPG consumption on average of 30000 kWh/year.

PVT solar collector

Brand	PVT Specifications			Thermal Specifications		
	Cell Type	Power Peak [W]	Eff. [%]	η_0	a_1 [W/m².k]	a_2 [W/m².k²]
Solarus	Mono	270	10	0.47	4.05	0.003
Dual Sun	Mono	280	17.2	0.472	9.1	0

Current situation of LVAT-ATB



Thermal & Electricity demand

Total estimated annual thermal energy demand at LVAT-ATB for cycle A and B is 52197 kWh (annual thermal energy demand of cycle A and cycle B in LVAT-ATB are 9249 and 42930 kWh, respectively).

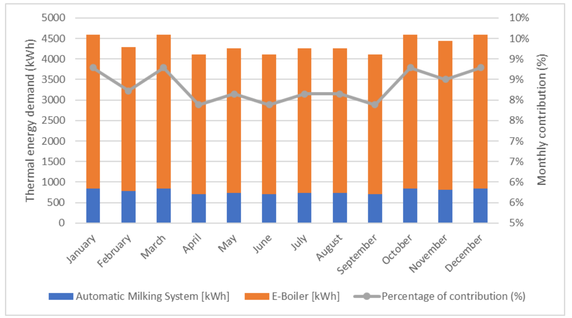


Figure 2. Estimated thermal energy demand breakdown and percentage of contribution to annual demand at LVAT-ATB in Germany.

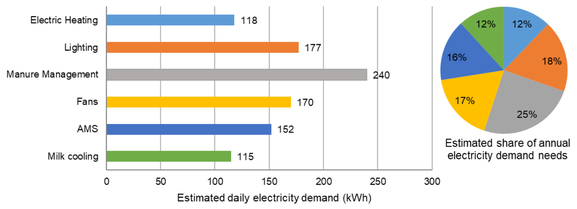
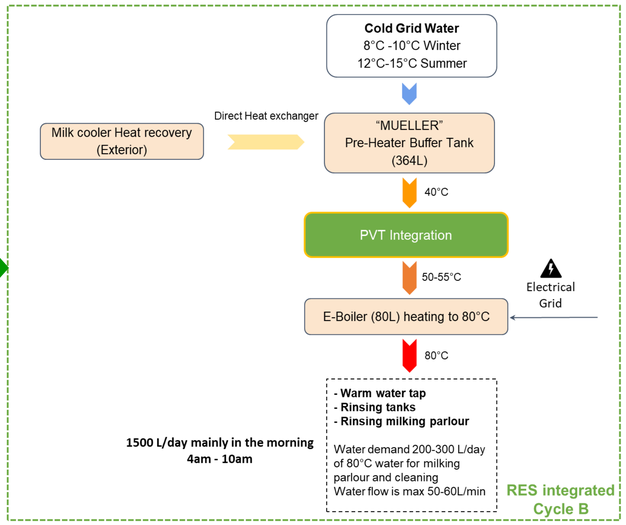


Figure 3. Estimated daily electricity demand breakdown and percentage of annual electricity demand for each application at LVAT-ATB in Germany.

RES solution for LVAT-ATB



Solarus CPVT collector for LVAT-ATB in Germany

- The **Solarus CPVT** is recommended as the LVAT farm requires the high temperature heat and concentrating PVTs having higher efficiencies at higher operating temperatures than flat plate PVTs (such as Dual Sun).
- Total annual thermal production of **Solarus CPVT** is 15058 kWh (at collector mean temperature of 45°C and total aperture area of 40m²)

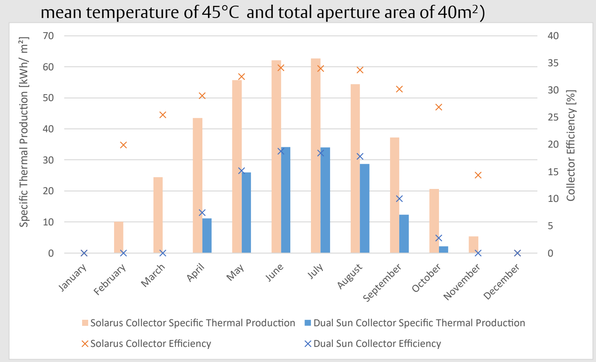


Figure 4. Specific thermal production and collector efficiency at collector mean temperature of 45°C (Inlet=40 °C and outlet=50°C) for total aperture area of 40 m²

References

1. Dubois, O, et al. Energy Access: Food and Agriculture. State of Electricity Access Report. Washington, DC: World Bank Group, 2017.

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