MG Sustainable Engineering AB, Sweden

Evaluation of solar concentrating photovoltaic thermal collectors (CPVT) on a dairy and swine farm in Europe

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Introduction

Livestock farms are a major contributor to CO2 emissions. The use of renewable energy sources (RES) is an important step in order to mitigate emissions from the farms [1]. One of the most energy consuming sub-sectors of agriculture is intensive livestock that is mainly based on fossil fuels use representing about 45% of the total energy demand in the agricultural sector [2]. With declining costs and improvement of reliability and performance of key RES technologies, the opportunities for farmers to engage in RES production are increasing. This study develops and evaluates market integrated, cost-effective and case sensitive RES solutions for livestock farms. The dairy farm at LVAT-ATB in Potsdam, Germany (three barns for milk production with a total area of 3950 m² and a total of 445 cows and calves) was considered, as well as the swine farm at ILVO in Melle, Belgium (barn area of 2500 m² accommodating 105 sows, 600 piglets and 750 fattening pigs. A solar system using concentrating photovoltaic thermal (CPVT) collectors is designed tailored to the dairy and swine farm to best make use of the solar energy in cooperation with other RES technologies and the specific heat demand of the farm. The performance and monthly thermal output of the Solarus CPVT collector is evaluated to perform a preliminary analysis to suggest a suitable integration point for the solar system, each for the dairy and swine case studies.

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.

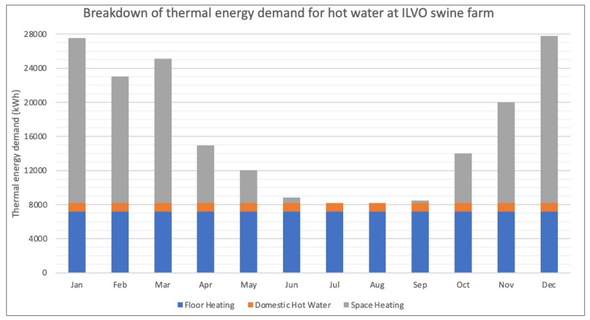
CPVT solar collector

CPVT is a concentrating, hybrid solar photovoltaic and solar thermal collector which generates both electricity (from PV) and heat (from the Thermal part) from the same gross area.

Solarus PC2S CPVT Collector							
Size [m²]		PV Specifications			Thermal Specifications		
Gross	Aperture	Cell Type	Power Peak [W]	Eff. [%]	η_0	a_1 [W/m².k]	a_2 [W/m².k²]
2.57	2.31	Mono	260	10	0.47	4.05	0.003

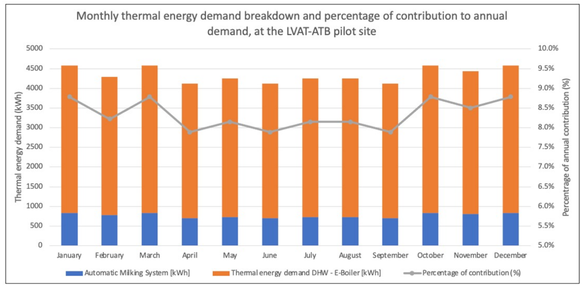
ILVO Swine Farm in Belgium

Heating at the ILVO swine farm is currently provided year-round by a 60 kW gas boiler with a LPG energy consumption of 220 MWh/year. Floor heating is constant at 86400 kWh/year. Domestic hot water is on average over the year constant at 11904 kWh/year. Space heating fluctuates based on the outdoor temperature. The overall average electricity demand of the farm is 110 MWh/year. The main electricity consumers are thermal lamps and ventilators.



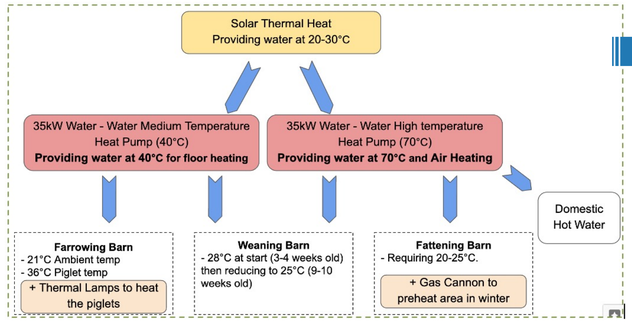
LVAT-ATB Dairy Farm in Germany

Total estimated annual thermal energy demand for milk production at LVAT-ATB is 52197 kWh. 9249 kWh is for the AMS and 42930 kWh for domestic hot water and cleaning of the milk tanks and milking parlour. Overall, the farm has an electricity consumption of about 201 MWh/year for the milk production.



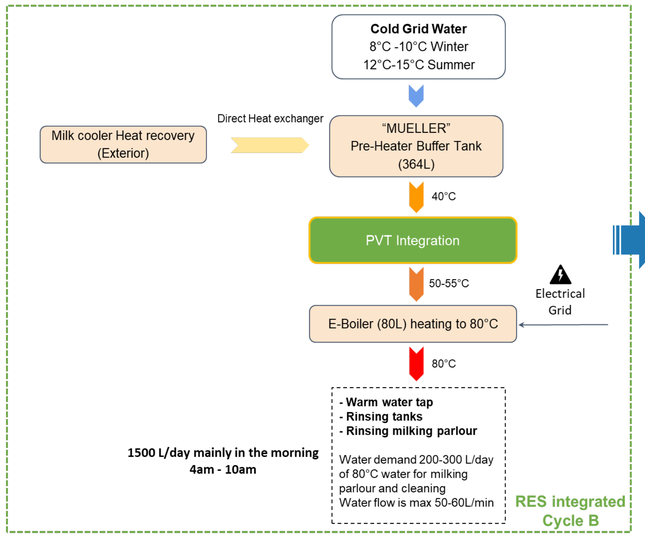
RES integration solution for ILVO

In order to meet the total annual demand for heating (70°C) at the ILVO farm using the Solarus CPVT collectors, at least 480 m² of collector aperture area is needed. The drawbacks would be high cost of collectors and seasonal storage, as heat is produced mainly in summer but needed in winter. To avoid this complexity and make use of the higher efficiency of the collectors when operating at low temperatures, it is suggested to integrate the solar collectors with heat pumps, lifting their COP. Two heat pumps at different temperatures are suggested target the specific demand.



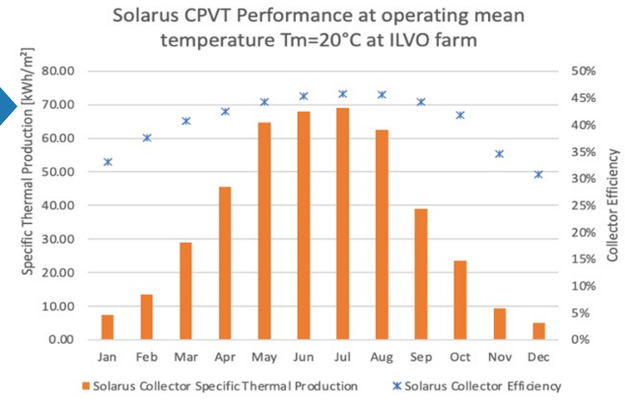
RES integration solution for LVAT

A unique feature in dairy farms in terms of energy is that they use a milk cooler in order to store the produced milk until it leaves the farm. At LVAT, there are two milk coolers, each with a heat recovery system. One supplies heat to the automatic milking system (AMS), the other to the e-boiler for hot water usage. In order to most effectively use the heat recovery of the milk coolers and reduce the electricity consumption of the e-boiler, it was decided to integrate the solar system between them supplying a temperature increase of 10-15°C before the e-boiler.



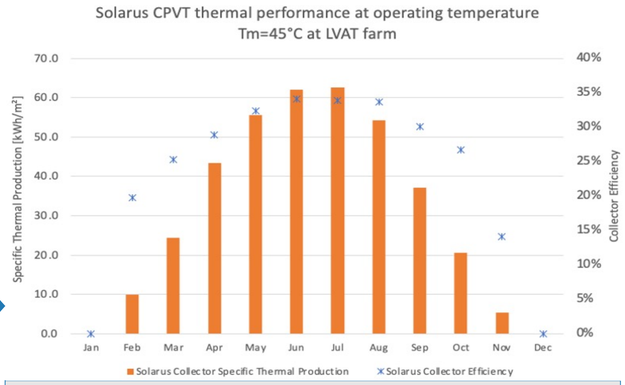
CPVT Performance at ILVO

- The annual thermal output of the Solarus CPVT at ILVO with mean temperature of 20°C is 436 kWh/m². An area of 50m² would produce 21806 kWh, 11% of the thermal demand of the farm.
- The specific annual electrical output is 111 kWh/m² and 5539 kWh/year with an area of 50m².



CPVT Performance at LVAT

- The annual thermal output of the Solarus CPVT at LVAT with mean temperature of 45°C is 375 kWh/m². An area of 50m² would produce 18773 kWh, 36% of the thermal demand for milk production.
- The specific annual electrical output is 142 kWh/m² and 7094 kWh/year with an area of 50m².



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2. Dumont B, Dupraz P, Sabatier R, Donnars C. A collective scientific assessment of the roles, impacts, and services associated with livestock production systems in Europe. Fourrages, Association Française pour la Production Fourragère, 2017, pp. 63-76.

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ILVO Flanders Research Institute for Agriculture, Fisheries and Food
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