First-year real monitoring results for a hybrid solar collectors heat pump system (PVT-HP) providing a single-family house heating and domestic hot water demands in a cold region in France

Summary

The abstract proposed herein presents and discusses the first-year real monitoring results for a solar assisted heat pump including hybrid solar collectors (PVT). The heat pump was installed in February 2025 in replacement of an oil boiler to provide both heating and domestic hot water demands of a single-family house located in one of the coldest regions in France. The results show that thermal comfort has been ensured even by -10°C outside without any activation of the backup electric heater (100% thermal coverage of the heat pump). The annual performance factor was 3,19 for this first year of operation. This factor is raised to 4,17 thanks to the solar photovoltaic production which is directly consumed by the heat pump. A quick economical study proves that the energy bill of the house was divided by more than 3 thanks to this innovative solution.

Keywords: hybrid solar collectors heat pump, energy efficiency, real monitoring results

Field of application for the findings: Sustainable Heating and Cooling Systems for Buildings

1. Introduction

Given nowadays environmental challenges in which more than 20% thermal domestic use is responsible, it is more than important to find and develop environment-friendly and energy-efficient solutions that ensure thermal comfort in buildings. Also, in accordance with European Union directives, the fossil fuel heating systems must be replaced by renewable energy driven systems. This must be done in parallel with building energy use reduction.

In this context, heat pump systems are an extremely good option. Many configurations exist according mainly to the heat source of the heat pump. Recently, an interesting heat pump solution has emerged: hybrid Photovoltaic Thermal (PVT) solar collectors heat pump system. This solution is interesting since the PVT collectors produce both electricity and heat, both needed by the heat pump to operate (Jaafar et al., 2022) (Chhugani et al., 2023) (Beltrán and Sommerfeldt, 2026).

The present abstract presents and discusses the first year results of monitoring of a PVT heat pump installed in a single-family house in the North-East of France. This work will be very valuable for the Task 73 about the PVT Heating Systems of the International Energy Agency.

2. System description

The thermal system studied herein is a direct combination of hybrid Photovoltaic Thermal (PVT) solar collectors and a brine to water heat pump (HP). The system provides both heating and domestic hot water needs of a single-family house of 100m2 constructed in 2000 and located in the Vosges department in the East North region of France. The location height is 325m above sea level and the reference temperature is -15°C.

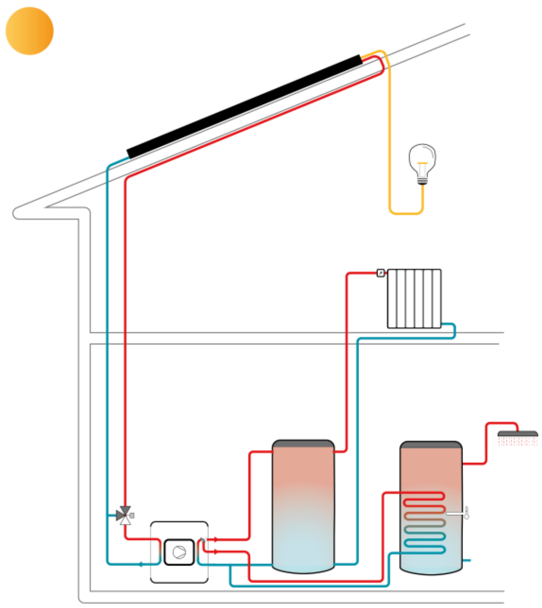

Fig. 1: the hydraulic principle of the PVT-HP system

The hydraulic schema is presented in the following figure. The only heat source of the evaporator of the HP is the PVT installed on the house roof, which absorb the heat in both ambient air (day and night) and sunlight (day). The heat is then transferred to the evaporator of the HP by the antifreeze heat transfer fluid. The mixing valve installed between the outlet of the PVT and the inlet of the evaporator is needed to make sure the temperature driven to the evaporator is not too hot. The setpoint of the mixing valve depends on the maximum temperature limit acceptable to the evaporator of the HP. The HP rises the low-temperature energy caught by its evaporator thanks to its refrigeration cycle and the gas-compressor. The high-temperature energy is then released by the HP condenser. The hydraulic configuration consists of two hot water tanks: one of 185 l providing the domestic hot water circuit and another of 100 l providing the heating circuit of average temperature radiators. The heat pump has a thermal power of 9,6 kW B0/W35. Fifteen PVT solar collector are installed on the house roof according to the following configuration: 10 PVT are oriented to the South and 5 PVT are oriented to the West. The used solar collector has a 1,95 m2 of total surface and is specifically developed to be the only heat source of a heat pump. It has fins on its backside to improve the heat transfer with ambient air during cold time. The peak power of each solar collector is 425 Wp. It has the following thermal coefficients according to Solar Keymark test:

Coefficient	Description and [unit]	Value
$\eta_{0,b}$	Optical efficiency [-]	0,38
a1	Heat loss coefficient [W/m²K]	37,44
a3	Wind dependence heat loss coefficient [J/m³K]	7,31
a5	collector capacity [kJ/m²K]	29,46
a6	Wind dependence conversion factor [s/m]	0,046

3. Results

The study shows the potential of the PVT-HP solution to provide thermal needs of buildings with high performance even in cold regions.

The first indicator studied was the thermal comfort in the building. The indoor room temperature was measured for the whole cold season. Figure 2 shows the distribution of the difference between this measured temperature and the setpoint indoor temperature which is variable between day and night. This figure shows that the thermal comfort of the house was fully ensured since only 1% of the measured temperature is less than the setpoint indoor temperature reduced by 1 K – the hysteresis of the heat pump.

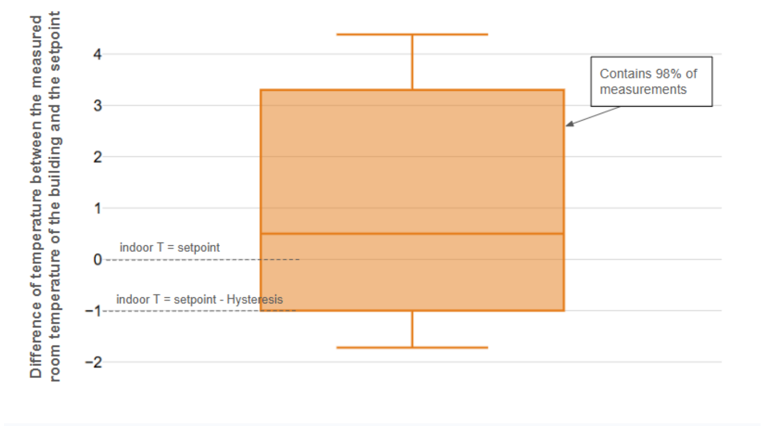

Fig. 2: Distribution of the temperature difference between the measured indoor room and the setpoint

The energy balances are estimated for each month and presented in figure 3. The performance factor is then calculated using the following equation:

$$Performance\ Factor = \frac{(HP\ Thermal\ production) - (Energy\ used\ for\ PVT\ defrosting)}{(HP\ electric\ consumption) + (Electric\ backup\ electric\ consumption)} \qquad \text{(eq. 1)}$$

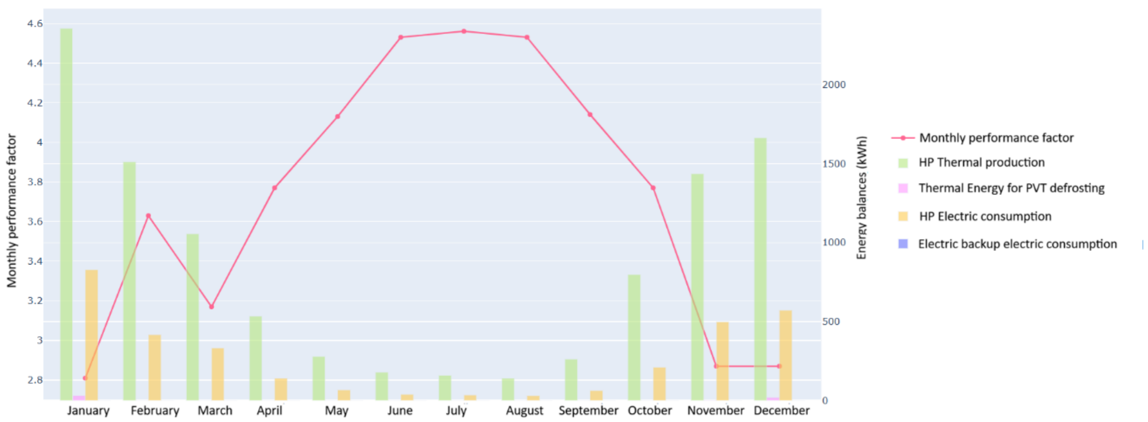

Fig. 3: Monthly energy balances and performance factor

The main findings of this figure are that the electric backup heater was not activated even in coldest months and that the PVT needed a very low heat to defrosted overall the year (less than 1% of the total produced heat is consumed for the PVT defrosting). Both elements explain the very good performance of the solution: the minimum calculated performance factor is 2.8 for the month of January.

More results including the PV production and a detailed analysis of the heat pump operation will be added in the article.

4. References

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