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Novel approach for heating/cooling systems for buildings based on photovoltaic-heat pump: concept and evaluation

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Abstract

The paper presents the complete results regarding the energy performance and reliability of a new heating/cooling system designed and developed around an economic and ecological concept: self-consume a maximum amount of energy produced by solar photovoltaic panels. To achieve this goal, a unique regulation system which takes advantage of each kW produced by the PV system was developed and implemented. This technology, compared to a conventional system, increases the performance coefficient for the HP, as well as for the overall installation. These improvements are justified by the accurate regulation of different components of the installation - power modulation of the HP and circulation pumps- and by use of photovoltaic panels allowing a reduction of the electrical energy consumed from the grid.
To quantify the contribution of the new system, the energy efficiency was established for the 2 cases: with and without solar PV panels. The results indicate that new system provides a significant gain in performance. This new technology, HP directly driven by PV, produces significant annual improvement compared with a conventional heating system, HP, of 22%.

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Keywords: heat pump; photovoltaic panel; storage; solar heating system; solar cooling system; artificial intelligence; regulation; energy production; solar energy; simulation; *economics*

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1. Introduction

Main actual challenges currently in the energy field are energy efficiency and energy dependence reduction to the grid. The current project uses a smart regulation to manage photovoltaic production, heat pump, storage management and thermal needs. This concept, based on the self-consumption, has been monitored on a pilot installation. Thanks to the monitored data, the energy efficiency of the pilot installation will be quantified and qualified.

Nomenclature

SC	Solar contribution	[%]
Q_h	Heat production by the heat pump (HP)	[J]
Q_{DHW}	Heat delivered to the domestic hot water (DHW) by the HP	[J]
Q_c	Cold source to the HP	[J]
$P_{el,HP}$	Electricity power consumed by the HP	[W]
$P_{el,PV}$	Electricity power provided by the photovoltaic panels	[W]
$P_{el,HPx}$	Electricity power consumed by the pumps of the heat pumps circuits	[W]
$P_{el,HS}$	Electricity power consumed by the pump of the geothermal heat poles	[W]
$P_{el,SH}$	Electricity power consumed by the pump of the heating system	[W]

2. Technological concept

Solarline was created on an economic and ecological concept: to self-consume a maximum of the energy produced by solar photovoltaic panels. It is a unique regulation system developed to achieve this goal. It allows to use every single kWh produced by the solar installation. Moreover, the system uses the storage capacity of water tanks to absorb the daily photovoltaic production variations. In water tanks, hot water can be stored as well as cold water for the cooling during summer. Another important point is the modulation of the heat pump power. The power is set to have the best performance and to consume the entire photovoltaic production.

2.1. Global technical installation concept

The technical system is composed of a heat pump, photovoltaic panels, a smart regulation and water tanks (Fig. 1). The heat pump is operated by the photovoltaic panels and the grid.

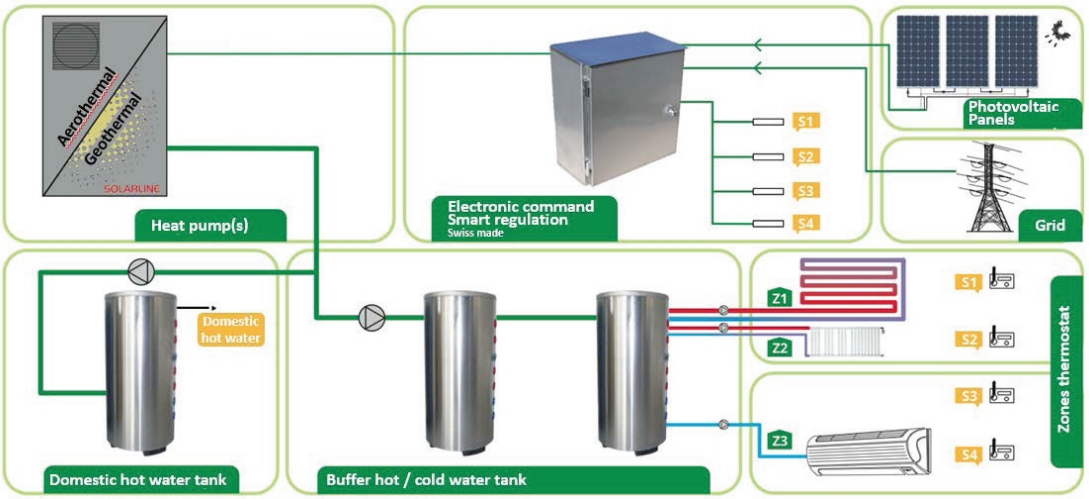

Fig. 1: Global technical system concept of Solarline