Simulation study of a solar residential heating system

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Abstract

The focus of the present research is to study a parametric simulation of a solar heating system. The system consists of vacuum solar panels, a storage tank in tank to provide heating as well as domestic hot water to a regular house. The simulation environment is Transol, a powerful software adapted for many types of solar systems. The results show the solar energy production as a function of different collector surface, accumulation volume, orientation, tilt and also shading. For all the simulations Constanta, Romania's climate is taken into consideration.

1. Introduction

Solar energy has become, in the last decades, the most important Renewable Energy Source (RES) worldwide, along with wind energy and wave energy. The utilization of this solar energy covers nowadays many fields of interest, such as: Domestic Hot Water (DHW) production, space heating, pool heating and even cooling, by means of desiccant systems. Moreover, solar energy could be used for electrical production, such in the case of Photovoltaic (PV) panels mounted within the buildings or used for stand-alone applications. Taking into account their large applicability, solar systems could be divided in two main categories: “solar thermal systems” and “PV systems”, with very different operational principles.

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The total installed capacity worldwide for solar thermal systems reaches about 75 GWth for plane and vacuum-type collectors and about 24 GWth for opaque plastic collectors. In North America (US and Canada) pool heating, with a total installed capacity of 19 GWth, is achieved with opaque plastic collectors, while in China (45 GWth), Europe (11 GWth) and Japan (6 GWth), the plane and vacuum-type collectors are used mainly for DHW production and heating purposes [13].

The global situation of solar market volume shows that Germany acts as the main leader, covering about 47% of the European market, followed by Greece (14%), Austria (12%) and Spain (6%). If we judge according to the operational capacity reported to 1000 inhabitants, Cyprus is the European leader, with 480 kWth/1000 inhab., followed by Austria and Greece, with about 200 kWth/1000 inhabit. Regarding the total sales volume, China is largely the worldwide leader, with about 10 million m² area of solar collectors (7 GWth) [2].

At the European level, a good practice example is represented by Austria, a country with a medium-solar potential, but having a good policy of investing and promoting in solar technologies over a long period (20-30 years), that has leaded to a large capacity of energy production for this type of RES.

The European Federation of the Solar Thermal Industry [3] forecasts for 2020 an ambitious goal, meaning a 1 m² of solar collector area per EU inhabitant. This goal is equivalent to a net thermal energy production of 700 kWth/1000 inhabitants or 320 GWth installed thermal capacity.

This goal is considered an average target for most developed EU countries, which have already modern advanced technologies for solar energy use. For the less developed EU countries (as Romania, Bulgaria or Czech Republic) their goal will be to reach 199 kWth/per 1000 inhabitants until 2020 (see table 1).

Table 1: Two scenarios for the solar thermal market until 2020

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<tbody>
<tr>
<td>Austrian scenario (minimum goal)</td>
<td>10,9</td>
<td>91,2</td>
<td>5,6</td>
<td>16 %</td>
</tr>
<tr>
<td>Scenario “1 m² of collector/inhab.”(ambitious goal)</td>
<td>320,4</td>
<td>19,7</td>
<td>31 %</td>
<td>700</td>
</tr>
</tbody>
</table>

All these goals could be achieved only after the implementation of coherent energy and fiscal policies by the EU member states, in order to encourage the rapid development of these products and technologies. This means the following measures to be taken:

- The reduction of administrative and fiscal barriers, and
- Introduction of “solar obligations”, in terms of “best practice technical rules”, helping to correctly design and operation of these systems

2. Materials and methods

2.1. Dynamic simulation in TRANSOL software

Transol is one of the best software for dynamic simulations of solar thermal systems. It has been developed by CSTB and AIGUASOL, and uses applications from TRNSYS. Transol is a common tool for design, and also optimization of solar systems, it has also an economical approach to calculate the payback period. It’s an user friendly software and easy to be used for even inexperienced persons. The software has 35 important configurations and can generate over 200 possible configurations. There is another free software related to Transol which is commonly used only for DHW simulations [4]. There are many other studies that use another well known simulation tools like Matlab/Simulink [5, 10, 11].

There are many possible configurations to be simulated like: domestic hot water production, heating, cooling, pools and industrial processes. One of the most complex system that can be used is the solar system combined with
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