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Citation: *J. Renewable Sustainable Energy* **5**, 041820 (2013); doi: 10.1063/1.4819254

View online: <http://dx.doi.org/10.1063/1.4819254>

View Table of Contents: <http://jrse.aip.org/resource/1/JRSEBH/v5/i4>

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## Maximizing performances of variable tilt flat-plate solar collectors for Belgrade (Serbia)

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(Received 28 January 2013; accepted 12 August 2013; published online 21 August 2013)

In Serbia, for heating of domestic hot water (DHW) it is customary to use electricity. As around 70% of electricity is produced by using low quality coal with high greenhouse emission, it is beneficial to environment to use solar energy by flat-plate solar collectors for heating of DHW in a solar DHW system (SDHWS). The SDHWS with variable tilt flat-plate solar collectors placed in north-south direction at roofs of houses are investigated for their optimal operation in Belgrade, Serbia. The investigated variable-tilt collectors annually take 2 tilts, 4 tilts, and 12 tilts. The used weather data are from the meteorological station. These investigations use three computer codes: EnergyPlus, GenOpt, and Hooke-Jeeves search algorithm. For different solar collectors, the investigations revile their optimum tilts that maximize the solar fraction by the SDHWS. Then, the solar fraction and avoided fossil energy by the SDHWS are maximized. In addition, the deficit in the solar fraction is estimated when the solar collectors are not at their optimum tilt. © 2013 AIP Publishing LLC. [<http://dx.doi.org/10.1063/1.4819254>]

### I. INTRODUCTION

During the first years of the twenty-first century, extensive efforts have been undertaken to alleviate global warming of the earth caused by emission of CO<sub>2</sub> in atmosphere. These emissions are generated by intensive burning of fossil fuels to satisfy the growing energy needs of humanity. The emissions may be mitigated when, instead by fossil fuels, the part of energy needs is satisfied by using non-polluting energy sources such as solar energy. Also, another important advantage of the usage of solar energy is that it does not pollute the environment with nitrogen oxides and sulfur dioxide.

In Serbian households, the high amount of domestic hot water (DHW) is used for shower, tap, cloths-washing, and dish-washing. It is customary to use electricity for heating of DHW. As around 70% of electricity is produced by using low quality coal with high greenhouse emission, it is important and the most rewarding to use solar energy for DHW heating instead of electricity. Accordingly, in Serbia and worldwide, the most rewarding application of solar energy is that it replaces electricity for heating of DHW in households.<sup>1</sup> In addition it is important to have a high efficiency of conversion of solar energy to heat. Then, the highest amount of avoided electricity and avoided fossil energy may be expected.

During its operation, the solar collector in some solar DHW system (SDHWS) has to take the optimal position to generate the highest amount of heat. The solar collector takes the north-south direction. Usually, the solar collector with only one optimal tilt during the year is used in practice, which is called stationary solar collector. Here, the variable tilt flat-plate solar collectors are investigated to enhance performance of stationary solar collectors. The investigated solar collectors are SC#2 (solar collector annually taking 2 tilts), SC#4 (solar collector annually taking 4 tilts), and SC#12 (solar collector annually taking 12 tilts). These tilts should be

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