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• Solar Photovoltaic Systems
• Solar Radiation Measurement and Sun-tracking
• Geothermal Energy Applications
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F O R E W O R D

The Fifth International Scientific Conference "Alternative Energy Sources, Materials & Technologies AESMT'21" was held between 27th and 28th June 2022 in Veliko Tarnovo, Bulgaria. Representatives of 23 countries (Belarus, Brazil, Bulgaria, China, Chile, France, Germany, India, Iran, Israel, Italy, Kazakhstan, Kuwait, Latvia, Poland, Portugal, Romania, Russia, Serbia, Spain, Tajikistan, Turkey, and United Kingdom) sent their works to the conference. Selected reports (63 works) have been published as short papers in the proceeding of the conference.

It is my pleasure to be an editor of the presented short papers, which focus on new international scientific results in the field of Alternative Energy Sources, Materials and Technologies (Solar and Hybrid Thermal Systems, Solar Photovoltaic Systems, Solar Radiation Measurement and Sun-tracking, Geothermal Energy Applications, Phase Change Materials (PCM) Applications, Wind Energy, Biotechnologies, Hydrogen Energy, Ocean/ Tidal Energy, Energy Materials Science, Mechanical Engineering and Technologies, Electrical Engineering, Low-Carbon Technologies, Energy Efficiency).

Prof. Aleksandar Georgiev, DSc (Institute of Chemical Engineering, Bulgarian Academy of Sciences, Sofia, Bulgaria)

Chair of the AESMT'22 conference

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ALTERNATIVE TECHNOLOGIES, Solar and Hybrid Thermal Systems

Application of renewable energy sources in greenhouses

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Greenhouses have significant importance in the field of agriculture and horticulture. A special type of greenhouse is solar greenhouse, which is designed to collect solar energy during sunny days and to store heat for use at night or during periods without the Sun. In this paper it is investigated a solar greenhouse with photovoltaic panels. For greenhouse heating in the winter period and cooling in the summer period, a ground source heat pump was used. Solar greenhouse is simulated in EnergyPlus environment, while Open Studio plug-in in Google SketchUp was used for greenhouse design. Energy analysis was performed with the major aim to minimize greenhouse energy consumption, and to achieve solar greenhouse with net-zero energy consumption. Cases of different solar greenhouse orientations, different photovoltaic slope and different photovoltaic cell efficiency were considered. The simulation results showed that total energy consumption for heating and cooling of the greenhouse can be significantly reduced by using the optimal parameters (orientation and photovoltaic slope angle). Also, by changing the photovoltaics area and by using photovoltaics with higher cell efficiency, a concept of net-zero energy solar greenhouses can be achieved.

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Keywords: Greenhouse, Renewable energy sources, Optimization, Simulation.

INTRODUCTION

Modern agriculture and horticulture today are based on greenhouses. Although agriculture has small share in total energy consumption, significant amount of energy is necessary to greenhouses, so application of renewable energy sources could be of great importance, because it can reduce energy consumption and CO_2 emission.

Special type of greenhouse is solar greenhouse, which uses solar energy with passive or active systems. Active solar greenhouses use photovoltaics for electricity production [1]. Also, geothermal energy can be used in solar greenhouses for greenhouse heating or cooling. Many of scientists have been studying various types of greenhouses with application of solar energy [2-4]. Also, some scientist discussed the using a different heat pumps system in greenhouse [5-8]. If there is possibility for installation of more renewable energy technologies simultaneously in a greenhouse, significant amount of energy can be saved.

This paper shows energy analyses of solar greenhouse located in the city of Kragujevac, which has the great opportunities for agriculture production, due to its good climate. Analyzed solar greenhouse has a photovoltaic system for electricity generation, and ground source heat pump for heating in the winter period and cooling in the summer period. Photovoltaic array is grid connected. The aim of this investigation was to define optimal position of solar greenhouse, optimal slope angle of PV array, and optimal size of photovoltaics. With these parameters, energy consumption can be minimized. Greenhouse is simulated in EnergyPlus software.

MODEL OF GREENHOUSE

Solar greenhouse (Fig.1) is south-oriented, with total area of 150 m^2. It was made with modular elements aluminum and glass.

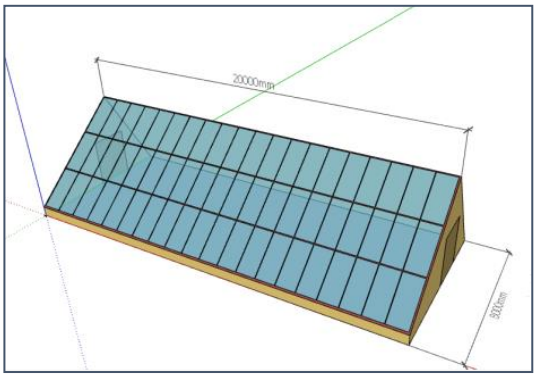

Fig. 1. Solar greenhouse model

Photovoltaics are installed on the ridge of the greenhouse. Ground source heat pump is also installed for greenhouses heating/cooling.

RESULTS AND DISCUSIONS

First, simulation for optimal orientation of solar greenhouse are conducted. Four different orientations are analysed: east-west, 20 º northwest-southeast, 20º northeast-southwest and 40° north–east-southwest. The simulation results show that the optimal orientation of solar greenhouse is the 40º northeast-southwest (Fig.2).

The second part of the investigation was the definition of the optimal slope angle of PV array. With this angle, PV cells will have the greatest electricity production. Solar greenhouse with PV slope angles of 0˚(horizontal modules), 20˚, 30˚, 40º (previous simulations) and 90˚ are analyzed. According to the simulation results, the optimal slope of PV is 30°.

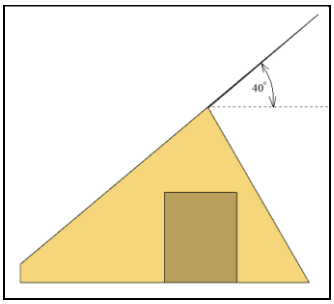

Fig.2. Different slope angle of photovoltaics

For optimal orientation and optimal slope angle, an energy analysis was performed, with PV cell efficiency of 1 %. Tab.1 shows the obtain results for generated energy, net-energy consumption and satisfaction of greenhouse energy needs in solar greenhouse with optimal parameters.

Table 1. Generated energy, net-energy consumption and satisfaction of greenhouse energy needs in solar greenhouse with optimal parameters and different PV cell efficiency

PV cell efficiency	Energy cons.	Generated energy	Net-energy cons.	Gener. electr./tot en. cons.
(%)	GJ	GJ	GJ	%
12	50.2	26.03	24.17	51.85

If PV cell efficiency increase, the larger amount of greenhouse energy needs can be satisfied. The simulations shows that whole energy needs in solar greenhouse with PV array and ground source heat pump can be satisfied with 16 % of PV cell efficiency, and 130 m^2 area of PV array.

CONCLUSIONS

The aim of this research also was to determine the optimal orientation of greenhouse and slope angle of installed PV array. After that, for optimal parameters, through simulation in EnergyPlus software, it is shown that solar greenhouse with ground source heat pump and photovoltaics, can generate enough energy for its own energy needs during one year.

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