Predrag MILANOVIĆ[1], Olivera EĆIM-ĐURIĆ[2],
Miloš JELIĆ[3], Vojislav TOMIĆ[4]

ANALYSIS OF GREENHOUSE HEATING SYSTEM USING GEOTHERMAL ENERGY AND STORAGE TANK

Abstract: This paper analyzes greenhouse heating system using geothermal energy and storage tank and the possibility of utilization of insufficient amount of heat energy from geothermal sources during the periods with low outside air temperatures. Crucial for these analyses is modelling of the necessary energy requirements for greenhouse heating yearly. The results of these analyses enable calculation of storage tank capacity so that the energy efficiency of greenhouse heating system with geothermal energy could be significantly improved.

Key words: *greenhouse, geothermal energy, numerical simulation, heating, storage tank*

1. INTRODUCTION

Application of geothermal energy in agriculture, especially in greenhouses has many advantages: improvement of energy efficiency of the facility, decrease of CO_2 emission by substitution of fossil fuels with renewable energy and establishment of a sustainable food chain. Setting-up the right working parameters in the greenhouse is subject to complex requirements [1,2]. Therefore, in these analyses heat requirements of the greenhouse during the heating period are dynamically described based on data obtained from typical meteorological year for given loca-

[1] Dr Predrag Milanović, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, 11001 Belgrade, Serbia

[2] Dr Olivera Ećim-Đurić, University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade, Serbia

[3] Dr Miloš Jelić, Insitute „Kirilo Savic", Vojvode Stepe 51, 11000 Belgrade

[4] Prof. dr Vojislav Tomić, University of Belgrade, Faculty of Mining and Geology, Đušina 7, 11000 Belgrade, Serbia

tion (Debrc, Serbia) in order to find an optimum between the desired temperature inside the facility and the geothermal energy source potential [3,4]. Numerical simulation results were validated with data obtained from experimental measurements in the facility [4]. The results of these analyses enable calculation of storage tank capacity so that the energy efficiency of the greenhouse heating system with geothermal energy could be significantly improved.

2. HEAT STORAGE TANK MODELLING

The analysed greenhouse is located in Debrc, Serbia about 50 km from Belgrade close to the main road between Obrenovac and Sabac. In the immediate vicinity of the greenhouse there are geothermal wells capacity of 22 l/s and temperatures around 53°C which are used for heating the greenhouse. Total area of the greenhouse is 4.2 hectares and is lying along east – west line, so that the two longer walls are oriented to the north and south respectively.

The existing heating system, according to previous measurements [4], had an energy deficit amounting to 219.4 MWh during the heating period, when the outside temperatures are low so that the desired air temperature in the greenhouse cannot be achieved. Also during the heating period there is 7677,6 MWh of excess energy when the outside temperatures are higher.

In order to increase the system energy efficiency, the heat storage tank with geothermal water was set up. For an efficient heat storage modelling, and selec-

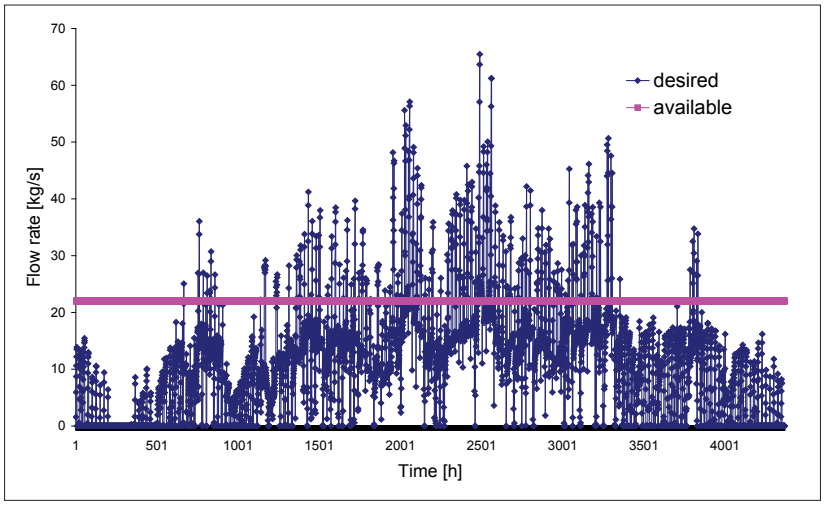

Fig. 1. Seasonal hourly values of desired water flow rate and available flow rate from the geothermal heat source

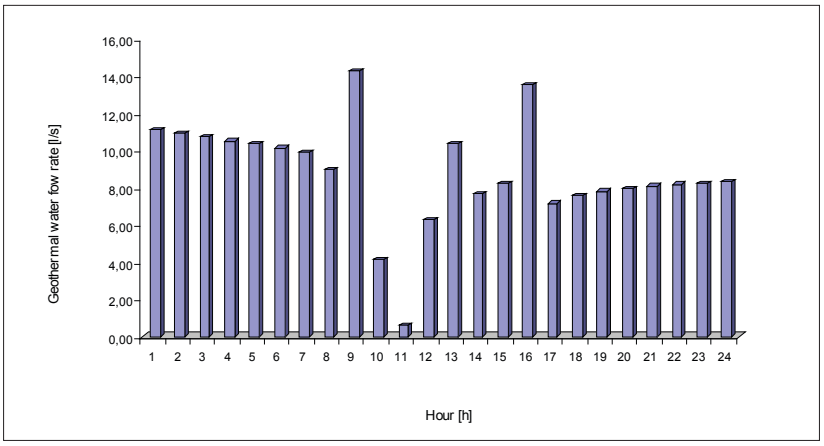

Fig. 2. Typical daily profile of the geothermal water consumption when the thermal load of the facility is lower than the available geothermal energy

tion of the appropriate tank volume, dynamic simulations are a very effective tool, which gives to the designer the possibility to optimize the system. Figure 1 presents seasonal hourly values of the necessary water flow rate from the existing geothermal source.

From Figure 1. it can be clearly concluded that the available water flow rate of 22 l/s can provide the necessary heat during the heating season (from October till April). Also the period with extremely high values of water flow rate, which goes up to 70 l/s can be identified.

Figure 2 presents a typical daily profile of the geothermal water consumption in the case when heat requirements of the greenhouse are lower than the geothermal energy potential. In comparison with Figure 1, this is the case which presents values below the line of available flow rate.

On the Figure 3, which is of particular interest in this analysis, the typical daily profile of the water consumption is given for the case when the heat requirements of the greenhouse are greater than the geothermal energy potential.

This case is usual occurring during the night time when the outside air temperature is low. In these periods, measured air temperature inside the greenhouse was lower than 20 ºC, especially when the outside air temperature was lower than -10 ºC. Numerical simulation of the greenhouse heat requirements shows that the energy from the geothermal source is insufficient in 475 hours during the heating season [4]. In these periods additional heating of the greenhouse is necessary because the inside air temperature is lower then the desired temperature of 20 ºC.

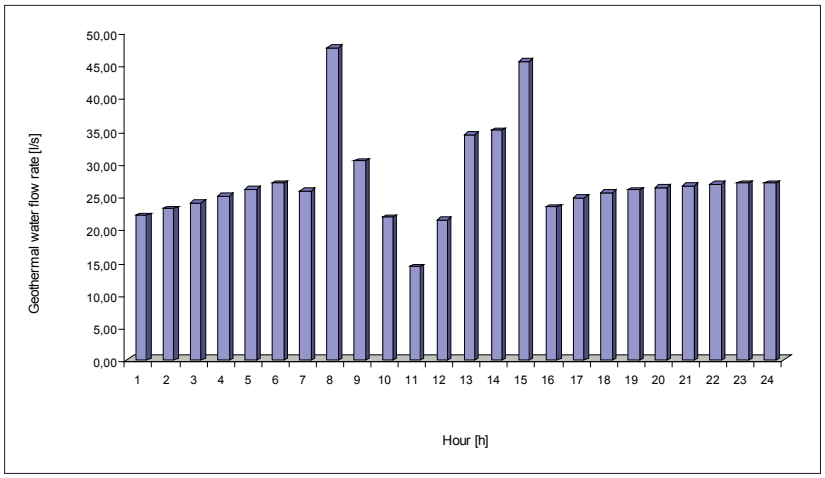

Fig. 3. Typical daily profile of geothermal water consumption when the thermal load of the facility is higher than the available geothermal energy

Figure 4 presents a diagram of charging and discharging the 20 m^3 storage tank with geothermal water during two typical days within heating period.

Figure 5 shows the relation between the storage tank volume and time in hours when the tank can not cover the heat requirements.

Without the storage tank, value of 475 hours presents the time while geothermal heating system is not able to cover all heat requirements. With the storage

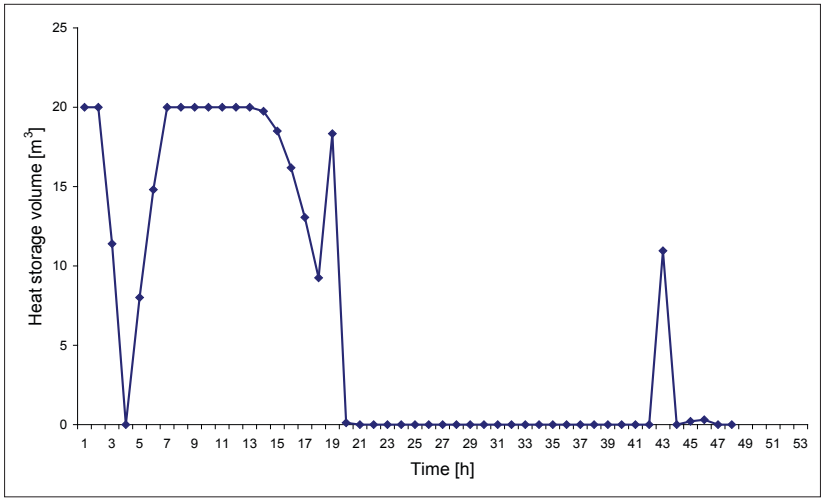

Fig. 4. Hourly profile of the heat storage tank charging and discharging for two typical days in heating season

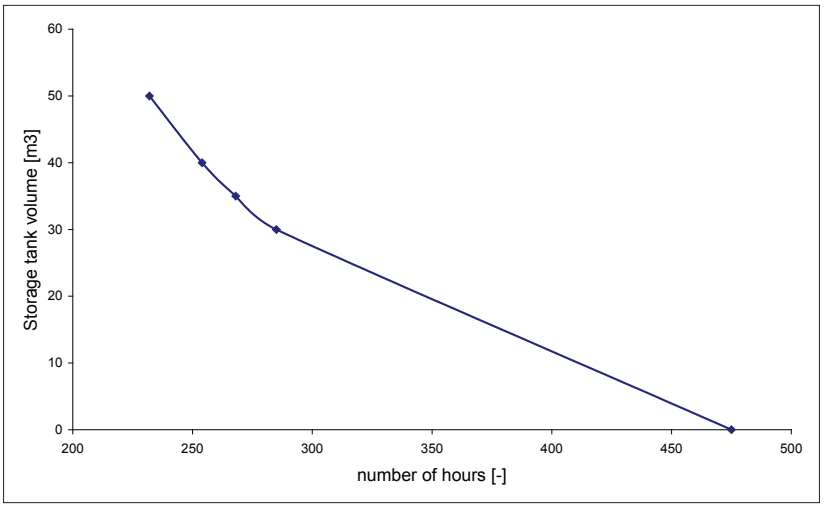

Fig. 5. Number of hours that could be covered with heat energy compared with storage tank volume

tank of 50 m^3 the geothermal heating system can not cover 225 hours of full heat requirements. For the full heat energy coverage the storage tank would have to have a volume of over 70 m^3.

3. CONCLUSIONS

Modeling of heat storage tank shows that the system would be able to cover almost the whole heat energy needed during the season. Also it can be concluded that the tank volume up to 30 m^3 is a rational solution. Tank volume greater than the suggested one would cause unnecessary costs.

The analysis of the greenhouse heating system with the storage tank of 30 m^3 shows that it enables saving of about 10 000€ per heating season so that the return period of the investment is less then one year. From environmental point of view, the CO_2 emission is reduced for more than 40000 kg.

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ANALIZA GRIJNOG SISTEMA ZELENE KUĆE KORIŠĆENJEM GEOTERMALNE ENERGIJE I REZERVOARA

Sažetak: U radu je analiziran grijni sistem plastenika sa geotermalnom energijom i dopunskim rezervoarom za smještaj viška toplotne energije iz geotermalnog izvora i mogućnost njenog korišćenja u periodima kada je spoljna temperatura niska. Ključno za ovu analizu je modelovanje toplotnog konzuma plastenika tokom cijelog grijnog perioda. Rezultati ove analize omogućavaju proračun kapaciteta dopunskog rezervoara tako da energetska efikasnost grijnog sistema plastenika sa geotermalnom energijom bude znatno povećana.

Ključne riječi: *plastenik, geotermalna energija, numerička simulacija, grijni sistem, dopunski rezervoar*