

# Optimization of PVT Geometry in Application of Ground Heat Source Regeneration

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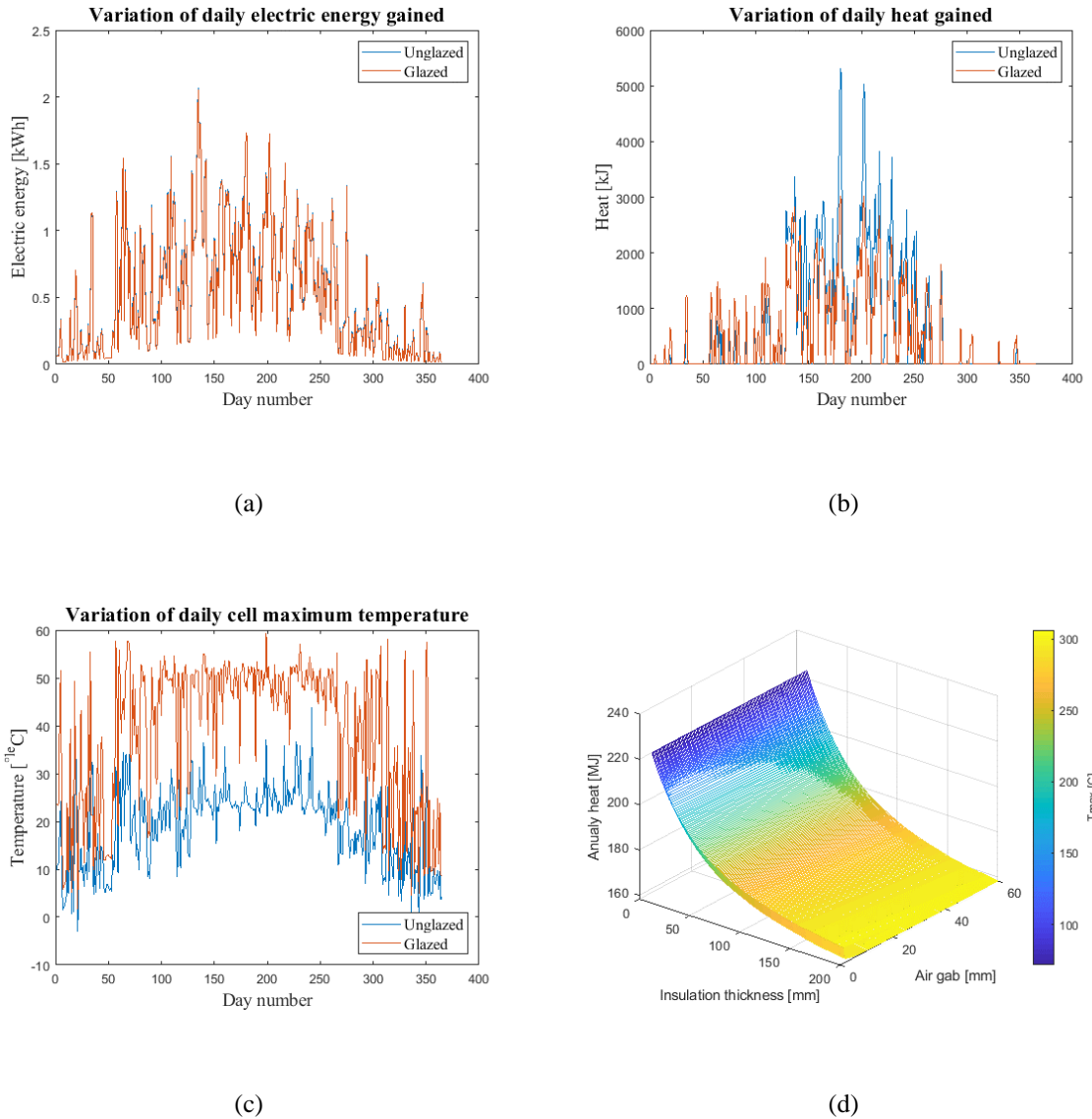
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**Abstract.** The problem of the combination of the heat pump and solar collectors is well known. The International Energy Agency have started in 1977 the Solar Heating And Cooling Program, under which a total of 53 projects regarding this issue has been conducted. The result from the Task 44 “Solar and Heat Pump Systems” has been presented in the book “Solar and Heat Pump Systems for Residential Buildings” edited by Jean-Christophe Hadron. From this source it is known that after examination through 4 years of over fifty installations in six countries the biggest seasonal performance factor were achieved by the ground source technologies. One of them is a system which energy collected from the sun is used for the regeneration of the ground thermal potential. But only one from these 50 installations was appointed in the hybrid photovoltaic thermal solar collectors (PVT) which allows to generate simultaneously heat and electric energy. Considering the fact that implementation in Poland of the net metering electric energy accounting system enables for seasonal storage, profitability of any hybrid installations with the heat pumps and the photovoltaics technologies (PV) is growing. Furthermore, the possibility for cooling PV with supplying the heat for regeneration increases yearly electricity gain. Thanks to regeneration designers may use more PVT collectors without risks of overheating which allows to compensate their lower thermal efficiency or to extend thermal power for domestic hot water (DHW) purposes. Taking into account all these advantages Authors decided to conduct the research in this field. The main goal was to define the benefits in overall hybrid solar and heat pump systems performance which utilize the PVT optimized for this purpose. Primarily developed mathematical model of PVT was the subject of another publication. In this paper the algorithm for the optimization of the PVT construction was described.

The mathematical model presented by the authors is based on the Hottel-Whiller-Bliss equation modified for PVT. PV model takes into consideration relation between solar cell efficiency and its temperature and solar irradiance. Heat loss coefficient is a sum of bottom heat loss and top heat loss coefficient. The convection from the back of the PVT is neglected. The back heat loss coefficient is computed from thermal resistance of the insulation. The top heat loss coefficient is computed from connection of thermal resistances of radiation and convection.

Unglazed (Ensol 2.0) and glazed (Ensol 2.0 with glass) photovoltaic thermal solar thermal collector was analysed. Various insulation thickness and air gap were considered. Simulations were conducted for yearly metrological data with hourly time step. The inlet temperature was set at 10°C and the mass flow rate was set at 1.2 l/min. If temperature rise was lower than required (dependent on simulation scenario), the mass flow rate was set at 0 l/min. The mathematical model was solved in the iteration algorithm. A reference simulation with insulation thickness provided by manufacturer was performed. Due to nonlinearity of the equations system, over 100 000 simulations with different insulation and air gap were

made to find local extremum. The results data were presented on 3D graphs. Local maximum has not been found. It was proven that a thin layer of the insulation enables to gain heat from ambient air on warm days.



**FIGURE 1.** The main results: (a) The variation of daily electric energy generation through one year for glazed and unglazed PVT, (b) the variation of daily heat gained through one year for glazed and unglazed PVT, (c) the variation of maximum cell temperature through one year for glazed and unglazed PVT, the correlation between insulation thickness and air gap space in glazed PVT.

The results show that the optimum construction of the PVT should be based on the unglazed technology of solar collectors and on minimum insulation. Those information will allow to design the solar and heat pump installations with optimum efficiency of hybrid effects. Obviously, the specific thickness of insulation need to be optimized to the specific parameters of the given system like the type and depth of borehole heat exchangers, parameters of the heat pump and the cases with and without additional heat exchangers between PVT and ground source. Basing on the obtained results Authors plan to conduct further research implementing the optimized PVT into the system with U-pipe borehole heat exchangers in PAS KEZO Research Center.