EFFICIENCY, SOLAR AND THERMAL ENERGY FOR THE HUMAN COMFORT

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HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

Efficiency, solar and thermal energy for the human comfort

Book of Abstracts

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CONTENT

PREFACE

This Conference is organized in the framework of the research project titled "Optimal production and distribution of hot water from renewable heat resources" supported by the National Research, Development and Innovation Office, Hungary (Grant No. 131895). The topic of the project concerns more vocational fields, among which the thermal and solar energy utilization as well as the maintaining of the human comfort have a distinguished role. This Conference would like to contribute in establishing a common platform where the Researchers interested in these areas are able to interchange their research results and ideas.

This Book of Abstracts contains a brief summary of the 16 lectures given, divided into three sections according to topics. We hope that the research results can be utilized in education and that they can result in new tender cooperation and partnerships.

Gábor Géczi
Richárd Kicsiny
László Székely
organizers and editors

THERMAL ENERGY SECTION

THE THERMAL WATERS OF THE ISLE OF ISCHIA (SOUTHERN ITALY): THE HYDROGEOLOGICAL SUPPORT TO DEFINE THE SUSTAINBLE YIELD

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Abstract
The volcanic island of Ischia (Fig. 1) represents one of the few cases in the world where there is a very high concentration of groundwater withdrawals used for health, wellness and recreational tourism. This is due to the presence of an active hydrothermal system which gives rise to a wide variety of groundwaters, very different in chemical composition (from calcium-bicarbonate to alkali-chloride waters), salinity (from 1 to 42 g/L) and temperature (from 13 to 90 °C). 264 groundwater tapping points (244 wells and 20 springs) are distributed over an area of about 20 km^2, mainly near the coast, and supply spas and tourism facilities. In natural conditions, the hydrogeological system of the island is mainly recharged by rainfall and by deep fluids. The pumping from the numerous wells present in the coastal area significantly increases the recharge of the island with seawater intrusion and upwelling of deep fluids. Although this does not compromise the availability of groundwater in quantitative terms, the pumping modulates the quality of the water captured by the wells often determining variation in composition and temperature of groundwater over time. A qualitative decay of the thermal waters can have a relevant economic impact, given that the European and Italian legislations establish that composition and temperature of thermal waters used for therapeutic purposes must remain constant over time.

The purpose of this research is to evaluate the sustainable yield of the wells that supply the various spas, maximizing the profit of the spas and limiting the qualitative decline of the thermal waters. To achieve this goal, the hydrogeology of the system, the aquifer response to the pumping and the distribution of groundwater withdrawals were considered, in order to develop a game-theoretical model.

The north-eastern area of the island, characterized by one of the highest density of wells, has been selected to assess the sustainability of groundwater withdrawals (Fig.1). For the spa facilities falling in this area, groundwater volumes required from the different plants were estimated, distinguishing volumes needed to fill the pools with thermal waters and those required for spa treatments in relation to the different daily income for the two uses. The various groundwater users were then located in the hydrogeological context of the area and five flow tubes of the aquifer with independent groundwater flow have been identified. For each flow tube, the groundwater flow rate and daily volume in natural conditions were compared with the volumes of groundwater withdrawals expected by the users falling in each flow tube. In order to avoid a significant seawater intrusion and an increase in upwelling of deep fluids during pumping, the sustainable flow rate of the well supplying each plant was determined taking into account the local elevation of the groundwater above sea level before pumping and on the

drawdown induced by pumping. One of the flow tubes under critical conditions was selected by way of example for mathematical modeling (Kicsiny et al. 2021).

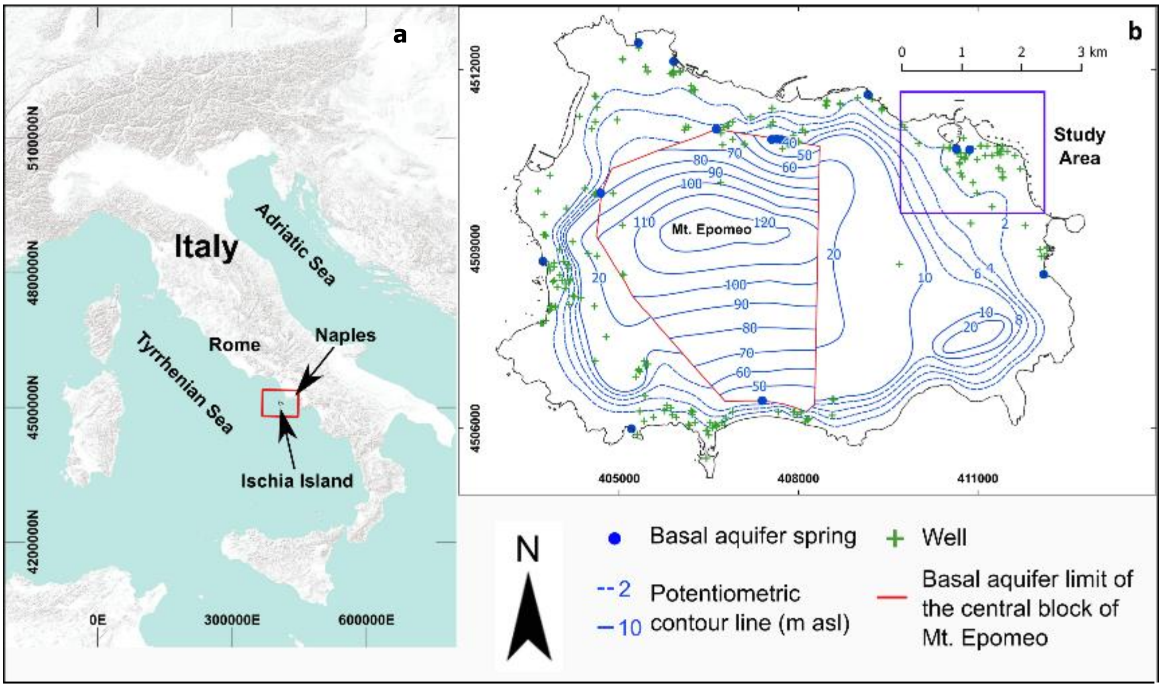

Fig. 1. ***a*** **Location of the Island of Ischia and** ***b*** **simplified hydrogeological map with the study area (modified from Piscopo et al. 2020)**

Keywords: volcanic aquifer, thermal water, sustainable yield, Island of Ischia

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GAME-THEORETICAL MODEL FOR THE SUSTAINABLE ALLOCATION OF THERMAL WATER RESOURCES. A CASE STUDY ON THE ISCHIA ISLAND

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Abstract
Based on an earlier research cooperation of the involved coauthors, in 2018 between the above universities a five-year academic collaboration agreement was signed in the field of *Mathematical modeling of the management of groundwater resources*. The present research was carried out in the framework of this agreement.

Fig. 1. Thermal Spas of Ischia

The volcanic island of Ischia (Italy) is a popular tourist resort for spa treatments. Spas and the associated swimming pools are supplied by pumping from the numerous wells present in the coastal area, but overpumping results in seawater intrusion and upwelling of deep fluids implying the chemical compositions, salinity and temperature of the thermal water resource. Therefore, *sustainability* of the spa activity requires *constraints* limiting both the total pumping flow rate and the total volume derived in one day. In a given flow tube of the hydrogeological system of the island, n units (thermal plants) are considered as players in the game. The strategy of a player consists of the pumping flow rate and the daily pumping times for spa treatments and for the swimming pools. The payoff of a player is the daily income from the thermal water used. Hence this conflict situation is modeled in terms of a normal form game with the particular feature that that the strategy choices of the players are not independent, due to the sustainability constraints.

Since each player is interested in the maximization of own payoff, we face a constrained vector optimization problem for the payoff vector. Solving it with the usual scalarization method (maximizing a convex combination of the single payoffs), we obtain a variety of *Pareto optimal* multi-strategies (and payoff vectors), considered *cooperative solutions of the game*. The latter means that there is no other multi-strategy choice that makes one player better off without making some other player worse off. From this variety of cooperative solutions, the so-called *nearly ideal cooperative solution* can be singled out in the following way: Let ω_i be the maximum of the payoff of the *i*-th player, then $\Omega = (\omega_1;\ \omega_2; \dots;\ \omega_n)$ is called the *ideal value of the game*. Now a multi-strategy is called *nearly ideal cooperative solution* of the game, if the distance of the corresponding payoff vector from the ideal value of the game is minimal among all Pareto optimal payoff vectors. In the present case study the *nearly ideal cooperative solution* is compared to the solution obtained by the constrained maximization of the total income of all units, taken with equal weights. In particular, in both cases the corresponding "costs of sustainability" can be calculated.

Finally, some options of possible extensions and further development of our game-theoretical model will be also mentioned.

Keywords: thermal water, sustainable yield, game-theoretical modeling, Island of Ischia

Reference

Richárd Kicsiny, Vincenzo Piscopo, Antonino Scarelli, Zoltán Varga (2021) Game-theoretical model for the sustainable use of thermal water resources: the case of Ischia volcanic island (Italy). *Environmental Geochemistry and Health*. 1-15.

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METHANE AND HYDROGEN-SULPHIDE LOAD FROM THERMAL WATER IN HUNGARY

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Abstract
The Due to its special geological attributes, Hungary is extraordinarily rich in medicinal thermal water and mineral water, as a result of which the country is ranked as the Nr. 5 thermal water-superpower, right after Japan, Iceland, Italy and France. With regards to the quantitative and qualitative properties, our thermal water wells are unique worldwide, therefore it is justified to state that our country owns an outstanding natural potential.

We utilise our thermal water wells of enormous volume and extremely versatile compound mostly in the following areas: balneology, drinking-water supply, agriculture, communal utilities and industrial usage. Beside the fields of use, methods of use, ratios of use; possibilities and features of execution and implementation it has to be emphasised also, how the extraction of thermal water resources and the quality parameters of these procedures will affect the quality of various natural elements, namely that of air in our case. In the recent years different by-gases of thermal wells, especially methane and hydrogen-sulphide, have played a more and more crucial role.

Since methane is a greenhouse-effect generating gas, and simultaneously has reasonably high energy content, therefore letting it exhaust into the atmosphere does not cause local and global pollution only but also it is considered as wasting the resources. As a result of this the relatively constant methane-content of thermal wells determines the correct method of usage and handling of these facilities, which means both environmental and economical advantage.

The importance of characteristic, bad-egg scented hydrogen-sulphide is due to its contradictional attributes, as it is a toxic and flammable gas considering the chemical properties; it can be detected even in low concentration, in higher concentration or in case of longer exposure the ability of smell is dulled persistently; at 0,07% respiratory organs might as well be paralysed. On the other hand its balneology-attributes are excellent, because wells containing hydrogen-sulphide – in other words: sulphuric wells – are able to compensate for the sulphur-deficiency of human system, in a form of a bath. Therefore it has a vital role in curing vascular-rheumatic- and certain skin-syndromes as well. Concerning the quality of the environmental air it is one of the most important sulphur-compounds.

Based on the above it is especially important to examine the amount of hydrogen-sulphide present in the air originating from thermal water, beside methane. I would like to present the air load of these two components, which was based on data provided by thermal spas and own measurements, utilising Radiello passive monitoring method.

Fig. 1. Hydrogen-sulphide concentration measured in July 2013 in 5 Hungarian baths

For determining the hydrogen-sulphide were used RAD 170 type cartridge and RAD 120-1 type blue diffusion jacket. The results of wider range hydrogen-sulphide measurements executed in July 2013 are presented in Figure 1.

Keywords: air load, air pollution, thermal bath, methane, hydrogen-sulphide

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ENERGY ANALYSIS OF AIR SOURCE HEAT PUMP DEFROST CYCLE

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Abstract
A good example of the constant popularity of heat pumps that in Germany, the 1 millionth heat pump has already been commissioned in 2020, a significant number of which are air heat source types. The advantage of the air heat source in addition to the low price is that the equipment is also able to utilize the latent heat of the water vapour content of the air. This results in less temperature drop of the air cooled on the heat exchanger, which has a beneficial effect on the Coefficient Of Performance (COP). The disadvantage, however, that the condensing water vapour, under certain circumstances, forms a layer of white frost on the heat exchanger, which can significantly reduce the effectiveness of the equipment. To avoid this, the equipment performs periodic defrost cycles, which results in an increase in additional energy consumption in addition to the removal of the white frost layer.

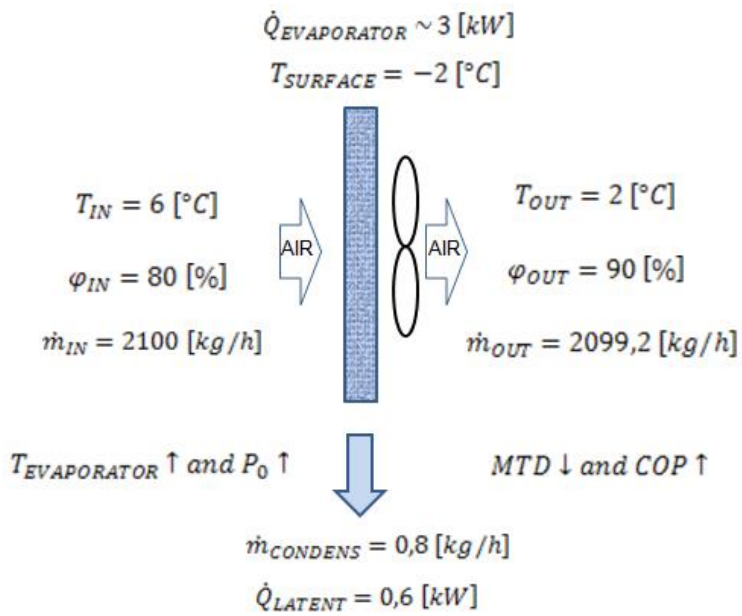

Fig. 1. The white frost formation model

From an energetic point of view, I would like to investigate the energy characteristics of the defrost cycle of the heat pump evaporator. At the same time, I analyze how effective the defrost is. The process may not proceed completely and liquid or solid condensate may remain on the surface of the heat exchanger or on the condensate collection tray. This phenomenon should be avoided at all, so I perform the tests under extreme conditions.

In order to carry out the planned tests, I had to re-design an existing cold room and built a suitable apparatus. The outdoor unit of the heat pump was placed in a well-insulated chamber, in our case a cold room. The heat extracted from the cold room was covered to a lesser extent by the heat flow entering the boundary structures, but a very large part was introduced in the form of hidden heat with the water vapour produced in the steam generator connected to the cold room. With this procedure, the highest possible indoor humidity can be achieved, which at the same time ensures the highest degree of frosting in the case of the evaporator tested. The indoor temperature can be kept almost constant by changing the switching cycle time of the steam generator and by using air equalisation fans. I performed temperature measurements at a total of 24 points, as well as electricity consumption and the amount of condensate generated per cycle.

During the test measurements, it was proved that the water vapour introduced by the steam generator at a temperature of about 100 ° C is able to distribute homogeneously in space and does not adversely affect the evaporation process of the evaporator. The heat flow entering through the boundary structures of the cold room (disadvantageous in terms of the measurement) remained small in the examined temperature range. The temperature of the cold room did not change significantly during the defrost cycles either. The temperature of the air drawn in by the indoor unit of the heat pump was kept almost constant, so this condition did not cause much error in the evaluation of the COP. Based on the experience of the trial measurements, I consider the real series of research measurements to be executeable.

Keywords: heat pump, defrost, energy, environment

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POTENTIAL APPLICATION AND SYSTEM OPTIMIZATION OF SOLAR DOMESTIC SWIMMING POOL HEATING SYSTEM IN COLD CLIMATES

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Abstract
In cold climates (such as central Europe Budapest), approximately 15% of its consumed energy is used for water heating purposes. Moreover, these applications require less than 100 °C which is easily achievable by renewable energy, for example solar domestic water heating (SDWH) technology. As conventional water heating systems using fossil fuels or electric heaters cause a greenhouse effect which is also high maintenance cost and expensive. Hence, the future of solar water heating system technology is promising for its eco-friendly nature and renewable energy usage.

SDWH can be divided into two parts such as design and operation. The collectors can be designed in many ways. Flat plate collector (FPC) and Evacuated tube collectors (ETC) are two major type solar collectors where the temperature can reach up to 65℃ and efficiency can be achieved 80% in Evacuated tube collectors. However, this varies from meteorological, design, load profile situation

This article aims to assimilate various Solar Domestic Hot Water (SDHW) systems in cold climates like Central European countries (Hungary) and define the best system. We compared three different systems: solar heating system without auxiliary heating nor heat exchanger (B6), with heat exchanger (B6.1) and with heat exchanger and auxiliary heating source (B6.2). Firstly, five crucial variables were chosen along with fixing the other parameters. Solar inclination is 24° for Budapest, daily freshwater requirements is 50 litres, 6 collectors have been used each collector has 1 m² narea, volume flow rate in each collector is 40 litre/hour, and 30% glycol is being added to the water to make it antifreeze in winter season. The variables are collector type, pool depth, pool temperature, cover, and windshield. The simulation conducted using T*SOL software to get the solar contribution ratio which refers to how much solar energy (in kWh) has been contributed to heat up our swimming pool, while the linear modelling was conducted using R scripts software using coded values for defining optimal value using the response surface method (RSM). The least-squares approach is used in the programming phase to provide a general rationale for the line's best match position among the data points under consideration. We found that the best system is B6.1 represented by Experiment No 8 which indicates the Collector type: evacuated-tube collector (ETC), pool depth: 2 m, pool temperature: 30 °C, no pool covers and no windshield, this all after considering several aspects such as financial and energetic considerations. To measure the solar contribution for each case, we used the T*SOL Valentine Software-2018. For modelling purposes, we used an R-program where we considered the top five impacting variables such as collector type, pool depth, pool temperature, cover and windshield. For each vector, our coded values range from [-1, +1].

The formula 2^k, where k is a vector number, defines the number of experiments. Since each variable has two possible values [-1, +1], the total number of experiments was $2^5 = 32$. In addition to these 32 experiments, we performed two more experiments for defining second degree non-linear coefficients with a pool depth (B) of 1.5 m and 28 °C pool temperature. These two additional experiments, however, had no impact on our results. Finally, a comparison of the swimming pool heating systems that is suitable in this weather was conducted.

Experiments 4 and 8 use Evacuated Tube collectors and their coverage ratio is 0. On the contrary, flat plate collectors were used in experiment no 25, where the coverage ratio is 29%.

Table 1: Possible swimming pool heating systems for Budapest in B6 system

Experiment No	Collector Type	Pool depth	Pool Temperature	Cover	Wind shield	Solar contribution y1	Coverage ratio y2
4	ETC	2 m	26 °c	No	No	2884 kWh	0%
8	ETC	2 m	30 °c	No	No	2884 kWh	0%
25	FPC	1 m	26 °c	Yes	Yes	2560 kWh	29%
26	ETC	1 m	26 °c	Yes	Yes	2773 kWh	29.2 %

After considering the solar contribution requirement, coverage ratio and financial perspective, we will choose experiment No 25 (Collector type: FPC, Pool depth: 1m, Pool temperature: 26°C, with cover and windshield are active) for Budapest in the B6 swimming pool heating system.

As the government is trying to reduce carbon emission and searching for an alternative energy source, this solar heating system can be used widely in central European countries.

*Keywords: SDHW, swimming pool, T*Sol, R script*

SOLAR ENERGY SECTION

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EXPLICIT ANALYTICAL SOLUTION OF SOME DIFFERENTIAL EQUATION MODELS FOR SOLAR HEATING SYSTEMS

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Abstract

In the issue of the environmental protection, the role of the widespread application of solar heating systems is very important. Well-usable mathematical models or their solutions can help to promote this aim. In the literature, analytical solutions for the models of solar heating systems are rather rare, despite of their advantages (fast and easy usability, low computational demand, low cost).
In the present talk, we intend to (partly) make up for this shortage with respect to some two-dimensional ordinary differential equation model of complete collector-storage systems.

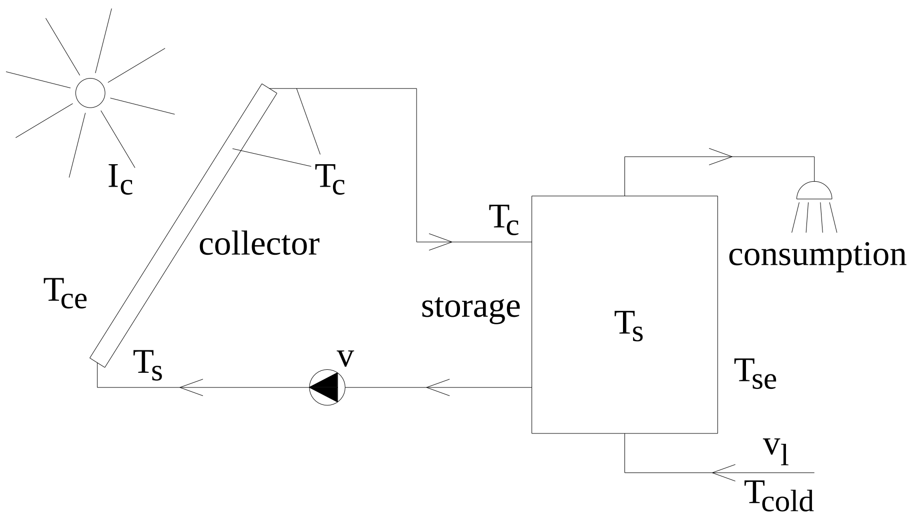

Fig. 1. Scheme of the studied system

The baseline model is the following system of linear ordinary differential equations

$$\frac{dT_c}{dt} = \frac{A_c\eta_0}{\rho c V_c} I_c + \frac{U_L A_c}{\rho c V_c}(T_{ce} - T_c) + \frac{v}{V_c}(T_s - T_c),$$
$$\frac{dT_s}{dt} = \frac{v}{V_s}(T_c - T_s) + \frac{v_l}{V_s}(T_{cold} - T_s) + \frac{A_s k_s}{\rho c V_s}(T_{se} - T_s)$$

with appropriate constants. The worked out new analytical system solution provides easy- and fast-to-use explicit formula (for direct algebraic substitutions) to determine both the temperature of the collector and the temperature of the storage.

The analytical solution is validated with the measured data of a real solar heating system. As a part of the validation of the (two-dimensional) system solution, the analytical solution of the (one-dimensional) collector sub-model (which is already known and successfully used in the literature) is also validated separately with the measured data of a real solar collector. Based on the validation containing a relatively long time period of 19 days, the error of the new system solution is 3.4% in case of the collector and 2.0% in case of the storage, which means an outstanding precision in the field.

We also discuss the existence of explicit analytical solutions in the case when the volumetric pump flow rate is not constant but proportional to the difference of the temperature of the collector and the layered storage.

Keywords: solar collector; mathematical model; ordinary differential equation; explicit analytical solution; validation

Reference

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STUDY OF THE MAXIMUM EFFICIENCY OF POLYMER-BASED SOLAR CELLS

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Abstract
The development of polymer-based solar cells is one of today's cutting-edge research. Although the proven maximum efficiencies of the most commercially available single-grade silicon-based silicon (26.7%) are much higher than those of polymer-based silicon (13%), they are difficult to install on uneven surfaces, so much scientific attention has been paid to these less efficient yet flexible (e.g. backpacks). , can be installed on tent roofs, on the human body), has turned to the research and development of organic solar cells with environmentally friendly and cheaper technology and thus have a great future both theoretically and experimentally. An important issue when testing solar cells is to estimate how theoretically what efficiency can be achieved. This is the famous Shockley-Quisser theoretical efficiency limit (33% without concentrators) for single-junctuion p-n solar cells (Shockley and Queisse, 1961). In the case of polymer-based ones, where after the photoexcitation the charge separation takes place in a polymer / fullerene system, we proceed according to Minnaert Burgelmann's formula (Minnaert and Burgelman, 2007):

$$\eta_{max} = \frac{E_{g,i} \int_{E_{g,abszorber}}^{\infty} N(E)dE}{\int_0^{\infty} EN(E)dE}.$$

Fig. 1: Relative LUMO, HOMO energy levels of donor and acceptor materials and interpretation of relationship (Minnaert and Burgelman, 2007) and the Hubbard model of polythiophene (Gulácsi, 2013; Farchioni and Grosso, 2011)

The LUMO and HOMO levels in the figure for p-material polymers were calculated based on the Hubbard model (Gulácsi, 2013; Farchioni and Grosso, 2011).

We investigated how the maximum efficiency of a polythiophene / fullerene-based solar cell (by choosing PCBM n-material) changes as a function of a selected parameter of the model, on-site potential E3. An important question of principle is whether energy levels change when we combine them into a solar cell. According to measurements, it may occur the so-called phenomenon of vacuum level shift (Guan et al., 2011).

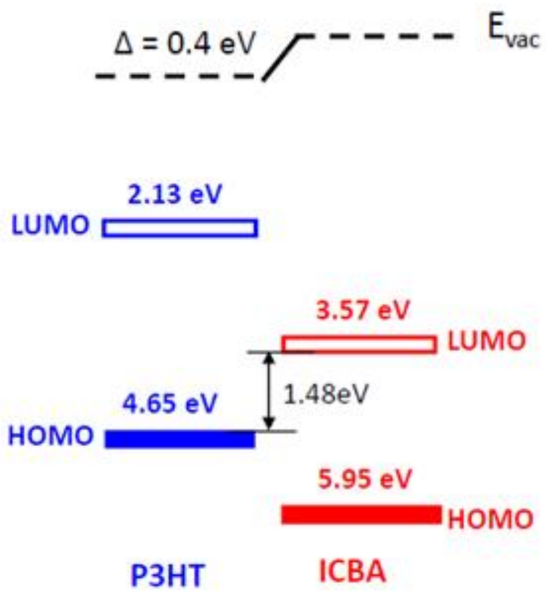

Fig. 2. The shift of the vacuum level also changes the relative position of each energy level (Guan et al., 2011)

This difference is due to the formation of a surface dipole on the donor-acceptor surface. The model ability of the phenomenon is a serious challenge today. A promising opportunity comes from Vázquez et al. (2005). A computer simulation of this is currently under research. The extent of the shift can be expected to be modeled from the band structure itself under assumptions about charge neutrality levels.

*Keywords: SDHW, swimming pool, T*Sol, R script*

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THE IMPACT OF PARTICULATE MATTER POLLUTION ON THE SOLAR ENERGY PRODUCTION

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Abstract
Over the last decades, Air pollution was a serious problem that damaged the environment and was the cause of many human diseases. The amount of sunlight that hits the surface of the earth in an hour and a half is enough to power the entire globe for a year. Solar technologies use photovoltaic (PV) panels or mirrors to concentrate solar radiation to convert sunlight into electrical energy. This energy can be converted into electricity or stored in batteries or thermal storage. As opposed of using fossil fuels, solar energy does not emit any pollutants during the operation, but the production of solar panels can emit some amount of pollution. Solar power productivity in a region is determined by solar irradiance, which varies throughout the day and is influenced by latitude and climate. It is also affected by temperature and soiling conditions in the area. The arid tropics and subtropics regions have the highest annual solar irradiance. Low-latitude deserts typically have few clouds and can receive more than ten hours of sunlight per day. These scorching deserts form the Global Sun Belt, which circles the globe. This belt includes vast swaths of land in Northern and Southern Africa, Southwest Asia, the Middle East, and Australia, as well as the much smaller deserts of North and South America. According to NASA, Africa's eastern Sahara Desert, also known as the Libyan Desert, is the sunniest place on Earth. The following map depicts various solar irradiance measurements (Figure 1).

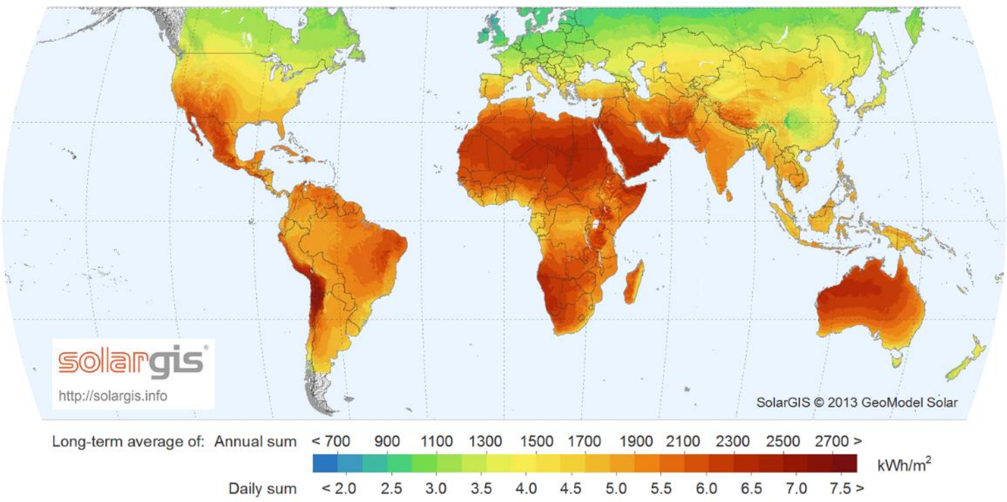

Fig. 1. World Map of Global Horizontal Irradiation, SolarGIS 2013

However, research showed that air pollution can affect solar energy production by affecting the amount of Solar Irradiation that arrived at the Earth's surface. Particulate Matter (PM) is one of the most dangerous air pollutants, many studies proved the negative relationship of high PM10 and PM2.5 concentration with solar irradiation.

In polluted regions of China and India, studies showed that high concentrations of PM10 and PM2.5 can reduce dramatically solar energy production. A study that was conducted from May 2016 to November 2017 showed a decrease in solar power production in New Delhi, India by ~12% for every 100µg/m3 of PM2.5 particle concentration. In 2016 the estimated solar energy capacities in India and China were ~6 and ~65 GW respectively, where the reduction due to PM pollution was ~1 and ~11 GW respectively. In Korea, PM pollution is responsible for 10% to 20% of solar energy losses. Moreover, studies in Mexico, California USA, and the Romanian state of Timisoara illustrated a decrease of solar irradiation by 21.6%, 8%, and more than 20% respectively.

While the influence of PM other than dust is evident in Asia, America, and other countries, the impact of Dust particles is also apparent in areas where the dust particles are always present in the atmosphere, which is the case of the African Saharan and Arabian Peninsula regions where the sand storms occur so often. The decline of solar irradiation due to dust particles in the African Saharan and the Arabian Peninsula regions can reach 25% annually.

The cost of Solar energy loss due to PM pollution and air pollution, in general, could be millions of dollars annually, especially in highly polluted areas. Thus, taking into account air pollution potential losses of Solar energy production could make the difference between successful and failed solar energy projects. Therefore, reducing air pollution should be a must of every nation in the world.

Keywords: PM10, PM2.5, Solar Energy

MODELLING AND SIMULATION OF A SOLAR WATER HEATING SYSTEM

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Abstract
Solar energy has been used almost primarily because of the availability and its lowest environmental impacts among various renewable energy technologies. At present, solar water-heating systems (SWHS) widely known in solar energy thermal applications. The solar heating system utilizes thermal technology to convert solar radiation from the sun into heat and transmit it to a transfer media such as air or water. Such solution can often replace traditional water heating systems. The small systems are used for residential water heating and space heating applications, while larger systems used for industrial processes. For SWHS analysis, several simulation tools are used, from these the TRNSYS software is one of the most efficient to work and adaptable for SWHS simulation. In the present work, the critical components of a SWHS system are reviewed, as is illustrated in Fig 1.

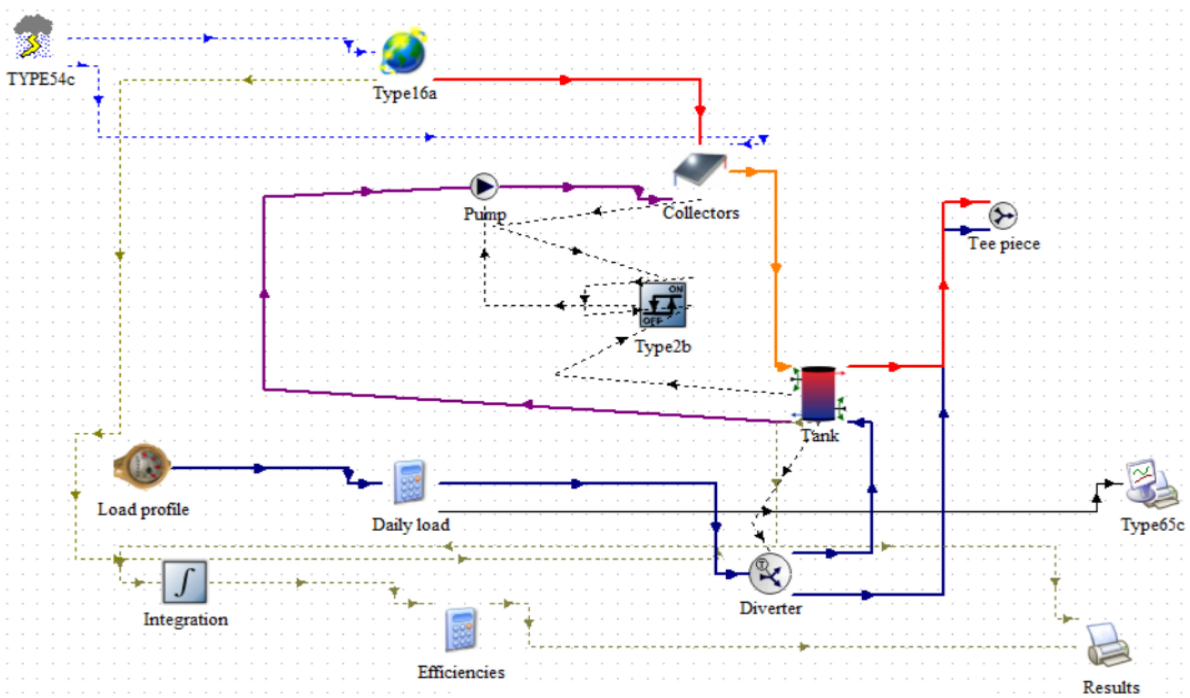

Fig 1. TRNSYS model of SWHS

The objective of this study is to create a model appropriate to the TRNSYS program for the performance evaluation of making solar hot water, a model to support consultancy engineers and designers to predict heating energy from the solar collector, and the results of simulations used to develop a generalized design procedure for SWHS in buildings at any place.

The recent work presents in detail one example, show the components of the model with their parameters, the location with its characteristic, meteorological data and the profile of planned hot water consumption.

Results of the application example show the auxiliary monthly energy, variation hot water temperature and auxiliary energy, flow rate, heating load, efficiency, and solar fraction of the SWHS model. In this case, the annual energy ratio solar and auxiliary were 62% and 38%, respectively.

Keywords: solar collector, performance evaluation, TRNSYS, energy ratio

THERMAL AND ELECTRICAL BEHAVIOUR OF A HYBRID SOLAR COLLECTOR UNDER TROPICAL CLIMATE

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Abstract
Renewable energy has been advanced as an alternative source of electric and thermal power. Most of its systems introduce a single form of energy, unlike the hybrid solar collector, PV/T, which simultaneously provides two forms of energy to the applications, e.g. electrical and thermal energies.

The flat plate absorber and the photovoltaic module are the main parts of the PV/T. The PV cell temperature decreases due to heat transfer between the PV module and the flat-plate absorber located behind it. Thus, the efficiency of the PV/T will be increased.

The most critical factors that affect the solar system's performance are the climate parameters like radiation, wind velocity, and ambient temperature. A tropical climate city is chosen to investigate PV/T outputs using software tools (TRNSYS) in this study. Therefore, Brazil city was selected for the simulation in this study as a tropical climate. Electrical and thermal performance comparisons were made with hot and cold climates cites Stuttgart and Kabul. The proposed system consists of standard parts, PV/T unit, thermal and electric parts, as illustrated in Fig. 1.

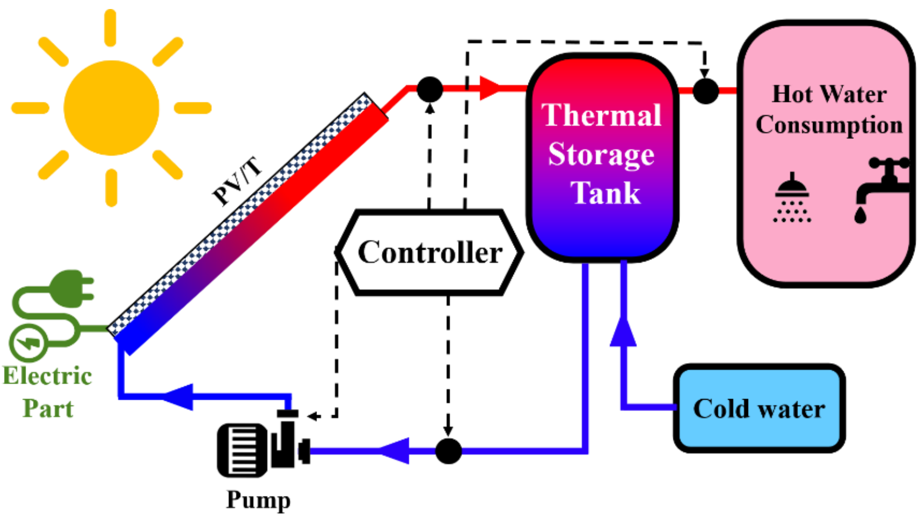

Fig. 1. A proposed system for simulation

During the simulations, the results for three sites (Kabul, Brazil, and Stuttgart) with the three typical climatic conditions (hot, tropical, cold) were compared, assuming local meteorological data for June and the same daily hot water consumption.

On June 15 (from 5 am to 7 pm), solar radiation, electrical and thermal power data are shown for the locations in Fig. 2.

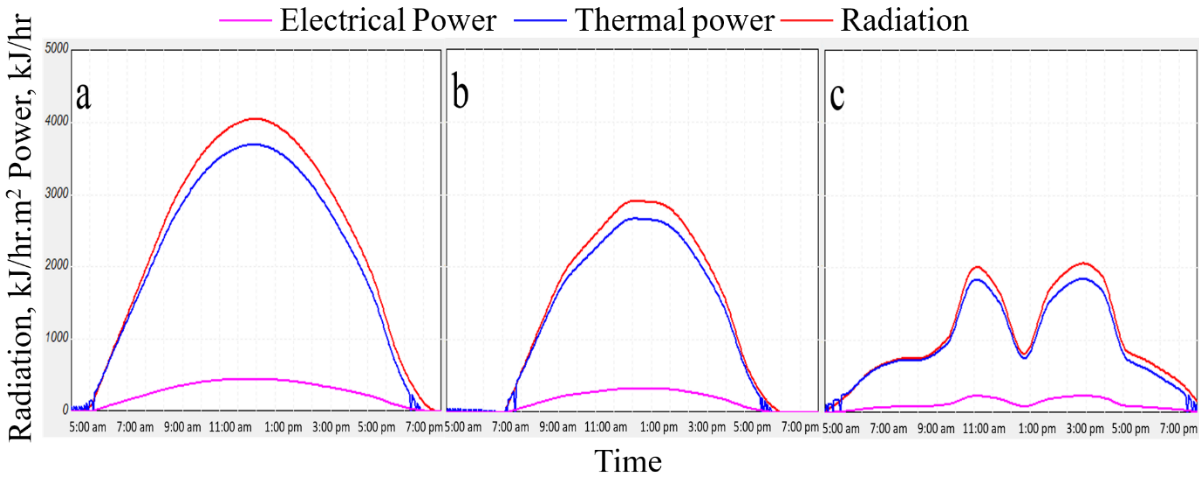

Fig. 2. PV/T behavior in three locations, (a) Kabul, (b) Brazil, (c) Stuttgart.

The result showed that the PV/T system in a tropical climate has higher significant effects compared to a cold climate. It has more than 30% thermal power, unlike the hot climate, which exceeds the tropical climate by 28.5%. Besides, the tropical climate has more electrical power than the cold by 28.5%, and less than the hot by 27.6%.

Keywords: PV/T collector, different climate, performance evaluation

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DESIGN OPTIMISATION AND CONFIGURATION OF SOLAR HEATING SYSTEM USED FOR PASTEURISING HEAT DEMAND IN TWO DIFFERENT REGIONS

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Abstract

In the recent decades, there is a noticeable increase in the ambient temperature all around the world, attributed to the greenhouse gas (GHGs) and carbon dioxide emissions because of the usage of the fossil fuel. Many daily duties such as domestic hot water (DHW), space heating, and industrial processes, all of it needs hot water which can be produced from solar thermal system. In the industrial food processes and to produce the final products, there is a massive consumption of hot water at moderate level for different duties. In addition to the low maintenance, another important advantage of using the solar thermal system in hot water production, that it does not require big amounts of water in comparison of fuel and geothermal systems. It requires only a rooftop or a ground space. In agri-food processes, a substantial amount of hot water can be produced using solar thermal systems where 77% of the demand is needs for heating processes and 60% of it is needed below 250℃. Also, there is matching between the demand of the heat process with the heat supplied from the solar systems in some services like food, textile, and brick industries. Also, in agri-food processes it is suitable for dyeing, boiling, washing, sterilising, and pasteurising. Using different solar thermal collector technologies from flat-plate collector (FPC), evacuated-tube collector (ETC) and compound parabolic collector (CPC) are able to provide not less than 60% of the solar fraction at 55℃ in normal circumstances. However, for higher temperature range locally made collectors made by local small and medium enterprises (SMEs) can reduce the prices of the collector system between three to ten times in comparison of importing it. In beverage and food sector there is a potential of 2.2 and 3.3 EJ for the demand of low to medium hot water temperature respectively, that provides thousands of new vacancies every year. Nevertheless, solar thermal energy utilisation in the industrial sector globally is still below one per cent due to some difficulties including the sporadic nature which makes it unsuitable in some industrial cases.

In our study, we conducted a simulation analysis to identify the optimum configuration of a small to medium pasteurising plant exist it two regions in term of the needed collector area. The two different regions are first: relatively cold climate represented by central Europe Budapest, and the second one is relatively hot climate represented by middle east Damascus). The optimisation process was conducted using T*sol software where the collector area was modified to find the optimum solution for both cases. The annual demand requirements for the pasteurising plant are around 7.3 MWh annually which means around 20 kWh on a daily usage. The used solar thermal system is a solar heat process one supported parallelly with 25 kW boiler in case of the insufficient solar radiations or overcast weather. During the simulation three different solar collector technologies were used (FPC, ETC, and CPC).

In the results, it shows for the above-mentioned duty and in a specific duty schedule continuous and fixed daily usage from 6AM till 4PM, solar collector systems consist of 30 m^2 and 20 m^2 for Budapest and Damascus respectively using ETC collectors. The reason beyond rejecting the CPC system is that it is very expensive and not easily available in those two regions compared to the ETC. Also, FTC was not chosen because the output temperature of the collector may exceed 100°C in some scenarios and the FTC are not as safe as the ETC. In addition to the diffusive nature of the solar radiation in both cities (around 50%).

For these systems, the annual respective solar fraction was 64% and 82% with total system efficiency of 14.9% and 17.2% which eliminates more than 2235 and 2746 tons of CO_2 for Budapest and Damascus respectively.

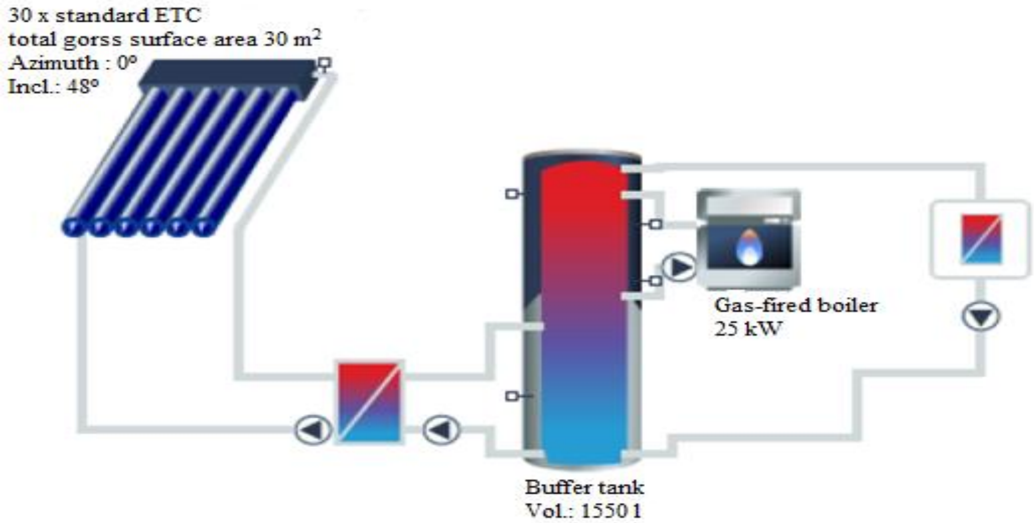
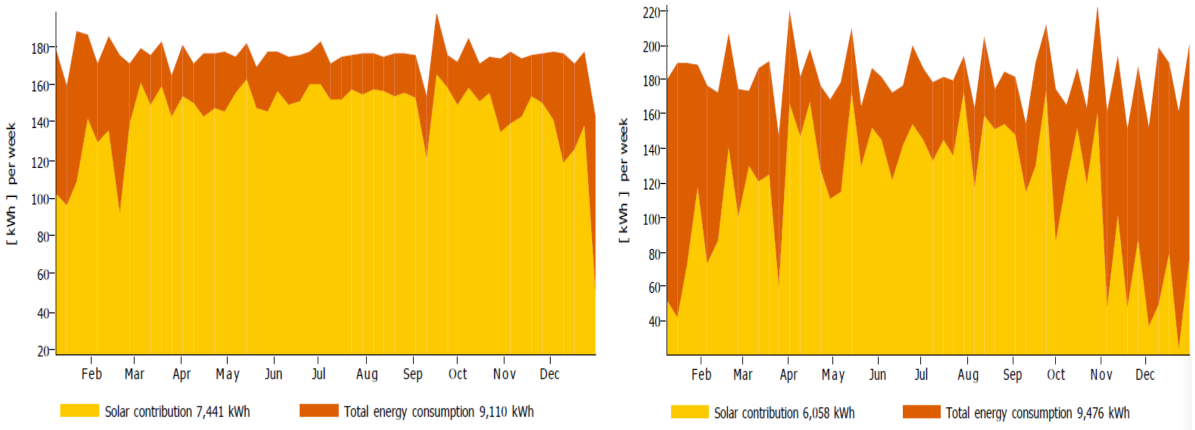


Fig. 1. Direct solar thermal system with a buffer tank for heat process



(a) (b)

Fig. 2. Solar energy consumption as a percentage of total consumption (a) Damascus and (b) Budapest

Keywords: Heat process, pasteurisation, solar thermal system, solar fraction

HUMAN COMFORT SECTION

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THERMAL COMFORT ASSESSMENT OF A PCM LAYER INTEGRATED COMPOSITE ROOF AT DIFFERENT POSITIONS UNDER HOT OUTDOOR CONDITIONS

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Abstract
Thermal comfort inside buildings is among the hot research topics worldwide for decades as it is associated with occupant's daily life. The comfort level inside buildings can be reached by controlling the temperature and humidity level, usually maintained by heating, ventilating and air-conditioning (HVAC) systems. In the Middle East hot locations, occupants often suffer from discomfort during the day mainly due to the poor construction pattern and thermally-poor construction materials used. Moreover, high-cost HVAC systems and their power consumption-related issues pushed the researchers towards using alternative solutions and techniques.

Various passive and active systems have been investigated by developing HVAC systems performance, introducing alternative renewable systems, or improving the building's envelope performance and insulation capabilities. Among recent cost-effective solutions for building envelope, phase change materials (PCMs) have attracted the attention as a successful heat storage material that can improve the building thermal inertia. PCMs have been investigated as heat supplier in cold locations, serving as heat barrier under hot climates. In this regard, several influential parameters need to be studied carefully for better functioning of PCMs such as the optimal melting point, the best PCM position, and the best thickness.

In this study, four composite roofs (three with PCM layers and one without) have been constructed with locally popular construction materials. In the PCM roofs, a PCM layer (~0.5 kg) made from paraffin wax encapsulated inside galvanized panels (10 mm thickness) were placed in different positions and tested along a full-day cycle (24 h) under a non-conditioned scenario and hot outdoor conditions. The PCM layer is positioned (i) between the roofing layer and main layer "Roof-B", (ii) in the middle of the main roof layer "Roof-C", and (iii) between the main layer and cladding layer "Roof-D". The thermal comfort earned from each PCM roof is tested against the reference roof "Roof-A" in terms of the operative temperature reduction (OTR) and discomfort hours reduction (DHR). The operative temperature (OT) is calculated using Eq. (1), as follows:

$$OT = \frac{T_a + \overline{T}_{mr}}{2} \tag{1}$$

where T_a represents the indoor air dry-bulb temperature (the room temperature, T_r, in the current work). $\overline{T}_{mr}$ is the mean radiant temperature that can be calculated using Eq. (2), as follows:

$$\bar{T}_{mr} = \frac{T_1 A_1 + T_2 A_2 + \cdots + T_n A_n}{A_1 + A_2 + \cdots + A_n} \qquad (2)$$

where T_1, T_2 and T_n are the surface temperatures of surface 1, 2 and n inside the room, respectively. A_1, A_2, A_n are areas of each surface of the room. In this work, there is only one surface hence the equation simplified to: $\bar{T}_{mr} = T_1$ (T_1 represent the inside surface temperature of the roof, T_i).

Therefore, OTR reduction is calculated considering Eq. (3), as follows:

$$OTR = \frac{OT_{,Roof-A} - OT_{,PCM\ Roof}}{OT_{,Roof-A}} \times 100\% \qquad (3)$$

For DHR, T_r is considered to study the reduction in each PCM roof compared with the reference roof, according to Eq. (4), as follows:

$$DHR = \frac{T_{r,Roof-A} - T_{r,PCM\ Roof}}{T_{r,Roof-A}} \times 100\% \qquad (4)$$

The peak temperature period from 12:00 to 16:00 is considered to calculate OTR and DHR as the heat is time-dependent energy. Therefore, the thermal comfort concerns appear significantly in the midday, encountered with the highest solar radiation and ambient temperature.

Findings indicated that all PCM positions within PCM roofs showed remarkable enhancement in the thermal comfort indicators compared with the reference case without PCM. Amongst PCM roofs, the best results reported for Roof-B wherein OTR and DHR of 10.3% - 23% and 8.4% - 19.9%, respectively, compared to Roof-A. Following that, Roof-C also showed good thermal comfort enhancements compared with Roof-C, as shown in Figure 1.

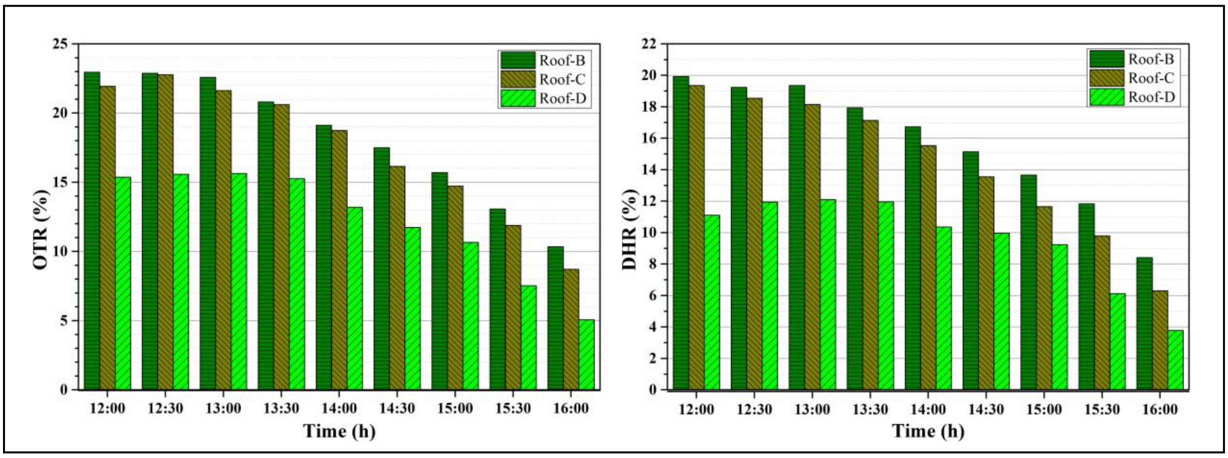

Fig. 1. Calculation results of OTR (Left) and DHR (Right).

Keywords: PCM, thermal comfort, composite flat roof.

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RESEARCH OF THE INTERNAL ENVIRONMENT OF THE MILITARY CAMP BUILDINGS

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Abstract
The operation of temporary military camps is a special operation task. In any case, it can be said that it is installed for a specific purpose and for a foreseeable (short) period.

In the light of the experience of the last 20 years, the concept of temporary facilities as military camps (Figure 1.) should be rethought on the basis of material research. Special attention should be paid to the planning of its operation. The basic design data and requirements that help to build a temporary infrastructure have generally been determined from empirical data that can be considered to be incorrect today. It is therefore necessary to conduct a comprehensive review of temporary installations in order to establish a sound design basis for today's requirements. In line with 21st century environmental engineering practice, energy efficiency and recyclability are an increased requirement for military facilities as well.

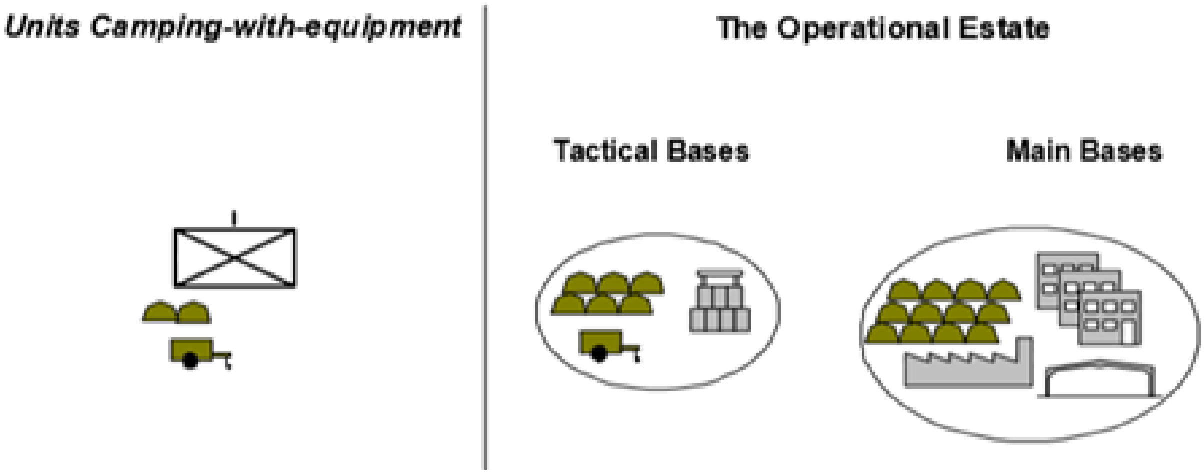

Fig. 1. Infrastructure on operations of short period time-built tent-camp and the built temporary facility (JTTP-4)

In our work, we study the most characteristic parameter of a complex camp operation: how well the internal environment provided in the installed facility is suitable for the rest of the soldiers. We studied the structure of the currently used technology and the design needs of the development of military camps. Based on all these, the direction of development can be determined, while maintaining functionality, rapid deployment and transport is also important. In order to determine a reasonable and sustainable energy requirement for camp operation, it is necessary to assess the indoor air conditions under which the performance of the deployed personnel can be maintained at the highest level.

Measurements were made in the accommodation ISO container (*2m x 6m x 2.5m*) with 4 persons placing sleep time in the air CO_2 concentration. When sleeping 4 people - *sleep time 6-8 hours* - we observe how the CO_2 content of the 30m^3 room air changes without the use of ventilation equipment.

Fig. 2. Modelling of the tent camp built and the container camp

Laboratory measurements in the building engineering laboratory of Hungarian University of Agriculture and Life Sciences, modelling the military camp accommodation areas, with a tent camp built for a short time and a container temporary facility building. In the constructed model, we measure the internal temperature and the parameters influencing it in order to determine the energy transport required to achieve the desired IAQ.

Keywords: Military camp, inside air quality (IAQ), temporary facilities

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FAMILY HOUSE ENERGY BALANCE MODELING

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Abstract
The main questions about a residential building today are:

- How energy efficient is the building?
- How big its ecological footprint is?
- Uses renewable energy?
- provide adequate comfort to the user?

We had the necessary data about this building. The original documentation was available and the completed building was surveyed on site. Gas consumption data for heat production and hot water supply, as well as the temperature value, must be available.

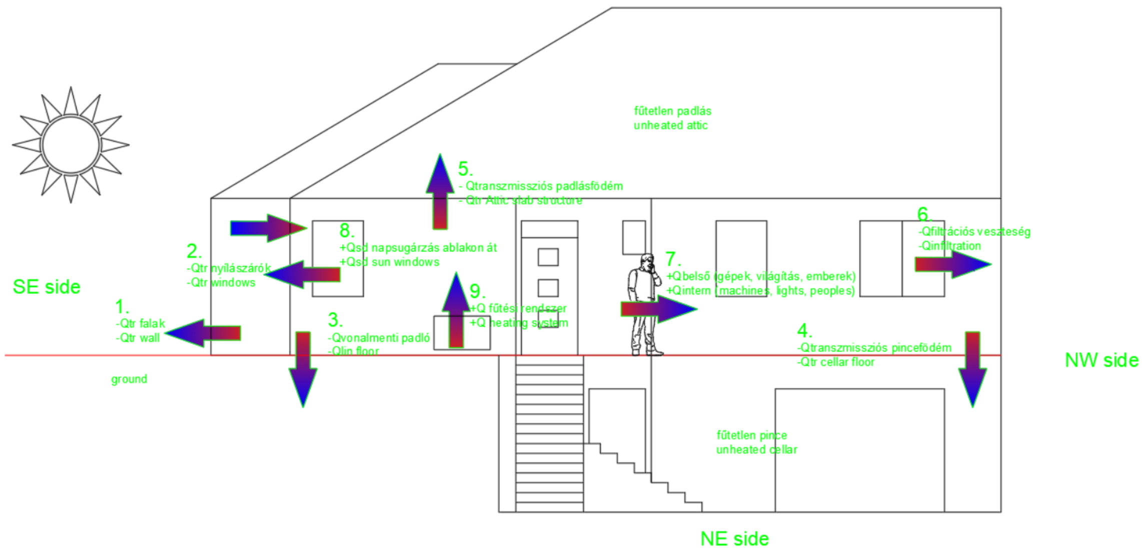

Fig. 1. Heat losses and heat gains in a building

As a first step, the energy rating of the building was determined using the heat loss calculation using Hungarian accepted method. Then a model was made based on this.

To create the model, we chose the traditional approach: the factors influencing the heat losses and heat gains of the building were divided into smaller independent parts. We have tried to create a model that can accurately determine each heat flow against the regulation. An excellent example of this is the heat loss and heat load in the direction of the attic of the building. The regulation calculates a specific overhead temperature, taking into account filtration. However, if we model the attic temperature, that is a significant difference from the accepted calculation method. So given the building and its model.

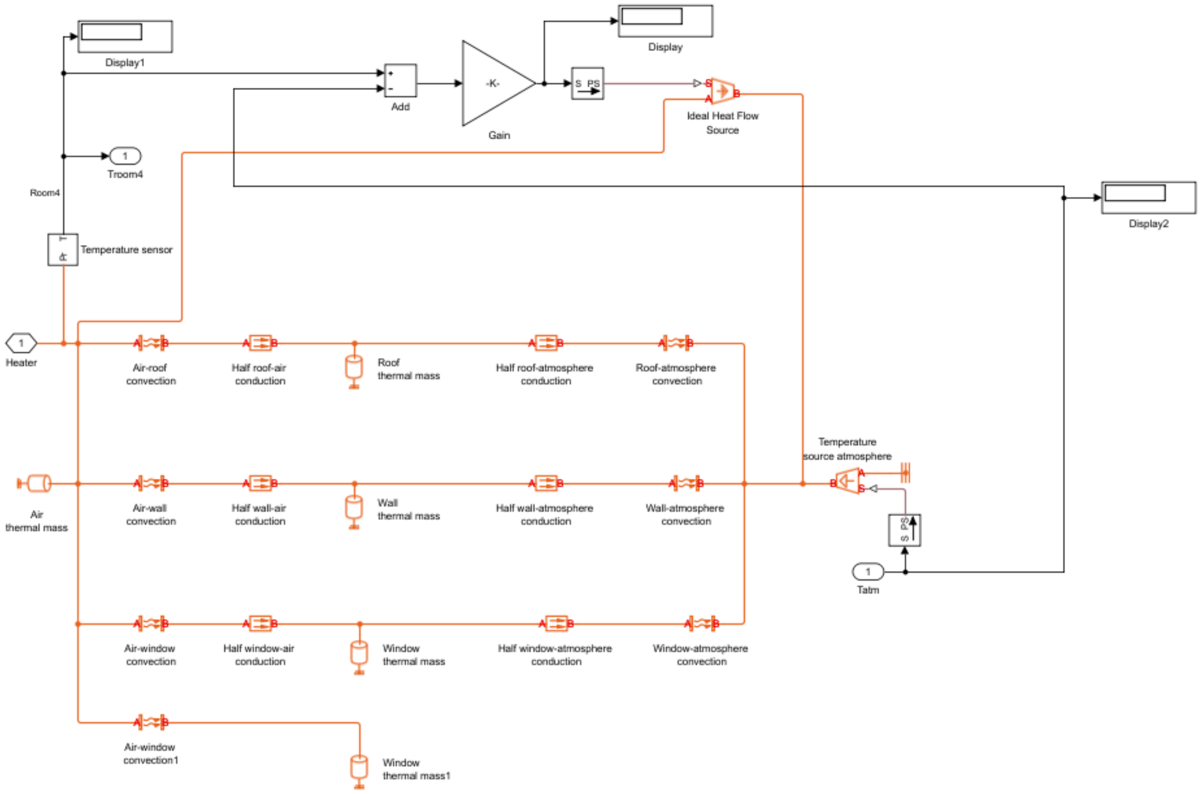

Fig. 2. Matlab model for heat losses

Examining the energy saving possibilities, it is obvious that since the building can be considered modern (appropriate wall structure, doors and windows, etc.), the modernization of the economy lies in the utilization of solar energy. Later, the model will be supplemented with a photovoltaic system, examining the potential for savings as a function of weather parameters.

Keywords: modeling, energy use of buildings, optimization, efficiency

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INDOOR AIR POLLUTANTS ON COMFORT INSIDE RESIDENTIAL BUILDINGS WITH DIFFERENT ENERGY CLASSIFICATIONS

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Abstract

Comfort theory with its several decades of history is gaining significant importance affecting a fast-evolving world and its industries. Having conducted a thorough review of existing academic research I find it fair to conclude that the subject of comfort theory, specifically the effect of pollutants on comfort, is a well-studied field. Ever stricter standards are setting stringent requirements for new residential developments. Considering how an average person will spend 80 to 90% of their lifetime in confined indoor spaces it is of paramount importance to provide for appropriate living conditions, meeting interior comfort parameters through the conscious use of building systems and building materials. In buildings without sufficient ventilation airborne pollutants can be harmful to health. Air quality is defined by multiple factors to be considered in conjunction with one another:

- CO2 content of air,
- Radon level of plastics,
- The evaporation of paints, chemicals, cosmetics, glues, household cleaning materials and varnishes, i.e. their VOC level,
- Humidity level increasing the likelihood of the presence of viruses, fungi and mould.

My research has focused on the presence of different pollutants in a classic family cottage built in 1976 and an energy efficient passive house built in 2019. I am currently conducting measurements in 27 buildings which I categorize based on the following factors:

- Number of occupants,
- The function of the building,
- The materials used during construction,
- Type of underlay and ceiling,
- Type of doors and windows,
- And most importantly, the exact location of the measuring devices.

During my research the measuring devices are replaced quarterly and after one year the measurements are collected and converted into statistical indicators. I then use these indicators to draw preliminary conclusions based on which I can narrow the focus group to a smaller number of buildings where I will conduct continuous measurements. Maximum allowed levels are set in both local and international legislation however in my opinion these limits are largely

outofdate. The identification and measurement of pollutants is a high-cost process and it is my opinion that there is a need to develop a new, simple, cost-efficient method for the setting of pollutant limits. This method would greatly helpoptimize development budgets while achieving appropriate comfort levels in future new-build projects. Developing a fast and cost-efficient method is an optimum solution benefiting the considerations of cost and comfort alike.

There are various pollutants present in indoors spaces such as residential buildings, where we spend up to 80-90% of our lives. It is a demonstrated fact that the concentration of these pollutants is often beyond regulatory limits. The concentrations can get particularly high in the absence of a well-designed, properly installed and operated ventilation system. During to the ongoing Covid-19 pandemic the importance of air quality, both indoors and outdoors, has gathered renewed attention.

Regardless of which part of the world we are and what type of a building (residential, office or a shopping mall) we are in there will be pollutants present in the air. This may lead us to the question of how radon concentrations increase in indoor spaces without artificial ventilation.

As a result of the recent energy policy objectives, the improvement of the energy efficiency of buildings and residential buildings for various purposes has started, which is also true for new buildings and old buildings awaiting renovation or undergoing renovation. As a result of the combined effect of stricter regulations, the rapid development of the construction industry, and the building materials used, many buildings do not have adequate ventilation.

The pursuit of energy efficiency has led to the use of building materials that provide complete airtightness with high quality, thereby reducing the natural filtration of buildings. In our performance-oriented world, achieving maximum performance in terms of work is a fundamental task, so it follows that companies, multinationals do everything they can to create the optimal comfort space in which employees feel comfortable, whether it is mental or physical work.

Buildings with inadequate indoor air quality have an effect on fatigue, irritability, and headaches. By the definition of indoor air quality we mean all non-thermal characteristics of the air in comfort spaces that affect a person's well-being. Due to the confinement caused by the epidemic, increased stress and psychological stress, the development of appropriate comfort must be given priority. The health of our body is at increased risk in the current situation, so regular ventilation by natural or artificial means is essential. Man perceives the quality of the inner air with his two senses.

Basically, by sniffing through the nose and through the behavior of the conjunctiva of the eye, sources of pollutants can come from outside air, occupants, fixtures, building materials, and air conditioning systems.

The most typical pollutant is gaseous carbon dioxide (CO_2), but other gaseous and solid pollutants are also present around us, such as e.g. radon (Rn^{222}), formaldehyde (CH_2O), and tobacco smoke, evaporation products of building and cladding materials, viruses, and so on.

Keywords: carbon dioxide, radon level, indoor air pollution

WASTEWATER AS POTENTIONAL RENEWABLE ENERGY RESOURCE

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Abstract
In the last decade the engineer's vision turned; instead of inventing new energy sources, there are many renewable sources, that humanity never ever acknowledged as an energy source. Of course, by nature the sun, the dynamic movement of water, wind and biomass was a clear and used renewable source, but potential renewables are discovered, like waste, or wastewater. These byproducts of the human civilization are reproducing daily, weekly, annually, and as urbanization grows, the number of waste and wastewater is increasing as well. If we consider them as a potential source, we can have a second benefit of these byproducts.

Biogas production is an older narrative of sludge digestion, and by the high caloric value it is used as a primal energy source nearby wastewater treatment plants, and many times beside landfills. In 2014 Urumqy (People's Republic of China) wastewater treatment plant produced more than 985 m^3 of biogas monthly, which covered approximately the 50% of the site's energy demand, by treating 2700 m^3 of sludge daily. With the investment of sludge compressors and the sludge digestive equipment and infrastructure the annual CO_2 emission of the sewage treatment plant decreased by approximately 80%. In 2018 Vancouver (BC, Canada) invested sludge digestive equipment to all the five sewage treatment plants, those produce heat energy for household, and governmental heating instead of using fossils for that purpose. Beside that research are being conducted on using wastewater, which is full of nutrients, to grow algae; these algae could then be turned into biofuel that could replace gas or gasoline, or even green manure/nutrient as agricultural application.

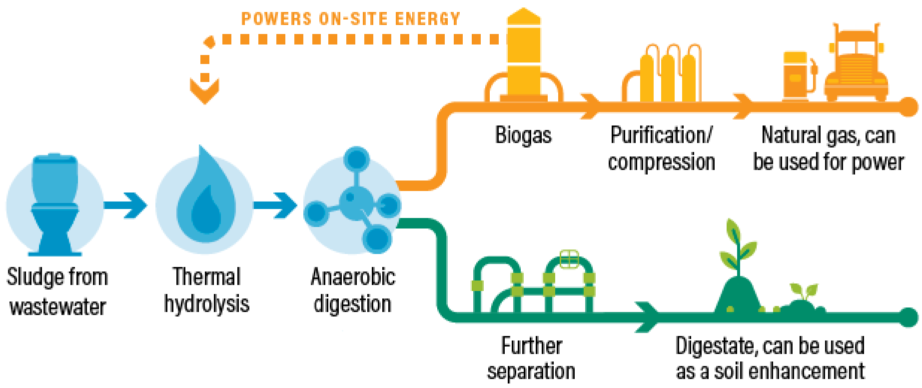

Fig.1. Wastewater to Energy System (World Resources Institute)

According to Kollmann et. al (2017) there are many possibilities to create urban planning concepts to involve wastewater as energy resource. In their study an Austrian urban settlement carried out for eight energy zone and discovered that wastewater even carries the possibility of its surprisingly constant temperature; the average temperature of wastewater is around 18-22 C° at summer, and 14-16 C° at winter, so by radiation it is possible the use wastewater and parts of the sewage system as a potential heat source without process or transformation for example road heating to avoid icing, and ice formation. The same idea was published as the wastewater is capable of cool these roads during heatwaves to avoid melting and deformation of the infrastructure. Of course, wastewater as a biological habitat has its own limit of temperature fluctuation, so heat exchange should be applied between boundaries, but the experiment and modelling show 40-60% decreasing of CO_2 emission annually, while fossils can be reduced by 30-50% only with the involving ow the sewage system, and sewage treatment plant.

Fig.2. Road heating with wastewater to avoid icing, and ice formation

Keywords: wastewater, renewable energy resource, heating, biogas

Reference

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