SZENT ISTVÁN UNIVERSITY GÖDÖLLŐ

Department of Physics and Process Control

26th WORKSHOP ON

ENERGY AND ENVIRONMENT

BOOK OF ABSTRACTS

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December 10-11, 2020

Gödöllő, Hungary

PREFACE

Successful events in the series of the Seminar/Workshop on Energy and Environment (EE) were organised yearly since 1995 under the auspices of the Department of Physics and Process Control, Szent István University Gödöllő, Hungary, including active participation also from foreign institutions working in the field of the application possibilities of renewable energy resources.

The aim of the Workshop is provided a forum for the presentation of new results in research, development and applications in connection with the issues of energy and environment.

This is now a call to take part in the above-mentioned event along with to submit one-page abstract of potential contributing papers falling into the Workshop topic. The Abstract Volume of the Workshop will be published and distributed among the participants during the event. The language of the Workshop is English, no simultaneous translation will be provided.

Due to the pandemic situation in this year the Workshop will be organized on-line way. The platform link will be provided later.

The deadline of the abstract submission: December 4, 2020

Further information, please, contact:

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26th WORKSHOP ON ENERGY AND ENVIRONMENT

December 10-11, 2020, Gödöllő, Hungary

Program
(on-line)

December 10 (Thursday)

14.30-17.00 Registration
Visiting the Department of Physics and Process Control
Visiting the solar installations

December 11 (Friday)

08.30-08.40 Opening the Workshop by:

Prof. I. Farkas	Head of Mechanical Engineering PhD School Szent István University, Gödöllő, Hungary
Prof. I. Szabó	Vice rector for Education Szent István University, Gödöllő, Hungary
Prof. L. Kátai	Dean of Faculty of Mechanical Engineering Szent István University, Gödöllő, Hungary

Session 1 *Chairmen: Prof. I. Farkas*
Dr. D. Rusirawan

08.40-09.00	I. Farkas: Achievements of the Hungarian Section of the International Solar Energy Society
09.00-09.10	D. Rusirawan and I. Farkas: Research and project activities in photovoltaic field at ITENAS Bandung
09.10-09.20	D. Atsu, I. Seres and I. Farkas: Power quality assessment of microinverters for grid-connected PV systems in low voltage networks
09.20-09.30	G. Pintér, N. Baranyai Hegedűsné, A. Vincze and H. Zsiborács: The potentials of using power-to-gas technology for balancing solar power plants in Hungary
09.30-09.40	G. Habtay, J. Buzas and I. Farkas: Solar energy potentials in Eritrea cities
09.40-09.50	I.R. Nikolényi and J. Tóth: Maximum efficiency study on polythiophene based all-polimer
09-50-10.00	Mensour Almadhhachi, I. Farkas and I. Seres: Designing a hybrid tree by a combination between black body and solar cells
10.00-10.10	L. Lidyawati, D. Rusirawan and I. Farkas: Forecasting of photovoltaic modules characteristics using ARIMA and Fuzzy time series models
10.10-10.40	COFFE BREAK

Session 2 *Chairmen: Prof. P. Weihs*
Dr. Cs. Mészáros

10.40-11.00	P. Weihs, A. Frisch-Niggemeyer, S. Schreier, M. Revesz, C. Gützer: Potential of digital cameras for scientific investigations: case studies
11.00-11.10	Cs. Mészáros and Á. Bálint: Symmetry aspects of the optical scattering processes in solar materials with incommensurate modulation
11.10-11.20	I. Kocsány, I. Seres and I. Farkas: Determining the absorbed solar radiation in solar collectors
11.20-11.30	Asaad Yasseen, I. Farkas and I. Seres: Performance enhancement of PTSC by selective absorber coatings
11.30-11.40	Ahssan M.A. Alshibil, P. Víg and I. Farkas: TRNSYS simulation of a flat plate-based hybrid solar collector system
11.40-11.50	Maytham H. Machi, J. Buzás and I. Farkas: Thermal performance of solar air collectors used in modular solar dryer
11.50-12.00	Ahmed M. Ajeena, P. Víg and I. Farkas: Performance enhancement of flat plate solar collector using nanocoating and nanofluids
12.00-12.10	P. Víg and J. Tóth: Effect of water droplets on solar modules performance
12.10-12.40	LUNCH BREAK

Session 3 *Chairmen: Dr. I. Seres*
Dr. S. Bartha

12.40-13.00	I. Seres, B. Bán, Cs. N. Dénes, M. Krasznai, M. Reményi, K. Tóth, P. Unyi: Sensor development for the ESA Cansat project
13.00-13.10	S. Bartha, L.C. Duarte, F. Carvalheiro, S. di Berardino: Landfill deposit gas emissions: Evaluation and measurement techniques, influence to the local air pollulion
13.10-13.20	P. Hermanucz, G. Géczi: Energy analysis of air source heat pump defrost cycle
13.20-13.30	A.M. Ahmed and A.R. Imre: Efficiency of organic Rankine cycles with hybrid solar-geothermal heating source
13.30-13.40	D.I. Permana, I. Farkas: Design and construction of organic Rankine cycle powered by solar thermal heat source
13.40-13.50	M.H. Ali, Z. Kurjak and J. Beke: Enhancement the efficiency of photovoltaic solar cell by using combination earth-air heat exchanger with assist solar chimney
13.50-14.00	Sz. Páger, A. Veres, and G. Géczi: Hydronic modelling and basic circuits grouping
14.00-14.10	L.R. Fekti, L. Szekely and G. Géczi: Researching the effect of pollutants on comfort inside residential buildings with different energy classifications
14.10-14.20	A. Qor-el-aine, G. Géczi and A. Béres: Source regions of PM10 particles during high concentration days in Kecskemét Hungary
14.20-14.30	CLOSING

ACHIEVEMENTS OF THE HUNGARIAN SECTION OF THE INTERNATIONAL SOLAR ENERGY SOCIETY

I. Farkas

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This paper is dealing with the achievements of the Hungarian Section of the International Solar Energy Society (ISES-H). The reason is that in 2020 we are celebrating the 50th year anniversary of the establishment of the ISES.

The ISES-H has been established on July 12, 1983 with 20 members. On September 6, 1990 ISES-H established the Hungarian Solar Energy Society (HSES). The recent number of members in the Society is 50. The HSES Society operates five (5) Working Groups as: Solar architecture; Photovoltaic application; Solar thermal applications; Energy politics and Youth.

ISES-H organized an International Workshop with the title of "Development and Use of Efficient Solar Systems", on June 2-3, 1988 in Budapest. Total number of participants were 60, from 14 countries. Abstracts of the lectures have been published.

The ISES World Congress has been taken place on the August 23-27, 1993 in Budapest. The number of participants was 960, from 73 countries. The Technical Program consisted of 5 plenary and 140 technical sessions, where 853 oral and poster presentations were given. The Proceedings has been published in 8 volumes edited by the sections' chairmen. The Solar World Exhibition was held in parallel with the Solar World Congress with an exhibition area of 3000 m^2. The exhibitors were from 49 companies from 14 countries.

In 1984 the Hungarian Section of ISES established a close contact with the Division of Technological Research and Higher Education of UNESCO and an effective and active co-operation has been realized in the European Solar Energy Network (ESEN). A Hungarian Solar Participation Program (SPP) has been prepared by considering the aims of the World Solar Summit Process of UNESCO. In the main regions of the country eight Solar Regional Centres have been established, most of them at high-schools and universities.

ISES-H proposed for the UNESCO ESEN to establish a closer co-operation with the FAO in the field of renewable energy technologies participating in several international meetings organized by the contribution of FAO.

Hungary served also actively in the Board of ISES and ISES-Europe.

Since 1994 the Sun-Day programs have been celebrated in every year by at the Szent Istvan University Gödöllő and since 1995 the Seminar/Workshop on Energy and Environment (EE) series were organised yearly with the support of HSES.

Under the auspices of the Society the following projects were/are running: UNESCO Solar Participation Program; PHARE program; Solar School Forum; EU Terminology research to identify the most suitable Hungarian equivalents to corresponding English IATE entries in the field of solar energy.

The HSES keeps close contact and active co-operation with the national companies working on the fields of solar energy installations and with the Scientific Energy Committee of the Hungarian Academy of Sciences are active.

RESEARCH AND PROJECT ACTIVITIES IN PHOTOVOLTAIC FIELD AT ITENAS BANDUNG

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Research in solar energy, especially in the photovoltaic (PV) field becomes interesting and important, as one of an alternative energy, in addressing on the challenging the depletion of conventional energy and global warming. The principle of the PV is to convert directly of solar energy to electrical energy (electricity), without impacts on environmental issues.

Since beginning of 2018, Institut Teknologi Nasional (ITENAS) Bandung has installed and operated a small scale of solar power plant (SPP), as a research equipment in the PV field. The schematic diagram of PV system included the control equipment is shown in Fig. 1.

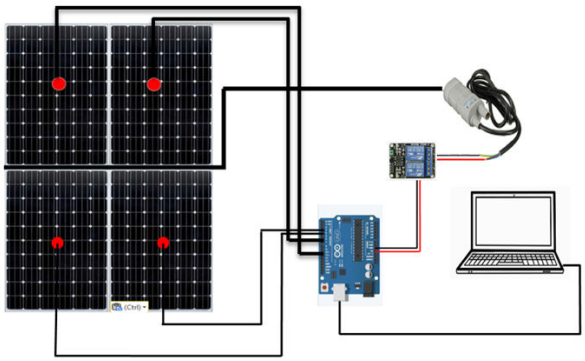

Fig. 1. PV modules and control equipment system

In general, a current (on going) and the future research activities related to the PV system is emphasized on the modelling of PV modules characteristics and cooling effect on those characteristics. The topic of current research can be summarized as follow:

- Modelling of the PV modules of the SPP by single and double diode model using visual basic for application (VBA) Microsoft Excel;
- Modelling of the PV modules characteristics using Fuzzy Time Series and Autoregressive Integrated Moving Average (ARIMA);
- Modelling of the yearly solar radiation and power using artificial intelligence (phyton software);
- Development of SPP cooling system to increase the SPP performance.

In spite of that, the existing of a small scale of SPP has been used also for training, not for internal only, but for teachers, students and public communities from external university, especially for elementary – senior high schools, as a part of capacity building program of university, in case of community services. Furthermore, based on public served activities, ITENAS got the opportunities from the company, as government representative, to make a feasibility study and detailed engineering design (DED) of the SPP for rooftop type in the existing building, especially for non-profit organization, in several islands in Indonesia.

POWER QUALITY ASSESSMENT OF MICROINVERTERS FOR GRID-CONNECTED PV SYSTEMS IN LOW VOLTAGE NETWORKS

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Solar PV has been growing continuously over the last decade and has taken the centre of the new trend of electricity generation through non-traditional sources. This growth has been as a result of the supportive government and sub-regional policies and enhanced efficiency technologies, providing the enabling environment for capital access. With the consistently decreasing cost of solar PV, it has become one of the sources that offer the cheapest electricity cost in the world with the most significant capacity additions being the utility-scale solar PV.

The role of grid inverters is very critical in feeding power from distributed sources into the grid. With the increasing high growth rate of grid-tied solar PV systems (both rooftop and large-scale), the awareness of power quality issues has risen with new power quality regulations and standards being imposed by different countries and to regulate power fed into the grid from distributed sources to ensure the stability of the power grid.

Power quality assessment of a microinverter has been conducted applying a constant solar irradiation and PV power source, and also under real outdoor conditions in compliance with the accepted solar PV integration requirements under the Hungarian grid infrastructure. Different technology solar PV modules were employed for the study which was conducted in the forecourt of the Solar Laboratory of the Szent István University, Gödöllő, Hungary.

The current total harmonic distortion (ITHD) recorded for the studied microinverter under the outdoor conditions far exceeded the ITHD for the study with the PV simulator. However, the results of the voltage THD for the two studied cases showed the opposite trend. The voltage total harmonic distortion and current total harmonic distortion for the 400 Wm^{-2} (60 Wp) and the 1000 Wm^{-2} (146 Wp) scenarios under the constant solar irradiation (PV power) were 2.24%, 13%, and 2.27, 6.93%, respectively.

The voltage and current total harmonic distortions for the outdoor study were 2.03% and 14.28% for Solarex (pc-Si module), 1.94%, and 27.43% for Juta (mc-Si modules), and 1.97% and 33.6% for Dunasolar (a-Si glass module). Results showed a correlation between the intermittency of solar radiation and the current THD. The percentage recorded power factor profile that violated the limits specified by the referenced standards was 67%, 54%, and 37% for Dunasolar, Juta, and Solarex modules, respectively.

Acknowledgements

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THE POTENTIALS OF USING POWER-TO-GAS TECHNOLOGY FOR BALANCING SOLAR POWER PLANTS IN HUNGARY

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Photovoltaic power plants with a nominal power of more than 50 kWp are obligated to provide production schedules in Hungary too. *Article 5, Balance Responsibility, of Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity* stipulates: "All market participants shall be responsible for the imbalances they cause in the system." According to the regulation quoted above, it is in the interest of the owners of power plants to keep their schedules, which is the first step towards the integration of variable renewable energy sources into electric energy systems, in the authors' opinion. Thus, the availability of balancing capacities, which can be based on several technological solutions, is crucial. This is also exactly why it is of primary importance to determine the type of balancing requirement, on the basis of which the suitable technology can be selected more precisely.

Having analysed the intraday schedules and the actual generation data of the Hungarian photovoltaic power plants submitted to the ENTSO-E by MAVIR, it was established that 3.6 GWh 'remaining' negative regulation need occurred, according to the simulations, due to the the extra regulation need resulting from the PV power plants' compliance with their schedules between 1 September 2019 to 31 August 2020, in the course of the battery-based balancing of a PV capacity of 100 MWp. This presupposes that the negative and positive regulation of photovoltaic power plants was managed directly with the help of electrochemical technology. The 3.6 GWh negative regulation need can also be regarded as 'remaining extra electric energy', which cannot be regulated by the electrochemical storage technologies installed directly connected to the power plants. However, for the solution of this problem power-to-gas technology can offer a viable alternative. Concerning the amount of the gas (synthetic methane) that can be produced in Hungary in the case of PEM electrolysis and biological methanation, presuming the use of the technology of Power to Gas Hungary Ltd. (where 97.5 GJ of synthetic methane is produced with 0.1 MWh of electric energy), the following results can be arrived at.

According to our calculations, the quantity of surplus electric energy from photovoltaic power plants exceeding the amount that could have been regulated by battery-based technology between 1 September 2019 to 31 August 2020 would have been 40.6 GWh, which would have been enough to produce 2 085 679 m^3 of normal, synthetic methane by using power-to-gas technology. Presuming a natural gas price of 0.34 EUR/Nm^3, this amount of methane represents a value of EUR 709 131.

SOLAR ENERGY POTENTIALS IN ERITREA CITIES

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For a country, the deployment of solar energy projects, including solar drying, needs precise information on the available solar resource. This study focuses on the solar energy potentials in Eritrea cities using different long-term data sources. Thus, solar radiation measurements have been made to provide engineers and scientists with local solar data.

Eritrea is a northeast Africa country on the Red Sea coast with a total population of 3.57 million as of 2020 (UN data). Based on temperature variations, Eritrea has three climate zones: the central highlands, the coastal region, and the western lowlands. The sunshine all year round ranges from 2900 to 3200 h. In this study, the three most important cities in Eritrea based on economic activities and population density were selected. The characteristics of these cities, including their locations, are presented in the next table.

City	Latitude (°N)	Longitude (°E)	Elevation (m)	Köppen climate classification	Population
Asmara	15.28	38.92	2325	Aw	563,930
Massawa	15.61	39.45	6	BWh	23,100
Asab	13.01	42.74	16	BWh	21,300

Global horizontal irradiation (GHI) and direct normal irradiation (DNI) data were used to calculate global tilted irradiation (GTI) received on the surface of flat plate collectors. Data sources were utilized from three sources, as: global solar atlas (Solargis), 1994-2018; PVGIS, 2005-2016 (both satellite observations), and Department of Ministry of Energy and Mines (MEM), 2000-2005 (local station using Pyranometer). The next Table shows comparison of the three yearly total GHIs.

City	PVGIS	Solargis	MEM	Percentage variation MEM-PVGIS	Percentage variation MEM-Solargis
Asmara	2235	2337	2211	-5.70%	-1.08%
Massawa	2169	2045	2089	2.10%	-3.83%
Asab	2390	2264	2374	4.63%	-0.67%

It can be concluded, the maximum variation of GHI between MEM and Solargis is -4%, whereas -6% between MEM and PVGIS. Therefore, data obtained from Solargis can be employed for future analysis of the solar project in the country. The data also shows that the daily mean GHI is around 6.2 KWh/m^2, which is among the best solar resources in the world.

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MAXIMUM EFFICIENCY STUDY ON POLYTHIOPHENE BASED ALL- POLYMER SOLAR CELLS

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Developments of the all-polymer type of solar cells (photovoltaic cells in which both the donor and acceptor materials are polymeric) possess very promising possibilities on the field of organic solar cells. Significant efforts are being made replacing the acceptor materials in the polymer/fullerene type of ones expecting better mechanical, chemical and electronic properties from these reseach works. These goals are achiavable with the usages of approprite plastic materials.

The one of the first polymer donor-polymer acceptor solar cell was the MEH-PPV/CN-PPV proposed by Yu and Heeger (Yu, Heeger, 1995). In this system the formation of the compatible energy levels needed for the operation was thanks to the cyano side group attached to the PPV backbone. Based on this principle we wish to study the poly(3-alkyl thiophene) (P3AT) polymer family from the viewpoint of its attainable maximum theoretical efficiency (Minnaert, Burgelman, 2007) in the frame of the Hubbard model. The donor material is the P3HT (poly(3-hexyl thiophene)) and the acceptor ones will be another members of this family differing to the donor by only the side groups. These latest ones will be taking in account by an on-site potential parameter as we made in our earlier paper (Nikolényi et al., 2020). Beside these we focus our attention to the optical transition of the P3HT between the two lowest energy band too. This means a strongly (hole) doped state of the solar cell materials. The band gap is in this case lower than in the original (half filled) one and we hope that the required difference between the LUMO levels of donor and acceptor materials will be also achievable.

References

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DESIGNING A HYBRID TREE BY A COMBINATION BETWEEN BLACK BODY AND SOLAR CELLS

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The world is facing fusil fuel-reducing problems while the increasing electricity demand never stops. Emission and noise problems have been controlled by a solar energy station, many types, and have many characteristics. For instance, in Iraq it has been recorded a large scale of solar radiation. The PV technology needs more development like increasing efficiency, reducing the initial cost, more generation, and shape enhancement, which is very important for building and city architecture.

In the modern cities building, the architectural form is carefully chosen for all the details of the facilities that will be in these cities and also taking care of the energy sources and the number of pollutants that will negatively effect on the environment, which negatively affects the health of the people who live in these facilities. One of the best environmental improvements are trees and plants, where they should take a suitable area within modern cities. We will mix the beautiful shape of grape trees to generate appropriate energy according to the available spaces and capabilities in this direction.

We can take advantage of the capabilities and reduce the risks to the environment in all the details of the assets in cities, and coordinate them so that the aesthetic of cities is the standard in designing to produce energy and reduce pollutants.

The hybrid tree is the new face of PV technology to generate electricity from an environmentally friendly shape. The grape is one of the world's famous trees. They are characterized by black pillows, which are the colour of the PV cells, and we can also use inside of the balls to generate electricity by a combination between PV technology and a black body. In such a way, we will get the electricity from the inside and outside the grapes.

The black body has been chosen to cover all inside surface ball to absorb all the solar radiation to enhance PV panel efficiency. The outer surface will be absorbed part of the falling sunlight and reflect the other light to fall in other ball in the grape vine to absorb the largest percentage of sun light.

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FORECASTING OF PHOTOVOLTAIC MODULES CHARACTERISTICS USING ARIMA AND FUZZY TIME SERIES MODELS

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Renewable energy technologies have been one of the most strategies in addressing sustainable energy development and climate change. The roles of renewable energy in developing countries are vital, which include the accessibility of modern energy services in rural areas, climate change mitigation, energy security, green job creation, and eventually improvement of quality of life. Solar energy is an important renewable energy, radiant light and heat from the sun is converted into electricity, straight through the photovoltaic (PV) solar cells/module. In the context of electricity generation, solar energy doesn't emit harmful greenhouse gases, pollute groundwater or deplete any natural resources. The power generation from PV solar modules varies in nature due to irradiance, ambient temperatures and other factors. The main issue of solar energy is its fluctuations in accordance to sudden weather change variables. Hence, forecasting energy generation is needed for solar electricity since it is required to ensure the power continuity in order to store the energy.

Refers to the preliminary discuss above, the studies of the energy forecasting are necessary to be developed, in order to overcome the uncertainty of the fluctuations on the sudden weather changing. In this paper, two forecasting time-series models i.e., Autoregressive Integrated Moving Average (ARIMA) and Fuzzy Time Series (FTS) models, are proposed. The ARIMA class of models is an important forecasting tool, and is a basis of many fundamental ideas in time-series analysis. ARIMA stands for autoregressive integrated moving average. ARIMA models are actually a combination of two, processes that are able to generate series data. Those two models are based on an auto regressive (AR) process and a moving average process (MA). In practice, ARIMA is generally used in stationary process; however, ARIMA can also be used in non-stationary process. ARIMA model is characterized by three parameters: p, d, and q where they represent the order of autoregressive terms (p), differencing terms (d), and moving average terms (q), respectively. In other side, Fuzzy time series (FTS) forecasting is an emergent research area which deals with the problems associated with uncertainty, vagueness, and imprecision. In FTS, the domain of the variable of interest, called Universe of Discourse (UoD), is divided into sub-domains, and each of them is linked to a fuzzy set. FTS forecasting methods have become attractive due to their simplicity, model transparency, forecasting accuracy. Non-stationary fuzzy reasoning and non-stationary fuzzy sets have a dynamic component that changes the function over time.

As a case study, ARIMA and FTS models are applied to predict of 1 kWp PV solar modules characteristics. As a forecasting result, both models are trained/compared concerning to the measured data (actual data from daily operation of 1 kWp PV solar modules installed at Institut Teknologi Nasional Bandung). Error analysis (especially Margin of Error, MoE) both models are performed to demonstrate the reliability of the proposed models.

POTENTIAL OF DIGITAL CAMERAS FOR SCIENTIFIC INVESTIGATIONS: CASE STUDIES

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The digitalization of images is used in many different scientific domains. Among other things it is used to determine the radiation climate in stands and to determine the density of the stand. This technology is also used for phenological studies. Newest investigations try to use webcam images to determine atmospheric turbidity and visibility.

In the present presentation two investigations using digital cameras will be presented. The first investigation deals with the determination of the beginning of phenological phases. We use 5 years of webcam images of abricot trees. We first try to determine the beginning of flowering and green leaves growth by using grey scale values and a greenness index. Whereas the determination of the leaf growth using the greenness index works very well, the determination of the flowers is more problematic. We therefore try another indirect method by determining the area of the red buds of the abricot trees. Since the determination of the red pixels is more accurate this seems to be a more promising method.

The second investigation deals with the determination of aerosol concentration by using two years of web cam images installed at the measurement platform of BOKU and overlooking the city of Vienna. Two different methods are used. One method is based on determining the ratio of blue to red of scattered atmospheric radiation. This method shows a good correlation with the atmospheric column aerosol concentration especially in Summer. The second method investigates the fluctuations in the grey scale values along a horizontal line of surface reflected radiance. This methods shows a very good correlation with in situ ground based measurements of particulate matter. Further investigations are still ongoing: by removing near infrared filters and adding small width filters we investigate methods to determine water vapor content.

SYMMETRY ASPECTS OF THE OPTICAL SCATTERING PROCESSES IN SOLAR MATERIALS WITH INCOMMENSURATE MODULATION

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It is well-known nowadays, that experimental and theoretical investigation of basic structural properties of different types of carbon nanotubes plays a role of continuously increasing importance in the whole domain of the contemporary condensed matter physics. Among them, the research activities connected to possible applications in solar cells recently became also very significant. In the present study we will demonstrate in detail some further possible and very promising applications of the group representation theory elaborated originally molecular systems characterized by chain-type arrangements, which may contribute to understanding and increase of the energy transformation efficiency in the relevant areas of the solar energetics, too. According to the definition, the complete set of symmetry transformations leaving invariant a *Q1D* system belongs to one of the discrete infinitely many line groups gathered into 13 families. The exact symmetry and representation theories of such types of discrete infinite chain systems has been elaborated in detail for decades, and have many important applications including setting up the basic selection rule formulae, too.

In the present study, the advanced mathematical physics methods mentioned above will be applied in detail and incorporated into correlation functions necessary for comparison of the experimentally determined-, and theoretically derived light scattering intensity curves. Although some of the such-type applications of the irreducible representations of line groups in solid state physics are also known for decades, they are completely absent even from the most complete recent works about applications in various types of structural investigations of the incommensurately modulated condensed matter systems. In order to overcome this problem, we apply here our own earlier results about generalized type description of structure factors (realized by a simple, but completely novel-type use of projective representations in the case of incommensurately modulated crystals) to extend the existing quantum mechanical formalism of selection rules to modelling of the inelastic-type light scattering processes in such types of materials. Finally, their possible future applications in the solar energetics will also be discussed.

DETERMINING THE ABSORBED SOLAR RADIATION IN SOLAR COLLECTORS

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Incident irradiance on a non-horizontal surface from a variety of incident angles may cause the reflectivity to change. Assumptions about the reflectivity of different geometry surface are frequently made for a variety of purposes but are rarely quantified. Theoretical calculations of multiple reflections on different type of active surface described both for flat plate and vacuum tube collectors.

After the optical analysis another important issue related to this topic, to determine the amount of radiation that is absorbed by the absorber of a solar collector. Difficulty of determining this value depends on the collector type. For a covered flat plate collector this calculation is a multiplication of the cover transmittance (τ) and the absorptance (α) of the absorber plate. If we wanted to determine this ration, multiple reflections with attention to incidence angles and polarization may have to include. If τ and α depends on wavelength, one may have to carry out separate calculations for different portions of the solar spectrum. Determining this value for vacuum tube collector is a little bit difficult to calculate. A model was developed for this case. From the law of energy conversation it is known, that the summary of reflective, absorptive and the transmission coefficient of the material are equals to one.

$$\rho + \alpha + \tau = 1.$$

Each coefficient is the function of the wavelength and they are depending on the incident angle of the radiation. In our case the absorption is considered negligibly in the first model, so if the reflectivity is measured, than the transmission can be determined as

$$\tau = 1-\rho.$$

In this paper a more accurate calculation was taken into account all the multiple reflections. The angle between the incoming radiation and the normal of surface is close the reflection is less than otherwise. In general, the magnitude of the reflected intensity a particular direction for a given surface is a function of the wavelength and the spatial distribution of the incident radiation. Long-wave radiation is can be emitted by several things like a collector or by the atmosphere. At this stage of the work the reflection of the total radiation is considered without wavelength dependence. Volume of intensity of radiation decreases if it is reflected or emitted.

PERFORMANCE ENHANCEMENT OF PTSC BY SELECTIVE ABSORBER COATINGS

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Parabolic trough solar collector PTSC is one of the most prominent and promising technologies utilized to convert the solar irradiation into useful process heat. PTSC consists of reflecting surface, absorber tube and the working fluid passing through the tube.

Absorbers are designed to absorb and convert the sun's rays to heat and transfer it to special heat transfer fluids which are pumped through the absorber tube. They are located at the focal line or focal point to the reflectors.

In PTSC, receiver tube is one of the most important elements in the photothermal conversion process. The high photothermal efficiency of the receiver tube greatly depends upon the coating type, and radiative, conductive and convective losses. The aim of this research is to increase the thermal efficiency of PTSC by selective coatings of absorber tube. Furthermore, is to be studied how the coatings of the absorber tube effects the heat transfer between the metal and the working fluid.

Solar selective coatings are classified into: intrinsic; semiconductor-metal; multi-layer; cermets or metal-dielectric composite materials; and finally textured surfaces. Selective coating should be chemically and structurally stable for the variable range of the temperatures, it should have good adhesion to the receiver tubes. The selective coatings of absorber tube should possess minimum emissivity, maximum absorptivity and stability at elevated temperature.

Coatings are used extensively in concentrating solar systems to improve the performance of both reflectors and absorbers in terms of costs, efficiency, durability and maintenance. The preparation of these coatings can be done by a number of techniques like physical vapour deposition, cathodic vacuum deposition (CVD), dip coating, electrochemical deposition, spray pyrolysis, various sputtering techniques, sputtering and cathodic vacuum deposition. Selection of deposition technique depends upon the requirement of specific coating material properties, operating conditions and economic aspects.

The coating is used in the reflectors to increase the reflection of solar radiation protect it from the dirt and corrosion. Antireflective coatings can increase the cover glass transmittance and Abrasion resistant reflective mirror can have 99% reflectivity after cleaning.

Furthermore, different coatings types and layers on absorber tube is examined to optimize performance of PTSC. Therefore, advanced composites (new coatings types) with better transmittance, enhanced absorptivity and negligible emittance need to be explored.

Acknowledgements

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TRNSYS SIMULATION OF A FLAT PLATE-BASED HYBRID SOLAR COLLECTOR SYSTEM

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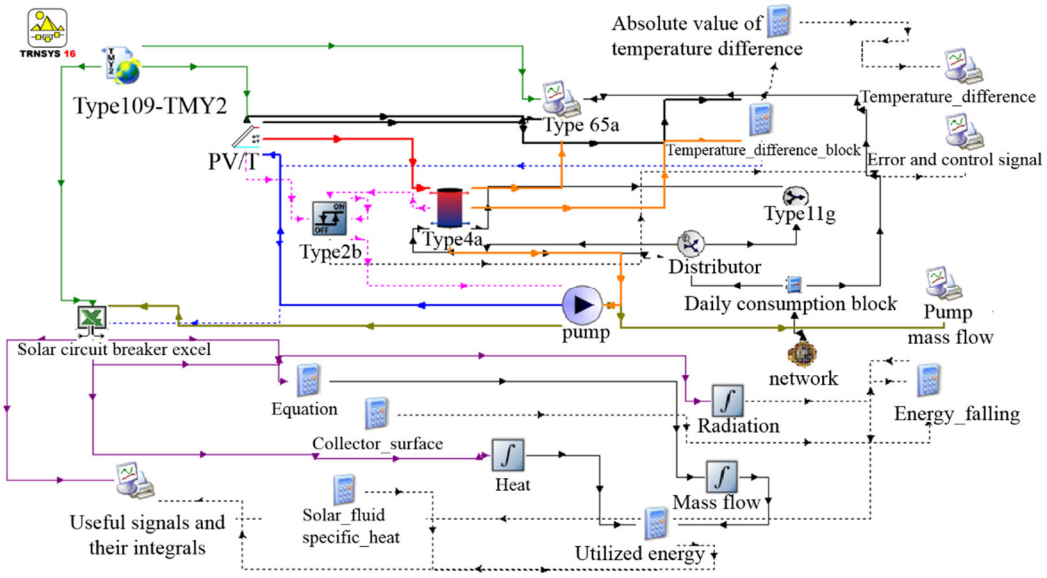
The hybrid solar collector system (PV/T) can produce both thermal and electrical energies at the same time, along with the benefit to reduce the cost and the space of the system. It combines Photovoltaic (PV) module and collector behind reducing the heat generation from PV module.

In the recent paper the following PV/T system is proposed for energetic study consisting of a flat plate-based PV/T collector, a thermal storage tank, a pump, a daily profile for consumption of water, a controller for the temperatures, weather data (Type109-TMY2) and all additional accessories. The properties of the PV/T module belonging to the Department of Physics and Process Control, Szent István University, Gödöllő, Hungary, that consist of a copper absorber and a mono-crystalline PV module, were used.

The first action of this study was to develop a tool for the performance evaluation of the PV/T collector via building of a mathematical model. For simulation purposes of the photovoltaic thermal hybrid system the TRNSYS software was selected to use, in which the complete system was be realised as it is shown in the Figure bellow.



The simulation results were analysed getting the relation between the solar radiation, mass flow rate, output temperature and the electric power. Based on the results, a comparison between the proposed system and the single units (PV module or collector) is possible to be evaluated.

Acknowledgements

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THERMAL PERFORMANCE OF SOLAR AIR COLLECTORS USED IN MODULAR SOLAR DRYER

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Solar energy is the most simply reachable among renewable energy sources due to environmental and economic concerns. It is clean and most inexhaustible of all known energy sources. The simplest way to utilize solar energy is to convert it into thermal energy for heating applications such as ventilation air preheating, space heating, hay, crop drying, and desiccant refrigeration.

Drying is a process of water content removal due to heat and mass transfer. It is a different product preservation technique, which provides longer life, lighter mass for the transportation process, and smaller space for the storage process. In many industrial processes, colossal energy is consumed by using traditional fuel, hence it is vital to look for alternative energy sources.

The solar drying system is considered as a promising application of solar energy systems nowadays. Various solar drying systems for agricultural and marine products used a drying chamber, chimney, and solar air collector as the main component. The solar air collectors are very popular among various nonconcentrated solar thermal collectors because of their simple design, easy to operate, have low manufacturing costs, no freezing, boiling, or pressure problems, generally lower weight.

Despite the advantages of solar collectors, it is still a challenge to maximize the heat gained from them, mainly because of their limited efficiency. The aim of the recent work is to overcome this matter by making a further modification on the solar collector (design and size, absorber material, glazing, coating, and isolation material) to harvest as much as heat, leading to an increase in the efficiency of the collector and the drying process. Furthermore, the drying process's efficiency depends on the heat losses from the dryer surfaces, the dryer design, air circulation inside the dryer and the airflow rate.

The preceding issues need to be investigated and provide a proper solution to improve the overall performance of the drying processes by focusing mainly on the collector efficiency and its effect on the drying process. Moreover, theoretical approaches will be made on collector size and shape and carry out its mathematical model and measurements will be performed to obtain the experimental results to validate the model developed for determining system performance.

The expected results are improving in the solar collector thermal performance and overall drying efficiency. Also, a developed mathematical modelling of the solar collector to be able to use in the drying process with understand the factors that have real impact on the drying process.

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PERFORMANCE ENHANCEMENT OF FLAT PLATE SOLAR COLLECTOR USING NANOCOATING AND NANOFLUIDS

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Solar energy is one of the leading renewable energy types since it is abundant, clean energy, freely available, utilized without polluting the environment and commercial potential. Solar energy is converted into different forms: chemical energy, mechanical energy, electrical energy using a photovoltaic solar cell, and thermal energy using a solar collector. Solar collectors are the critical components of a solar system. They can be classified as stationary (non-concentrating) and concentrating. flat plate solar collectors (FPSC) are stationary collectors, a heat exchanger device that converts solar radiation's energy to thermal energy in solar thermal applications. FPSC has been widely used in many areas with low thermal applications such as space heating, space cooling, solar water heating, and industrial process heating. Its components are glazing cover, flow tubes, absorber plate, thermal insulation, and the casing.

The primary factors impacting the optical and thermal performance of the solar collectors are the rate of heat loss, non-effective optical coating of the solar collector, and low thermal conductivity of the heat transfer fluid. Hence, there is a need to improve the properties of these collectors.

In pursuance of this issue, the research topic will focus more on reducing collector heat loss and increasing the optical and thermal performance of FPSC by using nanotechnology. Nanotechnology is a powerful tool for the solar system, which provides a wide range of resources to help resolving energy-related issues.

This study aims to use nanotechnology to improve the performance of the FPSC. It consisted of three major parts:

a) reducing collector heat loss and increasing the optical properties and thermal performance using a nanocoating on the glass cover (i.e. anti-reflective and self-cleaning nanocoating),

b) increasing optical properties of the absorber plate (higher solar absorptance (α) and lower thermal emittance (ε) coefficients) to improve the absorption coefficient of solar liquid using nanocoating on absorber plate (i.e., solar selective nanocoating),

c) increasing the thermo-physical properties of the working fluid such as the enthalpy, thermal conductivity, specific heat capacity, and density using nanomaterials in the solar liquid (i.e., nanofluids). These methods and the relevant studies and their details will be described in the subsequent sections of my literature review.

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EFFECTS OF WATER DROPLETS ON SOLAR MODULES PERFORMANCE

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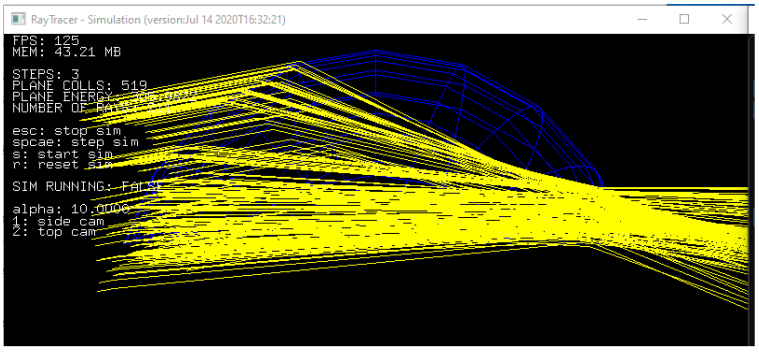
Since when the humanity realized that more emphasis should be placed on environmental protection, we are trying to cover our energy needs in an increasing share with renewable energy. For this, the one of the most dynamically developing area is the solar cell technology.

The efficiency of solar modules is not very high, so all efficiency-enhancing options should be considered. Among the factors influencing efficiency, the role of cleanliness is important. A novel solution for this is the use of self-cleaning coatings. These nanotechnological thin films can work on the principle of photocatalysis or use the lotus effect. In the latter case, the moisture, which come from the environment to the hydrophobic surface helps to remove the dirt. These water droplets also have additional effects on the solar cells, cooling their and affecting the coming radiation to the solar cell surface. This work deals the latter, optical effects.

When the water drop appears, the illumination of the surface of the solar cell will become uneven, and on the other hand the water drop returns some of the reflected rays to the surface, thus having antireflective effect. These two phenomena were examined with the model created in the RayTracer framework. The bases of the operation of the model are the laws of refraction, reflection, and the Fresnel equations, which give the intensity relations.



The parameters of the model can be easily changed, the parameters of the drop can be set (size x, y, z, position, relative to the solar cell), in case of examining the effect of more drops, can be set their position. At light source, the position and the length and width dimensions of the light source and number of the emitted rays should be determined. The parameters which necessary to specified for using the model are the refractive indexes of the environment, the droplet, and the thin film on the solar cell. It is also important to determine the value of the energy ratio for as long as the model is to follow the light rays. Before the simulation, can be set the incidence angle of the light rays, or can be set the incidence angles interval and step size of the simulations.

The results detailed in the presentation in addition can be used to the study of the intensity conditions of solar radiation reaching the surface of water drops covered solar cells, also in the study of the optical and energetic effects of water droplets on the leaves and on the human skin.

SENSOR DEVELOPMENT FOR THE CANSAT PROJECT

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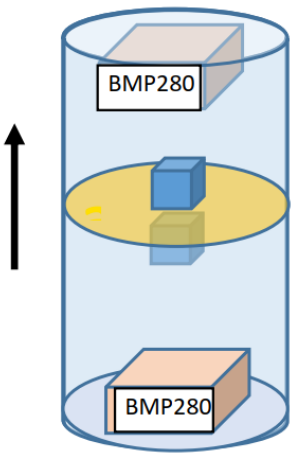
The Cansat project is a secondary school project of the European Space Agency (ESA), and in the framework of the program a small satellite has to be developed and built by secondary school teams. The name Cansat originates from the size of the unit (a Coke Can size) and from the satellite words. The developed Cansats are really launched by a rocket, but not to the space, just into the atmosphere, to the height of 1000 – 2000 meters. The Cansats after deployed from the rocket, have to do measurements of the atmosphere during the landing with a parachute, and they have to broadcast the measurement data to a ground station during the flight. Beside compulsory measuring tasks as the units as the pressure and the temperature of the atmosphere, secondary missions have to be developed as well.

There is a lot of Physics and engineering in the development of a Cansat from the structural design, through the sizing of the parachute system till the development and realization of the electric circuits, but the most innovative part generally is the development of the secondary missions.

In our case the basic idea was, that however the acceleration of the moving objects can be measured quite easily nowadays by the MEMS based sensors (mobil phones, drones, etc, are using the technology), but because of the size and structure of the sensor it is measuring very fats, so it can measure the transients of the acceleration even under very low range. But if we consider bigger living objects on the board (e.g. astronauts) their body (or the organs of the body) can not follow the fast transients, so the MEMS based accelerometer can not predict well, what short of forces reacts on the organs of a human being.

We decided to develop a accelerometer sensor, which measures better the real acceleration of a body with inertia, we called it inertial accelerometer. The developed sensor was a closed tube (a closed cylinder), with two air sensitive pressure sensor in the two ends of it. The two half of the cylinder was separated by an elastic membrane which was weighted by two small magnets as it can be seen in the figure. The workin idea, is the next: if the unit accelerates to the direction of the symmety axis, the pressures are changing isónside the tubes because of the inertia, which can be measured ny the sensors,



In the presentation the concrete implementation of the sensor, the measurement values during the flight (in the pictured rocket our Cansat is launched) and the evaluation of the measured data will be shown.

LANDFILL DEPOSIT GAS EMISSIONS: EVALUATION AND MEASURMENT TECHNIQUES. INFLUENCE TO THE LOCAL AIR POLLUTION

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The active and closed waste landfill deposits have an important contribution to the rising of the greenhouse gas emissions (GGE). The emitted methane resulting from the anaerobic digestion process by the natural degradation of the organic wastes, has important impact to the local pollution degrading the air quality in the area of the waste deposits, and after dilution with the natural air circulation has a negative impact to the atmosphere. Methane has a high "Global Warming" potential, being 34 times more aggressive as greenhouse gas than carbon dioxide. The European Commission ports the overall objectives for reducing global GGE by 50% up to 2050 in order to meet the 2 °C target in the global warming of the atmosphere. It is worth to note that the concentration of methane in the atmosphere has doubled in the last hundred years and that this was caused by the growing of the industrial and human activity. Based on the research data available, the landfill waste deposits are the third largest emitter (18 %) in EU, after fossil fuel production distribution and combustion (32%) and livestock farming (41%).

A possible way to reduce these methane emissions is to find new efficient technologies to collect and use this gas, as it can replace fossil fuels, thus transforming low quality waste into high quality fuel, and increasing society and economic independency of classical fossil fuels. For this, it is important to quantify the value of the emitted methane's in each landfill deposits. The EU landfill Directive (1999/31/EC) provides regulatory direction to control and present the requirement to operation of the waste deposits in optimal condition to minimise the emissions and to reduce the risk to human health and the local environment.

This paper presents the general aspects of the methane emissions in EU in correlation with the roles and actual strategies of the decarbonisation of the economy. In the second part, the methods used for monitoring and evaluation of emitted gas composition, are presented. Finally, real data collected from industrial waste deposits in Portugal and from one closed landfill waste deposit sited in Romania, collected by a portable gas analyser GFM 436 from Gas DATA^{TM}, are shown and discussed, taking into consideration possible solutions for the energetic use of the landfill gas in both locations.

Acknowledgements

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ENERGY ANALYSIS OF AIR SOURCE HEAT PUMP DEFROST CYCLE

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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.

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 executable.

EFFICIENCY OF ORGANIC RANKINE CYCLES WITH HYBRID SOLAR-GEOTHERMAL HEAT SOURCE

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Organic Rankine Cycle is a thermodynamic cycle used for conversion of low-temperature heat to work and subsequently to electricity. The cycle is similar to the traditional steam Rankine cycle used in traditional power plant, but as working fluid, organic material is used, instead of water. Choosing this fluid properly, the pressure of the organic vapour generated with the help of the low-temperature heat source will be sufficient to drive the expander and the generator.

Due to the Second Law of Thermodynamics, the efficiency to convert heat to work is quite low, when the heat source temperature is low, and the heat sink is the environment. Therefore, for the better utilization of the low-temperature heat sources (for example, a 85 °C thermal water), hybrid systems with secondary heating, most generally solar heating can be used to reach higher maximal cycle temperature. The upgrade to hybrid system has added cost; for example, the cost of the solar collectors. The hybrid system is financially viable when the increase of power (caused by the increase in efficiency) is sufficiently high to justify the extra costs.

In this presentation, we would like to show, that in an ORC system, using moderately dry working fluid, there is a narrow temperature range close to the vapour-liquid critical temperature, where the increase of maximal cycle temperature can cause a decrease, instead of an increase in efficiency. In this case, adding solar collectors to the system to increase the maximal cycle temperature is contra-productive. This will be demonstrated on a model system of geothermal+solar heat, using butane as working fluid. The result can be generalized for other, similar working fluids.

DESIGN AND CONSTRUCTION OF ORGANIC RANKINE CYCLE POWERED BY SOLAR THERMAL HEAT SOURCE

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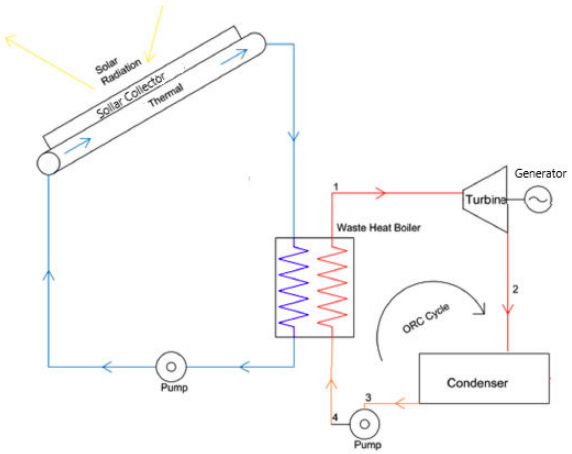
Renewable energies like solar thermal, geothermal and waste heat sources are capable of not only in decreasing the rate of the consumption of fossil fuels. However, these moderate and high temperature heat sources cannot be efficiently converted into electricity through the conventional Steam Rankine Cycle (SRC). Nevertheless, the Organic Rankine cycle (ORC) has been considered as most feasible cycle to generating electricity while recovering various heat sources.

ORC is similar as the SRC but uses low boiling temperature of organic fluids instead of water. Various advantages of ORC system are high efficiency, low turbine cost, compact size and the most important one is the environmental-friendly. The main disadvantage of the ORC system is that a separate precaution to prevent the leakage and contamination of organic fluid. Although, ORC can generate electricity in low range temperature, it still needs heat resource from another system, for instance from solar thermal system.

The recent research is aiming at to design and construct of a small-scale solar thermal ORC that addresses these challenges by making use of an air-conditioning unit such as chiller. The bellow figure shows a simple ORC that use solar thermal collector as a heat source through the heat boiler. In the boiler there is heat transfer occurred between hot steam and working fluid or organic fluid which has a low boiling temperature. In such a way, the working fluid changes phase into steam vapor which has sufficient temperature and pressure to turn the turboexpander, and so the rotation can be converted into electricity by the generator.



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ENHANCEMENT THE EFFICIENCY OF PHOTOVOLTAIC SOLAR CELL BY USING COMBINATION EARTH-AIR HEAT EXCHANGER WITH ASSIST SOLAR CHIMNEY

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Energy is fundamental for economic and human development. Using renewable energies such as solar for the production of electricity decrease pollution and saves the environment in our planet. Electrical energy can be generated from solar energy by two ways; solar thermal power plants and Photovoltaic (PV) solar cells. Moreover, there is also another method, namely solar chimney.

The efficiency of the PV solar cell is affected by the rise of the PV solar cell temperature, particularly, in hot climates. The rise in the temperature of the PV solar cells causes the reduction in their electrical efficiency. A solar chimney or solar tower is a form of passive solar design that can be used to produce electricity.

The efficiency of the PV solar cell is affected by the rise of the PV solar cell temperature, particularly, in hot climates. The rise in the temperature of the PV solar cells causes the reduction in their electrical efficiency. A solar chimney or solar tower is a form of passive solar design that can be used to produce electricity. A chimney operates by increasing the buoyancy force to aid the air flow through a structure.

This reason motivated me to investigate and study various aspects of the renewable energy systems more focusing on the efficiency of PV solar cell, solar chimney, earth-air heat exchanger, design performance and also the study extended to deal with the performance and economic feasibility of the system.

Some researchers were improving the efficiency of PV solar cell by using solar chimney, they are used the solar chimney technique to improve the solar cell system efficiency by using the particle swarm optimization. The numerical results show that the PV system efficiency has positively been affected by increasing the chimney height. Others carried out an experimental analysis of the solar chimney which integrated the solar panels to increase the efficiency of the solar panel by increasing the chimney height. Other researchers were improving the efficiency of the PV solar cell by using solar chimney and Geothermal energy, they are presenting a new idea of hybrid geothermal/PV/Solar chimney which was suggested to be built in the south region of Libya. Geothermal hot water was pumped and circulated through pipes on the soil under the collector roof. PV was added to the system to replace the glass roof.

This present work aims to enhance the efficiency of PV solar cell. To do this aim; I plan to use Geothermal energy (Especially earth-air heat exchanger (EAHE)) to supply relatively cold air for cooling PV solar cell in order to increase the total useful power produced by the system with assist solar chimney. The purpose of using a solar chimney is to increase air velocity (Kinetic power) without energy consumption, as a result, it is lead to enhance the efficiency of the PV solar cell by using hybrid system.

HYDRONIC MODELLING AND BASIC CIRCUITS GROUPING

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This area is closely linked to energy use and environmental protection, as the heating and cooling of our buildings is responsible for 40% of CO_2 emissions. The role of Building Engineering in modern buildings is twofold: the right comfort should be provided with the least possible investment in energy. There are many ways to reduce consumption, whether passive or active solutions. For example: utilizing solar gains, night ventilation or even heat recovery. Once we have the right and optimal building and system in place, we optimize investment and operating costs. We prepared the hydraulic design of the Heating, ventilation, and air conditioning (HVAC) system, scaled it and adjusted it to the desired values. Then we put the facility into operation. Did we take all these factors into account and model them? The practical experience is that designers prefer the solution they adopt, learn and use as a template. System modeling is limited to the designed system and does not necessarily take into account comparisons with other solutions. This research specifically covers the basic hydronic circuits used in heating and cooling systems. Let us take a look at what options we can choose from.

A: pressurized manifold (differential pressure is available)

B: unpressurized manifold (differential pressure is not available)

In hydronic basic circuits with different connections it is recommended to utilize type A and B manifolds.

The basic circuits: throttle, mixing, diverting, injection with 2-way valve, injection with 3-way valve (double injection circuit). Examining compatibility with each other:

Type A manifolds: throttle-, injection with 2-way valve, injection with 3-way valve and diverting circuits.

Type B manifolds: mixing, injection with 3-way valve, diverting circuits, and the installation of additional pumps can be used for all A type of connection. (However, for the type A application, only the modes indicated there are applicable.) Thus, mixing- and double injection circuits are not applicable to a pressure divider.

It can be seen that several technical solutions are available to serve each application. The advantages / disadvantages of each solution must be known in terms of their applicability. Our goal is to determine the difference between the individual solutions on the energy consumption side, supported by measurements and mathematical models. Values are measured on a hydraulic measuring wall (HMW) and then analyzed. This data helps to further optimize hydronic systems. (= This data facilitates further HS optimization). Our basic assumption is that properly optimized circuits can save ~ 10-12% pumping (electricity) energy.

RESEARCHING THE EFFECT OF POLLUTANTS ON COMFORT INSIDE RESIDENTIAL BUILDINGS WITH DIFFERENT ENERGY CLASSIFICATIONS

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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:

- CO_2 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 the likelihood of the presence of viruses, fungi and mould.

Our 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 our 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.

SOURCE REGIONS OF PM10 PARTICLES DURING HIGH CONCENTRATION DAYS IN KECSKEMÉT HUNGARY

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Air pollution is a phenomenon that causes millions of deaths every year. During the last century, many regulations took place due to air pollution problems. The atmospheric aerosols or Particulate Matter (PM) is one of the dangerous air pollutants that can cause harm to humans and the environment. Depending on the size of the PM, its chemical composition, and its concentration in the atmosphere, it can be deadly to humans and damaging to the environment. Two major sizes of the PM are measured and have critical limit values in all the air quality standards. PM10 is a particle with a diameter of 10 μm that is respirable and capable of entering the upper part of the lung. The other one is the PM2.5 a respirable particle with a diameter of 2.5 μm that can cross the lung barriers and enter the bloodstream, raising the risk of having lung and heart disease, cancer, and exposure to extreme PM2.5 concentrations can result in death.

Kecskemét is a city situated in the Southern Great Plain of Hungary, almost 86 km away from the capital Budapest. In October 2019, the PM10 daily limit value concentration of 50 $\mu g/m^3$ was exceeded 11 times, and 7 of those 11 days were consecutive days where the average daily PM10 concentration was above the limits. The purpose of the study is that to discover the sources of the PM10 particles contributed to the PM10 episode using the backward trajectory simulation of HYSPLIT software, and to analyse the relationship between PM10 concentration and temperature, relative humidity, and wind speed.

The results indicate that depending on the wind direction, Kecskemét was subject to long- and short-range transport of PM10 particles. The backward trajectories showed that particles were coming from the Apulia region, the southern coastal region of Italy, Crossing the Bosnia and Herzegovina from the middle, passing through the Slavonia region of Croatia during the period between 19th and 22nd of October 2019, Also, from the Banat, and Oltenia regions of Romania, along with the regions defining the borders between Romania and Serbia between 22nd and 25th of October 2019, from the borders between the Czech Republic and Austria, passing through Slovenia between 25th and 28th of October 2019, and from the borders of Poland and Germany, the south of Poland and the borders between the Czech Republic and Slovenia in the period of 28th and 31st of October 2019.

Moreover, both temperature and wind speed illustrated a negative relationship with the PM10 hourly concentration, while relative humidity had a positive correlation with the PM10 hourly concentration up to a threshold of 90%.

26th WORKSHOP ON ENERGY AND ENVIRONMENT

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