HUNGARIAN UNIVERSITY OF
AGRICULTURE AND LIFE SCIENCES

28th Workshop on Energy and Environment

December 8-9, 2022, Gödöllő, Hungary

Book of Abstracts

Editors: István Farkas
Piroska Víg

Gödöllő, 2022

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This event was supported by the Doctoral School of Mechanical Engineering, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary and the Hungarian Solar Energy Society

Published by
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary
H-2100 Gödöllő, Práter Károly u. 1.
Tel.: +36-28/522-000
https://www.uni-mate.hu
Under the supervision of Csaba Gyuricza

ISBN 978-963-623-016-6 [PDF]

CONTENT

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, Institute for Environmental Engineering Systems, Szent István University Gödöllő, Hungary (recently Department of Physics, Institute of Mathematics and Basic Science and Department Mechatronics, Institute of Technology, Hungarian University of Agriculture and Life Sciences, 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 to provide 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 abovementioned event along with to submit two-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 rebuilding situation in this year the Workshop will be organized on-line way via the Google Meet link of: https://meet.google.com/uhy-jrfr-ppm.

The deadline of the two pages abstract submission: November 25, 2022

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CFD MODELLING AND PREPARATION OF NANOFLUID FILLED FLAT PLATE SOLAR COLLECTOR

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The increasing energy demand and continuous confrontation of energy generation costs are preceded by a terrible depletion of fossil fuel power reserves and increased environmental pollution. In the recent years, renewable energy grew quickly to face the responsibility of the unforeseen energy problem. Solar energy is transformed into various types of energy such as electrical, chemical, mechanical, and thermal. The solar collector is a heat exchanger specialized in the conversion of sunray into energy kinds such as electrical energy and thermal energy. Flat plate solar collector (FPSC) is a stationary collector and an exchanger system that transforms sunray to thermal energy in solar systems (Mussard, 2017).

Solar fluid is essential in a solar collector system for carrying heat. The following criteria should be considered when selecting a heat transfer liquid for the solar system: thermal capacity, coefficient of expansion, viscosity, freezing point, and boiling point. In solar heating systems, traditional heat transfer fluids such as water and air are widely utilized. Water with high specific heat and low viscosity is nontoxic and inexpensive, thus one of the most widely popular operational fluids in solar water heating systems. Given that these fluids have lower thermal conductivity, the fluids cannot transfer high amounts of heat in thermal applications. The low efficiency of the FPSC energy conversion is drawback due to the coefficient of heat transfer between absorber and operation fluid being low.

One of the recent trends towards enhancing the FPSC performance is utilizing nanomaterials in solar fluids (i.e., Nanofluids) as working fluids instead of traditional fluids to achieve enhanced thermal efficiency. Thermophysical properties were advanced and effectively provided better thermal transfer and heat absorption than traditional fluids. Theoretical and experimental observations showed that NFs are extremely. promising and can be replaced with conventional fluids to enhance solar collectors' performance. NFs are powerful tools for the solar system, thus resolving energy-related issues. Nanotechnology science is expanding the research and development among several countries worldwide (Akram et al., 2021).

The most pressing concern with conducting nanofluids research is obtaining a uniform distribution of NPs and keeping them uniform in size. The particles' dispersion uniformity is mainly due to the preparation method, affecting the NF's thermophysical properties. Two different methods to create NFs are identified, namely, the Single-step (bottom-up) and the two-step (top-down). The two-step process is a widely used technique to prepare NFs. Nanoparticles are distributed to the base fluid using ultrasonic vibration, magnetic disturbing of energy, shear mixing, homogenizing ball milling. The two-step method is often used because it is cheaper, and the materials are commercially readily available. The two-step preparation approach for NFs is shown in Fig. 1.

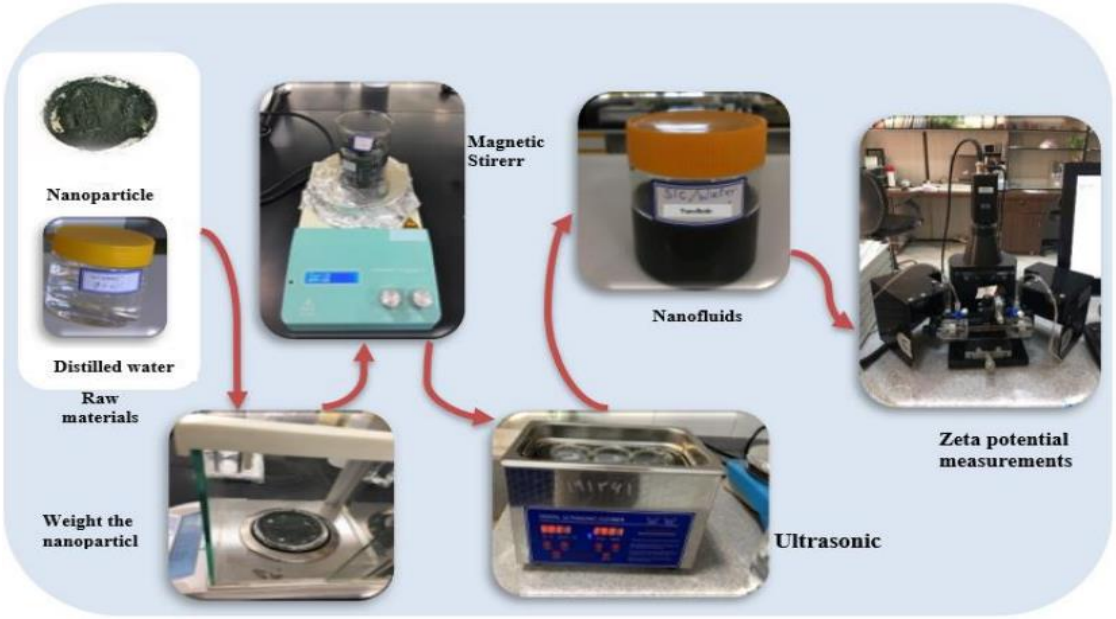

Fig. 1. Two-step preparation process of nanofluids

In this study, the effect of nanoparticle on the performances of the FPSC was analyzed. The effects of inlet temperature and mass flow rate were also discussed. The solar flat plate collector (SFPC) performance was evaluated through CFD simulations. It was observed that nanofluids gave higher efficiency due to high density and thermal conductivity compared to the conventional case without nanofluids. Modelling by Ansys can help establish a more efficient and economical of FPSC experimental investigation.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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OPTIMIZATION OF MINIATUR SOLAR POWER PLANT USING AUTOMATIC CONTROL AND DATA ACQUISITION SYSTEM

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Indonesia is located on the equator line, and the solar energy is abundant every month in a year. It is the reason why the solar energy can be said as a big potential resource to be utilized as an alternative electric power plant in Indonesia, through the Solar Power Plant (SPP) unit. Presently, the main problem is how to capture the solar energy as much as possible by Solar Power Plant (SPP) or in other words how to get the highest efficiency of the SPP.

The effect of surface orientations (tilt and azimuth angle) of the photovoltaic (PV) modules will affect to the yield of energy (Rusirawan and Farkas, 2011). In this research, implementation of Automatic Control System (ACS) and Data Acquisition System (DAS) will be constructed and tested in the miniature of the SPP (small scale of SPP).

ACS is provided to maximize of solar energy absorbed by the surface of PV module. As a rules of thumb, the PV module must be in the position perpendicular to the incoming of sunlight, and this position can be obtained by installing solar energy capture sensors on each side of the PV, as illustrated in Fig. 1.

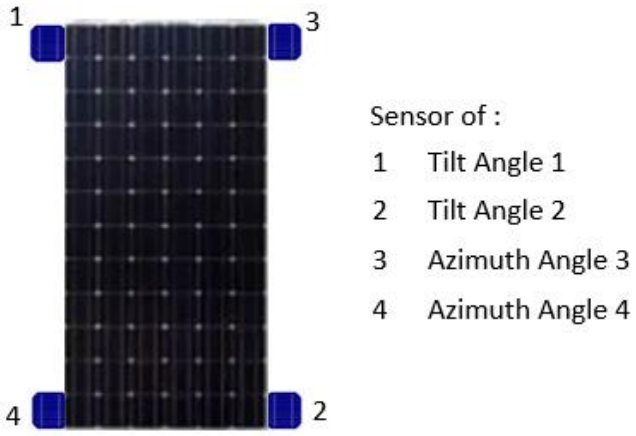

Fig. 1. Sensors position on the PV module

Sensors No. 1 and 2 are used for adjusting the tilt angle, meanwhile the sensors no 3 and 4 for the azimuth angle. All of the sensors work based on signal difference. If the difference input signal detected, both tilt motor control and azimuth motor control will "turn" the PV module, to correct the angle position until get the right position.

DAS is a computer system to record the variables of the PV system during the operation, i.e., current, voltage and surface temperature of the PV module, as shown in Fig. 2. These variables will be processed by the Arduino program and displayed in PC monitor as a graphic or data base. Pyranometer will also be installed for measuring tool for the solar irradiation. Furtherly, these variables will be used as an input data to evaluate the PV module performance, such energy and exergy efficiencies of the PV module (Rusirawan and Farkas, 2015).

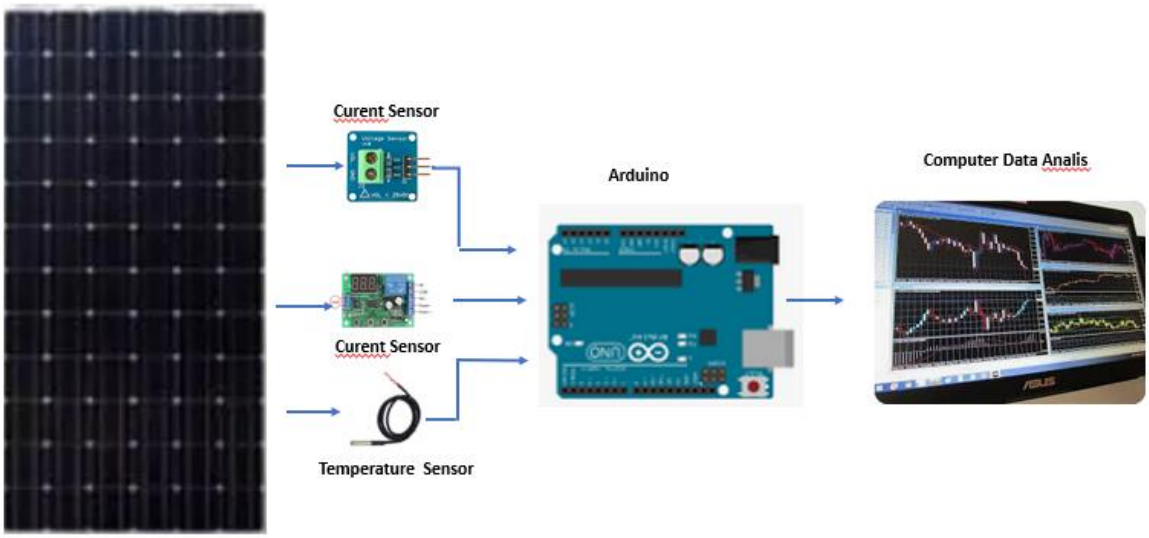

Fig. 2. Schematic diagram of DAS

Beside the tilt and azimuth angle correction system automatically, the surface of the PV module will be blown by fresh air using the fan to get an ideal surface temperature of PV module temperature. The direction of fresh air will be set in upward, downward, leftward or rightward.

The output from this research is the comparison of the PV module characteristics during daily operation, in fixed tilt angle and tracking mode, will be acquired with relative constant surface temperature. The outcome from this research, some suggestion related to optimize the SPP can be proposed.

Acknowledgements

The short synopsis of this research is released as an outcome of multidisciplinary international partnership between ITENAS Bandung, Indonesia and MATE Gödöllő, Hungary.

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HEMISPHERICAL SHAPE SOLAR TRACKING SYSTEM WITHOUT ANY MACHINERY

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Solar trackers allow your solar modules to follow the sun's path in the sky, just like a sunflower, so that they can produce more solar power. Trackers are used to minimise the angle of incidence between the incoming sunlight and a photovoltaic module, sometimes known as the cosine error. Reducing this angle increases the amount of energy produced from a fixed amount of installed power-generating capacity. Still, the solar tracking system has many disadvantages work as a limitation for this technology; Solar trackers are slightly more expensive than their stationary counterparts due to the more complex technology and moving parts necessary for their operation (Mohanapriya et al. 2021).

Thin film PV modules are widely separated worldwide due to wide application. Therefore, it is necessary to use innovative technology to reduce module costs further. However, only the proven thin-film module technologies amorphous silicon and nanocrystalline silicon films (a-Si), cadmium telluride (CdTe), and copper indium/gallium diselenide (CIGS) appear to be able to produce meaningful module quantities in the near future. Therefore, it is crucial to set reasonable performance and manufacturing-cost estimates based on what is known. For comparable degrees of manufacturing maturity, this necessitates comparing module performance and manufacturing cost (Roedern, 2016).

This research aims to develop a 3D-shaped PV module to solve the footprint issue in traditional PV systems and harvest more solar power without any tracking system. The proposed module is fabricated from a metal structure covered by six thin-film PV leaf modules to create a hemispherical shape to ensure a perpendicular area from early morning tile to late evening in front of the sun as shown in the figure below.

The hemispherical PV module was tested under natural illumination conditions. Its performance was compared to conventional fixed flat panels with the same surface area of the thin-film PV modules at a 45-degree inclination angle, which is the annual average tilt angle in Hungary. In addition, the system efficiency was evaluated based on the maximum power output.

The output power of the 3D solar module was found to drop with an increasing angle of incidence or decrease when following the cosine of the angle of incidence. However, the superior solar-tracking performance of the shape-transformable 3D solar module was slightly affected by the angle of incidence. Furthermore, the shape-transformable solar tracking raised the installed-area-based efficiency in all cases. Therefore, the efficiency of shape transformable solar module concerning the installation area can provide superior omnidirectional performance compared to flat fixed solar panels.

By utilizing a hemispherical PV module, the land cost has been reduced, resulting in a reduction in the cost of the PV system compared with using the tracking system. In contrast to conventional PV systems, the suggested form harvests sunlight throughout the day to produce the most power without using any supporting equipment, such as tracking systems. In addition, the proposed hemispherical shape benefits the PV system's flat black profile in terms of aesthetics.

The achievement from the new design of a 3D PV hemispherical shape, which requires less ground footprint than the conventional (flat) shape (19%) and might be less than 50% in a perfect hemispherical shape, the current work aims to ease these worries.

The output power of the hemispherical PV module has been calculated and compared with the traditional thin-film PV module. The results show an increase in the producing power by 4% daily generated power.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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HEAT TRANSFER ENHANCEMENT OF PTSC BY USING Fe_3O_4/WATER NANOFLUID

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The parabolic trough solar collector (PTSC) is one of the most developed and technologies in solar systems. Studies were done on the design of PTSC and their geometrical parameters, like the aperture area, rim angle, focal length, absorber diameter, concentration ratio, and other important optical parameters, such as reflectivity, receiver tube intercept factor, and incident angle, in order to improve the performance of the collectors.

Nanofluids are a new type of heat transfer medium that have improve thermo-physical properties in engineering applications. These fluids are produced by adding nanoscale metallic and non-metallic particles to common base by using special techniques.

The aim of the current study is to examine the thermal performance of solar parabolic trough collector with nanofluid under turbulent flow conditions. The numerical simulation is implemented using Computational Fluid Dynamics (CFD). The effect of nanoparticle volume fraction on flow and heat transfer characteristics is investigated. Numerical study has been done on the effect of distilled water and metal oxide nanofluid type Fe3O4 nanoparticles with distilled water at concentrations of 4% on the PTSC.

Fig. 1 shows the use of the ANSYS fluent software on PTSC model (LS-2) with Reynolds number 31750. Table 1 shows the model parameters, and Table 2 shows the thermophysical properties.

Table 1. Physical parameters of the analyzed collector

Parameters	Value
Diameter of outer the tube	70 mm
Diameter of inner the tube	66 mm
Concentration ratio	30%
Lower heat flux	19500 W/m^2
upper heat flux	750 W/m^2

Table 2 Thermophysical properties of the base fluids and nanoparticle

	Cp (J/kgK)	ρ (kg/m^3)	k (W/mK)	Viscosity (Ns/m^2)
Water	4180	997.5	0.613	0.0010016
Fe_3O_4	670	5180	80	-
Nano fluid	3555	1164	0.66	0.00111

The nanoparticles have higher heat transfer properties than the base fluid (distilled water). The maximum enhancement of Heat Transfer Coefficient and Nusselt Number were 12.78% and 1.6%, respectively, for nanofluid with a concentration of 4%.

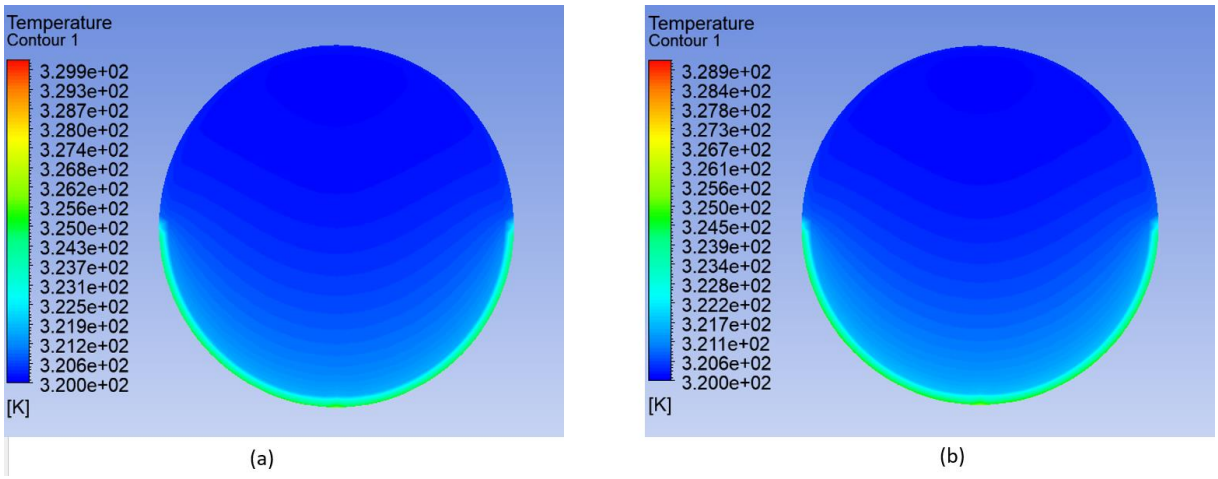

Fig. 1. Temperature contours: a) water, b) nanofluid

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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COMPARATIVE STUDY OF AN AIR-BASED HYBRID PHOTOVOLTAIC THERMAL MODULE IN DIFFERENT ABSORBER CONFIGURATIONS

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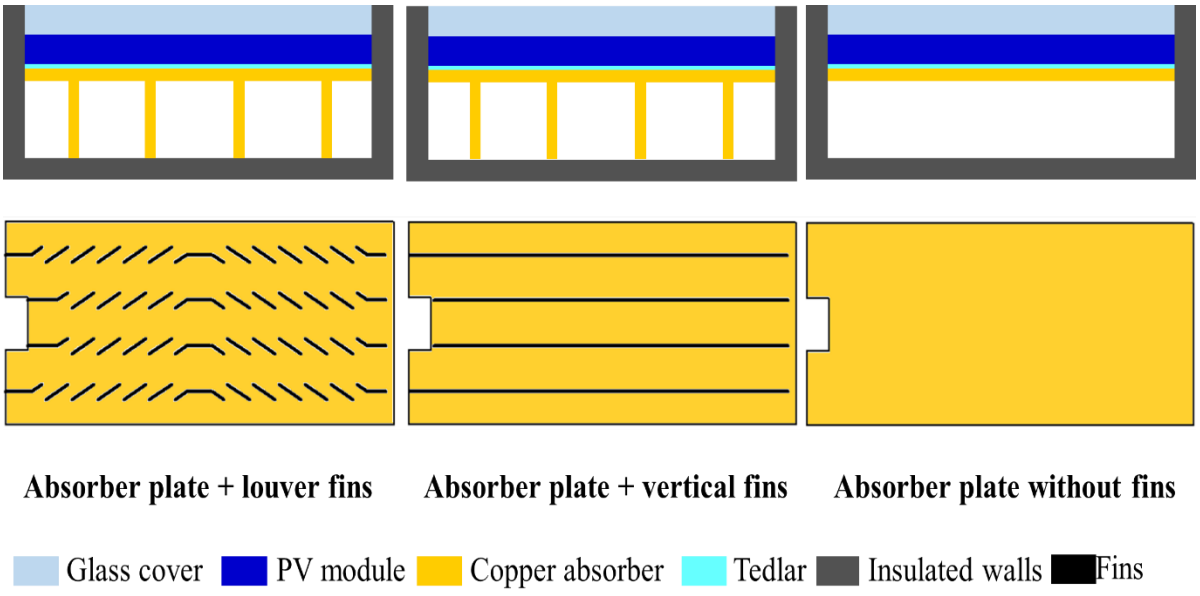
The first outstanding energy source and the most promising is renewable energy. It is upcoming to the future. The fast depletion rate of fossil fuels, environmental problems and cost fluctuation in fossil fuels are the fundamental reasons to trend to renewable energy. Hybrid solar thermal collectors are promising technology because they have a dual thermal and electrical energy sources (Alshibil et al., 2022).

In various applications, it is necessary to make one system to produce thermal and electrical energy, i.e., the hybrid photovoltaic/thermal collector (PV/T), which consists of a PV module with a solar collector behind it. Electrical efficiency decreases due to the rising temperature of solar cells. The absorber extracts the heat from solar cells and investigates it for space heating or hot water domestic (Alshibil et al., 2021). In addition, PV/T collector decreases the installation space and cost. Water, air, water and air, and nanofluids are the most coolants used in this hybrid technology (Gagliano and Aneli, 2021).

The first classical configuration of the PV/T module is the air-cooled unit, which simply consists of an air channel under the PV module and air flowing through it to extract the heat from the solar cells. Another possibility was that the researchers mounted a copper or aluminium absorber plate to the PV module, and in another design, they put fins within the absorber.

This study compares three different copper absorber configurations of an air-cooled PV/T module. The first one was without fins, the second with vertical fins in the direction of the air, and the last one investigated the louver-shaped fins. As shown in the following figure, these were the three configurations used in this study.



The different absorber configurations made up the study of the modules. The experiment was conducted in Gödöllő City within the Solar Laboratory of the Hungarian University of Agriculture and Life Sciences.

These experiments aim at to assess the performance of a presented module of the air-cooled PV/T through the three cases by enhancing the heat removal rate from the PV module to decrease the cell temperature that positively affects the performance of the PV/T modules.

As a result of this study, the new shape of the absorber that used the louver-shaped fins was efficient in heat removal compared to the other absorbers used in this study. The lover-shaped absorber unit also enhanced the electrical and thermal efficiency due to the cell's temperature decrease.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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PHOTOVOLTAIC UTILIZATION AS ENERGY SOURCE FOR AUTOMATIC SPRINKLERS IN AGRICULTURE

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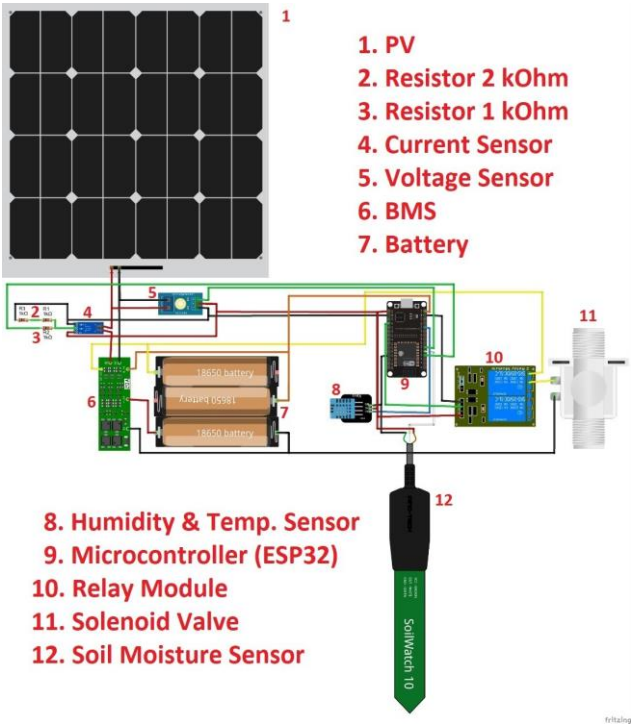
Gapoktan Lembang Agri, which consists of seven farmer groups with 230 members consisting of 185 men and 45 women, has succeeded in fostering its members to become successful, independent, and prosperous farmers (Kastara). To increase this success, they began to implement Smart Farming technology in their agricultural areas.

One of the technologies created is IoT-based automatic plant watering (sprinkles). This tool uses an ESP32 microcontroller with the Arduino IoT Cloud application connected to the internet via a router/Wi-Fi (Kaburuan et al., 2019). Wi-Fi is used to control and monitor watering plants in the area.

The aim of this research is to applying smart farming by utilizing photovoltaic as an energy source. This system is designed for affordable solar powered soil, and developing smart farming set-up for farmer (Devapal, 2020).



This system previously used not connected PV. However, for areas far from energy sources, it requires an energy source that can use solar energy. The combination of smart farming and renewable energy sources can increase agricultural productivity. In the developed system, PV

is used as an energy source to recharge the battery used to operate microcontroller-based devices.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary and Lembaga Pengabdian Pada Masyarakat (LP2M) – Institut Teknologi Nasional Bandung.

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SIMULATION AND EXPERIMENTAL ANALYSIS OF SOLAR DRYER FOR MOLDING SAND USING MATLAB

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The rapid rise in the population and the living standards, the world seems to engulf into major crisis, called energy crisis. If this growth continues with the same speed the condition would go from bad to worse (Eustache, 2017). The reverse of conventional source of energy like coal, petroleum and natural gas are depleting at a very fast rate to fulfil the demand of the growing population. So, there is a need to look for some other energy sources that could meet this growing demand. One such source is solar energy, which is cheap available in abundance (Bolaji, 2014). Drying is a common technique for preservation of food and other products including fruits and vegetables and other crops (Gatea, 2010).

Sand that is utilized in molding processes is called silica sand. It acquires the bonding properties of the raisin, which binds the silica sand together, when a catalyst is given to it. Extremely important sand addition, its moisture content (17.24% starting and 0.5% final moisture content) can significantly affect casting quality.

Because it is the most significant type of solar collector, has a straightforward construction, no moving components, and requires low maintenance, flat plate solar collectors were utilized in this study. The analysis of the heat transfer coefficient (losses) through the flat plate collector was covered, along with the methods employed to lessen these losses (by using insulation). In this research, the sun dryer for silica sand's performance is evaluated.

An Akaki spare part is the main industry in Ethiopia producing spare parts. Casting process is employed to create these spare parts. The primary raw material used to make these spare parts is sand for molding. Molding sand (silica sand) is currently being washed and dried in order to improve its quality and manufacturing efficiency.

In the dryer, heated air is routed through a tray and the drying chamber's vertically blackened wall, which is exposed to solar radiation, at the same time. According to the test period's findings, the temperatures, moisture eliminated, drying rate, and drying efficiency through the dying chamber were all moving upward.

As shown in the accompanying Fig. 1 Matlab software was used to estimate the plate temperature, glass temperature, air temperature, and mass follow rate of the solar dryer for a variety of (average) months (January 17). Fig. 2 shows that measurements of the input and exit temperatures of the solar air heater as well as the variation in air temperature in each tray's drying chamber were made.

Silica sand solar dryer models and tests. In terms of drying pace, drying efficiency, moisture removal, and temperature variation across the drying chamber, the trial's findings showed that sunlight drying was superior to open sun drying. In a solar dryer, one kilogram of silica sand can be dried in two days during the rainy season, but on a sunny day, it only needs one. However, if the weather is bad, it will take three to four days to dry in the sun.

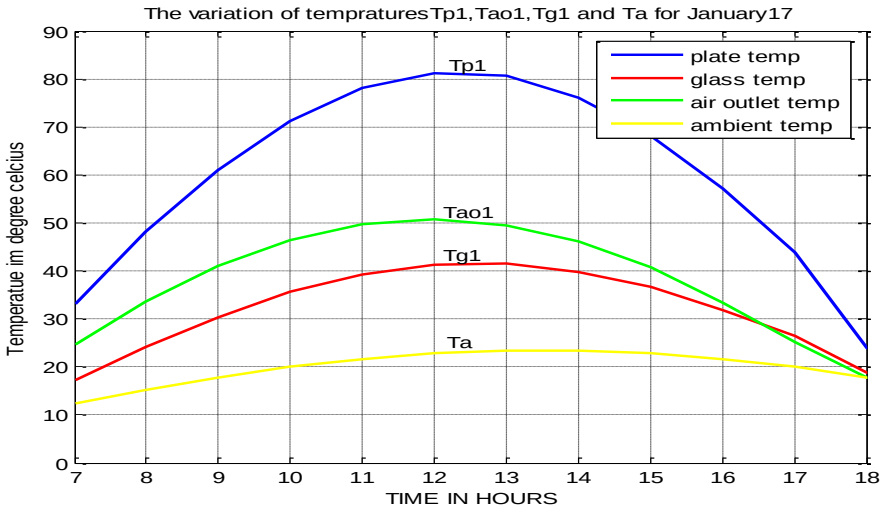

Fig. 1. Variation of temperature of plate, glass and air

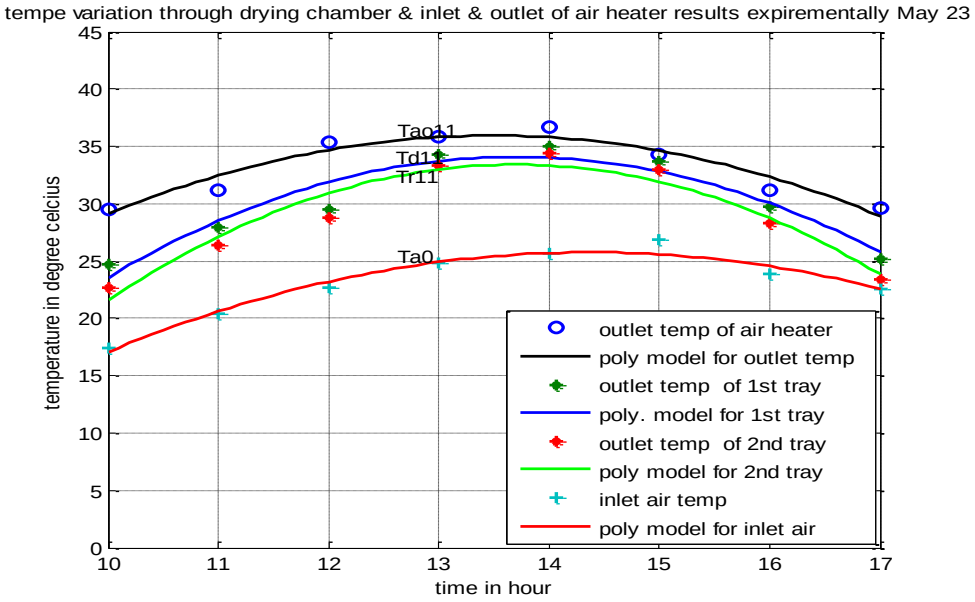

Fig. 2. Temperature variation through drying chamber experimental results

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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OVERVIEW OF ENVIRONMENTAL ASPECTS AND INFLUENCE OF THE CLIMATE CHANGE ON THE WATER QUALITY OF THE EUROPEAN VOLCANIC LAKES

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Microalgae are unicellular organisms with complex and robust cells, whose growth rate is positively influenced by the increasing temperature and CO_2 content of the atmosphere and the presence of nutrients, like N, P in the water.

The climate change scenarios induced by greenhouse gas emissions suggest that the average summer temperature in some European regions could increase as high as 6º C by 2070. This temperature increase is also expected to be associated with precipitation reduction. These can boost lake eutrophication processes caused by microalgae growth. And indeed, data from the scientific literature is starting to show that these factors are already affecting the water quality of European lakes. This is especially evident for lakes under more stringent anthropogenic pressures, namely related to fertilizers and organic matter discharges that increase nutrient concentration, a factor further contributing to microalgae growth.

All these factors can have a strong influence on the water quality of European Lakes, especially the volcanic lakes. Although these lakes are not very numerous, they constitute themselves as very relevant heritage and protection sites. Among, the most well-known examples are ”Lacul Sfânta Ana/Szent Anna-tó“ located in Central Romania (Tușnad, Eastern Carpathians), and another in Western Europe (Fig. 1), “Lagoa do Fogo”, located in the middle of the Atlantic Ocean, in the centre of the island of São Miguel in the Portuguese archipelago of Azores (Fig. 2).

This paper deals with the assessment of the main water quality parameters of the afore mentioned lakes and compares the results of the scientific works realised in the last periods for “Lagoa do Fogo” (Antunes and Rodrigues, 2011), to the data being collected in ”Lacul Sfânta Ana/Szent Anna-tó“.

For instances, the type of the microalgae that are present in both lakes are compared and their relation to the eutrophication process are discussed. In the case of ”Lacul Sfânta Ana/Szent Anna-tó“ in 2020 it was identified the following types of microalgae: *Parvodinium*, *Gymnodinium*, *Cosmocoldium* and *Stichococcus* genera.

The main parameters of water quality were also evaluated *in situ*, namely levels of nitrate, nitrite, total phosphorous, dissolved oxygen (Winkler method), pH, conductivity and total dissolved solids. From the collected water it was measured the chlorophyll content which provides information from the state of art of the presence of the microalgae in the water and that value was used for evaluating microalgae concentration. To this evaluation it was use a spectrophotometric method presented in SR EN-10260-96. In the second part it is presented the aspects of the microalgae cultivation process from the collected water samples.

Finally, a preliminary discussion of the environmentally aspects and their impact on the phytoplankton growth rates are presented.

The final conclusion is that, in both cases, it is necessary to reduce the nutrient content in the lakes water, as only in this way algae growth can limited. That can be observed in the presented photos (Fig. 3 and Fig. 4.) from the algae growing process in laboratory condition, the samples without nutrients after 3 months testing period don't indicate the presence of the microalgae, that experiment was realised only with the collected water probes from Szent Anna – lake.
In the next is it presented photos from the studied lakes, Lagoa do Fogo and Szent Anna - lake

Fig. 1. Szent Anna - lake, Transilvania Romania-Photo by Visual Waves

Fig. 2. Azoures Lagoa do Fogo, Portugal, sources:https://www.azoresemotions.com/trilhos/full-day-lagoa-do-fogo/

The following photos was realised in the period of the measurements and tests in the microalgae growing in lab condition

Fig. 3. Microalga growing in lab condition – experiment start in June 2022

Fig. 4. Experiment results after 3 Month growing period – the green samples show the presents of microalgae

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CASE STUDY OF PM CONCENTRATION VARIATION DURING THE HEATING SEASON IN PEST COUNTY

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Given the changes that have occurred last year, it has become necessary to seek another source of heating during the winter, when people spend most of their time indoors and ventilation is limited. Biomass boilers, which are widely used in Hungary, are one of the renewable heating solutions. (Popp et al., 2011).

Boilers have an automated burning process and use fuel standards for pellets and wood chips to ensure a consistent fuel quality, in contrast to stoves. As a result, boilers typically produce few emissions of black carbon and particulate matter PM than burners do. However, they still release a great deal of microscopic particles into the air (Layman's Report, 2019).

According to the European Commission, outdoor air pollution causes around 400,000 premature deaths in Europe each year. In addition, millions of Europeans are afflicted with severe ailments. A premature mortality caused by air pollution results in a loss of ten years of life on average. Due to air pollution, around 4 million life years are lost annually in the EU. Annually, the accompanying socioeconomic health expenses amount to almost 500 billion euros (Press-Kristensen, 2016).

The aim of this research is to measure PM10 and PM2.5 concentrations during the winter period to analyse the biomass burning effect on particulate matters in Gödöllő, Isaszeg and Pécel.

For monitoring indoor air pollution, a microcontroller-based measuring instrument with a low-cost PMS7003 sensor was deployed. Another study has already published the general layout (Báthory et al., 2019). In addition to measuring particulate matter, a BME680 sensor also measured temperature, humidity, and pressure values. The sensors are controlled by an Arduino Nano microcontroller, which also analyses the collected data. A DS3231-based real-time clock was connected to the microcontroller in order to record time and save timestamps to an SD card. During the measurement, a three-stage coloured lamp indication was attached to the measuring instrument to indicate the concentration level of the particulate matter. The properties of the measuring device, including the above-mentioned components, is shown in Table 1.

Table 1. Sensors used in the measuring unit and their properties

Microelectromechanical system (MEMS) environmental sensor	Accuracy	Temperature	±1°C
		Humidity	±3 %RH
		Pressure	±1 hPa
	Supply voltage	1,71 V - 3,6 V	
Plantower PMS7003 Laser scattering dust sensor	Measured concentrations	PM_{10}, $PM_{2,5}$, PM_1	
	Measuring range	0-1000 µg/m^3	
	Accuracy	±10 µg/m^3, 10%	
	Supply voltage	4,5 V - 5,5 V	

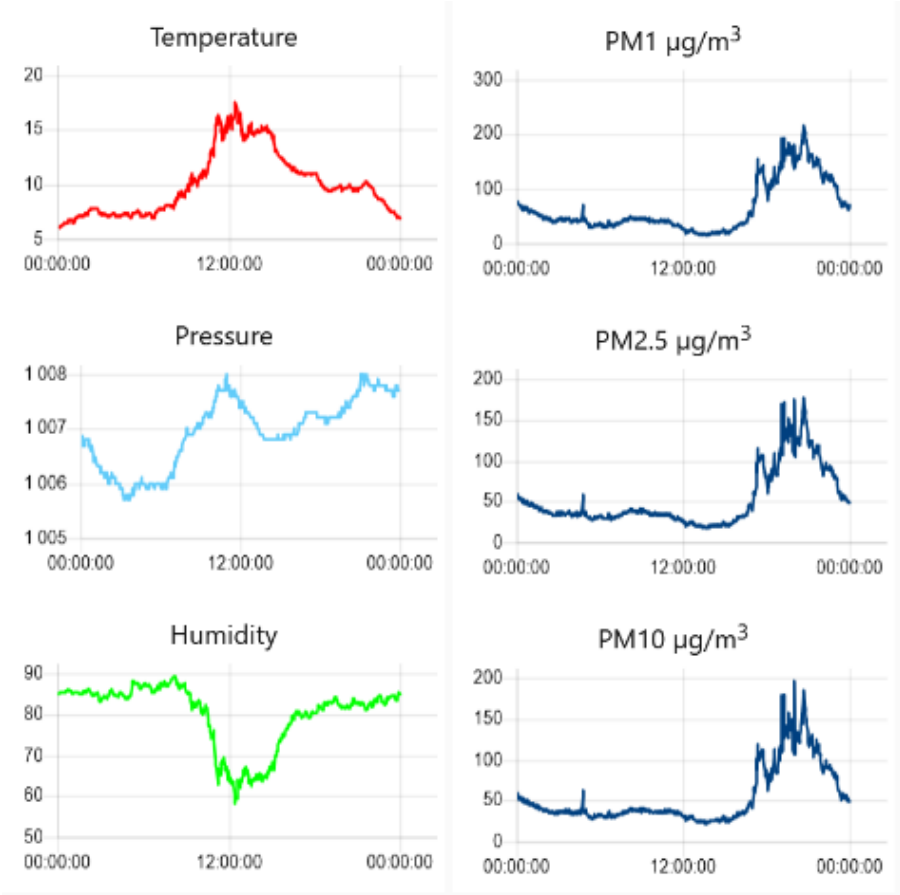

Fig. 1. Evaluation of the PM concentration in relation to the temperature and humidity on a single November day

First results from this study, which is not yet completed, reveal that PM concentration rises after 6 p.m., when everyone is home, and the temperature is falling approaching 0 °C. The fact that biomass used to generate the heat contributes to the observed rise as seen in Fig. 1.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Environmental Science Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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ENERGY PRODUCTION MODELLING OF 1000 Wp SOLAR POWER PLANT WITH NAÏVE BAYES ALGHORITM

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The world's energy demands continue to increase based on reports from the International Energy Agency (IEA), world energy demands in 2030 will increase by 45%. On the other hand, the average energy demand in Indonesia increases by 1.6% per year (Rudiyanto et al., 2019).

Solar energy is one of the most affordable and clean renewable energy sources, and due to its advantages, the utilization of solar energy continues to increase throughout the year. One way to convert solar energy into electrical energy is to use a Photovoltaic (PV) (Ikhsan, 2020).

Institut Teknologi Nasional Bandung (Itenas Bandung) has been operating a 1 kWp grid-connected system of the solar power plant (SPP) since January 2018, as can be seen in Fig. 1. This SPP has the main parts i.e., FV module and inverter. The purpose of the establishment of this SPP is not only to be used as lighting in part of the corridors at the 4th floor of building 1, it is also used for research facilities, educational facilities for various level of students and the public (Hidayat et al., Rusirawan, & Tanjung, 2019).

Fig. 1. Installation of 1 kWp of the SPP at ITENAS Bandung

In this study, modeling the energy production of a 1 kWp solar power plant will be described using the Naive Bayes algorithm, as a classification method from machine learning using several scenarios to compare training data and test data.

The data used for modeling was taken from 1 June 2020 - 31 December 2021 (579 data samples). There are 3 input parameters used, namely temperature (℃), radiation (hour) and solar radiation (kWh/m) while the output parameters are the analytical data used, namely 1 data classification label Energy (kWh). Each of feature is divided into five class labels, namely Very Low, Low, Medium, High, and Very High. Analysis of energy production modeling using the naïve Bayes algorithm method is in the form of a graph accompanied by an assessment of accuracy, precision, recall or sensitivity and f-score while the evaluation of the model is carried out through the values of RMSE (Root Mean Squared Error), MAPE (Mean Absolute Percentage Error) and MAE (Mean Absolute Error) using 3 (three) comparison scenarios of training data and test data, namely the first scenario 90%:10%, the second scenario 80%:20%, and the third scenario 75%:25%. Errors evaluation and forecasting results in various scenarios can be seen in Table 1 and Figs 2-4.

Table 1. Model evaluation

Scenario Modeling	MAE Value	RMSE Value	MAPE Value
1 (90% : 10%)	0,24	0,51	9,78
2 (80% : 20%)	0,17	0,41	7,75
3 (75% : 25%)	0,14	0,38	6,52

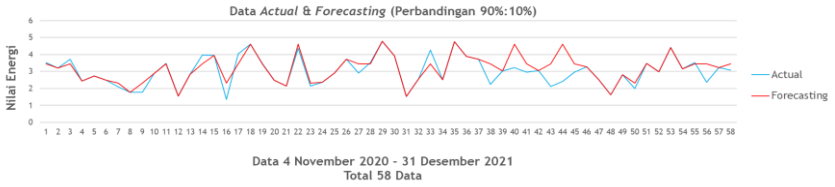

Fig. 2. Graph results of actual data and forecasting scenario 1

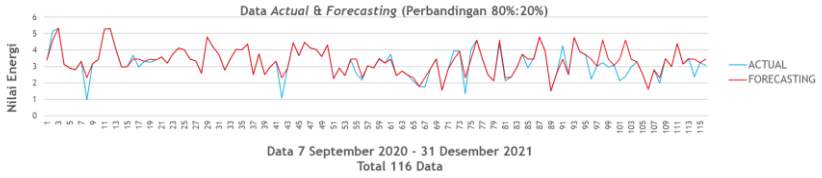

Fig. 3. Graph results of actual data and forecasting scenario 2

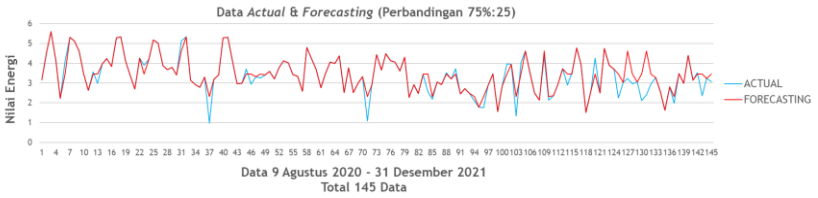

Fig. 4. Graph results of actual data and forecasting scenario 3

Scenario 3 has the four largest model assessment parameters compared to others. It has 94% accuracy, 57% precision, 54% recall or sensitivity and 55% f–score. Meanwhile, scenario 1 has 83% accuracy, 49% precision, 52% recall or sensitivity and 51% f–score, and scenario 2 has 91% accuracy, 55% precision, 51% recall or sensitivity and 53% f–score. Scenario 3 has the three smallest model evaluation parameters compared to other scenarios. It has a MAE (Mean Absolute Error) of 0.14, RMSE of 0.38, and MAPE of 6.52. Meanwhile, scenario 1 has MAE 0.24, RMSE 0.51, and MAPE 9.78, and scenario 2 has MAE 0. .17, RMSE 0.41, MAPE 7.75.

Acknowledgements

The short synopsis of this research is released as an outcome of multidisciplinary international partnership between ITENAS Bandung, Indonesia and MATE Gödöllő, Hungary.

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SCENARIOS OF THE USE OF SOLAR PHOTOVOLTAIC TECHNOLOGIES

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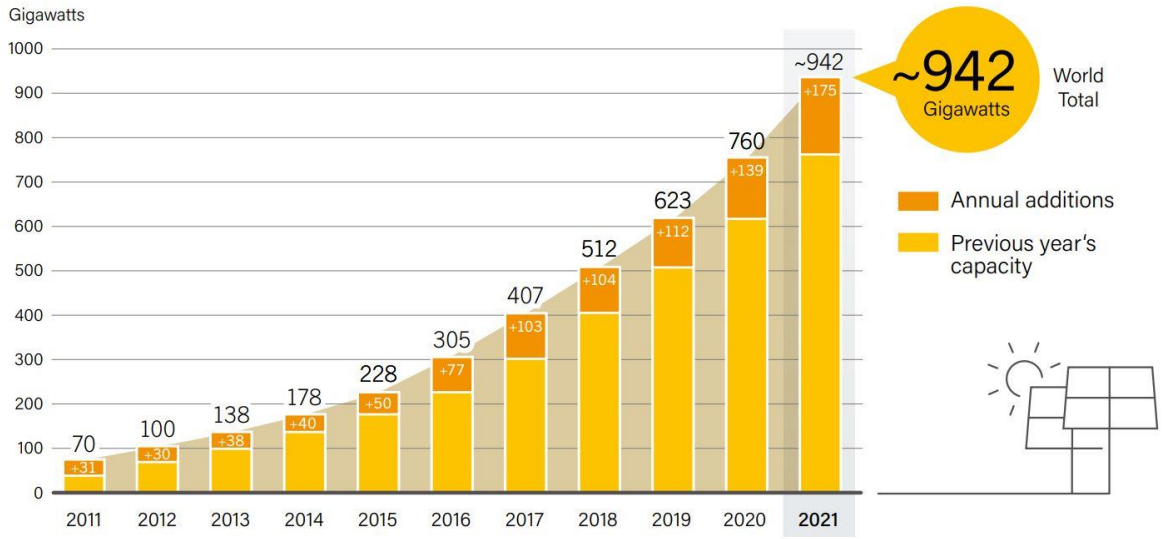
The recent paper is dealing with the status and future scenarios of the rapidly developing field of solar photovoltaic technologies. The worldwide situation is analysed based on the topic touched upon at the Solar World Congress (SWC 2021) organised online by the International Solar Energy Society in 2021 and at the EuroSun 2022 Solar Conference organized in Kassel, Germany. A very relevant event was the COST Action PEARL PV's Conference on Enabling the PV Terawatt Transition, Enschede, The Netherlands during 14-16 March 2022. Additionally, the most recently published books in this topic serve information overviewing the recent statements.

In 2021, the solar PV market increased by about 25% reaching the global capacity of 942 GWpv along with the annual additions of 156 GWpv (Renewables 2022; IEA PVPS, 2022).

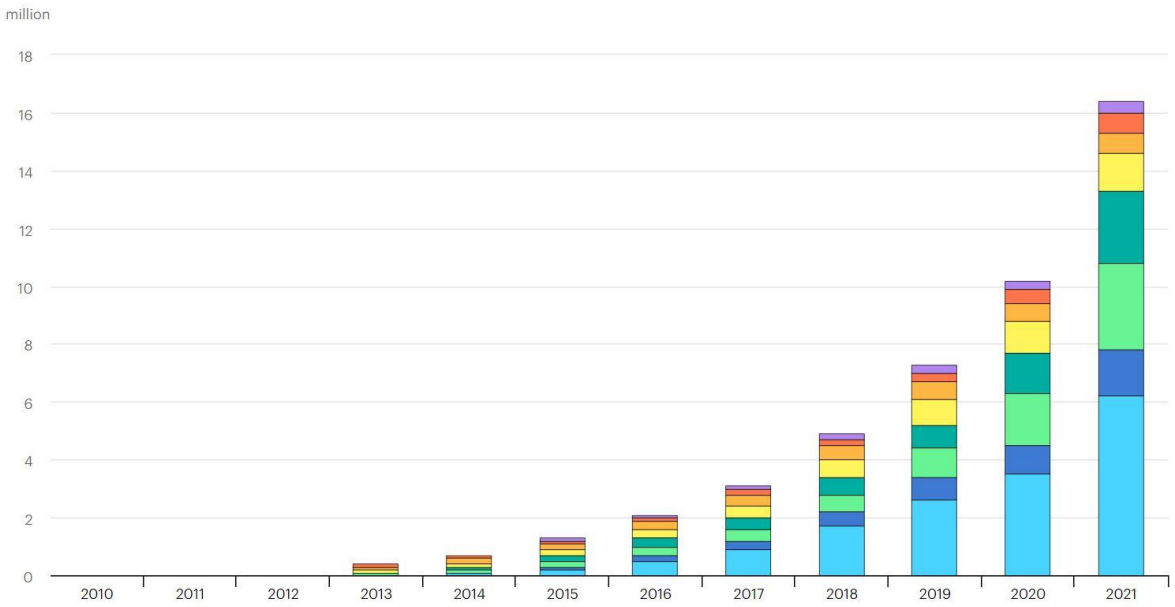


Solar PV capacity and annual additions - 2021

The five countries who performermed mainly the achieved capacity were China, USA, India, Japan, and Brazil, comprising around 61% of new installation. In the last decade, Asia dominated in new solar PV installations, representing 52% of the global added capacity in 2021.

Generally saying, the usual field of application as the utility-scale PV and the rooftop market experienced growth in 2021, but at the same time their relative shares of annual installations stayed the same at the level as the previous year.

Concerning to the PV application development it is also a significant factor that the number of electric vehicles is getting increase. Despite the economic slowdown in 2021, which caused the global car industry to shrink by 16% last year, a record 3 m new electric cars were registered around the world, to bring the total to above 16 m electric cars. There are also approximately 1 m electric vans, heavy trucks and buses. There are some countries having a national plan to reach the 100% electric vehicle target. The new concept in the vehicle-integrated PV can result in a 40% annual reduction in a vehicle's charging time. It has been initiated in several pilot project and research activities. In Germany, especially the application for heavy-duty truch can play an important role which could help in the transport.



Global electric passenger car stock, 2010-2021

In case of large-scale ground-mounted plants there are concerns about the environmental impacts. In the last decade the floating photovoltaics and agricultural PV markets increasingly gaining interest. Recently, in South-East Asia and Africa where the solar projects tend to compete with agricultural land uses, and enableing solar installations without compromising water and food resources.

In 2021 the world largest agricultural PV project was installed in China, with a capacity of around 1 GW, and consecvently Asia hosts the majority of agri-voltaic plants. In Europe, among the others France, Greece, the Netherlands, Spain, and Italy are the main actors in supporting for agri-voltaics.

Floating PV plants also continued to expand with installed capacity exceeding 3 GW in 2021. The world's largest floating PV plant (320 MW) came online in China in 2021. In Europe, Portugal held an auction for 500 MW of floating solar to be located at hydropower dams (Renewables, 2022).

After several years of declines, PV module costs increased by estimated 57% in 2021, from an average of USD 0.21 to 0.33 per Wp, as because the cost of raw materials increased sharply. The main factors contributing to rising module costs included a polysilicon shortage and a rise in shipping costs from China, as he is the world's dominant module producer.

At the same time, strong research activities are conducted to reach more efficient cell technologies, for instance Perovskites, in tandem with crystalline silicon or thin-film base. There are projects focusing on the long-term stability of Perovskites. In the laboratory, the high concentration multi-junction solar cells achieved an efficiency of 47.1%, and modules with concentrator achieved 38.9%. The record cell efficiency for Perovskite is 23.7% (Fraunhofer ISE, 2022). At module level it is intended to develop higher power ranging at 600 W-plus mainly for building applications.

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MODELLING OF PV ENERGY PRODUCTION USING TIME SERIES AND SUPPORT VECTOR MACHINE

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The issue of the energy crisis which is marked by very high price increases for two primary energy sources, namely coal and natural gas, requires us to look for alternative energy sources that are reliable and economical, solar PV by utilizing solar energy is a promising choice to answer the challenge of the energy crisis. Indonesia has enormous potential for new and renewable energy, as reported in the Indonesia Energy Out Look 2019, a total renewable energy potential equivalent of 442 GW and half of which is solar energy potential (Suharyati et al., 2019).

Solar energy as the biggest energy potential in the mix of renewable energy sources has its own challenges, namely energy production is very dependent on local atmospheric or weather conditions, which include water vapor, clouds and pollution (Yuliarto, 2017) so that energy production is very difficult to predict, unlike solar power plants. conventional electricity, resources are not accessible and fulfilled on demand (Wolff et al., 2017).

To answer the challenge of estimating energy production in a SPP system, research on production forecasting in PLTS emerged as a brilliant idea (Sobri et al., 2018). The researchers carried out two approaches, namely using analytical equations and statistical methods with machine learning methods, besides that there was also a mixed or hybrid model approach, Antonanzas et al. (2016) reported forecasting energy production in SPP 72% using statistical models, 17% using hybrid model, and 11% use a physics model, as shown in Fig. 1.

This study proposes the creation of an energy production forecasting model for the 1 kWp ITENAS SPP based on time series energy production data to predict the next period. The Support Vector Machine (SVM) algorithm is used in machine learning to create models that predict the future. SVM with the development of regression analysis into Support Vector Regression (SVR) is a learning method developed from statistical theory that has the best performance for classifying non-linear data compared to other methods (Shi et al., 2012).

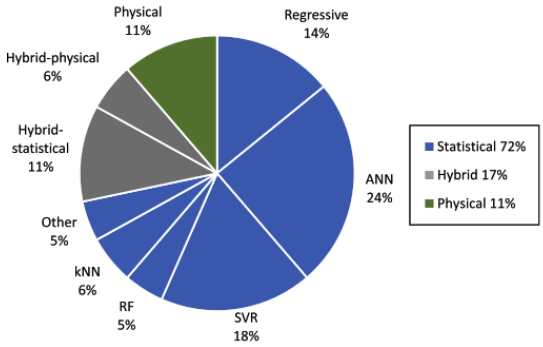

Fig. 1. Distribution of studies with respect to the technique used

As with machine learning models in general, the model is always built with construction data divided into two, namely training data and test data. In this study, the training data is energy production from January to December 2021 and the test data is energy production from January to May 2022. See Fig. 2.

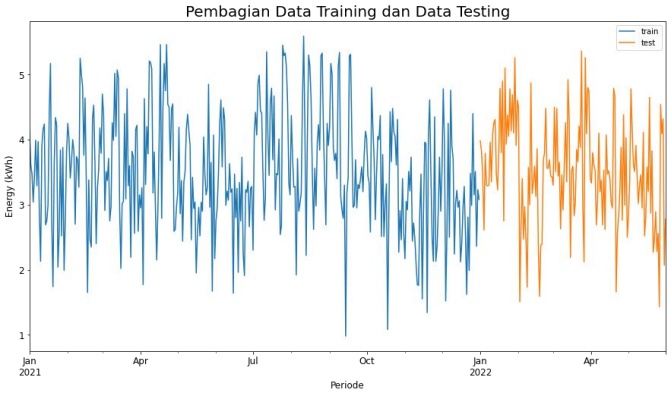

Fig. 2. Training data and test data period

Furthermore, in this study the method of building a forecast model with SVM based on time series data and the evaluation results on training data and test data will be presented, as well as the evaluation results for the monthly period forecast as the basis for evaluating whether the forecast model is very good, good, feasible or bad.

Acknowledgements

The short synopsis of this research is released as an outcome of multidisciplinary international partnership between ITENAS Bandung, Indonesia and MATE Gödöllő, Hungary.

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SMART FARMING APPLICATION BASED ON AUTOMATIC SPRINKLER AND ARDUINO IoT CLOUD

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The Indonesian government has launched a national priority program, "making Indonesia 4.0" since 2021, in preparing Indonesia to embark the 4th industrial revolution. However, until the present, many farmers are only at the introduction level, and not really recognizing digitalization in agricultural technology (Rachmawati, 2021). Introducing and training farmers to use smart farming technology need collaboration with various parties. On the other hand, smart farming is expected to attract young generations to work in agriculture.

In introducing one of the smart farming technologies, the Lembang Agri Farmers Group collaborated with Institut Teknologi Nasional Bandung (Itenas Bandung) has constructed an IoT-based automatic plant sprinkler that is economical, easy to make, and apply. The Lembang Agri Farmers Group has become a Self-help Rural Agriculture Training Center (P4S) for farmers and young farmers who want to advance in farming (Kastara.id, 2022).

The automatic sprinkler is connected to the internet through the arduino IoT cloud application and uses the ESP32 microcontroller, which is open-source and economical (Oton, Iqbal, 2021). This tool detects soil moisture with a capacitive soil moisture sensor, an economical sensor for smart agriculture (Kulmány et al., 2022). The water flows through the solenoid valve to the specified soil moisture limit. The energy source of the tool uses 3 of 18650 batteries which can be recharged. Containers made from PVC consider the conditions of the installation site and weather as well as the ease of manufacture. The schematic system can be found in Fig. 1.

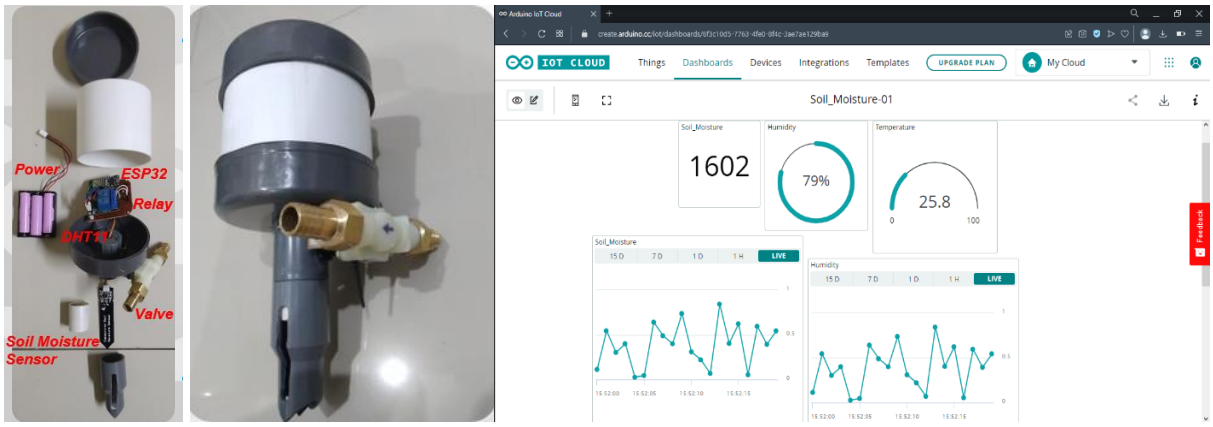

Fig. 1. The schematic system of automatic sprinkler

From the function test, the tool has been able to show the value of soil moisture, temperature, and humidity in the container and changes in valve conditions when reaching the limit. Furthermore, field tests are needed to determine the tool's reliability and develop the use of photovoltaic as an energy source to recharge batteries.

Acknowledgments

This work was supported by the Institute for Research and Community Services (Lembaga Pengabdian Pada Masyarakat/LP2M), Institut Teknologi Nasional Bandung, and as an outcome of multidisciplinary international partnership between ITENAS Bandung, Indonesia and MATE Gödöllő, Hungary.

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RISK ASSESSMENT FOR OFFSHORE RISER DUE TO SHIP COLLISION

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In natural gas industry, pipeline in which located under the sea is used as a transport equipment to transfer energy in the form of hydrocarbon fluids. One of the main components to use as a transport equipment from under the sea into the surface of the sea is a riser, which is supported by a platform. Riser is also used to tranport fluids from and to ships and vessels. These high activity of ships and vessels around the platform provoke the concern of safety for ship collision occasions, therefore this research is conducted. For this concern, a risk analysis is conducted based on Norwegian standard DNV-RP-F107, from probability of failure to calculate the failure frequency.

This research is conducted using four types of vessels that are typical to having a busy traffic around the platform: Passing Vessels, Random Distributed Vessels, Standby Vessels, and Supply Vessels. The results of failure frequency are in the range of 10-2-10-3 out of 10-5 occasions in a year with the range of class of category 3-5 out of 5. Next is defining the consequences of failure in which is defined in economical perspectives based on the downtime period of a platform to conduct repairment and maintenance. Risks are calculated by multiplying the failure frequency with consequence of failure. The results range are rated class of A to C. The data from failure frequency and risk evaluation are then to be plotted into risk matrix as depicted by Fig. 1 to define these occasions are in categories of acceptable or not acceptable.

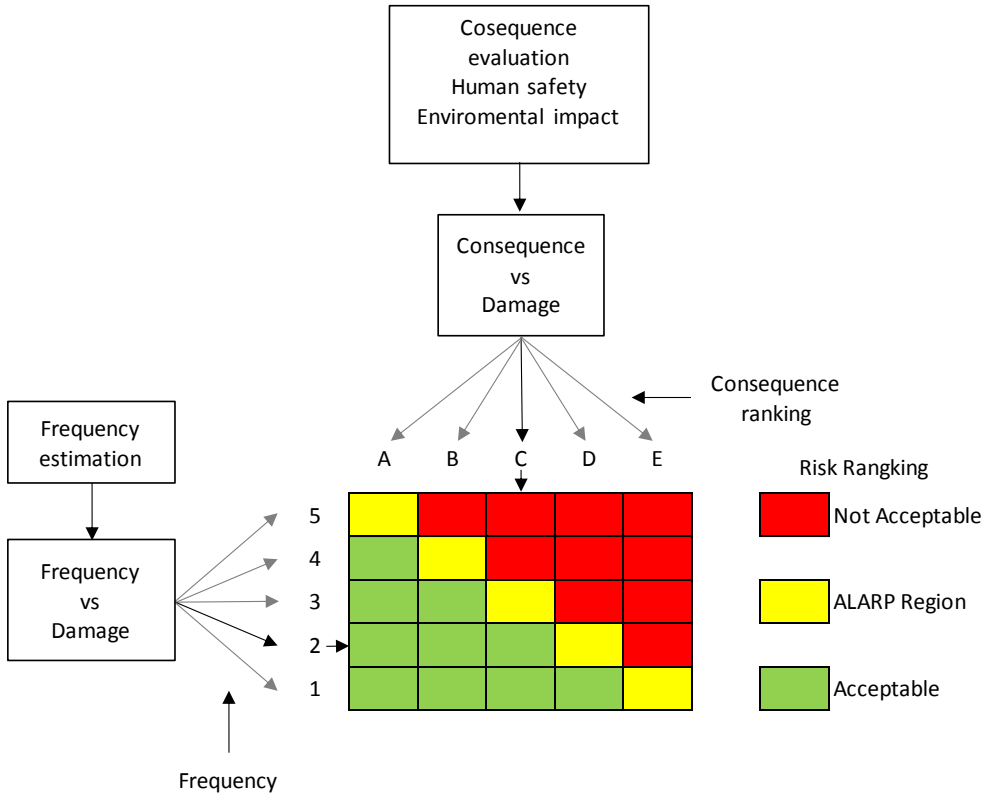

Fig. 1. Risk matrix (DNV-RP-F107)

The results of ship collision occasions are in high risk and in the category of not acceptable. Furthermore, the worst case scenario that might happened because of the hydrocarbon fluid that leaked into the sea would sparked and caused a fire, called Fire and Explosion Occasion as illustrated in Fig. 2. This ship collisions occasion has the result of thermal radius of R = 133 meters. By this result, a series of mitigation measures can be arranged as a risk reducing measure to decrease the risk until this occasion becomes the category of acceptable, furthermore these measures also take the concern for environmental damage caused by this occasion.

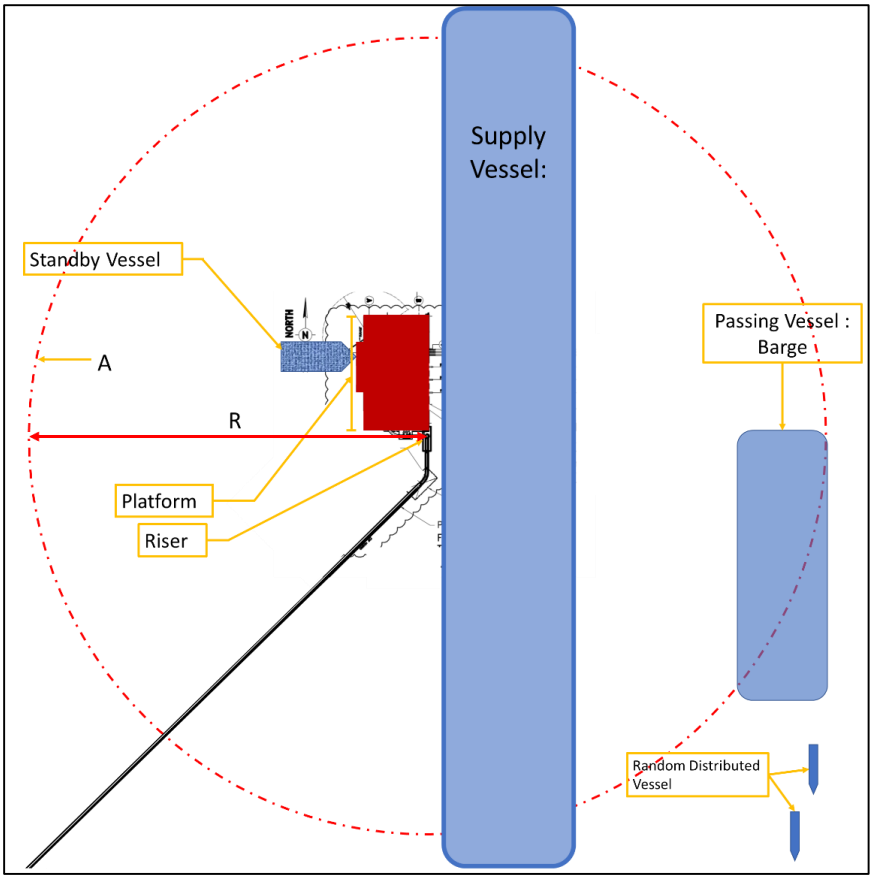

Fig. 2. Fire and explosion occasion

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APPLICATION OF THERMAL STORAGE SYSTEMS FOR INDIRECT SOLAR DRYERS

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Energy plays an important role in different aspects of human's day to day activity and it is key elements for the economic and social developments of one nation. Thus enegy can be gainedfrom diffrent sources. Renewable energy are icreasingly seen as best option especially interms of enviromental and global warming issues.Solar energy among the common renewable energy resource which is plentiful, clean, and safe source of energy .How ever it is intermittent, it only works in the day time only, vary from time to time and place to place and even we can not predict it.Thus, can change it magnitue suddenly. Thermal storages are best options to adress solar energies drawbacks.

Thermal energy storage has recently attracted increasing interest related to thermal applications such as space and water heating, solar drying,waste heat utilization, cooling and air-conditioning. Energy storage is essential whenever there is a mismatch between the supply and consumption of energy. The energy storage can even out this imbalance and thereby helps in saving of capital costs. It is desirable for more effective and environmentally benign energy use (Regin et al., 2008).

Energy storage is a key issue to be addressed to allow intermittent energy sources, typically renewable sources, to match energy supply with demand. There are numerous technologies forstoring energy in various forms including mechanical, electrical and thermal energy. Thermal energy can be stored in wellinsulated fluids or solids as a change in internal energy of a material as sensible heat, latent heat and thermo-chemical or combination of these. The classification of thermal storeges is shown in Fig. 1 (Bal et al., 2010).

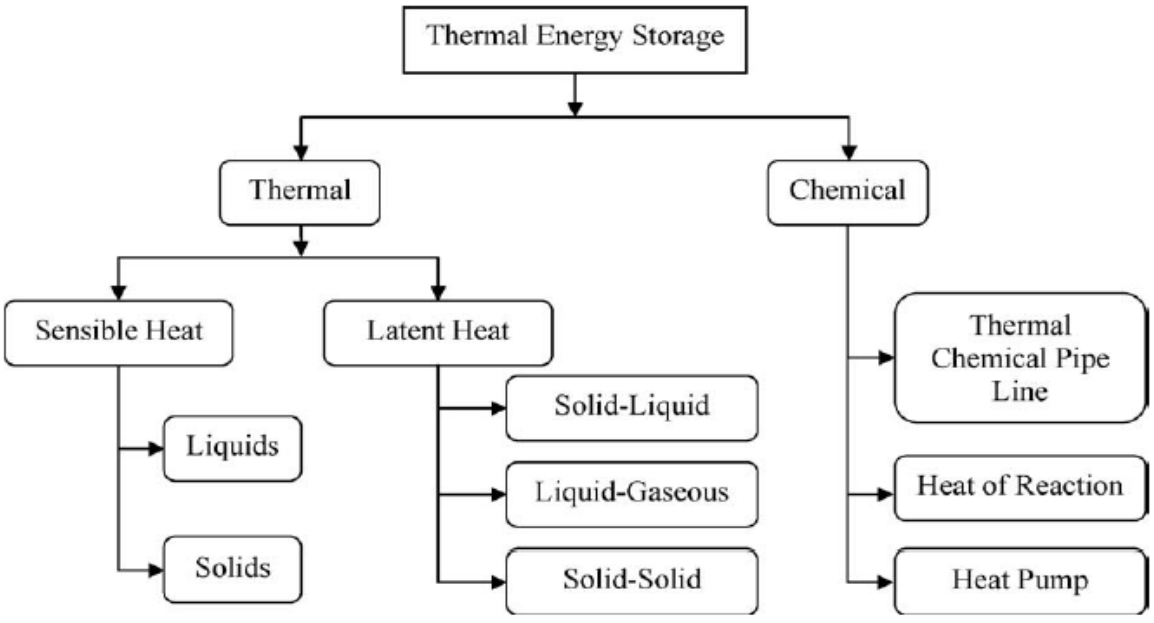

Fig. 1. Different types of thermal storage of solar energy

A thermal energy storage system mainly consists of three parts, the storage medium, heat transfer mechanism and containment system. The thermal energy storage medium stores the thermal energy either in the form of sensible heat, latent heat of fusion or vaporization, or in the form of reversible chemical reactions. Today, sensible heat materials in the form of synthetic oil and molten salt are the most widely used storage materials in large-scale CSP systems while systems that utilize latent heat, thermochemical, and other sensible heat materials are still being developed (Kuravi et al., 2013).

Acknowledgement

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COMPARISON OF RESIDUAL NEURAL NETWORK 152 V-1 AND V-2 WITH HYPERPARAMETER OPTIMIZATION FOR COVID-19 CLASSIFICATION

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Corona virus disease (COVID-19) is an infectious disease caused by the Severe Acute Respitatory Syndrom (SARS-CoV-2) virus. In most cases, this virus only causes mild respiratory infections, i.e., the influenza. However, this virus can also cause severe respiratory infections, such as lung infections (pneumonia), Middle-East Respiratory Syndrome (MERS), Severe Acute Respiratory Syndrome (SARS), and can even cause death. The World Health Organization (WHO) suggests a method to avoid this disease by introducing the 3T (Testing, Tracing and Treatment). The most common way to test this disease, by applying the Rapid Test and the Swab Test.

Further testing to obtain the accurate examination is implementing an Artificial Intelligence (AI). The process in AI classifies the disease based on an X-ray image. The X-ray itself is an examination procedure using electromagnetic wave radiation and mainly used to look at the internal part of the body. X-ray often becomes the first procedures where the patient should have if the doctor suspects that there is a heart or lung disease. This procedure is done since it can reveal many things inside the patient's body.

Several researches applied Deep Transfer Learning, in one case is Residual Neural Network (ResNet)-152, stated that this method obtained the accuracy up to 99% compare to ResNet-50. Thus, the purpose of this study is to classify using the deep learning method to identify Covid-19 disease, examining the ResNet-152 as shown in Fig. 1.

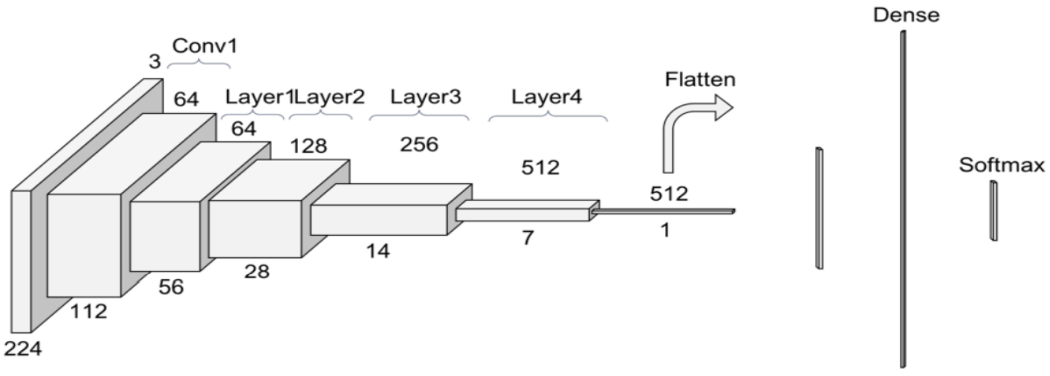

Fig. 1. Residual Neural Network Architecture (Source: medium.com)

To conduct the research, a classification system was built based on the architecture of residual neural network 152 version 1 and residual neural network 152 version 2, comparing them with hyperparameter optimization batch size 32, optimizer SGD, learning rate 0.01, epoch 30, and drop out 0.4 and 0.3. The application is built as shown in Fig. 2.

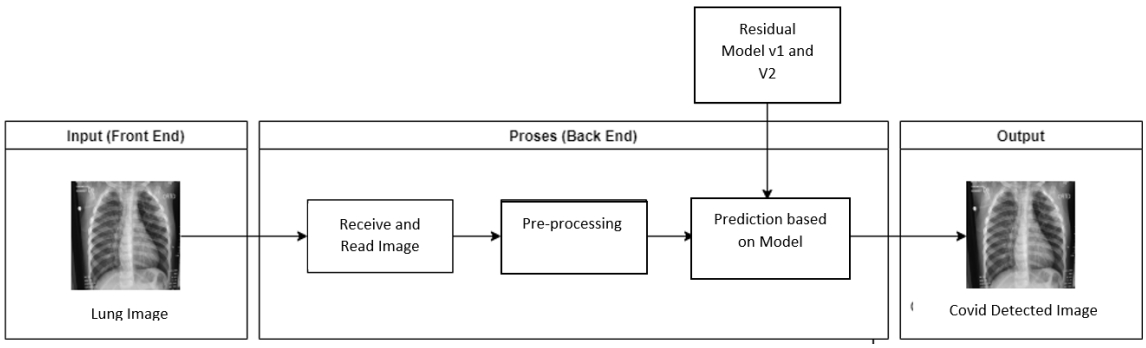

Fig. 2. Application of Covid Detection

The preliminary results of the training process (Fig. 3.) show that the residual neural network 152 version 2 outperforms the accuracy at 99.61% of version 1 which achieves 99.42% accuracy and the confusion matrix of the residual neural network 152 versions 1 and version 2 achieves a precision, recall, and f1-score of 0.953.

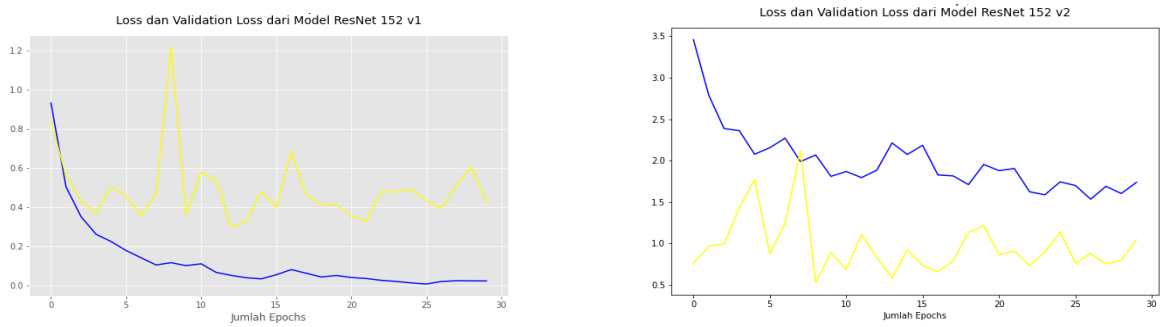

Fig. 3. a) Training and Validation Toward Loss by ResNet 152 Version 1 b) Training and Validation Toward Loss by ResNet 152 Version 2

Acknowledgements

The short synopsis of this research is released as an outcome of multidisciplinary international partnership between ITENAS Bandung, Indonesia and MATE Gödöllő, Hungary.

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SMS SPAM FILTER USING MACHINE LEARNING BASED NAÏVE BAYES, SUPPORT VECTOR MACHINE AND K-NEAREST NEIGHBOR (KNN) ALGORITHMS

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SMS spam is a message that is useless for the recipient and is often misused by irresponsible parties. Most of the SMS are spam SMS consisting of credit card offers, discount offers, promotions, and others. The purpose of this research is to design and analyse a Machine Learning-based SMS spam filter algorithm model in order to minimize crime through fraudulent SMS. The methodology used in this research includes obtaining spam and ham SMS datasets in .csv format, pre-processing stages, forming algorithm models, and system implementation by measuring the accuracy of the system in classifying data.

The research results obtained are in the form of large comparison data on the value of the accuracy of the algorithm model in detecting spam and ham messages, and the number of SMS accuracy and errors classified from the original data. The accuracy of the methods/algorithms in view of errors characteristics is shown in Fig. 1.

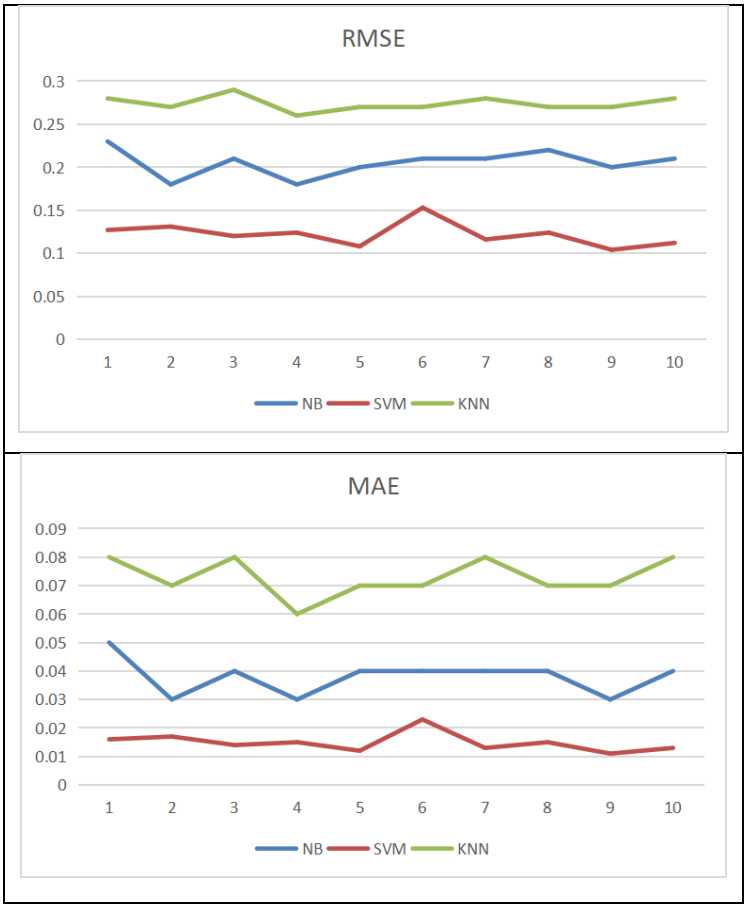

Fig. 1. Characteristics of errors the algorithms

Test data and training data are divided by a ratio of 20% test data and 80% training data. The average accuracy comparison results for each model in data training were Naïve Bayes of 97.24%, Support Vector Machine (SVM) of 100%, and K-Nearest Neighbor (KNN) of 94.85%. While the results obtained in testing the data are in the form of accuracy, precision, recall, and f1-score values. The average accuracy value in data testing is Naïve Bayes at 95.74%, SVM at 98.51%. and KNN of 92.37%. The average precision value of Naïve Bayes is 95.25%, SVM is 98.39% and KNN is 91.82%.

MAE			
No	NB	SVM	KNN
1	0.05	0.016	0.08
2	0.03	0.017	0.07
3	0.04	0.014	0.08
4	0.03	0.015	0.06
5	0.04	0.012	0.07
6	0.04	0.023	0.07

The average results of the recall values of Naïve Bayes, SVM, and KNN are 100%. The average result of the Naïve Bayes f1-score is 98%, SVM is 99.14% and KNN is 95.76%. The factor that affects the results of accuracy is the distribution of test data and training data, namely test size of 20% of the dataset. The greater the test size value in the model, the greater the accuracy value obtained. The more data used, the model will perform learning with maximum results. In KNN, the value of *n* neighbors determines the final classification decision. The smaller the *n* neighbors value, the smaller the accuracy results obtained.

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THE EFFECT OF CHANNEL HEIGHT ON THE PERFORMANCE OF A SINGLE PASS SOLAR AIR COLLECTOR

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The importance of renewable energy sources is increasing rapidly over traditional fuel for several reasons: the lack of fossil fuels, their higher price and their harmful effect on the environment. Solar energy represents the most abundant and safest energy source in our life, which will be enough if it is well utilized. The solar air collector (SAC) is one of the crucial rigs in the solar energy field, as it is used in space heating and crop drying. However, the solar air collector has an issue which is the lower performance due to the limited heat capacity and thermal conductivity of the air (El-Sebaii et al., 2011).

Several techniques were reported in the literature for enhancing the performance of the SAC, for instance: adding obstacles, using multi-channel instead of one, using selective coatings, and proper design for the flow pass geometry.

This work investigates the influence of the flow channel height on the performance of a single-pass solar air collector. A mathematical model was used for modelling the SAC, and MATLAB code was developed to solve the equations. The heat transfer coefficient and the thermal resistance scheme network can be seen in Fig. 1.

The proposed model was validated initially with experiments conducted in the laboratory of the Hungarian University of Agriculture and life sciences (MATE) Gödöllő, Hungary. Then it was used for modelling the new parameter of the collector. The theoretical approach to the thermal analysis of the proposed collector can be presented by making necessary assumptions important for simplifying the model (Ong, 1995). The collector is made of the wood, copper plate as an absorber, polystyrene sheets as insulation material, and crystal transparent polystyrene sheets as glazing.

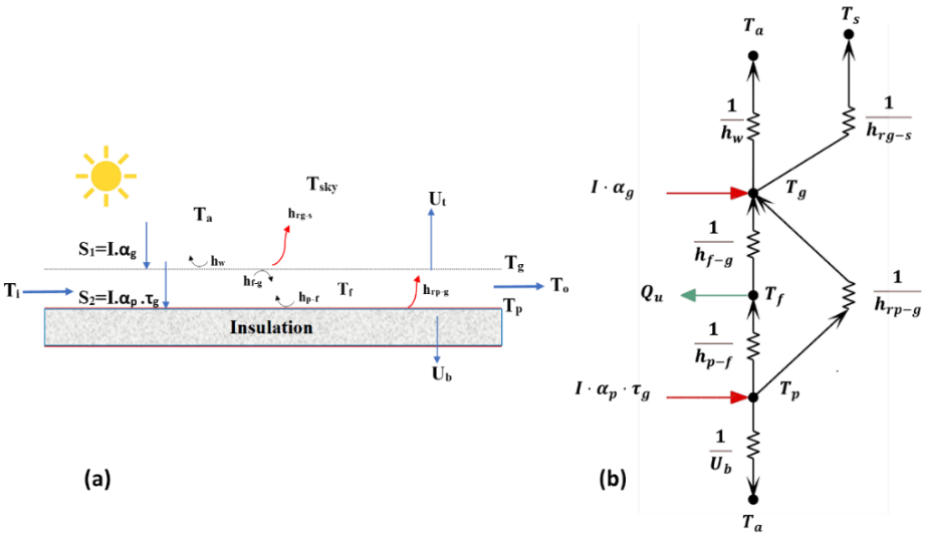

Fig. 1. Schematic views: a) heat transfer coefficient, b) thermal resistance network of the proposed SAC

The results showed that the outlet temperature has an inverse relationship with the channel height, which decreases when the channel height increases and vice versa. The reason for this behaviour is that any change in the channel dimensions affects the Reynolds number, which directly affects the Nusselt number at the end, increases or decreases the convective heat transfer coefficient, which affects the outlet temperature. The effect of channel height on the outlet temperature will be negligible when the airflow is increased to a specific limit, as seen in Fig. 2.b. An increase in the outlet temperature is desirable to improve the performance of the collector along with proper heat gained to increase the thermal efficiency of the collector.

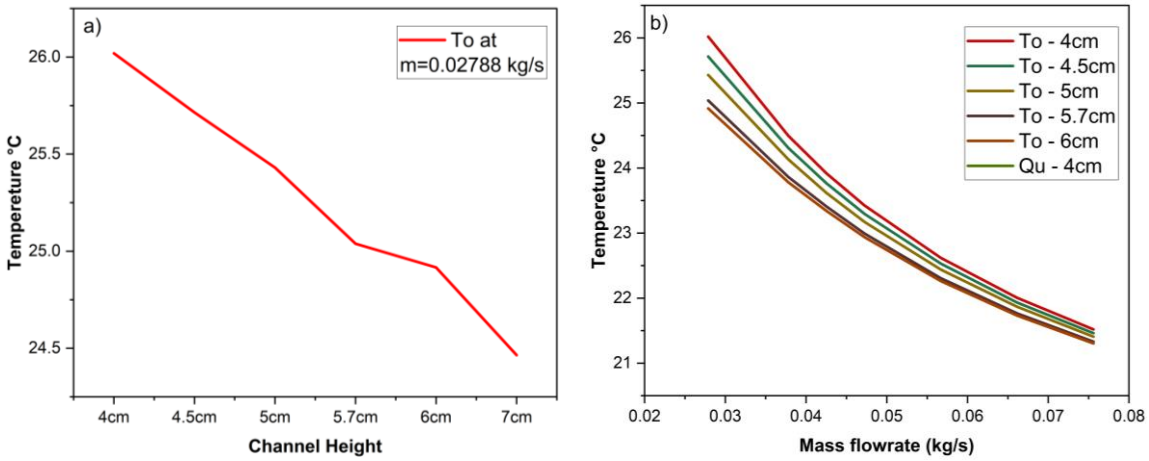

Fig. 2. a) The outlet temperature verse different channel height, b) The outlet temperature at different channel height under several mass flowrate

Decreasing the channel height will not always be efficient as it will cause an increase in the friction loss and then increase the pressure drop of the forced blower, which makes the collector inefficient from the exergy analysis viewpoint. On the other hand, an increase in the channel height will increase the heat loss from the collector. For that the optimal channel height should be considered for a specified collector by taking consideration the exergy and energy analysis.

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NEW SOLUTIONS OF THE SIMULTANEOUS CONVECTION-DIFFUSION EQUATIONS

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Since mathematical modelling of the convection-diffusion processes through porous media plays an important role in many fundamental-and practical engineering transport process problems, elaboration of new and more accurate models for it represents a permanent research task, whose complexity is also reflected in the nonlinear character of the relevant ordinary differential equations (ODEs) and partial differential equations (PDEs) to be solved.
Concretely, we would like to apply our own research method in detail (Mészáros et al., 2011), developed for travelling wave-type solutions of the convection-diffusion processes, which may be of crucial importance from the point of view of understanding of the „wandering moisture level zones" at drying of the bulk porous materials.

Accordingly, we would like to study in detail such new variants of the Riccati-type ordinary differential equation, whose coefficients we assume – probably among the first researchers in this area – that they show percolative state-dependence and presented the relevant new-type solutions.

Since the solution of the Riccati equation modified according to the basic approximation was possible to represent in a closed form too (Mészáros et al., 2011) in the planned forthcoming work of ours we intend to extend the modification expressed via dominant percolative term only, and to consider further potentials of the D'Alembert-type independent variable. During realizations of all these calculation procedures – as it has been done – we will exploit extensively possibilities ensured by contemporary computer algebra systems.

We intend to describe the simultaneous convection and diffusion processes in the soil column being investigated experimentally in a more refined manner by detailed calculation methods, which have proven to be confident (Eck et al., 2008) in the given research area.

Therefore, the travelling-wave form of the general solution of the simultaneous convection-diffusion problem must be used. Then, using D'Alembert-type independent variables, i.e., $c = c\left(\zeta = x + y - \lambda t\right); \lambda = const.$, the general form of the solution will be:

$$c\left(\zeta\right) = a_0 + \sum_{i=1}^{q}\left(a_i \omega^i + b_i \omega^{-i}\right), \omega = \omega\left(\zeta\right)$$

$$a_0, a_i, b_i = const., \left(1 \le i \le q\right),$$

where $q \in \mathbb{N}^+$ and the component solution functions obey the Riccati-type ODE $\frac{d\omega}{d\zeta} = k + \omega^2$, with *„k"* as a parameter depending on the actual experimental conditions and to be determined subsequently. Firstly, we assume, that there is only one „dominant term" in this expression, i.e., the following first order Riccati-type ODE must be solved:

$$y' - y^2 - a_n\left(p\right) \cdot x^n = 0.$$

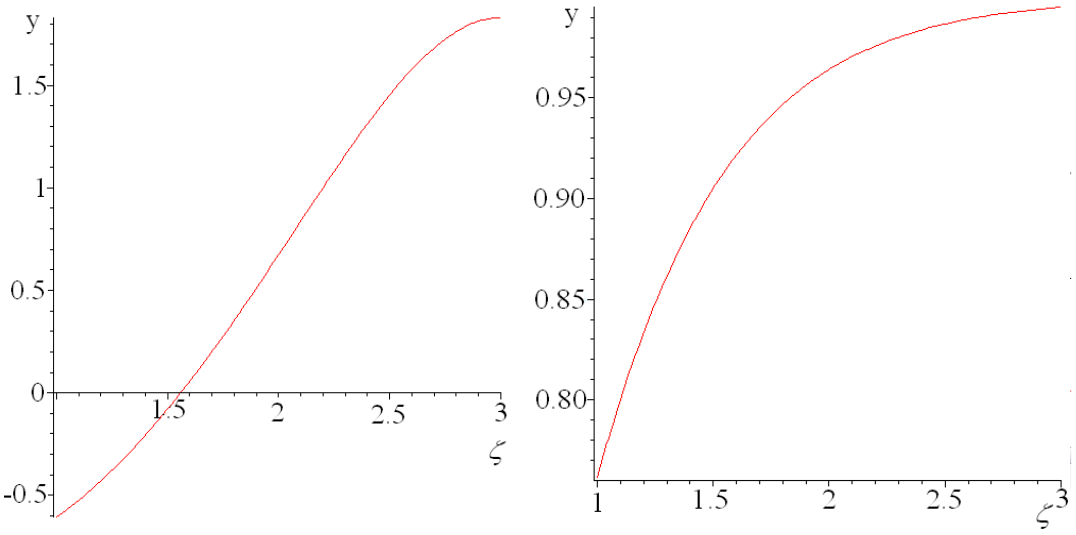
Accordingly, if we perform linearization of the original Riccati-type ODE, we arrive at the following equation to be solved:

$$\frac{d^2u}{dx^2} - a_n(p)\cdot x^n u(x) = 0.$$

The solution of this ODE can also be obtained directly (by use of the MAPLE 10 computer algebra system), whose final form is more concise, than those obtained from direct solution of the first order form of the Riccati-ODE:

$$u(x) = C_1\sqrt{x}\cdot J\left(\frac{1}{n+2}, \frac{2\sqrt{-a_n(p)}\cdot x^{\frac{n}{2}+1}}{n+2}\right) + C_2\sqrt{x}\cdot Y\left(\frac{1}{n+2}, \frac{2\sqrt{-a_n(p)}\cdot x^{\frac{n}{2}+1}}{n+2}\right), C_1, C_2 = const.,$$

i.e., the final result is also explained by use of Bessel-type special functions. On the following figures solutions of the modified Riccati-type ODE and of its simple, original form are presented:



It is obvious, that solution of the generalized form shows the same tendency, i.e., it fits well with the earlier modelling results, but its further application will make possible introduction of more refined models.

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AN INNOVATIVE TRAINING SOLUTION FOR RADIATION PREPAREDNESS

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The remote measurability of radioactive materials is receiving a previously unimaginable level of attention due to today's war events. Attacks on nuclear power plants and the deployment of the dirty bomb have a shocking effect on public opinion. Alpha-emitting substances are the most biologically dangerous to the human body if they enter, but their outdoor remote detection is not possible with traditional detectors, since the range of alpha radiation in air is only a few cm and thus direct contact with the source is necessary. Currently, there is no suitable measuring system available for the detection of large-scale area pollution of alpha emitting materials.

The EMPIR 2020 19ENV02 RemoteAlpha project, a collaborative work between 8 European Union institutes, develops a new type of measuring system and metrological infrastructure, which overcomes the shortcomings of traditional detectors and enables the remote, real-time detection of alpha-emitting radionuclides (Krasniqi et al., 2021; RemoteAlpha, 2020).

The principle of the method is of optical origin and based on the so-called air-radioluminescent phenomenon (Baschenko, 2004) the alpha radiation source ionizes or excites the surrounding air molecules and the processes of recombination and excitation emit light. For to collect these radioluminescent photons an optical receiving system can be optimized and installed on a UAV vehicle (e.g. drone) or operated from tripod. As a complement to the method, the applicability of an active, laser-induced fluorescence spectroscopy method is ongoing at the feasibility level, as well as the development of calibration procedures of these novel-type detector systems and the corresponding infrastructure (e.g. production of well-characterized alpha active environmental samples) are also under development.

As a consortium partner MATE with collaboration IDEAS Science Kft. is currently developing on-line curriculum which can be used in BSc and MSc level university education, but can also be integrated into the training system of CBRN specialists, persons responsible for nuclear medicine technologies, radiation safety officers, environmental protection and waste management officers too.

In addition, the topic of the project was simultaneously introduced into the MATE education system, and the educational experiences gained in teaching the related subject will also be taken into account in the development of the above-mentioned on-line course material.

Acknowledgements

This project 19ENV02 RemoteALPHA has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. 19ENV02 RemoteALPHA denotes the EMPIR project reference.

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THE POTENTIAL OF BIOMASS UTILIZATION USING ORGANIC RANKINE CYCLE

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Electricity is one of the most important infrastructures for a country's economic success. For an example, the Indonesian government has indicated that the power ratio objective of 99.7% must be met by 2025. Electricity transmission must cover all of Indonesia, including rural regions, isolated systems, and tiny islands, in order to meet the aim. The government has established a target for the energy mix of power plants by the end of 2025 of 54.4% coal, 23% renewable energy, 22.2% oil and gas, and 0.4%, respectively (PLN, 2020). Until 2020, the installed capacity of renewable energy power plants in Indonesia was 63.3 GW, with hydropower plants accounting for 8%, geothermal power plants accounting for 4%, and other renewable energy resources power plants accounting for 1%. The renewable energy power plant contributed 11% of the total.

Generally, it can be stated that not all the presently available renewable energy sources can be directly converted to electricity without the need of additional technologies, such as Organic Rankine Cycle (ORC).

Several research have investigated similar ORC systems that use agricultural biomass as a heat source. However, most of the research on ORC systems using heat from biomass combustion are combined heat power or cogeneration and district heating. On the other hand, Tosun (2015) has examined a 5 MW hybrid ORC using agricultural biomass heat sources, resulting in electricity production with about 60-70% thermal performance through cogeneration. Moreover, the use of biomass as a diesel fuel mixture has been widely used in commercial diesel fuel in Indonesia with a blend of 30% biodiesel (B30) (Tarsisius et al., 2022).

According to Fig. 1, the majority of available research are based on the ORC system as a secondary unit of biomass power production, therefore there are still few studies employing a single ORC system with a biomass heat source. The biomass employed in this study is Napier grass. Napier grass was chosen because it is one of the bioenergy crops that can be grown in practically all climates and soil conditions in Indonesia, with a high heating value (HHV) of 16.56-18.11 MJ/kg (Said et al., 2015). The goal of this study was to analyse the thermo-economic performance of Napier grass as a biomass heat source using ORC analysis.

Based on the results of a thermodynamic analysis, the primary components of a centrifugal chiller air conditioning system may be turned into ORC components by calculating the correct operating conditions. Furthermore, after analysing the investment costs of different working components, it was discovered that R245fa has a greater potential to be employed as a working fluid than R123 for ORC power plants with biomass fuels and an electrical output of 200 kWe.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Science, Gödöllő, Hungary and the Department of Mechanical Engineering, Itenas Bandung, Indonesia.

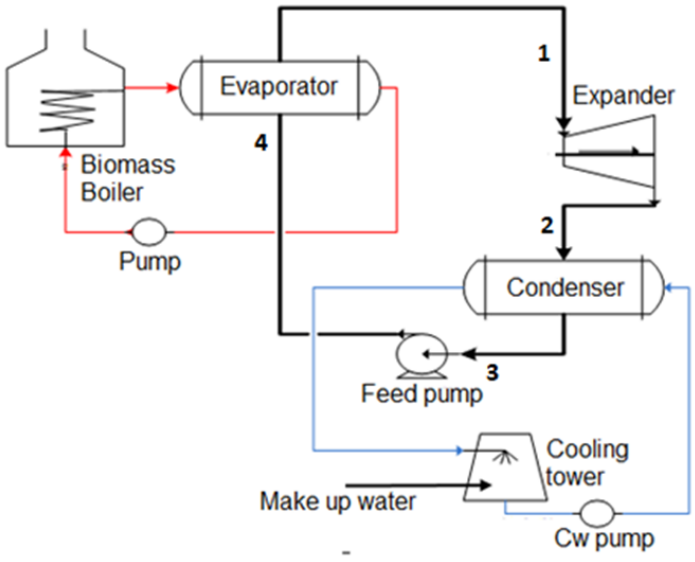

Fig. 3. ORC design using biomass heat source

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EFFECT OF THE EFFICIENCY OF MODULAR SOLAR DRYING SYSTEMS

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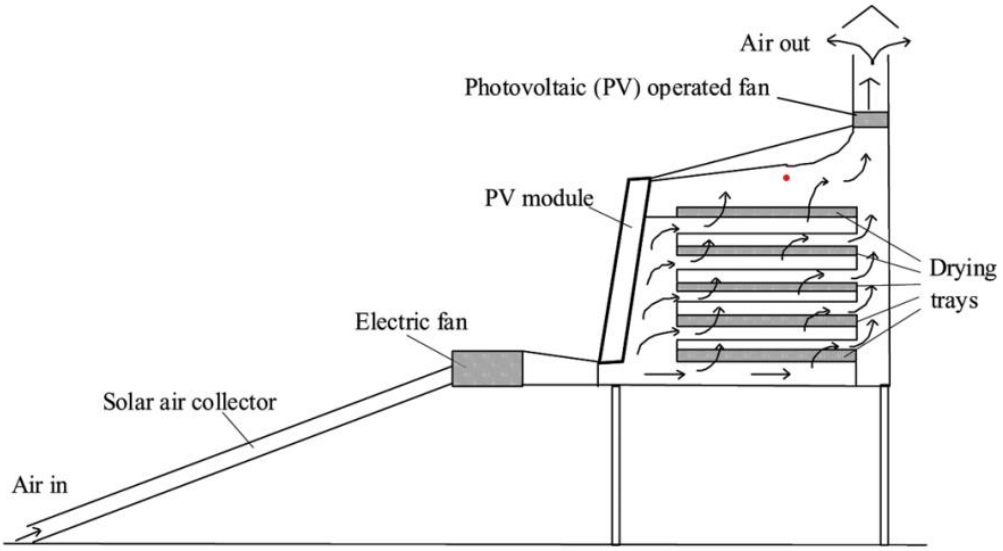
Solar drying system are a cost-effective drying method commonly used to dry products such as grains, vegetables and fruits. At present, there are many traditional drying methods, but it is time-consuming and laborious, and only solar drying can provide both economic and environmental benefits (Farkas, 2013).

Solar drying is a complex process. The drying process consists of two stages: the first stage involves applying heat to the surface of the item being dried at a constant rate, and the second stage involves reducing the drying rate. The solar drying system is to convert solar energy into heat energy through the collector, and the air heated by heat energy enters the drying room, takes away the moisture of the product, and flows out of the chimney to achieve the purpose of drying.

The solar drying system is basically composed of a solar collector, a drying chamber and a chimney. The purpose of this study is to study the effects of air collectors, drying chambers and chimneys on the drying process in order to find the ways to improve the overall efficiency of the drying system.



The scheme of the modular solar system (Seres and Farkas, 2007)

Solar thermal collectors are the core subsystems in solar thermal applications. Solar collectors are mainly divided into two categories: non-centralized collectors and concentrated collectors. Non-concentrating collectors have the same cross-sectional area as their absorbing area, while solar collectors typically have concave reflective surfaces that receive more heat flux with a smaller area (Tian and Zhao, 2013).

The drying chamber is used to store dry items in the drying system. Its material, volume and performance will affect the drying efficiency of the items. To guarantee a uniform drying of the product, the drying chamber must be constructed with efficient air distribution. Any heat

exchanger design should aim to simultaneously achieve a primary air side pressure drop and increase the moisture mass transfer rate.

The chimney working principle is that the air with high indoor temperature has a small specific gravity and rises, and is discharged from the upper outlet, and the air with low external temperature enters from the bottom inlet, and the air in the system flows faster, which can improve the drying efficiency of the system.

Drying is a time-consuming and energy-intensive process, so finding an efficient drying system is critical. The purpose of this study is to analyse the impact of functional components on solar drying systems and to find ways to maximize drying efficiency.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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INTERNATIONALIZATION OF ITENAS BANDUNG THROUGH INCREASING SCHOLARLY COLLABORATION

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One of program of Institut Teknologi Nasional Bandung (ITENAS Bandung) in period 2020-2025 is internationalization of ITENAS Bandung. Since 2 years ago ITENAS Bandung involved actively in some higer education programs which organized by the world's leading global higher education such as Quacquerelli Simonds (QS) and Times Higher Education (THE). Mostly evaluation results published by two institutions above is represented in the form rank, i.e., university of ranking (world, region and country).

As a private university in Indonesia, participation of ITENAS Bandung in such QS Ranking or THE Ranking actually is emphasized on how to improve the acceleration of the ITENAS Bandung to be good university in the transfer knowledge. In other words, the university ranking is not main goal, but the ranking can be used as tool to improve the academic atmosphere of our university, and it is surely that later will increase the university reputation, and the rank university will guide and attract students/academics/governments/industry, besides raises visibility of our university. The evaluation indicators in the QS and THE is shown in Table 1.

Table 1. Various indicators in QS and THE evaluation

Times Higher Education (THE) indicators	Quacquarelli Simonds (QS) indicators
Teaching (The learning environment)	Academic reputation
Research (Volume, income, reputation)	Employer reputation
Citations (Research influence)	Faculty student ratio
International outlook (Staff, students and research)	Papers per faculty
Industry income (Knowledge transfer)	Citations per paper (per faculty)
	International Faculty (ratio)
	International students (ratio)
	Faculty staff with PhD
	International Research Network
	Inbound exchange
	Outbound exchange
	Employment outcome

Based on above Table, it is found that partnership is key point to fulfil most all indicators, therefore one of the strategies to strengthening the partnership is increasing scholarly collaboration with university partner, which can be developed through various joint activities.

A great partnership ITENAS Bandung and MATE Godollo (Hungarian University of Agriculture and Life Sciences), as successor of Szent Istvan University, can be viewed as bridging for the ITENAS Bandung to interact with wider institution in European countries network, especially the countries with closely relation with MATE Godollo, Hungary.

The involvement of the ITENAS Bandung in various scientific activities with the countries in Visegrad four (Hungary, Poland, Slovakia and Czech republic) has made ITENAS Bandung proposing an idea to establish the partnership consortium with the name Visegrad four+ (Visegrad four plus) consortium, with the members are Hungarian University of Life Sciences (MATE), Institute of Agrophysics – Polish Academic of Sciences (IA – PAS), Slovak University of Agricultural in Nitra (SUA), Czech University of Life Sciences Prague (CZU) and ITENAS Bandung. The concept Visegrad Four+ countries can be seen in Fig. 1. (Rusirawan et al., 2021; Rusirawan et al., 2022).

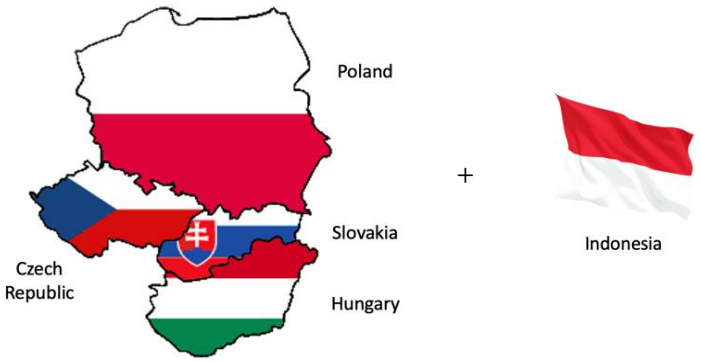

Fig. 1. Involvement countries in consortium of Visegrád Four+

Actually, the new policy in Indonesia about "freedom to learn (independent learning) – independent campus" is a challenge for ITENAS Bandung, and with establish of the Visegrad Four+ consortium, it is hope will enhance various scholarly collaboration and mobility, included joint activities, such as joint proposal, joint research, joint publication, joint conference, joint workshop, joint supervision, joint education program (joint/double degree), commitment to recognize adjunt professor each other, etc.

With this international collaboration, it is to be sure that academic atmosphere all institutions will increase, and strongly give contribution not for the national education level, but also for the global education.

Acknowledgements

This work was supported by the 4 (four) institutions in the Visegrád Four countries, as collaboration partnership to establish the Visegrád Four+ Consortium, with ITENAS Bandung, Indonesia.

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ENVIRONMENTAL MEASUREMENTS BY A CANSAT STUDENT "SATELLITE"

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The Cansat project is a secondary school project of the European Space Agency (ESA), in the framework of the program a small satellite has to be developed and built by secondary school teams. The developed Cansats are launched by a rocket into the atmosphere, to the height of about 1000 meters. The Cansats after deployed from the rocket. have to do measurements of the atmosphere during the landing with a parachute. Beside compulsory measuring tasks as the units as the pressure and the temperature of the atmosphere, secondary missions have to be developed as well [ESA, 2022].

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.

From this year a special Hungarian National Cansat Competition is organized by the Hungarian Astronautical Society (MANT), where about 40 teams were participant teams were indicated their willingness to build an own "satellite", among them three teams from Gödöllő (Cansatverseny.hu)

How are these satellites connected to the Energy and Environmental topic? The answer is the secondary mission. The teams from Gödöllő aims to measure different atmospheric parameters, and the "electro-smog".

This year one of the teams aims to measure the vertical distribution of the air pollution. The members believe that environmental pollution, including air quality, is a factor affecting the lives of many people. This is likely to be particularly important during the current energy crisis, when previously unused solid fuels, which have a serious air polluting effect, can greatly increase the concentration of airborne dust. However, since jet dust contains particles heavier than air, it is assumed that their density decreases as they go up in the atmosphere.

They would also like to verify this assumption with measurements in connection with their Cansat project, for which they would measure the total PM2,5 and PM10 concentration during the satellite descent as a function of height. In addition to the airborne dust concentration, they also aims to measure other components that regulate air quality, for example the vertical change in the ozone level, and other possible toxic gases.

From the last year some measurement results for the vertical change of the radioactive background radiation was carried out, which is planned to present, as well.

Another team's mission is to get an impression on the spreading of the artificial EM radiation toward space. Although their Cansat does not fly very high altitudes, they would like to know how the often used electromagnetic (EM) radiations spread toward space. Of course, the problem is frequency dependent, and some EM frequency ranges can travel very big distances, but other ranges have limited distance to travel.

They plan to measure the vertical change in the signal level of some often-used EM radiation, such as GSM, WIFI (each band) and the effect of the signal strength change for the information transfer speed.

For getting the proper results they plan to install to the launch site some transmitter devices (e.g. WIFI routers with 2,4 and 5 Ghz), broadcasting a sine wave with constant power, and the received signal strength is planned to measure as the function of the distance.

In the presentation the sensors planned to use, and some measurement results will be presented, as well.

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SPATIAL AND TEMPORAL COMPLEMENTARITY OF PV AND WIND POWER

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The need for cleaner energy production draws the attention of research community for its environmental and socio-economic advantages. As a result, the utilization of solar PV and wind power generation units have been significantly increased in the past few decades. However, solar and wind conversion technologies cannot produce power when needed instead they produce power when solar and wind resources are available. This intermittent behavior is therefore the main reason for hindering high-penetration of renewable technologies in to the existing grid. Researchers are looking for different approaches for solving the diverse challenges emerged from the intermittent nature of renewables. One of the most promising approach to overcome this challenge is resource complementarity between solar PV and wind power. Complementarity can significantly increase renewable penetration by solving several operational challenges (Solomon et al., 2020). This is done by locating sites which have anti-correlated behavior on spatial or temporal scales (Parra et al., 2020). Resources complementarity is proven to increase grid matching capability by smoothen the variability that leads to increase ramping requirement and transmission congestion. Complementarity analysis is thoroughly studied in Europe and US (Becker et al., 2014) however, there is a gab in African countries. The objective of this paper is therefore to conduct a comprehensive spatial and temporal complementarity analysis between solar PV and wind power in Eritrea, Africa.

Eritrea is located in north east Africa around 15^{o}N latitude with moderate and semi-arid climate. The country is divided in to three major topographical regions-central highlands, western lowlands and eastern lowlands (coastal region).

In this work the spatial and temporal complementarity of solar and wind resources is studied with the aim to include all the topographical regions of the country. All the regions have good solar potential however wind potential differs significantly depending on the geographical location. One-year hourly weather data was obtained from a free web-based high resolution PVGIS data base. PVGIS and Global Wind Atlas are publicly available and reliable data bases. The web-based PVGIS interface provides solar radiation, PV power, ambient temperature and wind speed for most part of the globe with high quality data. Similarly Global Wind Atlas is well known data base for identifying the potential wind sites worldwide. The total PV power generation for crystalline silicon with system loses of about 14% is calculated from the PVGIS interface. However, the magnitude of the wind speed obtained from PVGIS is to some extent under-estimated for that reason the wind speed is scaled by the more reliable hourly average wind speed from Global Wind Atlas and extrapolated to hub height using log law equation. The hourly power output of all sites is calculated using power curve from Vestas (V150-4.00 MW) by correcting the power curve to local air density. The aggregate values of solar and wind power are then calculated for determining aggregate correlation coefficients.

Based on the analysis solar sites are strongly correlated in hourly time scale but the correlation significantly decreased when the time scale is changed to daily. In contrary wind is highly volatile and significant variability is observed between wind sites dispersed over a large area. For all wind sites there obtained a weak positive correlation for the hourly time scale regardless of their proximity. But the relation slightly changed when the time scaled is changed

to daily time scale. Anti-correlation and complementarity behavior was observed between northern coastal region sites and highland sites. Similarly, the northern and southern coastal sites have weak anti-correlation behavior at a distance of about 450 km. On the other hand, the temporal (single sites) complementarity analysis showed that the highland and southern coastal sites luck complementarity, but the northern coastal region sites showed to complement each other at daily time scale.

The combined complementarity behavior is evaluated for the aggregate values of solar PV and wind power sites. The analysis showed that PV and wind power is negatively correlated which smooths the energy generation curves. Similarly, anti- correlation between wind and load is observed which is undesirable outcome. In dispatchable energy generation technologies it is desirable if the generation behaves in similar manner to the load. The PV generation have showed weak positive correlation to the load profile which is an expected outcome.

Finally, we developed a model to forecast the load behavior of Eritrea. Different mixing ratios of solar PV and wind power is then computed to find the optimum variability of netload. The optimum mix that lowers the variability of the netload was found to be at 0.62 PV ratio and 0.38 wind power ratio. In this work we can conclude that PV and wind power are to some extent complement each other in selected sites of Eritrea. The most interesting finding is that the high potential wind power sites are not suitable for complementing solar power.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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LIGHT POLARIZATION AT DIFFERENT TYPES OF SOLAR CELLS

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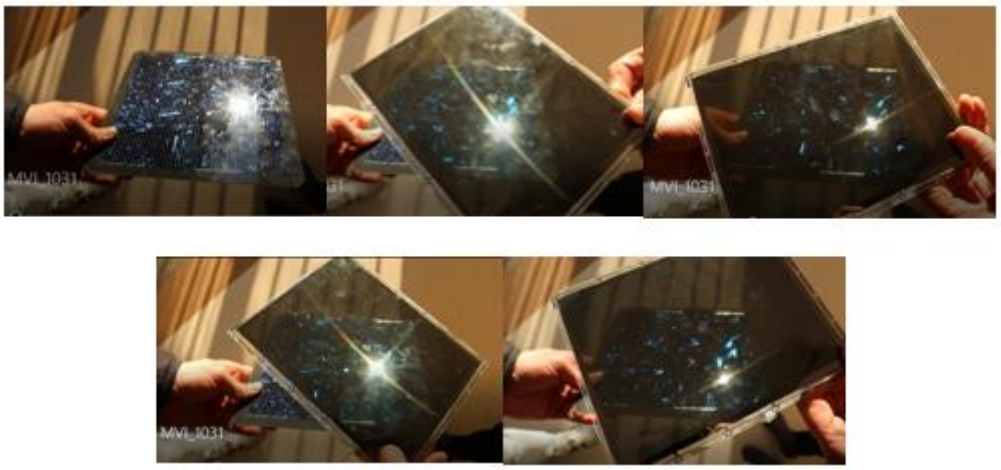
In addition to traditional forms of environmental pollution (harmful substances in air, water, soil; noise pollution) an increasingly important form of environmental pollution nowadays is the light pollution caused by artificial light sources.

This includes light from artificial sources and reflected ones from various surfaces, which is often polarized. Although the human eye cannot sensitive the polarization of light, the examination of polarization provides useful information about our world.

Polarized light is especially important for aquatic insects because they use it for their orientation. In a natural environment, only the light reflected from the surface of the water is polarized, but with the development of technology, there are more and more artificial surfaces that reflect light (e.g. asphalt surfaces, black plastic films used in agriculture, glass walls, dark car bodies, etc.) and in the latest time the solar modulls, as well. Such surfaces can result in light polarization, thus representing an ecological trap for polarization-oriented insects.

The purpose of this study is to investigate whether the light reflected from the solar cell is polarized and how it is polarized. In the case of polarized light, there is a difference in the intensity of the light coming through the polarizing filter when the filter is rotated. The image below shows that the light reflected from the solar cell is definitely polarized to some extent.



The difference in intensity can be easily measured with a light intensity meter (lux meter) and with this the degree of polarization can be quantified. The solar cell used during the test is a 20x20 cm amorphous silicon solar cell with a maximum 4 W power. The measurements were carried out in a laboratory under artificial lighting, the light source was a traditional 40 W bulb.

The intensity of the reflected light of rays arriving at the solar cell at different angles of incidence was examined in different directions.

Goniometer was used for measured the angles and distances. The accuracy of the angle measurement was 1 degree and the distance cased accuracy was 1 mm.

During the measurement, after adjusting the light source and the sensor of the lux meter, the light intensity was measured without a polarfilter, and then with the polarfilter placed in front

of the sensor in 3 different rotation positions (0°, 45° and 90°).The measurements were carried out with the lamp set at different angles (20°, 30°, 45°, 60°, 90°) compared to the solar cell. In addition to the reflected direct radiation, the intensity of the scattered radiation was also examined.

The obtained results are going to detail in the presentation. The results can be further refined with a series of measurements for additional angles of incidence, on the basis of that a map can be made of how polarized the light reflected by a solar cell is in its environment. By performing the measurements with additional solar cells, the dependence of the polarization on the type of solar cell can also be investigated.

If the solar modules serve as an ecological trap, it may result the depletion in insect population and also reducing the efficiency of the modules, due to the presence of contamination. For that reason, the study of polarization at solar modules is rather important and useful from both pints of view.

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CHARACTERIZATION OF THE RADIATION FIELD IN THE VICINITY OF PV PLANTS

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PV modules not only use the incident radiation for the production of electric power but they also change the radiation field of the surroundings. Bifacial PV modules also use the reflected radiation of the sun to produce electricity. The installation of PV modules over agricultural land has also gained importance. PV panels partly shade the ground below the panels and may directly impact plant growth below and around the panels. The incoming solar radiation which includes a direct and a diffuse component is partly reflected or absorbed by the PV modules. The PV modules cast a shadow on the ground. The diffuse or direct radiation incident at the ground is reflected as a function of the albedo of the ground. The reflected radiation may then hit the bottom of the PV modules. The radiative fluxes will depend on various factors such as the geometry of the PV modules (size, height, orientation, inclination, distance between the panels), the sun azimuth and zenith, the atmospheric conditions (cloudiness, turbidity), the elevation of the horizon and the ground albedo. The exact 3-D environment needs to be taken into account in order to determine the 3-D radiation field.

The present study shows results of experimental and model based investigations which characterize and quantify the radiation field around and below PV modules. The relevance of the individual radiation components is discussed. The impact of the 3-D radiation field and the ground reflectance on yield of bifacial PV is adressed.

Experimental investigations:

Measurements were performed at one experimental site in Keszthely. At this site situated in a private garden 3 rows of PV modules (cristalline, multicristalline and bi-facial) are installed. Some additional measurements of the radiation balance with 2 Apogee 4 component radiometers were performed. One apogee radiometer was mounted just beside the bifacial PV module, with the same inclination of 30 degree. The second radiometer was mounted below the edge of the bifacial PV module. In addition fish eye camera photographs of the upper hemisphere and looking downward were performed (Fig. 1 and 2).

A Python programm was developed in order to simulate the influence of the 3-D environment on the radiation field. The program allows to calculate the impact on ground incident radiation as a function of the geometry of the PV modules. It works in such a way that fish eye photographs are manipulated to include fictive assumed PV modules in the fish eye photographs (Fig. 3). This fish eye photograph is then used by a special software to calculate the daily radiation fluctuations at the ground.

Discussion of results and conclusion:

Fig. 4 shows one exemplary day of the measurements performed at the experimental garden in Keszthely. It shows that the albedo of lawn is with a value of 0.13 rather low. The measured albedo values correlate very well with the PV yield data, which showed that the downward looking side of bifacial PV module contributed only to 10% of the total yield.

Fig. 1. Downward looking fish eye photograph taken from the bifacial PV module

Fig. 2. Upward looking fish eye photograph from the bifacial PV modules

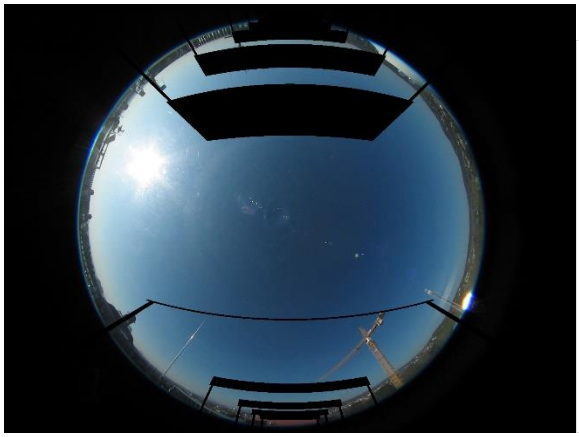

Fig. 3. Manipulation of a fish eye Photograph by including PV modules (black objects)

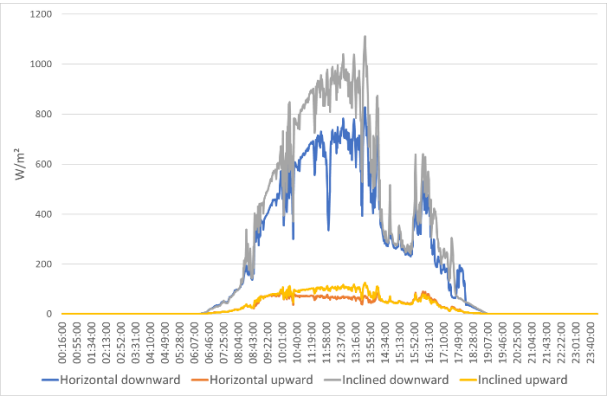

Fig. 4. Result of measurements of radiation balance on the horizontal and of the inclined plane of the bifacial module resulting ratio of upward to downward radiation are for both around 0.13

Another type of ground cover such as white gravel (with an albedo around 0.4) would strongly increase the PV yield. We could expect with a ground covered with white gravel, that the downward looking face of the bifacial PV would roughly contribute to 40% of the PV yield and increase the total yield. One factor which strongly influences the ground reflected radiation is the elevation of the horizon which may reduce the incident radiation at the ground and in turn the total reflected radiation. For more accurate planning, a software (Fig. 3) was designed which allows to accurately determine the incident radiation as a function of PV module geometry and elevation of the horizon.

Acknowledgements
This work was supported by Stiftung Aktion Österreich-Ungarn, project No 110öu1.

THE POTENTIAL BENEFITS OF USING BIFACIAL PHOTOVOLTAIC TECHNOLOGY IN THE NEIGHBOURING NATIONS OF AUSTRIA AND HUNGARY

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Nowadays the world is witnessing the dynamic proliferation of photovoltaic (PV) systems, with a total capacity of 760 GW in 2020 (Renewable Energy Policy Network for the 21st Century (REN21), 2022). This figure was 1.3 GW in Austria and 1.4 GW in Hungary (European Network of Transmission System Operators for Electricity (ENTSO-E), 2022). Based on some projections, by 2025 it is expected that the nominal power of PV systems in the world will exceed 2 000 GW (SolarPower Europe., 2022). In order to increase the annual yield of PV systems, in addition to the appropriate tilt angle and orientation, the role of solar tracking or new technologies (e.g., bifacial solar modules) is also coming to the fore.

Unlike in conventional PV technologies where only one side of the modules, the one facing the sky, generates electrical energy, bifacial PV modules feature two sides that are able to do that simultaneously (Bouchakour et al., 2021; Katsaounis et al., 2019). The transparent glass on both the upper and lower sides of the module make the production of electric power possible by also utilizing light reflected from the environment, including the surface below the supporting structures. Under optimal circumstances, which also depend greatly on the albedo, i.e. the reflective ability of the surface (Guerrero-Perez et al., 2019), of the ground/base and the height of the installation, an extra 30% can be achieved in terms of PV module performance by using this new technology, compared to modules with only one side generating electricity (Beardsworth and Shishavan, 2020; LG Electronics Inc., 2017; Park et al., 2019).

As of today, neither Hungary nor Austria has extensive practical experience and scientific observations on the advantages associated with this new technology. Similarly, the amount of research devoted to the potentials of increasing the amount of generated PV energy on a given site by deploying ground-mounted bifacial technology is less than sufficient. Therefore, this research aims to contribute to the understanding and knowledge of the above-mentioned aspects in the context of these two countries.

Acknowledgements

We acknowledge the financial support of 2021-2.1.1-EK-2021-00001 project. This research was supported by the Austrian Hungarian Action Foundation, AÖU Project 110öu1.

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