OV2040REP

Oman Vision 2040: Renewable Energy Program

NEWSLETTER

Volume 1, Issue 1, September 2020

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Articles

1. Project initiation

1.1. To consider the scope of the problem

Renewable energy utilization in Oman is a topic with growing interest by the Omani government and the private sector. The existing renewable energy resources, which can be used as an energy alternative and eco-friendly energy systems, needs further research, development, planning and awareness. This initiative presents a step in the direction toward renewable energy vision of Oman 2040 along with a detailed discussion with regards to sustainable energy, energy sources, technologies, building capacity, and strategic planning, all with relation to the vision.

1.2. Goal

This goal is to be in line with the aims of the Oman vision 2040, aim to reduce the dependency on non-renewables and effectively develop resources such as renewable energy to lower production cost and enhance competitive element in economic sectors. Also, develop the infrastructures and building the human capacity of Omanis to meet the vision 2040.

1.3. Objectives

- Conduct scientific research to investigate renewable and sustainable energy sources parameters, options, and improve its applications in Oman.
- Establish a massive collection of research committed to improving sustainable power sources incorporation in Oman power and energy systems for private and public sectors.
- Assist, through research, governmental and private associations to arrive at the top of the line innovative improvements in the field of renewable and sustainable energy sources and technologies.
- Initiate scientific and technical discussion between researchers and experts in the renewable energy field with younger Omani researchers.
- Increase Oman community awareness toward renewable energy.

1.4. Phases of the work

TBA

1.5. Conceptual framework

TBA

1.6. Community awareness campaign

- Increase the awareness of the public about renewable energy vision 2040 for Oman.
- Increase the awareness of the public about different types of renewable energy and how to be part of the new vision.
- Contribute to the development of local people by providing the needed energy which will help them socially, economically, culturally and educationally.

Evaluation of the electrical performance of a photovoltaic thermal system using nano-enhanced paraffin and nanofluids

- Raises the standard of living of the people living in rural areas, by providing them with energy solutions to get clean water, preserve their foods and enjoy a healthier life.
- Contribute to the current energy policy in Oman.
- Develop a team of researchers who are aware of the needs of the Omani energy and environment.

1.7 Family of Omani younger researchers

This family or group focus on the Omani younger researchers interested in renewable energy from different levels (i.e. undergraduate, fresh graduate and postgraduate). The group will work together as a family to collect and analyze related data, training and increase awareness, discuss and collaborate toward the vision 2040. This group will prepare the new generation to participate positively when Oman is approaching 2040 based on education, knowledge, experience, and new ideas.
Note: to be part of this family, click “Follow” to this project in RG.

Energy, exergy and efficiency of four photovoltaic thermal collectors with different energy storage material

2. Communications
2.1. Founders meeting
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3. Annual Report
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A novel model and experimental validation of dust impact on grid-connected photovoltaic system performance in Northern Oman

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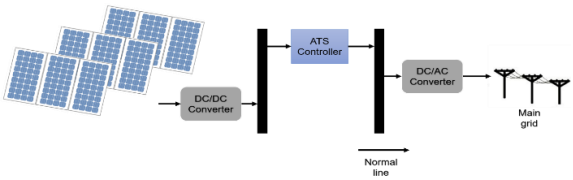
Highlight:

- A new model of dust impact on grid-connected PV was proposed.



(a)

(b)

Figure 1. Installed grid-connected PV system. (a)schematic diagram, (b) capture of the PV system.

- The dust characterization and effects in Sohar, Oman was investigated.
- Experimental validation of the proposed model with the techno-economical evaluation presented.

Brief:

The dust impact on solar photovoltaic technology was investigated in the last sixty years as an essential problem facing solar energy technology. On our best knowledge, there is no general model to simulate dust impact. This study proposed a model based on dust ingredients, which has been taking into consideration the dust impact on photovoltaic performance in a novel way. The outcomes demonstrate that the proposed model precisely anticipated the system performance and validated through experimental results. The new model is general for any dust type, anywhere on our planet or other planets in the universe as example dust in Mars. The information in this project is worthwhile for researchers, designers, and investors interested in PV systems in dusty and desertic weather condition locations.

Theory:

From literature, it is found that most researchers were interested in the results of grid-connected photovoltaic (GCPV) systems in practice or theoretically based on weather data and rarely introduced regression behavior in their models. The main objective of this study is to characterize, investigate and evaluate the techno-economic performance of the GCPV system in Oman. In general, from a comprehensive literature review, most researchers, when evaluating the performance of GCPV systems avoided studying the impact of dust on performance for several reasons, including that some studies in areas with little or no dust, others preferred to use clean cells all the time to neutralize the impact of dust accumulation and pollutants, and so on. In this study, the impact of dust on the PV performance was taken into consideration in a new way. PV module and inverter models are built and divided into empirical, regression models and an improvement model that includes dust impact. The study was concentrated on the proposed model and validation as well as on system performance and techno-economic evaluation. The information in this study is worthwhile for researchers, designers, and investors interested in grid-connected PV systems in dusty and desertic weather condition locations.

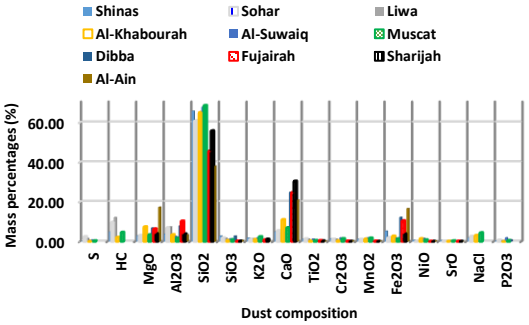


Figure 2. Sample of dust composition in Oman and UAE.

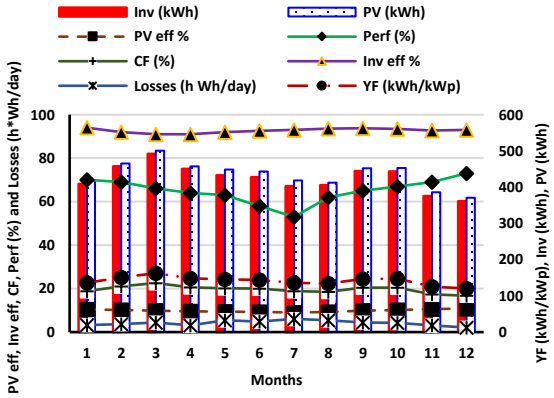


Figure 3. GCPV system performance for the entire year.

Achievements:

A proposed mathematical model was derived using the entire year secondly measured data in Oman weather for the characterization and performance evaluation of a grid-connected PV system. Dust impact has been taken into consideration in the proposed model in a new way. I-V, P-I and P-V characteristics was compared with the experimental results for validation. The proposed model shows high accuracy and low error compared with the ideal model and experimental results. The proposed model errors are MSE, MAE, and RMSE found they are 0.0313, 1.711, and 0.078, respectively, and the accuracy R^2 is 0.896. Furthermore, statistical analysis shows that the results of the proposed model are closely related to the experimental results. The GCPV system performance found is 64.92%, while the maximum PV and inverter efficiencies found to be 10.80% and 94.00%, respectively. Also, the average yield and capacity factors are 141.39 kWh/kWp and 19.64%, respectively. It concluded that GCPV system productivity is worth and within the prospected rate. The information in this study is useful for engineers, researchers, and investors interested in the GCPV system in Oman and nearby country.

Evaluation of PV output in terms of environmental impact based on mathematical and artificial neural network models

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Highlights:

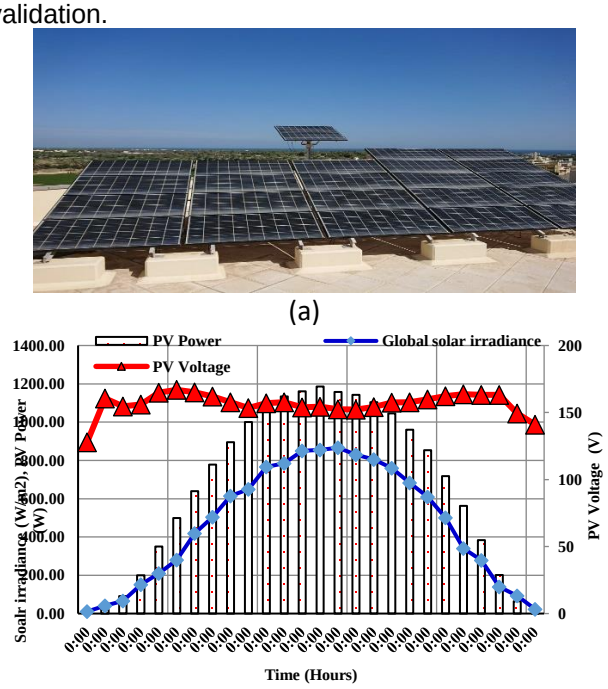
- A mathematical and ANN model for grid-connected PV presented in term of environment parameters.
- A five years experimental data used for validation.
- The predicting models verified simple and accurate results.
- The accuracy of the proposed ANN model compared with literature accordingly.

Brief:

This work presents the modelling of solar photovoltaic systems performance in Oman in term of environmental parameters. The mathematical and artificial neural network models used based on five-year measurements. The results have been compared with published results in the literature.

Theory:

Based on literature, much attention has been given for modeling grid connected (GCPV) systems using artificial neural network (ANN). In this project a novel proposed cascade-forward back propagation neural networks (CFNN) model is presented. The proposed model for the output of a GCPV system was in term of two environmental parameters (ambient temperature and solar irradiation). The novelty of the proposed system model presented in the consideration of uncertainty of the predicted model due to the details and long-term real measurement, which reflected positively on the model accuracy. This research is part of GCPV system investigation conducted to evaluate and correlate the electrical performance (current, voltage and power) and environment parameters in Oman. A 1.4 kW PV system installed in Sohar, Oman has been used, and data were recorded for five years (1 May 2014 to 30 April 2019) has been used. The system records the data every 1 second so that there is a considerable amount of data collected, which reduces the uncertainty compared with hourly data discussed in the literature. Finally, the proposed prediction models have been compared with the measured values and different researchers' models for validation.



(a)

(b)

Figure 1. Installed GCPV system. (a) capture of the GCPV system, (b) GCPV power, voltage & solar irradiation in Sohar.

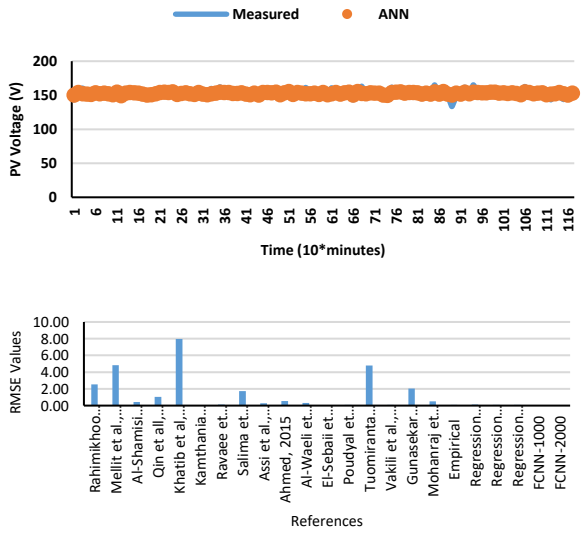


Figure 2. (a) GCPV voltage, (b) comparison of proposed models with different researcher models in literature in term of RMSE

Evaluation of the electrical performance of a photovoltaic thermal system using nano-enhanced paraffin and nanofluids

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Highlights:

- Cooling of the PV panel using nanofluids and nano-PCM led to a rise in electrical efficiency.
- Higher power is achieved by the studied system (nano-PCM PV/T cooling by nanofluid) due to its cooling mechanism.
- The performance of the PV panel is enhanced immensely under operating conditions, and it has better electrical behavior than conventional PV panels.

Brief:

Performance degradation of photovoltaic panels occurs when cell temperature increases; this is due to losses within the cell and the effect of surrounding weather as well. An increase in cell temperature leads to a decrease in the open-circuit voltage and hence, the electrical power produced by the panel. Different cooling techniques were presented in the literature to protect the output of the panel and ensure a cost-effective outcome. PV/T collectors were found to be the most efficient methods. Therefore, a nanofluid and nano-PCM (paraffin wax) based PV/T hybrid collector were employed. In this project, experimental and numerical investigation focus on the electrical performance and characteristics of the PV panel are conducted. The cooling technique used is attaching the panel to a nano-PCM tank and running nanofluids within.

Theory:

Photovoltaic thermal (PV/T) systems combine the production of electric power and thermal energy into a single system. The main objective of creating this technology is due to the rise in the temperature of the solar cell causes productivity and effectiveness diminish reduction.

In the presence of the solar collector, PV cells will benefit from the heat accumulated in its body in other applications such as heating the rooms for comfort or water heating. As a final result, the photovoltaic cell will operate in conditions close to standard conditions and yield high productivity with the benefit of heat transferred by the cooling fluids (air, water, nanofluid, etc.) in various other applications.
In this study, the PV/T system as a whole is raised, but more focus will be granted in favor of the electrical side of the PV/T. The proposed system cools the solar cell using a nanofluid and a phase-changing material (PCM) mixed with nanoparticles to improve its thermal conductivity. Two climatic variables, irradiation and ambient temperature impact on the PV/T outcomes, was studied in detail.

Achievements:

The results from the experimental tests show a maximum PV efficiency of 13.7% under operation for PV/T collector as appose to conventional PV panel, which achieved an efficiency of 7.1%, which is suitable relative to the efficiency of 14% under standard testing conditions.

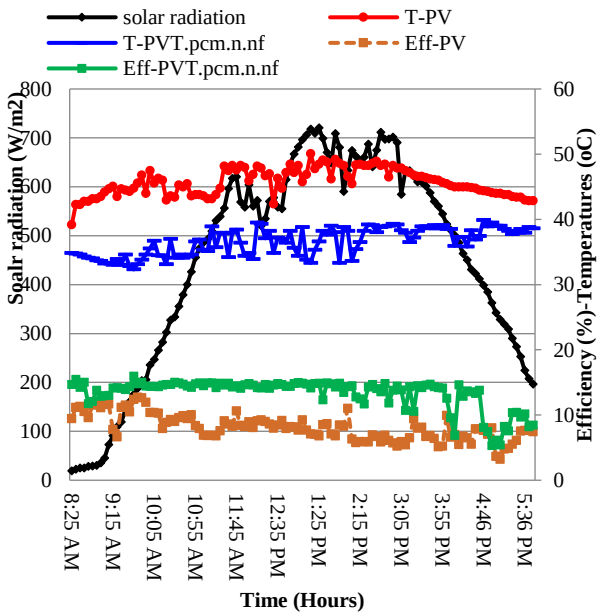

Figure 1.

Energy, exergy and efficiency of four photovoltaic thermal collectors with different energy storage material

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Highlights:

- Four configurations of photovoltaic thermal collectors were investigated.
- Energy and Exergy performance were analysed and compared.
- Highest performance is observed for nanofluid-based PV/T with nano-PCM.
- Thermal and electrical exergies were compared for the proposed designs.

Brief:

Hybrid photovoltaic thermal (PV/T) is a technology with many variations and designs. The aim of this unit is cooling down PV temperature while producing hot water. In this study, different PV/T designs are compared in terms of energy, exergy and efficiency. Data from experiments and numerical calculations conducted at Bangi, Malaysia was used for the comparisons. The proposed systems were tested in outdoor conditions. The designs in question are water-based PV/T, water-based PV/T with PCM tank, nanofluid-based PV/T with nano-PCM tank and conventional PV module. Effect of mass flow rate and solar irradiance are emphasized in this study.

Theory:

In this project, an evaluation of the performance of four configurations of PV/T system is presented for comparison in performance under the tropical climate of Malaysia. The proposed system is a nano-PCM and nanofluid based PV/T with nanofluids flowing within it. The purpose of such design is to store thermal energy in the nano-PCM tank and extract it through heat transfer using nanofluids; due to their high thermal conductivity. The contribution of this study is the investigation made comparing different innovative PV/T systems and a conventional PV form energy and exergy viewpoints. Exergy is highlighted in this study as it serves as a tool to demonstrate the thermodynamics of each collector. Unlike energy, exergy can be consumed or destroyed due to the irreversibility that occur in the processes, with exception to ideal and reversible processes) and hence it is very important to analyse the exergetic performance of these collectors to assess and highlight the differences between these systems. In most research, conducted in the area of PV/T, the focus has been towards the energy efficiency, while the exergy analysis is not carried out, usually. This study is part of a research project conducted to investigate the performance of nanofluid and nano-PCM based PV/T collectors. The other configurations are used to display the utility, or lack thereof, of PCM and nanofluid joint combination in a system and to highlight the differences between proposed design with typical PV/T systems, which are used in the literature. The fourth considered design is a typical PV module used as a reference.

Achievements:

The results of the experiments show the impact of changing the mass flowrate on the average electrical efficiency of the PV/T. The increase of the mass flowrate of the nanofluid from 0.0833 kg/s to 0.175 kg/s led to an increase in the efficiency from 11.5% to 12.2%, respectively. This increase was attributed to the impact of mass flowrate on the heat transfer and hence leading to better cooling and higher reduction in the cell temperature of the photovoltaic.

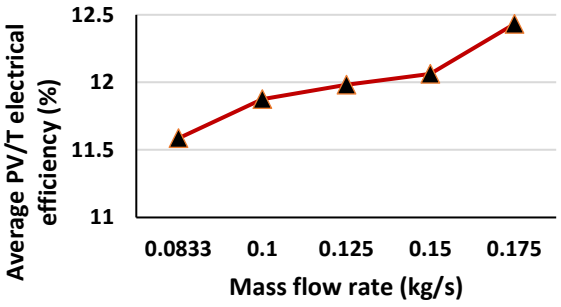

Figure 2.

Moreover, the comparison between the tested system designs in terms of energy and exergy shows that the PV/T system with nanofluid and nano-PCM outperforms the remaining systems in Malaysian climate conditions. The peak total efficiency of this design is 85.7%, compared to 63% and 47% for the PV/T with PCM and water and the water-based PV/T, respectively.

News and updates:

- Congratulation to Professor Miqdam A Chaichan for the new position as Director of Energy and Renewable Energies Technology Center (ERETC) (https://eretc.uotechnology.edu.iq/index.php/).
- Congratulation to Dr Ali H A Al-Waeli for the new position as a lecturer in the National University of Malaysia (https://www.ukm.my/portal/).

References:

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All **OV2040REP** members are kindly invited to submit articles for publication in future **OV2040REP** newsletters. Articles can be on a range of topics surrounding the word of renewable energy technologies. With more than 30 members, the **OV2040REP** newsletter provides a great opportunity to publicise new ideas, technologies or products – all free of charge!

Articles should be no more than 400-500 words and one or two photographs would be very much appreciated. Submissions should be emailed to ali9alwaeli@gmail.com (**OV2040REP** coordinator). Furthermore, please contact **OV2040REP** coordinator regarding any conferences, seminars or symposiums relating to topics of renewable energy technologies that you wish to be advertised in the newsletter.

Once again, thank you for your continued support to **OV2040REP**.