ENHANCING PHOTOVOLTAIC POWER PREDICTION FOR SUSTAINABLE ENERGY FUTURES

Authors:
Cempaka Amalin Mahadzir[1]
Ahmad Fateh Mohamad Nor[2]
Siti Amely Jumaat[3]

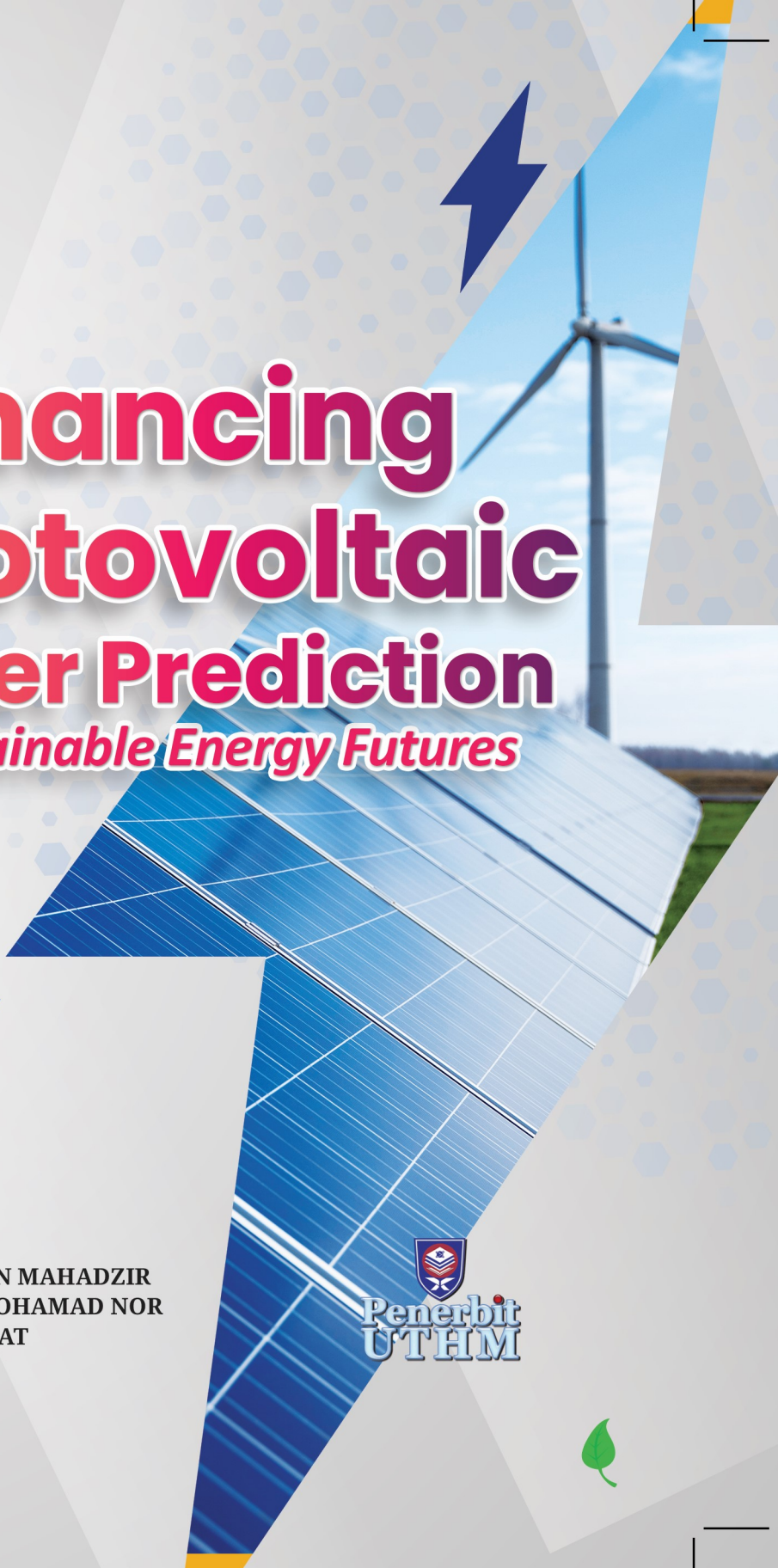
Email:
afateh@uthm.edu.my[2]
amely@uthm.edu.my[3]

Abstract: In an era where transitioning to sustainable energy sources is becoming increasingly important, Enhancing Photovoltaic Power Prediction for Sustainable Energy Futures explores the vital developments required to maximize solar power output. This book meticulously analyzes the methodologies and stateof-the-art technology that improve solar power prediction accuracy and dependability. It comprises the difficulties in incorporating solar energy into conventional power systems and emphasizes the significance of predictive analytics in attaining energy sustainability by crossing the gap between theoretical models and real-world implementations. With an eye on the future, this research effort is an indispensable resource for scholars, professionals, and decision-makers who are dedicated to advocating renewable energy sources and creating a more environmentally friendly future for future generations.

Keywords: Ambient, Climate, Development, Software

Enhancing Photovoltaic Power Prediction

for Sustainable Energy Futures



CEMPAKA AMALIN MAHADZIR
AHMAD FATEH MOHAMAD NOR
SITI AMELY JUMAAT

Penerbit UTHM

Enhancing Photovoltaic Power Prediction

for Sustainable Energy Futures

Enhancing Photovoltaic Power Prediction

for Sustainable Energy Futures

CEMPAKA AMALIN MAHADZIR
AHMAD FATEH MOHAMAD NOR
SITI AMELY JUMAAT

Penerbit UTHM
2024

First Published 2024

Author:
Cempaka Amalin Mahadzir
Ahmad Fateh Mohamad Nor
Siti Amely Jumaat

Published by:
Penerbit UTHM
Universiti Tun Hussein Onn Malaysia
86400 Parit Raja,
Batu Pahat, Johor
Tel: 07-453 8698/8529

Printed by:
Percetakan Ilham Selatan,
No.10,Jalan Perdagangan 16,
Taman Universiti,
81300 Skudai, Johor.
Tel : 017-7779313

Website: http://penerbit.uthm.edu.my
E-mail: pemasaran.uthm.edu.my
http://e-bookstore.uthm.edu.my

Penerbit UTHM is a member of
Majlis Penerbitan Ilmiah Malaysia
(MAPIM)

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

ISBN 978-629-490-105-6

Contents

Preface

In an era where transitioning to sustainable energy sources is becoming increasingly important, *Enhancing Photovoltaic Power Prediction for Sustainable Energy Futures* explores the vital developments required to maximize solar power output. This book meticulously analyzes the methodologies and state-of-the-art technology that improve solar power prediction accuracy and dependability. It comprises the difficulties in incorporating solar energy into conventional power systems and emphasizes the significance of predictive analytics in attaining energy sustainability by crossing the gap between theoretical models and real-world implementations. With an eye on the future, this research effort is an indispensable resource for scholars, professionals, and decision-makers who are dedicated to advocating renewable energy sources and creating a more environmentally friendly future for future generations.

Cempaka Amalin Mahadzir

Chapter 1

ENVISIONING A SUSTAINABLE ENERGY FUTURE: THE ROLE OF PHOTOVOLTAIC POWER

1.1 INTRODUCTION

In the rapidly changing global environment of nowadays, finding sustainable energy is essential to solving the growing issues brought on by climate change and rising consumption of electricity. In its simplest form, sustainable energy is defined as power produced using techniques that effectively utilize natural resources neither depleting them nor endangering the environment. It is impossible to overestimate the significance of sustainable energy as it is a major step in the right direction toward reducing the damaging impacts of conventional energy sources on the environment. This introduction seeks to clarify the concept of sustainable energy in this context and emphasize its vital role in supplying the world's growing energy needs while conserving the endangered ecological balance.

Chapter 2

INTRODUCTION TO PHOTOVOLTAIC TECHNOLOGY

2.1 BASICS OF PHOTOVOLTAIC PANELS

Photovoltaic (PV) panels as in Figure 7 are usually constructed from silicon or alternative materials which is designed to allow the movement of electrons. The radiation from sunlight reacts with the semiconductor surface to release electrons, which starts an electric current. The movement of electrons within the semiconductor produces an electric field, which makes it easier for electricity to flow. The semi-conducting property of the semiconductor, which has been purposefully doped with impurities to create an electron deficit (p-type) on one side and an electron excess (n-type) on the other, is essential to this process. These electrons are stimulated by sunlight, which causes them to move across the electric field and start a current flow. The efficiently transform sunlight into energy, offering a combination of cost-effectiveness and high efficiency.

Chapter 3

FACTORS AFFECTING PV PANEL EFFICIENCY

3.1 SOLAR IRRADIANCE

Solar irradiance, often referred to as the lifeblood of renewable energy, constitutes the radiant energy emitted by the sun and reaching the Earth's surface. This abundant and inexhaustible energy source serves as the bedrock for renewable energy generation and is indispensable in the assessment and measurement of the power output of PV panels. The photovoltaic effect, a cornerstone principle in solar energy conversion, elucidates the mechanism by which sunlight interacts with PV panels, effectively converting light energy into electrical power for the use of various implementations pictorial in Figure 8.

Chapter 4

CALCULATION METHODS FOR PV POWER OUTPUT PREDICTION

4.1 INTRODUCTION TO CALCULATION METHODS

The evolution of calculating methodologies tailored to predict the electricity output of PV systems marks a pivotal stride in the realm of solar power output. These methodologies represent a fusion of complex algorithms and computational models designed to predict the electrical power that a given solar system will generate. These predictions serve as indispensable tools to engage in the design and deployment of PV systems, providing crucial insights into the economic viability and operational efficiency of such installations. By delivering precise predicts of power output, these methodologies empower decision-makers to optimize various system parameters, including panel configuration and capacity, with the aim of maximizing energy yield while minimizing costs.

One of the key strengths of these prediction methodologies lies in the comprehensive consideration of various parameters influencing PV system performance. Factors such as solar irradiation levels, fluctuations in temperature, shading effects stemming from nearby structures or vegetation and the orientation

Chapter 5

DATA COLLECTION AND ANALYSIS: INSIGHTS INTO PV POWER OUTPUT PREDICTION

5.1 SENSOR TECHNOLOGY

In order to establish a comprehensive monitoring system tailored to specific parameters, a strategic deployment of sensors is essential within the system's architecture. These sensors encompass various functionalities, including measuring solar irradiance, temperature, density of dust, electrical parameters and motion. With advancements in sensor technology, specialized sensors have emerged capable of detecting parameters with heightened precision. Integration with wireless communication protocols facilitates seamless real-time data transmission and analysis, empowering stakeholders with timely insights for informed decision-making and proactive maintenance measures. The meticulous selection and deployment of sensors play a pivotal role in ensuring the effectiveness of data collection processes, thereby contributing to the overall efficiency and optimal operation of PV systems.

Chapter 7

STRATEGIC PATHWAYS: NAVIGATING CHALLENGES WITH SOLUTIONS TOWARDS CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

7.1 TECHNICAL CHALLENGES

From Chapter 6, it can be seen that PV power output prediction confronts a number of frequent technical challenges due to the complexity and constantly changing characteristics of solar power systems. Accurate projections are severely limited by the unpredictability of solar irradiance, which is impacted by weather, time of day and changing seasons. Cloud cover, humidity and air pollution are examples of atmospheric conditions that bring uncertainty into the solar energy that affects solar panels. In short, through addressing the complexities of atmospheric effects, system dynamics and solar variability, these novel methods bring up a more reliable period for PV power prediction.

Bibliography

Arulkumar, D.C. (2023). Sustainable Energy Development: Transitioning Towards a Cleaner Future. *International Journal for Research in Applied Science and Engineering Technology. 11*(5), 6265–6274.

Guo, Q., Abbas, S., AbdulKareem, H. K., Shuaibu, M. S., Khudoykulov, K., & Saha, T. (2023). Devising strategies for sustainable development in sub-Saharan Africa: the roles of renewable, non-renewable energy, and natural resources. *Energy*, *284*, 128713.

Mahadzir, C. A., Mohamad Nor, A. F., & Jumaat, S. A. (2023). Photovoltaic Power Output Prediction using Graphical User Interface and Artificial Neural Network. *Majlesi Journal of Electrical Engineering*, *17*(4), 73-78.

Kumar, M. (2020). Social, economic, and environmental impacts of renewable energy resources. *Wind solar hybrid renewable energy system*, *1*.

Choudhary, P., & Srivastava, R. K. (2019). Sustainability perspectives-a review for solar photovoltaic trends and growth opportunities. *Journal of Cleaner Production*, *227*, 589-612.

Alami, A. H., Alasad, S., Aljaghoub, H., Ayoub, M., Alashkar, A., Mdallal, A., & Hasan, R. (2023). First-generation photovoltaics: history and conventional manufacturing. In *PV Technology and manufacturing* (pp. 7-19). Cham: Springer International Publishing.

Sekhar, V. R., & Pradeep, P. (2021). A review paper on advancements in solar PV technology, environmental impact of PV cell manufacturing. *International Journal of Advanced Research in Science, Communication and Technology*, 485–492.

Yi, A. L. W. (2023). Access to Clean, Affordable, and Reliable Energy Sources to Promote Economic Prosperity. In *Climate and Energy Governance for a Sustainable Future* (pp. 109-121). Singapore: Springer Nature Singapore.

Kumar, B., Garg, D., Swamy, K., & Kumar, P. (2022). Clean Energy Production Using Solar Energy Resources. In *Sustainable and Clean Energy Production Technologies* (pp. 269-288). Singapore: Springer Nature Singapore.

Fundamentals of Solar Photovoltaics Technology. Sustainable Energy Development Authority (SEDA MALAYSIA). (2022). 5.

Franklin, E. (2019). Calculations for a grid-connected solar energy system.

Sun, V., Asanakham, A., Deethayat, T., & Kiatsiriroat, T. (2020). A new method for evaluating nominal operating cell temperature (NOCT) of unglazed photovoltaic thermal module. *Energy reports*, *6*, 1029-1042.

AbdulBaqi, F. K., & Abdulrahman, K. R. (2021). The Effect of Humidity, Temperature and Total Solar Radiation on The Efficiency of Polycrystalline Solar Panel. *Diyala Journal for Pure Science*, *3*(91), 551-568.

Mejía Ruiz, S. (2021). Effects of environmental conditions on photovoltaic generation system performance with polycrystalline panels. *International Journal on Advance Science engineering information technology.*

Index

E

F

G

H

I

L

M

N

O

P

Q

R

S

T

U

V

W

Enhancing Photovoltaic Power Prediction

for Sustainable Energy Futures

In an era where the transition to sustainable energy sources is increasingly critical, Enhancing Photovoltaic Power Prediction for Sustainable Energy Futures explores innovative methodology and cutting-edge technologies designed to enhance the accuracy and reliability of solar power predictions.

Addressing the challenges of integrating solar energy into conventional power systems, the book underscores the vital role of predictive analytics in achieving energy sustainability. By bridging the gap between theoretical models and real-world data, it offers a comprehensive resource for undergraduate as well as post-graduate students, scholars, and industry professionals dedicated to advancing renewable energy.

With a forward-looking perspective, this research book is an indispensable guide for anyone committed to fostering a more environmentally friendly and sustainable future for generations to come.

Penerbit UTHM

ISBN 978-629-490-105-6

9 786294 901056 03700

For more information, please scan the code