

Curriculum vitae

Dr. Sourav DIWANIA

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CAREER OBJECTIVE

To secure a challenging and a responsible career in a reputable organization and to expand my learning, knowledge and skills, while making a significant contribution to the success of the organization.

WORK EXPERIENCE

JULY 2017-PRESENT	Assistant Professor at KIET GROUP OF INSTITUTIONS, GHAZIABAD Department of Electrical and Electronics Engineering. Courses taught: Basics of Electrical Engineering Power System Analysis, Power Electronics.
JUL 2015-JUL 2017	Assistant Professor at ABES ENGINEERING COLLEGE, GHAZIABAD Department of Electrical and Electronics Engineering Courses taught: Power System, Control System, Power Electronics.

EDUCATION

Nov 2016-Nov 2020 Thesis successfully defended	Doctor of Philosophy in ELECTRICAL ENGINEERING, JAMIA MILLIA ISLAMIA, NEW DELHI, INDIA Department of Electrical Engineering Thesis: "Life Cycle Analysis of Single Pass Hybrid PV/T Air Collector" Supervisor: Prof. ANWAR SHAHZAD SIDDIQUI %MARKS: 84 %
JUL 2013-JUL 2015	Master in Engineering in POWER ELECTRONICS, PUNJAB ENGINEERING COLLEGE, CHANDIGARH Electrical Engineering Department Dissertation : "Integration of PV Array with Utility Grid" Supervisor: Dr. LOVELEEN KAUR CGPA: 9.67
AUG 2009-JUNE 2013	Bachelor of Technology in ELECTRICAL AND ELECTRONICS ENGINEERING, ABES ENGINEERING COLLEGE, GHAZIABAD Affiliated to UTTAR PRADESH TECHNICAL UNIVERSITY, LUCKNOW Department of Electrical and Electronics Engineering Project: "Fault Detection using Automatic Phase Shifter" Supervisor: Ms. KUSHBOO ARORA % MARKS: 76.23%
JUL 2008-JUNE 2009	Intermediate KHALSA SCHOOL, BULANDSHAHR, Affiliated to CBSE, NEW DELHI % MARKS: 84.42%
JUL 2006-JUNE 2007	High-school KHALSA SCHOOL, BULANDSHAHR, Affiliated to CBSE, NEW DELHI % MARKS: 81.00%

PUBLICATIONS AND PATENTS

Journal (9)

1. **Sourav Diwania**, Anwar S Siddiqui, Sanjay Agrawal & Rajeev Kumar, “Modeling and assessment of the thermo-electrical performance of a photovoltaic-thermal (PVT) system using different nanofluids”, *Journal of the Brazilian Society of Mechanical Sciences, Springer*, 43(4), (2021), pp. 1-18.
2. **Sourav Diwania**, Anwar S Siddiqui, Sanjay Agrawal & Rajeev Kumar, “Performance assessment of PVT-air collector with V-groove absorber: A theoretical and experimental analysis”, *Heat and Mass Transfer, Springer*, 57, (2021), pp.665-679.
3. **Sourav Diwania**, Sanjay Agrawal, Anwar S Siddiqui & Sonveer Singh, “Photovoltaic-thermal (PV/T) technology: a comprehensive review on applications and its advancement”, *International Journal of Energy and Environmental Engineering, Springer*, 11, (2020), pp. 33-54.
4. **Sourav Diwania**, Sanjay Agrawal & Anwar S Siddiqui, “Performance enhancement of single-channel glazed photovoltaic thermal module using Whale Optimisation Algorithm and its comparative study,” *International Journal of Ambient Energy, Taylor & Francis*, 42(4), (2021), pp.424-434.
5. Rajeev Kumar, Pavan Khetrapal, Manoj Badoni & **Sourav Diwania** “Evaluating the relative operational performance of wind power plants in Indian electricity generation sector using two-stage model”, *Energy & Environment, Sage*, (2021)
DOI: <https://doi.org/10.1177/0958305X211043531>
6. Rajeev Kumar, **Sourav Diwania**, Rajveer Singh, Haroon Ashfaq, Pavan Khetrapal & Sheetal Singh, “An intelligent Hybrid Wind–PV farm as a static compensator for overall stability and control of multimachine power system”, *ISA transactions, Elsevier*, (2021)
DOI: <https://doi.org/10.1016/j.isatra.2021.05.014>
7. Rajeev Kumar, **Sourav Diwania**, Pavan Khetrapal, Sheetal Singh, & Manoj Badoni, “Multi-machine Stability Enhancement with Hybrid PSO-BFOA based PV-STATCOM”, *Sustainable Computing: Informatics and Systems, Elsevier*.
8. Rajeev Kumar, **Sourav Diwania**, Pavan Khetrapal, & Sheetal Singh, “Performance assessment of the two metaheuristic techniques and their Hybrid for power system stability enhancement with PV-STATCOM”, *Neural Computing and Applications, Springer*, (2021).
9. **Sourav Diwania**, Rajeev Kumar, Sudhir Kumar Singh, Gagandeep Singh Dua, & Pavan Khetrapal, “Performance assessment of a serpentine tube PVT system using Cu and TiO₂ nanofluids: an experimental study”, *Journal of the Brazilian Society of Mechanical Sciences and Engineering, Springer*, 44(2), (2021), pp.1-18

Conferences and book chapters (9)

1. **Sourav Diwania**, Devender Rawat, Maneesh Kumar, & Gagandeep Singh Dua, “Hybrid GSA-CS assisted performance evaluation of single-channel PVT air collector” In: Third International Sustainability and Resilience Conference: Climate Change, IEEE (2021), pp. 519-523.
2. **Sourav Diwania**, Anmol Gupta, Anwar S Siddiqui & Sanjay Agrawal, “Exergetic Analysis of Glazed Photovoltaic Thermal (Single-Channel) Module Using Whale Optimization Algorithm and Genetic Algorithm” In: Kalam A., Niazi K., Soni A., Siddiqui S., Mundra A. (eds), *Intelligent Computing Techniques for Smart Energy Systems. Lecture Notes in Electrical Engineering*, vol 607. (2020) Springer, Singapore.

3. **Sourav Diwania**, Anmol Gupta, Anwar S Siddiqui, SanjayAgrawal & Yash Pal, "Performance assessment of hybrid PVT air collector using GSA-CS algorithm." In: IOP Conference Series: Materials Science and Engineering. vol 691(1). (2019), IOP Publishing.
4. Sumit Kumar, **Sourav Diwania**, Anwar S Siddiqui & Sanjay Agrawal, "Role of Optimization Algorithms in Enhancing the Performance of Photovoltaic Thermal (PV/T) Systems," In: *Advances in Renewable Energy and Sustainable Environment. Lecture Notes in Electrical Engineering*, vol 667. pp. 253-263, (2020) Springer, Singapore.
5. Anmol Gupta, **Sourav Diwania**, Sanjay Agrawal, Anwar S Siddiqui & Yash Pal, "A Bibliographical View on Research and Developments of Photovoltaic and Thermal Technologies as a Combined System: PV/T System," In: Kalam A., Niazi K., Soni A., Siddiqui S., Mundra A. (eds), *Intelligent Computing Techniques for Smart Energy Systems. Lecture Notes in Electrical Engineering*, vol 607. (2020) Springer, Singapore.
6. Sudhir Kumar Singh, Rajveer Singh, **Sourav Diwania**, Ankit Singhal & Shivam Saway, "Impact of Inverter Interfaced DG Control Schemes on Distributed Network Protection," In: *Recent Advances in Power Electronics and Drives. Lecture Notes in Electrical Engineering*, vol 707. pp. 229-242, (2020) Springer, Singapore.
7. Mohd Faisal Jalil, Mohammad Shariz Ansari, **Sourav Diwania** & Mohammed Aslam Husain, "Performance Analysis of PV Array Connection Schemes Under Mismatch Scenarios," In: *Renewable Power for Sustainable Growth. Lecture Notes in Electrical Engineering*, vol 723. pp. 225-235, (2021) Springer, Singapore.
8. Mohammad Shariz Ansari, Mohd Faisal Jalil & **Sourav Diwania**, "Techno-Economic Analysis of Diesel/Wind/PV/Battery Hybrid Energy System for Androth Island," In: *Renewable Power for Sustainable Growth. Lecture Notes in Electrical Engineering*, vol 723. pp. 285-295, (2021) Springer, Singapore.
9. Sudhir Kumar Singh, Atul Kumar Kushwaha, Ankit Singhal & **Sourav Diwania**, "Enhanced Operation of Grid-Connected Inverter to Improve Power Quality Issues, Harmonic Compensation with the Proposed Novel Approach," In: *Power Electronics and High Voltage in Smart Grid. Lecture Notes in Electrical Engineering*, vol 817. pp. 13-20, (2022) Springer, Singapore.

Patent (2)

1. Abhas Kanungo, Monika Mittal, Himanshu Sharma, Vikas Mittal, Pankaj Kumar, Varun Gupta, Chandan Choubey, **Sourav Diwania**, Neeraj Kumar & Nitin Kumar Saxena, "A NOVEL WAVELET-BASED MULTIREOLUTION METHOD WITH OPTIMIZATION TECHNIQUES FOR PROCESS CONTROL AND DISTURBANCE REJECTION," In: *Australian Innovation Patent*, Patent Number: 2021105027, Sep. 2021. Status: **Granted**.
2. Varun Gupta, Vikas Mittal, Himanshu Sharma, Monika Mittal, Abhas Kanungo, Chandan Choubey, **Sourav Diwania**, Rajeev Kumar & Sudhir Kumar Singh, "A MEMORY BASED BRAIN COMPUTER INTERFACE (BCI) SYSTEM FOR MONITORING PHYSIOLOGICAL SIGNALS OF BRAIN," In: *Australian Innovation Patent*, Patent Number: 2021104513, Jan. 2022. Status: **Granted**.

In communication:

1. Journals: 5
2. Conference: 1
3. Patent: 1

SCHOLARSHIPS

1. GATE scholarship for M.Tech. course given by Ministry of Human Resource Department (Govt. of India) Year - 2013.

POSITIONS OF RESPONSIBILITY

1. FIRST YEAR INTERNSHIP COORDINATOR, EN Department, KIET Group of Institutions, Ghaziabad.
2. ORGANIZING COMMITTEE MEMBER, Virtual Conference on Innovative Applications of Computational Intelligence on Power, Energy and Controls with their impact on Humanity (VCIPECH-2018), held at KIET Group of Institutions, Ghaziabad.
3. ORGANIZING COMMITTEE MEMBER, Virtual Conference on Innovative Applications of Computational Intelligence on Power, Energy and Controls with their impact on Humanity (VCIPECH-2020), held at KIET Group of Institutions, Ghaziabad.
4. PROJECT COORDINATOR, Electrical and Electronics Engineering Department, ABES Engineering College, Ghaziabad. Duration: August (2016-2017).
5. REVIEWER of the International Journal of Renewable Energy Research and the Journal of the Institution of Engineers: Series B.
6. EDITORIAL BOARD MEMBER, MC Engineering Themes, Medicon Journal.
7. ORGANIZED workshop on “Programming with MATLAB” in August 2016 at ABES Engineering College, Ghaziabad.
8. DISCIPLINE COMMITTEE MEMBER, Annual Fest EPOQUE-2018 at KIET Group of Institutions, Ghaziabad.
9. ORGANIZING COMMITTEE MEMBER, Annual Fest EPOQUE-2018 at KIET Group of Institutions, Ghaziabad.
10. MENTOR, Team URJAVAAN, National Convention and Exhibition of Chhatra Vishkarma Awards 2019 held on 24th Feb, 2020 at AICTE, HQ's New Delhi.

TRAINING PROGRAM, WORKSHOPS, SHORT TERM COURSES AND SEMINARS ATTENDED

1. Three day workshop on “Innovative teaching learning pedagogy” at KIET, Ghaziabad, India on Jan 08-10, 2020.
2. One-week workshop on ‘Energy Engineering: Economics Planning and Management’ at KIET, Ghaziabad, India on Jan 25-29, 2021.
3. Short-term course under NPTEL on “Power System Engineering” from Aug 2018 to Nov 2018.
4. Two-week workshop on “Entrepreneurship Development” conducted by KEC, Ghaziabad, India from Dec 18, 2018 to Dec 30, 2018.
5. One-week workshop on “Emerging Trend and Challenges in Electric Power Systems” organized by ABES Engineering College, Ghaziabad from Jan 18, 2016 to Jan 22, 2016.
6. One-week workshop on “Advance Computer Networks & Security” conducted by AKTU, Lucknow from Jul 11, 2016 to Jul 15, 2016.
7. Vocational training at Vedanta Limited (Jodhpur Unit) from Jun 1, 2012 to Jul 15, 2012.

COMPUTER SKILLS

Word Processing tools	MS Word, MS Excel, MS Power point
Simulation tools	MATLAB & Simulink
Computer languages	C, C++

RESEARCH INTERESTS

1. Photovoltaic-Thermal Technology

2. Renewable Energy Integration
3. Power Converters

REFERENCES

1. **Dr. Anwar Shahzad Siddiqui**, Professor, Department of Electrical Engineering, Jamia Millia Islamia, New Delhi, India. Email: assiddiqui@jmi.ac.in
2. **Dr. Sanjay Agrawal**, Professor, School of Engineering and Technology, IGNOU, New Delhi, India. Email: sanjay.agrawal@ignou.ac.in
3. **Dr. Loveleen Kaur**, Assistant Professor, Electrical Engineering Department, Punjab Engineering College, Chandigarh, India. Email: loveleentaneja@yahoo.co.in

LANGUAGES

HINDI	Mother tongue
ENGLISH	Fluent

PERSONAL DETAILS

PLACE AND DATE OF BIRTH	Bulandshahr, Uttar Pradesh Feb 01, 1991
FATHER'S NAME	Mr. Jitender Choudhary
MOTHER'S NAME	Mrs. Shashi Choudhary
GOOGLE SCHOLAR PROFILE	https://scholar.google.co.in/citations?user=Y2qRAMOAAAAJ&hl=en
LEISURE ACTIVITIES	Playing Cricket & Swimming.



Modeling and assessment of the thermo-electrical performance of a photovoltaic-thermal (PVT) system using different nanofluids

Sourav Diwania^{1,3} · Anwar S. Siddiqui¹ · Sanjay Agrawal² · Rajeev Kumar^{1,3}

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Abstract

The proposed study aims to test the thermo-electrical, and exergy efficiency of a hybrid PVT collector cooled by pure water, copper (Cu)/water, and aluminum-oxide (Al_2O_3)/water nanofluids, respectively. A model is mathematically constructed using the energy-balance equation across all the layers of the hybrid PVT collector. For the validation of the proposed mathematical model, the outcomes of the proposed numerical model are compared with the experimental data of the literature. The impact of volume fraction (vol%) and mass flow rate (m) of the nanofluids on the PVT outcomes has been analyzed and demonstrated. The study displays a better PVT performance with Cu/water nanofluid compared to Al_2O_3 /water nanofluid and pure water. Merely a 2% volume concentration of Cu nanoparticles results in a 4.98% and 5.23% improvement in the average electrical and thermal efficiencies, respectively. At a mass flow rate of 0.03 kg/s, the thermo-electrical efficiency of the PVT with Cu/water nanofluid improve by 4.45% and 2.9%, respectively, concerning the pure water. Further, the impact of several tubes and their diameter is also investigated on the thermo-electrical efficiencies of the hybrid PVT collector. The tube diameter has not any substantial effect on the performance, whereas the thermo-electrical performance significantly enhanced with the rise in the number of tubes.

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This article has been selected for a Topical Issue of this journal on Nanoparticles and Passive-Enhancement Methods in Energy.

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Performance assessment of PVT-air collector with V-groove absorber: A theoretical and experimental analysis

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Abstract

In this paper, the performance of a PVT (photovoltaic thermal) air collector with V-groove absorber in the air channel is theoretically and experimentally examined under different climate conditions of Ghaziabad city, India, in summer, June 2019. A low power brushless DC fan is fixed at the input of the air-channel to ensure the circulation of air through the V-groove. The energy balance equation is developed with the matrix-inversion method to estimate the PV (photovoltaic) cell and air output temperatures. The theoretical results obtained using mathematical modeling has been compared with that of the real-time experimental results. The electrical, thermal, and overall efficiencies for the theoretical and experimental studies are found in the range of 10.39–10.26%, 41.78–41.57%, and 52.17–51.81%, respectively. It has been observed that the theoretical results are coherent with experimental results for the proposed model achieving an accuracy of 98.98%, 99.43%, and 99.31% for electrical, thermal, and overall efficiencies, respectively.

Keywords PVT air-collector · Exergy · Electrical and thermal efficiency · V-groove

Nomenclature

A_c	Collector area (m ²)
H_t	Collector top loss coefficient (W/m ² °C)
H_b	Collector back loss coefficient (W/m ² °C)
T_c	Cell temperature (°C)
d	Channel depth (m)
D_c	Equivalence diameter of channel (m)
Ex_{in}	Exergy input
Ex_{out}	Exergy output
T_f	Fluid Temperature (°C)
m	Mass flow rate (kg/s)
A_m	Module area (m ²)
N_u	Nusselt number
P_r	Prandtl number

Re	Reynolds number
I	Solar radiation (W/m ²)
C_f	Specific heat (J/kg °C)
T_{in}	Temperature at the channel inlet (°C)
T_{out}	Temperature at the channel output (°C)
T_{sun}	Temperature of the sun (°C)
k	Thermal conductivity (W/m °C)
Q_t	Usable heat (W)
W	Width of the channel (m)

Abbreviations

PV	Photovoltaic
PVT	Photovoltaic Thermal
HTC	Heat transfer coefficients

Greek symbols

α	Absorption coefficient
ρ	Air density (kg/m ³)
ϵ_p	Emissivity of PV
η_{ele}	Electrical efficiency, %
η_{Ex}	Exergy efficiency, %
$\eta_{overall}$	Overall efficiency, %
σ	Stefan Boltzman constant
β_0	Temperature coefficient of efficiency
μ	Viscosity (kg/ms)
η_{th}	Thermal efficiency, %
τ	Transmission coefficient

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Performance assessment of a serpentine tube PVT system using Cu and TiO₂ nanofluids: an experimental study

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Abstract

A high photovoltaic (PV) panel temperature causes a reduction in the terminal voltage that results in low output power. Therefore, the extraction of heat from PV panels is a very important and crucial area to enhance the electrical power output. A PVT (Photovoltaic-Thermal) is a combined version of photovoltaics and solar thermal collector to generate electrical and thermal energies. Despite its popularity, the thermo-electrical performance of water-based PVT systems is not up to the mark because of the poor thermal conductivity of water. The present work experimentally investigates the concentration and MFR (mass flow rate) variations of copper (Cu) and titanium oxide (TiO₂) nanofluids on the performance of a hybrid PVT system. The developed model is deployed to examine the performance of the PVT system for the weather conditions of Ghaziabad city (India). The research outcomes show how the PVT with Cu/water nanofluid exhibits a better thermo-electrical performance as compared to the PVT with TiO₂/water nanofluid and water cooling. The results also show that using Cu/water nanofluid (1 vol %) as a coolant improved the PVT electrical efficiency by 5.98% concerning the basefluid. At a higher MFR, the average PV panel temperature is reduced that results in better cooling of the PVT system. At 0.03 kg/s MFR, a reduction in 17.18 °C temperature in the PV panel enhances the thermo-electrical efficiency by 2.58% and 5.43%, respectively.

Graphical abstract

- The present paper investigates the thermo-electrical performance of serpentine tube-based PVT collector with Cu/water and TiO₂/water nanofluid.
- The influence of nanofluid type and concentration on PV temperature (T_{PV}), electrical efficiency (η_{el}), thermal efficiency (η_{Th}), and overall efficiency (η_{PVT}) are evaluated experimentally.
- The energy balance equations of PVT collectors with nanofluid are derived from analyzing the impact of operating parameters.

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This article has been selected for a Topical Issue of this journal on Nanoparticles and Passive-Enhancement Methods in Energy.

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Research article

An intelligent Hybrid Wind–PV farm as a static compensator for overall stability and control of multimachine power system

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ABSTRACT

The paper demonstrates the potential of a hybrid Wind–PV farm as STATCOM (Static Synchronous Compensator) for damping and control of overall chaotic oscillations in a two-area power system. Kundur's modified system associated with a hybrid Wind–PV farm is simulated in MATLAB to demonstrate the detailed performance assessment of the hybrid farm. A unique controller is deployed to regulate the AC and DC currents of the STATCOM using two PI controllers. A swarm-based hybrid metaheuristic optimizer PSO-BFOA optimally tunes and controls the PI controller parameters. The system is compensated to an optimum level of 85% and exposed to a 3-phase fault. Zero dampings are accompanied by additional disturbances of a 20% change in electric torque and the reference voltage. The disturbances are made to model the worst conditions to examine the rigorous performance of the hybrid Wind–PV farm in alleviating the overall chaotic oscillations. The simulation results for the performance assessment in different cases, i.e., without control, with Wind-STATCOM, with PV-STATCOM, and with the hybrid Wind-PV-STATCOM, reveal the potential of the hybrid Wind–PV Farm as STATCOM in alleviating the overall chaotic oscillations.

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1. Introduction

Nowadays, the power system dynamics have been considerably influenced because of the growing renewable power penetrations. Wind and PV are the two most prominent renewable energy sources that significantly alter the modern power system dynamics. The ever-increasing concentration of renewable energy in terms of Wind and PV power penetrations in the modern power system results in many stability concerns. The chaos caused by the increased Wind–PV power penetration or other perturbations can be alleviated largely by modulating the power flow of such renewable generating units in response to the system oscillations. In [1], a DFIG-based WF is used to enhance the transient and dynamic stability of a synchronous generator. In [2], power system stability is improved by damping SSR with synchrophasor data-based control of wind turbines. In [3], an H_∞ control of the DFIG farm is proposed to damp SSR control interactions for power system stability enhancement. Stability enhancement of multimachine power system by regulating the power flow of FSWT wind farms using UIPC is discussed

in [4]. [5], compares impedance models of the various renewable generating units for subsynchronous interaction stability analysis of power system. In [6], SSR control interactions have been mitigated by fractional sliding mode control of wind farms to aid the power system stability. [7], proposed variable-gain super-twisting sliding mode control (VGSTSMC) of DFIG farms for power system stability by alleviating subsynchronous control interactions. Stability enhancement of DFIG-based power system with optimal control of LQR (linear quadratic regulator) is discussed in [8]. In [9], a probabilistic robust, coordinated control is proposed for a DFIG-based power system stability. An analysis of S^2SI (Sub-/super-synchronous interactions) using a shifted frequency impedance model of DFIG integrated Wind Farm for power system stability has been performed in [10].

To cater to the growing need for clean energy in modern power systems. Apart from the WPPs, PV-power penetration is significantly increasing day by day with advancements in mono and poly-crystalline technology. In [11], Power system stability has been enhanced by alleviating SSR with high penetration PV farms. [12], demonstrates a unique control of a PV plant as STATCOM [13] for alleviating SSR to aid the power system stability. [14], proposed a synchronous motor–generator pair to improve the dynamic and large-signal power system stability with

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Photovoltaic–thermal (PV/T) technology: a comprehensive review on applications and its advancement

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Abstract

Over the most recent couple of decades, tremendous consideration is drawn towards photovoltaic–thermal systems because of their advantages over the solar thermal and PV applications. This paper intends to show different electrical and thermal aspects of photovoltaic–thermal systems and the researches in absorber design modification, development, and applications. From the previous review articles, it has been concluded that the heat energy exhausted from the PV module can be further utilized in different ways and helps in achieving better efficiency. Furthermore, the types of photovoltaic–thermal systems such as air collector, water collector, and combi system, coupling with heat pump and their application to buildings are also stated. This paper also discussed certain design aspects like modifications in the flow channel by adding fins, thin metallic sheets, roll-bond absorber, and porous media and the effect of these modifications on the hybrid system's efficiency. Furthermore, the use of the latest technologies such as nanofluids, thermoelectric generators, and phase-change materials improves the overall system performance. The role of soft-computing techniques is forecasting the impact of various parameters on the photovoltaic–thermal system is also discussed.

Keywords PV/T combi · Thin metallic sheets (TMS) · Phase-change materials (PCM) · Nanofluids

List of symbols

η_{cpower}	Power conversion factor
A_m	Area of PV module (m ²)
c_p	Fluid-specific heat (J/kg K)
G_t	Sunlight intensity (W/m ²)
I_m	Current at MPP (A)
m	Fluid mass flow rate (kg/s)
N_C	Channels in SCPV/T module

Q_{th}	Usable heat (W)
T_c	Temperature of solar cell (K)
T_0	Ambient temperature (K)
T_{in}	Temperature at the inlet of channel (K)
T_{out}	Temperature at the output of channel (K)
T_{SUN}	Sun temperature (K)
V_m	Voltage at MPP (V)

Greek letter

β_0	Temperature coefficients of efficiency (/K)
L_f	Latent heat of fusion
λ	Thermal conductivity
η_{ele}	Electrical efficiency
η_{Ex}	Exergy efficiency
η_0	Efficiency at STC
η_T	Overall efficiency
η_{th}	Thermal efficiency

Abbreviations

ANN	Artificial neural network
COP	Coefficient of performance
ELM	Extreme learning machine
EVA	Ethylene-vinyl acetate
FPC	Flat-plate collector
HASS	Hybrid active solar still
GSA	Gravitational search algorithm

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Performance enhancement of single-channel glazed photovoltaic thermal module using Whale Optimisation Algorithm and its comparative study

Sourav Diwania^a, Sanjay Agrawal^b and Anwar S Siddiqui^a

^aDepartment of Electrical Engineering, Jamia Millia Islamia, New Delhi, India; ^bSchool of Engineering & Technology, IGNOU, New Delhi, India

ABSTRACT

In this communication, three different optimisation techniques, i.e. Whale Optimisation Algorithm (WOA), Gravitational Search Algorithm (GSA) and Genetic Algorithm (GA) have been implemented to optimise the parameters of single-channel glazed photovoltaic thermal module (SCGPVT) module by using exergy efficiency as an objective function. Four variable parameters viz. Channel length (L_M), channel depth (d), velocity of air streaming into the channel (V_F) and fluid temperature at the inlet of channel (T_{in}) have been considered for optimisation. The present work concludes that the average exergy efficiency achieved from the SCGPVT module when optimised with WOA algorithm is 27.47% more than the system optimised with GA and 3.050% more than the system optimised with GSA. Hence it has been proven, that WOA is superior algorithm with respect to the other two algorithms viz. GSA and GA because of its faster convergence rate. Further the time taken by WOA technique in identification of the optimised values of the parameters is lesser in contrast to the other two optimisation techniques.

ARTICLE HISTORY

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KEYWORDS

Photovoltaic thermal (PVT); Whale Optimisation Algorithm (WOA); Gravitational Search Algorithm (GSA); Genetic Algorithm (GA); exergy efficiency

1. Introduction

Now a days the demand of electrical energy has been increasing at a tremendous rate while the generation is restricted. With the existing conventional energy sources, it is extremely challenging to fulfil the growing electricity need. Therefore the role of renewable energy sources are very important to bridge the gap between electricity generation and its consumption. Apart from this, conventional energy resources are limited in nature and generation of electricity using these sources has adverse impact on the environment as well. Therefore, it's a high time to shift our focus towards non-conventional energy sources rather than conventional energy sources for electricity production. Abundant quantity of renewable energy sources exists, but solar energy is capable of fulfilling the country's electricity demand by converting sunlight into electricity. However, the major task is to improve the electrical efficiency of solar cell since it just changes over (8–12%) of sunlight into electrical energy while the major portion of incident solar radiations is converted into heat. It is a known fact that the electrical efficiency of solar panel reduces with rise in cell temperature (Schott 1985). Therefore, keeping the solar cell temperature within the limits is necessary. PVT- system has proven its effectiveness in the last four decades as a result of its capabilities to produce thermal and electrical energies simultaneously in contrast to the conventional photovoltaic and solar thermal system which produces these energies separately.

In PVT-systems, both electrical and thermal components combined together in one unit. Further, in this system, a channel is utilised underneath the PV panel in which air or water can be used as a cooling medium to extract the heat energy associated with the PV surface. In PVT combi systems, both air

and water units are installed below the PV panel to generate hot air and hot water simultaneously. In applications of PVT-system, the major task of the PV module is to produce electricity, and this requires the PV module to operate at a lower temperature thereby maintaining its electrical efficiency at a desired level. The heat energy transferred to the back surface of PV module is pulled back with the help of natural air flowing through the duct or forced air circulation (Ibrahim et al. 2011). Although natural air circulation is the simplest and cost-effective technique, however, this technique is less effective in topographical regions where the surrounding air temperature is higher than 20°C for most of the time (Lamnatou and Chemisana 2017). The hybrid PVT-systems is characterised based on the medium of heat extraction, method of heat extraction, type of solar input, and system configuration as shown in Figure 1.

The performance of hybrid PVT-system is estimated on the basis of its electrical efficiency, thermal efficiency and exergy efficiency. Exergy is considered as a measure of the economy of the system. Therefore, most of the researchers focus on exergy based cost analysis (exergoeconomic analysis) of PVT collectors. Agrawal and Tiwari (2011a) did an experimental investigation of hybrid micro-channel photovoltaic thermal (MCPVT) module which is essentially a series and parallel arrangements of micro-channel solar cell thermal (MCST) tiles. The experimental analysis is performed on weather data gathered from four urban cities namely (Srinagar, Bengaluru, Jodhpur and New Delhi). From the investigation, the author concluded that the total exergy gain, exergy efficiency and thermal gain of MCPVT is significantly improved compared to MCST. Agrawal, Tiwari and Pandey (2012) designed a glazed PVT tile and worked upon experiments to investigate the effect of the number of tiles



Performance assessment of the two metaheuristic techniques and their Hybrid for power system stability enhancement with PV-STATCOM

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Abstract

The paper demonstrates a comprehensive performance assessment of the two metaheuristic swarm-based optimization algorithms namely PSO (Particle swarm optimization), BFOA (Bacterial foraging optimization algorithm), and the hybrid PSO-BFOA optimizer for the alleviation and control of the power oscillations in a two-area four generator system integrated with a large-scale PV-farm. After sunset, the PV-plant operates as VSC (Voltage Source Converter)-STATCOM (Static synchronous compensator) using its overall inverting capabilities for the power system stability improvement. While in the daytime during the faults, the PV-farm immediately stops the active power production and behaves as PV-STATCOM until the normal operating conditions are resumed. The modified version of Kundur's two-area system comprising of a large-scale PV-farm is simulated with MATLAB software. An innovative control strategy employing the two PI controllers distinctly controls the DC-AC currents of the PV-STATCOM. The series compensation is set to an optimal value of 85% and subjected to a 3- ϕ fault. Zero mechanical dampings, along with extra disturbances of 20% variation in reference voltage and electromagnetic torque are introduced to flaunt the worst damping scenarios. The simulation outcomes and time-domain analysis for various test conditions: without a controller, with PSO-based PV-STATCOM, with BFOA-based PV-STATCOM, and with the Hybrid PSO-BFOA-based PV-STATCOM, reveal that all the system modes are stabilized with PSO application. The stability of modes is progressively improved with BFO control, eventually, the modes are optimally stabilized by deploying the hybrid PSO-BFO algorithm.

Keywords Solar farm · Intelligent PV-STATCOM · Hybrid PSO-BFOA algorithm · Stability and control · Multi-machine system

1 Introduction

Recently, the dynamic behavior of the interconnected power grid has been substantially modified due to the increased deployment of renewable sources. Nowadays, wind energy has evolved and become one of the leading

renewable energy sources that are widely used in India [1] and across the globe. Moreover, with the advent of mono and polycrystalline technology, the participation of solar power has been significantly increased in the overall renewable power input to the grid. Solar farms with a capacity of more than 500 MW are increasingly connected day by day. This includes Kamuthi solar power project of 648 MW in Sengappadai Tamil Nadu, India [2], Rancho Cielo PV farm of 600 MW in the USA, solar star I and II PV power plant of 579 MW near Rosamond, California, USA, TOPAZ solar photovoltaic power plant of 550 MW in San Luis Obispo County, California.

The increasing renewable power incursion in the system leads to several instabilities that result in a weak grid [3]. The impact of low inertia power injection through PV farms on grid stability is discussed in [4–6]. An overview

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