AICCEES

AFRICA INTERNATIONAL CONFERENCE ON CLEAN ENERGY & ENERGY STORAGE

2nd Edition

CONFERENCE PROGRAMME & BOOK OF ABSTRACTS

26th & 27th September, 2024

IPES Hall, University of Port-Harcourt
Rivers State, Nigeria.

Tovero Energy
Energy to power your dreams

AICCEES

Africa International Conference on Clean Energy & Energy Storage

2nd Edition

26th & 27th September, 2024

IPES Hall, University of Port Harcourt, Rivers State
Nigeria.

Supported by:

Energy Technology Institute, ETI
Centre for Power Systems Studies
University of Port Harcourt. Nigeria

Organised by:

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PREFACE

Welcome to the Africa International Conference on Clean Energy and Energy Storage (AICCEES) 2024. In the pursuit of advancing clean energy and energy storage solutions for a sustainable future in Africa, AICCEES 2024 brings together an assembly of brilliant minds, innovative researchers, and industry leaders. This book is a testament to the vibrant exchange of ideas and knowledge that took place during the conference.

AICCEES in Retrospect

AICCEES serves as a pivotal platform for researchers, practitioners, and policymakers to converge and deliberate on the latest developments in the field of clean energy. The conference aims not only to showcase the current state of research but also to foster collaborations and inspire future breakthroughs.

We extend our deepest gratitude to all the authors who shared their insights, research findings, and expertise. Your dedication to advancing the discourse on clean energy is evident in the quality and diversity of the abstracts included in this compilation.

Appreciation

A special appreciation goes to Tovero Energy Ltd, team: the driving force behind the organization of AICCEES 2024. Their commitment to fostering knowledge exchange and innovation has been instrumental in the success of this conference. We also express our heartfelt thanks to the Conference Chairs, members of the Scientific Committee, Master of Ceremony, and Keynote Speakers for their leadership, guidance, and contributions that shaped the conference agenda.

The success of AICCEES 2024 would not have been possible without the support of organizations that share our commitment to advancing clean energy solutions. We extend our appreciation to CODAHEA, ACE-FUELS, Transforming Energy Access Learning Partnership (TEA-LP), ENERPRO Consulting, Integrated African Power, Energy Technology Institute (ETI) University of Port Harcourt, Scientific.net, and others who have played a vital role in supporting this conference.

The Vision

As we present this Book of Abstracts, we invite readers to explore the cutting-edge research and ideas that emerged from AICCEES 2024. May this compilation serve as a source of inspiration and a reference for those committed to the pursuit of sustainable and cleaner energy solutions.

Thank you for being a part of this transformative journey.

Best regards,

Engr. Anthony Mbukobong Akpasoh
Tovero Energy Ltd.

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ABOUT TOVERO ENERGY

As international organizations and countries look for the best approaches to transition to cleaner and more sustainable energy, Tovero Energy has strategically positioned itself as a dependable partner, leading discussions on the development of energy systems that are both resilient to prevailing climatic conditions, and capable to meet the growing demand for energy in ways that are both clean and sustainable.

Our Vision

To empower futures through sustainable energy solutions.

Our Mission

To empower individuals, communities, and industries by delivering tailored and innovative sustainable energy solutions that drive positive environmental impact, economic growth, and social progress.

Our Core Values

We are committed to being trustworthy, accountable, and organised. Prioritising our integrity, we remain noble, passionate, honest and service oriented in all our dealings.

WHAT WE DO

- **Energy Education & Advocacy**
- **Energy Advisory**
- **Clean Cooking Solutions**
- **Energy Planning & Audit**
- **Energy Systems Design & Development**
- **Mini-grid Development**

We are a world-class provider of clean and sustainable energy solutions. We are committed to empowering futures by spearheading research and initiatives aimed at developing resilient energy systems capable of meeting the growing demand for energy while prioritizing cleanliness, safe access and sustainability. As a brand, we are dedicated to empowering dreams sustainably!

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ACKNOWLEDGEMENTS

Tovero Energy Ltd sincerely thanks God Almighty, for making the 2024 edition of the Africa International Conference on Clean Energy and Energy Storage a great success. Tovero Energy Ltd would like to thank the Conference Chairperson, Professor Roland Uhunmwangho, the Conference Co-Chairpersons, Professor Sunday Oyedepo, Professor Fidelis Abam, Dr. Ogheneruona Diemuodeke, and the management of the University of Port Harcourt, who worked really hard in making this conference what it is by providing scientific and logistical support.

Tovero Energy Ltd would like to express its appreciation to all members of the scientific committee for their tremendous efforts and contribution to the success of the 2024 Africa International Conference on Clean Energy and Energy Storage. Tovero Energy Ltd is grateful to be known as an organisation that amasses a highly qualified and competent team who relentlessly worked for months to make this conference successful in hopes of creating a well-rounded society.

We further express our sincere appreciation to our partners for their tremendous contributions to the 2024 edition of the conference, Energy Technology Institute (ETI) of the University of Port Harcourt, Nigeria, Transforming Energy Access – Learning Partnership (TEA-LP), ENERPRO Consulting, Consortium for the Development and Advancement of Hydrogen Economy in Africa (CODAHEA), African Center of Excellence in Future Energies and Electrochemical System (ACE - FUELS) and Integrated Africa Power (IAP).

We acknowledge the prominent role undertaken by the brilliant keynote speakers, Professor Youba Sokona, Professor Emeka Oguzie, Professor Foluke Ishola, Associate Professor Amina Batagarawa, Hon. (Prof) Robinah Nanyunja, and Dr. Ioannis Tsipouridis, the authors, moderators, and panel session members who contributed scholarly and industry knowledge to the success of the 2024 conference.

CONFERENCE ORGANISERS

Conference Chairs

Professor Roland Uhunmwangho Former Dean, Faculty of Engineering, University of Port Harcourt	*Conference Chair*
Professor Sunday Oyedepo Faculty of Engineering, Bells University of Technology, Ogun State, Nigeria.	*Conference Co-Chair*
Dr. Ogheneruona Diemuodeke Head of Mechanical Engineering Department, & Director of Energy Technology Institute, University of Port Harcourt.	*Conference Co-Chair*
Professor Fidelis Abam Faculty of Engineering & Technology, University of Calabar.	*Conference Co-Chair*

Organising Committee

Dr. Veronica Akpasoh CEO, Tovero Energy Ltd	*Chairman*
Engr. Anthony Akpasoh COO, Tovero Energy Ltd	*Co-Chairman*
Peace Esuuk Ikpokonte Projects Cordinator, Tovero Energy Ltd	*Technicals and Logistics*
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Dr. Daniel Ekpah University of Port-Harcourt	*Audio Visuals*
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SCIENTIFIC COMMITTEE

1.	Dr. Celestine Ebieto	*University of Port Harcourt*
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Rapporteurs

1.	Nwachukwu Chinedum	*University of Port Harcourt*
2.	Felicia Friday Paul-Jazom	*University of Port Harcourt*

KEYNOTE SPEAKERS

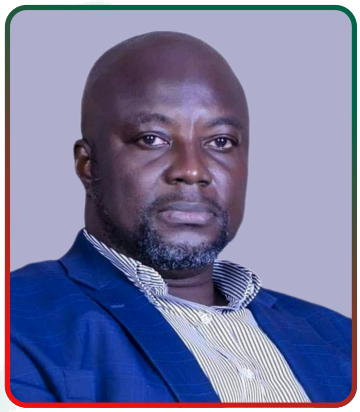
PROF. YOUBA SOKONA

PROF. FOLUKE ISHOLA

PROF. ASIF AFZAL

ASSOC. PROF. AMINA LAWAL BATAGARAWA

PROF. IOANNIS TSIPOURIDIS



PROF. EMEKA OGUZIE

HON. (PROF.) ROBINAH K. NANYUNJA

ABOUT THE CONFERENCE

More than 600 million people in Sub-Saharan Africa are living without electricity according to World Bank research. Reports from SEforAll indicate that achieving SDG 7 will accelerate the achievement of ten out of the seventeen Sustainable Development Goals (SDGs) because of the dependence of the other SDGs on renewable energy. While countries in the African continent are committed to achieving SDG 7 which is ensuring access to affordable, reliable, sustainable, and modern energy for all by 2030, various studies have shown that the major challenges in the renewable energy sector include the high cost of renewable energy solutions, the lack of knowledge about them, the absence of technologies that are suitable to the local context, low research and development efforts, and technical skills gap in the field of clean energy.

In order to achieve the Sustainable Development Goals in Africa, effective collaboration between academia and industry is necessary to create a sustainable and transformative win-win situation for all stakeholders. However, research conducted by African institutions addressing the unique challenges faced by the continent often ends up in academic libraries with little or no impact on society. To address this issue, the Africa International Conference on Clean Energy and Energy Storage (AICCEES) is organized by Tovero Energy Ltd providing the platform to cross-share knowledge for the clean energy transition in Africa. It brings together researchers and industry experts to share knowledge and discuss innovative solutions for the clean energy transition in Africa. The conference features industry leaders, experts, researchers, government agencies, regulators, multilateral organizations, industry bodies, and more in the field of clean energy and energy storage. Participants of the conference will benefit in the following ways;

- **Publication of Research in a Scopus-indexed journal as well as Conference proceedings with Scientific.net**
- **Discuss research findings with experts & stakeholders**
- **Professional career development opportunities**
- **Professional network growth**
- **Certificate of participation**

CONFERENCE CHAIRMAN'S SPEECH

It is with great pleasure and honor that I welcome you all to the African International Conference on Clean Energy and Storage, holding at the prestigious University of Port Harcourt, from the 26th to the 27th of September, 2024. On behalf of the Local Organizing Committee, I would like to extend a warm welcome to all our esteemed speakers, participants, and guests who have traveled from across the globe to join us for this landmark event at the Institute of Petroleum and Energy Studies.

This conference represents a pivotal moment for Africa as we seek to address the energy challenges of the 21st century. Clean energy solutions and efficient storage technologies have never been more critical, especially as we move towards more sustainable energy practices that address climate change while fostering economic development across the continent. Our collective expertise and collaboration will be instrumental in driving innovative solutions that can redefine Africa's energy landscape.

Over the next two days, we will engage in profound discussions, share groundbreaking research, and explore the latest advancements in clean energy and storage technologies. This conference will serve as a platform for exchanging knowledge, fostering partnerships, and inspiring the next generation of researchers, engineers, and policymakers to lead the energy transition across Africa and beyond.

I must express my heartfelt appreciation. First and foremost, a profound thanks to the meticulous organizers of this event, Tovero Energy Ltd. Your dedication and tireless efforts have transformed an idea into the reality we are now living. Equally deserving of our gratitude are our esteemed partners: the Energy Technology Institute (ETI) of the University of Port Harcourt, Nigeria, Transforming Energy Access – Learning Partnership (TEA-LP), ENERPRO Consulting, Consortium for the Development and Advancement of Hydrogen Economy in Africa (CODAHEA), African Center of Excellence in Future Energies and Electrochemical System (ACE - FUELS) and Integrated Africa Power (IAP). whose commitment has made this conference a reality. Special thanks go to our distinguished keynote speakers and panelists for their invaluable contributions, as well as the tireless efforts of the Local Organizing Committee in ensuring the success of this event.

As we embark on this journey together, I encourage you all to take full advantage of the sessions, workshops, and networking opportunities. Let us collaborate, innovate, and push the boundaries of what is possible as we collectively shape a cleaner, more sustainable future for Africa and the world.

Once again, welcome to the African International Conference on Clean Energy and Storage. I wish you all fruitful deliberations and a memorable experience here at the University of Port Harcourt.

Professor Roland Uhunmwangho
Conference Chair,
Professor of Engineering, Faculty of Engineering,
University of Port Harcourt, Rivers State, Nigeria.

CONFERENCE PROGRAMME OF ACTIVITIES

Master of conference: Mr. Willie Akpan

Day One: *Thursday 26th September, 2024*

TIME	ACTIVITY (OPENING CEREMONY)
08.30am - 08.50am	**Accreditation (Online/Physical)/Collection of Conference materials** Organising committee
08.50am - 09.00am	**Opening formalities / Introduction of guests** Mr. Willie Akpan, Master of Ceremony
09.00am - 09.10am	**Welcome Speech** Professor Owunari Abraham Georgewill Vice Chancellor, University of Port Harcourt.
09.10am - 09.15am	**Tovero Energy Presentation** Dr. Veronica Akpasoh CEO, Tovero Energy.
09.15am - 09.25am	**Opening Speech** Professor Roland Uhunmwangho Conference Chair and Director, Center for Power Systems University of Port Harcourt.
09.25am - 10.00am	**Keynote Address:** "Prospects for climate resilient development and just energy transitions in African countries" Professor Youba Sokona

Group Photographs & Tea Break

TIME	ACTIVITY (PAPER PRESENTATIONS)

SESSION 1: HYDROGEN DEVELOPMENT IN AFRICA

Moderator: Associate Professor Ogheneruona Diemuodeke

10.25am - 10.40am	**Design and Analysis of a Supercritical Metal-Water Reactor for Hydrogen Gas Production.** Igwe Chijindu; Eze Paschal; and Eze Miracle
10.40am - 10.55am	**Full Spectrum-driven Photocatalytic Hydrogen Production using Fe-doped TiO2-MoS2.** Oleka Ikechukwu John, Akalezi Christogonus, Agbo Solomon, Oguzie E. E.
10.55am - 11.10am	**A Two-Parameter Computational Thermodynamic Analysis of Hydrogen-Impurity Mixtures in a Repurposed Pipeline.** Elijah Binfa Bongfa, Abubakar Yakubu Khartum, Bongfa Binfa, Shaibu Muhammed, and Zumami Ahmad Muhammad.

11.10am - 11.25am	**Development And Evaluation Of An Alkaline Electrolyzer For Production Of Hydrogen And Electrical Energy In A Fuel Cell.** Igwe Chijindu; Achebe Chinonso; Chinweze Arinze; Chukwuneke Jeremiah

SESSION 2: ENERGY EFFICIENCY & SMART SYSTEMS

Moderator: Dr. Celestine Ebieto

11.25am - 11.40am	**Energy Efficiency, Cost-Saving Opportunities and Nearly Zero Emissions Analysis in the Residential Sector; Case Study of Nigeria and Ghana.** Omata David Omakoji
11.40am - 11.55am	**Use of Natural Rocks as Heat-Storage Materials for Food Drying Applications in Sub-Saharan Africa.** Alde Belgard Tchicaya Loemba, Kichonge Baraka, and Kivevele Thomas.
11.55am - 12.10pm	**Performance Analysis of a Photovoltaic System with Thermoelectric Generator and Phase Change Material; An Experimental Approach.** Tobechukwu Okamkpa, Joshua Okechukwua, Divine Mbachu,Chigbo Mgnemene
12.10pm - 12.25pm	**Energy Auditing for University Energy Management: A Tool for Enhancing Sustainability.** John Jeremiah Jay, Azodo Adinife Patrick, Bawa-Boyi Emmanuel Uda, Mezue Francis C.
12.25pm - 12.40pm	**Energy Optimization of Wireless Body Area Network (WBAN) Using TDMA Duty Cycling and Thermal Energy Harvesting** Nkolika O. Nwazor, J.C. Erowele, R. O. Okeke, E. S Mbonu, O. M Horsfall

SESSION 3: MINIGRIDS & HYDROPOWER DEVELOPMENT

Moderator: Associate Professor Ogheneruona Diemuodeke

12.40pm - 12.55pm	**Assessing the Viability of Mini-Grids in Rural Electrification: Overcoming Challenges and Exploring Sustainable Business Models.** Ayodeji Stephen Adekanbi
12.55pm - 1.10pm	**Mini-Grid Sustainability Framework and its Application to Selected Mini-Grids in Kenya.** Mourice Wambua Kausya, Nyumba Rosebella, Onsongo Elsie, Kerr Daniel, and Bhattacharyya Subhes.

1.10pm - 1.25pm	**Decarbonisation in the Transport Sector of Ghana Using Autogas.** Appiah, Janet Osei; Adamou Rabani; Kabo-Bah Amos T. and Narra Satyanarayana.

Lunch Break / electric cooking demonstration exhibition/Networking

SESSION 4: ENERGY STORAGE & SUSTAINABLE BATTERY MANUFACTURING IN AFRICA

Moderator: Dr. Celestine Ebieto

2.10pm - 2.25pm	**Keynote Presentation** Professor Asif Afzal
2.25pm - 2.40pm	**Investigation of High-Performance Green-Synthesized $NaTi_2(PO_4)_3$ Nanocomposites for Advanced Electrochemical Energy Storage Applications.** Peredy Khwesa, and Onoh Edwin.
2.40pm - 2.55pm	**Modelling And Optimisation of Integrated Renewable Energy Conversion Technologies With Dual Energy Storage for Island.** Ekwueme, Brendan Ifeanyi. E. O. Diemuodeke, and M. M. Ojapah

SESSION 5: ENERGY ACCESS & ENERGY SUPPLY IN AFRICA

Moderator: Associate Professor Ogheneruona Diemuodeke

2.55pm - 3.10pm	**Hybrid Renewable Energy Systems (HRES) for Nigerian Airports: An Economic Feasibility and Stakeholder Insights Assessment.** Chidi Cletus EMELU, Johnson Ojiyovwi Okorhi, Roland Uhunmwangho, and Ameze Big-Alabo.
3.10pm - 3.25pm	**Predictive Modelling for Optimizing Wind Turbine Performance and Structural Health Monitoring: Adapting Turkish SCADA Data for Sub-Saharan Africa.** Sikiru Abdulganiyu Siyanbola, Olamide Mercy Oluwatade, and Emmanuel Emeka Okafor.
3.25pm - 3.40pm	**Enhancing Carbon (iv) Oxide Adsorption from Flue Gas Mixture at Elevated Temperature Using Composite of Nanoparticles.** Ojong Elias Ojong; Benibo, Preniyobo Diepriye; Dagde, Kenneth Kekpugile; Abam Fidelis.
3.40pm - 3.55pm	**Presentation by Portharcourt Electricity Distribution Company** Edith Imaekhai (PhD)

Day Two: *Friday 27th September, 2024*

TIME	ACTIVITY (OPENING CEREMONY)
08.30am - 08.50am	**Accreditation (Online/Physical)** Organising committee
08.50am - 09.00am	**Opening formalities / Introduction of guests** Mr. Willie Akpan, Master of Ceremony
09.00am - 09.10am	**Welcome Speech** Associate Professor Ogheneruona Diemuodeke, Director Energy Technology Institute, University of Port Harcourt.
09.10am - 09.15am	**Opening Speech** Professor Fidelis Abam Conference Co-Chair and Professor of Mechanical Engineering Covenant University, Nigeria.
09.15am - 09.35am	**Keynote Address :** *"Waste to Energy: Innovative Solutions for Sustainable Development in Africa."* Professor Foluke Ishola
	Group Photographs & Tea Break
9.35am - 10.35am	**Keynote presentation:** "Skilling-up for the Energy Transitions" Professor Emeka Oguzie

TIME	ACTIVITY (PAPER PRESENTATIONS)
	SESSION 1: RENEWABLE ENERGIES *Moderator: Professor Fidelis Abam*
10.15am - 10.30am	**Keynote presentation: "**Renewable Energy Supply for Clean and Affordable Energy Access for all." Dr. Ioannis Tsipouridis
10.30am - 10.45am	**The Potential of Geothermal Energy in Decarbonization and Direct Use Applications.** Dominic Kata, Gatune Julius, Mwiti John, Koroso Lucas, and Kipkorir Victor.
10.45am - 11.00am	**Off-Grid Energy Solutions for Agro-Rural Community Development in Nigeria.** Nwazor Nkolika, Aguni Julius, and Okeke Remigius.

11.00am - 11.15am	**Design and Assessing the Effectiveness of Solar Disinfection Systems in Treating Rooftop Harvested Rainwater for Sanitation and Hygiene Purposes in Rural Maternal Health Facilities.** Desire Clifford Mussa, Mbewe Peter, Mcguigan Kevin, and Christabel Kambala
11.15am - 11.30am	**Simulation and Experimental Performance Analysis of Portable Locally-Made Solar-Powered Cooler for Vaccine Storage** Vicent Marwa Kikohi, Kichonge Baraka, Selemani Juma, and Kivevele Thomas.
11.30pm - 111.45pm	**A Framework for Sizing Solar PV Systems Adaptable to Off Grid Areas.** Kerina Isaac, and Omwenga Vincent.
11.45pm - 12.00pm	**Impact of Protective Devices on Photovoltaic (PV) System Performance and Installation.** Cyril Francis Praise, Adesina Rukayak, and Sall Abubakarr.
12.00pm - 12.15pm	**Optical Characterization of dye sensitized solar cells (DSSCs) using natural dyes obtained from leaves or Dacryodes Edulis, mimosa Pudica, delonyx regia and Xanthosoma Saggittifolium.** Ujoatuonu Amaka Love
12.15pm - 12.30pm	**Assessing the Impact of Generator-Related Air Pollution on Stress Levels Among Printing Press Workers in the UTC Garki Area 10, Abuja: A Generalized Linear Model (GLM) Analysis.** Sammy Joel Panwal
12.30pm - 12.45pm	**Modelling and Optimization of Hybrid Photovoltaic-Wind Turbine with Energy Storage System for Autonomous Electricity Generation.** C.P. Iwundu, E.O. Diemuodeke, J.C. Ofodu

Lunch Break and electric cooking demonstration exhibition/Networking

1.30pm - 1.45pm	**Keynote presentation:** "Improved Architectural Design in enhancing Energy Efficiency." Associate Professor Amina Batagarawa,

SESSION 2: WASTE TO ENERGY

Moderator: Professor Abam Fidelis

1.45pm - 2.00pm	**Microbial Fuel Cell as a source of energy and BOD remover from petroleum wastewater.** Kabo Benedict Jongman, Ayalneh Girum, and Getachew Ayalneh.

2.00pm - 2.15pm	**Comparison of energy recovery from organic waste from human body and primary sludge.** Xumay Bura Hhaygwawu, Achisa Cleophas, and Jacqueline Makatiani
2.15pm - 2.30pm	**Bioelectricity and Biohydrogen Production from Mixed Blackwater/Agricultural Wastes.** G. Plason Zuerkanah Plakar
2.30pm - 2.45pm	**Design and Construction of a Smart Solar-Powered Water Purification Machine.** Ajao, K.R. , Audu, B.H. , Bello, O.M

PANEL SESSION: SCALING E-COOKING SOLUTIONS: *Technological Advances, Market Opportunities, & Policy Support.*

Moderator: Esuuk Ikpokonte

Panelists;

Dr. Helen Osiolo
Research Associate, MECS

Dr. Veronica Akpasoh
CEO, Tovero Energy

Dr. Rihab Khalid
Research Associate, MECS

Abubakar Swarray

END OF CONFERENCE / CLOSING REMARKS BY ENGR. ANTHONY AKPASOH

AICCEES 2024 SPONSORS

ACE FUELS
Africa Centre of Excellence in Future Energies & Electrochemical Systems

The Africa Centre of Excellence in Future Energies and Electrochemical Systems (ACE-FUELS), domiciled in Owerri at FUTO, is a World Bank-funded organisation, set up primarily to fill a growing education skills and information gap in the the field of renewables and other clean energy sources in Sub-Saharan Africa.

The Centre prioritises research and development; knowledge sharing and dissemination; community education; technical skills and development.

ACADEMIC PROGRAMMES:

- MSc/PhD in Future Energies
- MSc/PhD in Corrosion Technology
- MSc/PhD in Electrochemical Technology
- MSc/PhD in Nanotechnology
- MSc in Energy Management and Entrepreneurship

ACE CAPACITY BUILDING ACADEMY

The academy leverages modern technologies and innovations to deliver virtual, in-person, and hybrid capacity development programmes, and provides interactive platforms to facilitate knowledge synthesis among participants.

OUR SHORT COURSES

- Preparing for the Energy Transition
- Fundamentals of Renewable Energy
- Innovations in Renewable Energy
- Leadership Essentials for Energy Professionals
- Entrepreneurship for Sustainable Development
- Climate Change Adaptation
- Starting and Managing an Energy Business
- Workplace Motivation for Energy Professionals

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Transforming Energy Access
LEARNING PARTNERSHIP

The Transforming Energy Access and Learning Partnership (TEA-LP) is an initiative that unites African and Indo-Pacific universities to cultivate professional graduates equipped to drive sustainable energy access across the continent. TEA-LP is part of the broader Transforming Energy Access (TEA) platform, which focuses on research and innovation to support the technologies, business models, and skills needed to achieve an inclusive clean energy transition.

MISSION

Prepare graduates and professionals to lead Africa's transition to sustainable energy for all.

SCOPE

Partnering with 30 universities across Africa and the Indo-Pacific, TEA-LP offers new, first-of-its-kind postgraduate curricula that address the unique challenges of energy access in these regions.

INNOVATION FOCUS

Supports the development of innovative technologies, business models, and professional skills required for an inclusive clean energy transition.

CONTINUED PROFESSIONAL DEVELOPMENT (CPD):

Provides tailored CPD courses to professionals in the energy sector, ensuring ongoing skill development and a highly qualified workforce across Africa.

NETWORK BUILDING:

TEA-LP fosters collaboration across partner universities and energy professionals to create a robust network capable of advancing the clean energy agenda.

WHAT WE OFFER

POSTGRADUATE CURRICULA:

TEA-LP develops and implements specialized postgraduate programs aimed at fostering expertise in sustainable energy.

CPD COURSES:

In addition to formal education, TEA-LP offers professional development courses tailored for those already working in the energy sector.

OUR IMPACT

By equipping both students and professionals with essential skills and knowledge, TEA-LP aims to enable the continent's energy transformation while building a strong network of expertise to support Africa's long-term sustainable energy goals.

Visit us at: **https://tea-lp.org/**

Africa International Conference on Clean Energy and Energy Storage (AICCEES)

A Book of Abstracts submitted in the Second Edition of the Africa International Conference on Clean Energy and Energy Storage (AICCEES) 2024.

This Book of Abstracts is compiled by Tovero Energy Ltd. Some of the research abstracts within this book will be considered for publication in a conference proceedings book series by Trans Tech Publications. The publication will be supervised by highly professional members of an International Editorial Board to ensure high-quality publication material.

PART 1
HYDROGEN DEVELOPMENT IN NIGERIA

Design and Analysis of a Supercritical Metal-water Reactor for Hydrogen Gas Production

IGWE Chijindu Ikechukwu, EZE Paschal Chizuruoke, EZE Miracle Izuchukwu

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Keywords: Clean energy; Hydrogen production; Supercritical metal-water reactor; Sustainable technology.

Abstract: In this study, a supercritical metal-water reactor for hydrogen production was designed, simulated, and analysed. As the world urgently seeks to transition towards sustainable energy, hydrogen stands out as a pivotal solution in this shift. This project aims to fill knowledge gaps related to the transition to supercritical conditions through comprehensive analysis, thereby contributing to the advancement of clean energy technologies. Mechanical and thermal properties suitable for a supercritical metal-water reactor were modelled and simulated in SolidWorks 2022, utilizing plots and mesh results. The reactor was designed to produce hydrogen gas and metal oxide as by-products, with the hydrogen gas being released through a pressure relief valve. The reactor cylinder, made of Ti-6AL-4V, was found suitable for operation at a constant pressure of 25 MPa and a temperature of 380℃. The reactor wall was observed to buckle at pressures exceeding 27 MPa and temperatures above 144,000℃, which are beyond the design conditions. The elastic limit of the cylinder was determined to be 868 MPa, and its ultimate tensile strength was 1,258 MPa, with fracture occurring at 620 MPa. The average damage percentage was calculated to be 0.001%, and the total lifecycle was estimated at 10,000,000 cycles. The integrity of the reactor designed for supercritical states was found to be structurally sound. Detailed insights into the effects of pressure and temperature on the selected material were analysed, enhancing understanding of the reactor's performance under various conditions.

A Two-Parameter Computational Thermodynamic Analysis of Hydrogen-Impurity Mixtures in a Repurposed Pipeline

Yakubu Khartum Abubakar, Binfa Bongfa, Elijah Binfa Bongfa, Muhammed Shaibu, Ahmad Muhammad Zumami

Department of Mechanical Engineering, The Federal Polytechnic P.M.B 1037, Idah, Kogi State, Nigeria.

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Department of Computer Science, The Federal Polytechnic P.M.B 1037, Idah, Kogi State, Nigeria

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Keywords: A two-parameter thermodynamic analysis, hydrogen impurity, repurposed pipeline, Peng-Robinson, hydrogen transportation, non-destructive acoustic emission.

Abstract: In this study, a two-parameter computational thermodynamic analysis of a hydrogen-impurity mixture in a repurposed pipeline was performed. The hydrogen purity is a vital aspect of the hydrogen value chain, and it is essential to constantly monitor its purity. We anticipate that refineries will use repurposed pipelines for bulk hydrogen transportation to consumers; however, these pipelines are known to contain impurities. Therefore, there is a need for such an analysis. This study considered two basic thermodynamic parameters: the pressure and gas molar concentration. The Peng–Robinson equation of state was used for the analysis. We implemented octave programming for the Newton-Raphson numerical scheme to obtain the molar volume of the pure hydrogen. Four scenarios were considered: scenario 1 (only hydrogen), scenario 2 (hydrogen mix with H2S), and scenario 3 (hydrogen mix with H2S, and pentane), and scenario 4 (hydrogen mix with H2S, pentane, and propane). We studied the variation in gas pressure with molar concentration. The results showed that, as the number of impurities considered in the analysis increased, the pressure decreased. The pressure of scenario 1 and 2 is approximately Pa, scenario 3 is around Pa, and scenario 4 is around Pa. We can develop a non-destructive acoustic emission hydrogen quality monitoring system by considering how impurities in hydrogen moving through a repurposed pipeline might affect the pressure of the gas moving through the pipeline.

Development and Evaluation of an Alkaline Electrolyzer for Production of Hydrogen and Electrical Energy in a Fuel Cell

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Keywords: Alkaline, Electrolysis, Electrolyzer, Hydrogen, Water.

Abstract: In this study, a single-cell, zero-gap, unipolar alkaline water electrolyzer which operates on a 30 wt.% KOH electrolyte solution was developed for production of hydrogen. Suitable material properties such as density, toughness, electrical conductivity, and corrosion resistivity were evaluated in Ansys Granta 2019 with the aid of material property charts; and thermal and stress simulations of the modelled components performed using Autodesk Inventor Nastran 2019. A DC power source supplied voltages below 3.0 V across the nickel electrodes, maintaining an operating temperature of 50 oC, and operating pressure at 0.1 MPa. The electrolytic process produced hydrogen and oxygen gases at the electrodes, and the membrane performed the gas separation. Polytetrafluoroethylene plastic was experimentally found to be a superior and more suitable material for the electrolyzer endplates and spacers to polypropylene plastic. Polypropylene nonwoven geotextile fabric was also found to be a low-cost and efficient membrane material, against Zirfon Perl UTP 500 membrane which is an efficient but expensive industrial membrane; polyester geotextile fabric got corroded after about 24 hours of good service. The optimal performance of the electrolyzer cell was obtained at a cell voltage of 2.2 V and a current of 1.30 A, while producing 14 ml of hydrogen gas per minute. This performance gave an electrolysis efficiency of 55.6%, an energy efficiency of 67.3%, and a hydrogen production efficiency of 75.4%. The produced hydrogen and oxygen gases generated electrical energy in a reversible PEM fuel cell device which powered a 0.2 W DC electric motor for a minute.

Full Spectrum- driven photocatalytic hydrogen production using Fe-doped TiO2-MoS2 Nanocomposites

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Keywords: Water splitting, green hydrogen, full spectrum, Fe-doped, TiO2-MoS2, renewable energy, sustainability.

Abstract: The development of efficient and sustainable methods for hydrogen production is crucial for transition to a renewable energy future. In this ongoing research, we will explore the potential of full spectrum driven photocatalytic hydrogen production using Fe-doped TiO2-MoS2. By leveraging the unique properties of this novel material, we aim to harness energy from the entire solar spectrum to drive hydrogen evolution reactions. Fe-doped TiO2-MoS2 composites have been successfully synthesized using impregnation and solid state approaches respectively. Our preliminary results show that Fe-doped TiO2-MoS2 exhibits enhanced photocatalytic activity and stability under full spectrum illumination, outperforming traditional TiO2-based photocatalysts. The incorporation of Fe dopants and MoS2 is expected to enhance the material's ability to absorb visible and infrared light, increasing hydrogen production rates. This research has significant implications for the development of scalable and efficient photocatalytic hydrogen production systems, offering promising solution for renewable energy storage and conversion. This ongoing study focuses on optimizing material synthesis, characterization, and reactor design to further improve hydrogen yield and overall system efficiency.

PART 2
ENERGY EFFICIENCY AND SMART SYSTEM

Energy efficiency,cost-saving opportunities and nearly zero emissions analysis in the residential sector.

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Keywords: Energy efficiency, nearly zero emission, cost-saving opportunity, renewable energy, Ghana, Nigeria.

Abstract: This study evaluates the energy efficiency, cost-saving opportunities and nearly zero emissions for the residential sectors of Ghana and Nigeria, focusing on three household appliances: fridges, freezers and bulbs. It analyses the integration of renewable energy systems in residential households, comparing energy-efficient and non-energy-efficient scenarios in both countries. The study uses field data, existing data on RETScreen software and analytical methods to examine the energy consumption patterns of key household appliances and their impact on renewable energy system design, cost, and emissions reduction. As for the energy consumption patterns, Ghana showed higher daily usage of household appliances, with longer operational hours for fridges and freezers averaging 20.3 hours/day, while Nigeria had lower daily usage, averaging 11.8 hours/day for similar appliances. For Nigeria, the annual electricity cost in the non-energy-efficient scenario is approximately 109.69 USD, while for energy-efficient households, the cost is reduced to 79.31 USD. In Ghana, non-energy-efficient households spend around 379.97 USD annually, compared to 317.55 USD for energy-efficient homes. The results highlight the significant cost-saving opportunities of adopting energy-efficient technologies. This higher energy demand in Ghana and its higher electricity tariffs lead to greater overall consumption and higher costs. Despite similar appliance wattages, Nigeria's lower tariff results in comparatively lower energy expenses. Using the energy consumption patterns for both countries under the energy-efficient and non-energy-efficient scenarios, system sizing for solar PV and battery storage was conducted to know the economic viability of renewable energy integration through Levelized Cost of Energy (LCOE) and Net Present Value (NPV) assessments. In both scenarios, the payback period for solar PV and battery systems in Nigeria is 22 years, making it not economically viable under current electricity tariffs. In contrast, Ghana shows a payback period of 10.3 years, making solar PV systems financially viable. The RETScreen simulation examined two important scenarios for energy efficiency in Nigeria and Ghana: compact fluorescent lamps (CFLs) as the baseline and LED lighting as a proposed alternative. The results show different GHG (greenhouse gas) reduction equivalences for the number of automobiles that are not driven, the number of individuals who cut their energy use, the number of hectares of forests that absorb GHG, etc. The study's conclusions highlight the significance of energy efficiency in lowering overall energy usage, tariff rates, and expenses associated with solar and battery systems. The results have also provided more insights for both countries to create more comprehensive policies that will encourage adopting energy-efficient practices and make it cheaper for homes to integrate and use renewable energy systems.

Use of Natural Rocks as Heat-Storage Materials for Food Drying Applications in Sub-Saharan Africa

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Abstract: The development of affordable solar thermal energy systems for residential and commercial use stands out as one of the best ways to lower the costs of energy consumption and the reliance on solar energy, which is intermittent. Natural rocks are becoming an attractive alternative for thermal energy storage systems in sub-Saharan Africa due to their low cost and accessibility. This study review research on natural rocks that are used in Sub-Saharan Africa as heat storage materials for food drying applications. The findings of this study indicate that current research on the combination of drying systems with thermal energy storage systems using natural rocks as storage material focuses on indirect solar dryers (66.67%), mixed mode solar dryers (16.67%), and solar-assisted heat pump dryers (16.67%). These dryers perform admirably, particularly in extreme weather conditions and when there is no sunlight, such as at night. According to the results using a natural rock as storage medium can increase dryer's efficiency up to 17.48%, reduced drying time up to 50%, and extend drying operation from 2 to 4 hours after sunset. Furthermore, the study highlight areas that require additional research, with a particular focus on the characterization of the storage materials used, which is underrepresented in most studies on the continent. In addition, the techno-economic analysis of all these dryers is neglected, making it difficult to assess the economic impacts of these technologies and facilitate their adoption in communities. Exergoeconomic analysis should also be carried out in order to facilitate optimization and understand the actual efficiency of these dryers.

Performance Analysis of a Photovoltaic System with Thermoelectric Generator and Phase Change Material; An Experimental Approach

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Keywords: Photovoltaic panel, Thermoelectric generator, Phase change material, Experimental analysis, Electrical efficiency.

Abstract.: This study explores the integration of thermoelectric generators (TEGs) and phase change materials (PCMs) to enhance the efficiency of photovoltaic (PV) panels in high-temperature conditions. An AP-PM-20 Polycrystalline PV panel, SP-1848-27145 Bismuth Telluride TEG, and paraffin wax PCM in an aluminum container were used. Four configurations were tested: standalone PV, PV-PCM, PV-TEG-PCM, and PV-PCM-TEG, under identical conditions from 10:30 AM to 6:00 PM at 25-minute intervals. Data on PV and TEG voltage, current, and solar irradiance were collected and analyzed.

The results show significant performance improvements: the PV-PCM configuration boosted power output by 68.04%, while PV-PCM-TEG and PV-TEG-PCM configurations improved efficiency by 43.06% and 37.51%, respectively. Efficiency gains relative to the standalone PV system were 33.33% for PV-PCM, 25.76% for PV-PCM-TEG, and 21.21% for PV-TEG-PCM, demonstrating the effectiveness of PCMs and TEGs in enhancing PV performance.

Energy auditing for University energy management: A tool for enhancing sustainability

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Keywords: Energy audit, energy monitoring, power consumption, sustainability, efficiency

Abstract: Universities are significant energy consumers, and effective energy management is important for sustainability and cost reduction. This article explores the role of energy audits in helping universities improve their energy management and sustainability practices. It analyzes research from 2010 to 2024 to identify various energy auditing techniques, tools, and methodologies used by different institutions. The article demonstrates how diverse auditing approaches can uncover energy inefficiencies and propose practical solutions. Key findings indicate that thorough energy audits are important for promoting sustainability goals through improved energy efficiency and waste reduction. However, universities face challenges in implementing audit recommendations due to infrastructure limitations and technological constraints. The review emphasizes the essential role of energy auditing in enhancing both environmental and economic performance and underscores the importance of ongoing innovation and adaptation in energy auditing practices. In conclusion, the article suggests exploring new technologies and improving auditing techniques to better support sustainability efforts in universities.

Design and Construction of a smart solar-powered water purification machine

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Abstract: This work presents a solution to the problem of consuming contaminated water in developing nations such as Nigeria, which is blessed with abundant sunlight, by designing and constructing a smart solar-powered water purification machine. The water purification machine employs a six- stage reverse osmosissystem incorporating a single-stage RO membrane arrangement. The machine also incorporates sensor and IoT technology, enabling it to self-operate and detect deviations from expected water quality. Water samples from a well and stream in Tanke, Ilorin, Nigeria, were taken.Samples before and after the purification were taken to the Laboratory to test important water quality parameters. Results obtained were within <600ppm for TDS, 6.5 - 8.5 for pH, <5 NTU for turbidity, <600 mg/L for salinity, <500 mg/L for water hardness, <2500 µS/cm for EC, >6.5 mg/L for DO,

and 30 - 400 mg/L for total alkalinity, values of which were sourced from WHO and other international bodies that established standards for drinking water quality. The machine's output was determined to be 8 litres/hour, and the ratio of purified water to concentrate was 1:3, signifying a reasonable rate of purified water production.

Energy Optimization Of Wireless Body Area Network(WBAN) Using TDMA Duty Cycling And Thermal Energy Harvesting

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Keywords: Wireless Body Area Network (WBAN), Energy Harvesting, TDMA, Duty Cycling, Energy Harvesting, Thermoelectric Harvesting

Abstract: Energy Harvesting Is An Effective Technique For Optimizing Wireless Body Area Network (WBAN) Devices Used In The Delivery Of Continuous Healthcare Services To Patients. Constraints In Power Associated With WBAN As A Result Of Storage Limitations Have Prompted The Study Into Means Of Scavenging, Harvesting And Utilizing Available Energy Sources. In This Paper, Energy Optimization Of WBAN Using TDMA Duty Cycling And Thermal Energy Harvesting Is Proposed. The Proposed Model Aims To Enhance Energy Efficiency In A Wireless Body Area Network (WBAN) By Using Time Division Multiple Access (TDMA) And Thermoelectric Harvesting (TEH) Techniques. At The Heart Of This Model Is An IoT Controller Which Runs On A Single-Sensor Activation Principle At All Times, Controls The Sensor Function And Stores The Sensor Data In Its Internal Memory (Buffer), Enabling Efficient Data Management And Transfer, Guaranteeing That Just One Sensor Is Turned On When Data From That Sensor Is Required. Implementing The TDMA Duty Cycle Guarantees That Sensor Nodes Are Enabled And Powered Only When Necessary, Reducing Idle Time And Saving Energy. The TDMA Scheduling Ensures That Multiple Sensors Are Engaged In A Coordinated Manner, Reducing Network Collisions And Contention, Hence Contributing To Energy Savings Which Is Critical To Our Energy Optimization Plan. The Proposed Optimization Model Shows A 52.40% Improvement In The Energy Conversation Of The WBAN Device, Thus Increasing The Battery's Useful Life By More Than 50%.

PART 3
MINI-GRIDS AND HYDROPOWER DEVELOPMENT

Assessing the Viability of Mini-Grids in Rural Electrification: Overcoming Challenges and Exploring Sustainable Business Models

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***Keywords**: Mini-grids, rural electrification, Energy access, Solar, Renewable energy*

Abstract: In a world where approximately 733 million people lack electricity, the urgency for sustainable energy solutions is paramount. The COVID-19 pandemic has exacerbated the challenge of reaching isolated and vulnerable populations, threatening the goal of universal power access by 2030. Solar mini-grids stand as a beacon of hope, capable of delivering consistent, high-quality electricity to nearly 500 million individuals in regions bereft of power infrastructure. This paper evaluates the economic viability, technological advancements, and challenges hindering the scalability of solar mini-grids. Despite the World Bank's commitment of $1.4 billion across 30 countries, the current pace suggests that only 44,800 new mini-grids, serving 80 million people, will be established by 2030. The deployment rate of solar mini-grids has accelerated, with installations per country rising from 50 in 2018 to over 150 currently. The cost of electricity from these grids has decreased from $0.55 per kWh in 2018 to $0.38 per kWh, enabling the operation of transformative electrical devices. The paper emphasizes the importance of solar mini-grids in reducing CO2 emissions and proposes actionable recommendations for stakeholders to accelerate deployment. To align with Sustainable Development Goal 7, the paper advocates for the integration of mini-grids into national electrification strategies and innovative financial solutions to mitigate risks. Achieving universal access to power by 2030 will require significant investment and strategic partnerships to bridge the energy divide. Future research directions include exploring new business models to harness the full potential of solar mini-grids and enhance their impact on global electrification efforts. This paper adopted a mixed-methods approach, combining qualitative and quantitative research methods to provide a comprehensive understanding of the potential of mini-grid in rural regions to improve energy access and global electrification efforts. Examining existing rural mini-grid projects through in-depth case studies to understand implementation processes, socio-economic impacts, and challenges faced. Review national and regional policies, regulations, and incentives related to off-grid solar energy deployment to identify gaps and opportunities for improvement. Using economic and business modeling techniques to assess rural mini-grid projects' financial viability and cost-effectiveness, including return on investment and income generation potential.

Mini-grid Sustainability Framework and its Application to Selected Mini-grids in Kenya

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Keywords: sustainability indicators; mini-grids; qualitative data; performance comparison.

Abstract. This paper presents an indicator-based framework for the sustainability analysis of mini-grids and applies this to a selection of mini-grids in Kenya. Although various frameworks exist, they have been criticised for lack of attention to long-term perspectives, high data needs, prescriptive nature of the attributes and limited user-friendliness. Considering that data availability is a major concern and that data available is qualitative in nature, this paper proposes a set of indicators and a scoring system that can be used with a broad qualitative understanding of the sustainability attributes of the mini-grids. The paper first presents the framework and the scoring system and applies this to the data gathered from the fieldwork in Kenya. The results indicate that the significant variation in sustainability performance of the mini-grids covered and the performance is relatively poor in social, institutional and environmental dimensions.

Decarbonisation of the transport sector of Ghana using autogas

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Keywords: CNG, clean mobility, LPG, mathematical model

Abstract: Decarbonisation is instrumental in attaining sustainable mobility. To actualize the Ghana Nationally Determined Contribution (NDC) set emission reduction target of 15% relative to BAU scenario by 2030, sustainable transport actions should be encouraged. Thus, promoting the use of LPG and CNG in automobiles is very crucial to ensure efficient and green mobility. Nonetheless, existing policies in Ghana overlook autogas (LPG/CNG) as prospective decarbonizing solution in the transport sector. The study employed survey analysis and analytical modeling approach to elicit the benign effects of autogas in the transport sector. The ecological, economic and social dimensions of autogas were expatiated to extrapolate effective measures to facilitate the smooth implementation of the technology. Survey was carried out in the central business district of Accra to attain the percentage of autogas and gasoline used by taxis operators for the first time per author's knowledge. From the survey, 14% of taxis were powered with LPG whilst 86% were gasoline, however, the LPG-powered taxis were retrofitted gasoline engine vehicles. The analytical model was based on physics principles involving three resistance forces- aerodynamic, rolling resistance and inertia. CO2 emission savings of 29% and 18.4% were elicited from the use of CNG and LPG relative to gasoline fuel at the end of the simulation using the ambient conditions in Ghana. Thus, use of autogas will limit global warming impact and aid the country to fulfill its pledged emission target by 2030.

The government is entreated to regulate autogas use in the transport sector and increase its patronage by promoting flexible policies like meager custom duty on imported CNG/LPG vehicles as well as tax credits.

PART 4

ENERGY STORAGE AND SUSTAINABLE BATTERY MANUFACTURING IN AFRICA

Comprehensive Investigation Of High-Performance Green-Synthesized $NaTi_2(PO_4)_3$ Nanocomposites For Advanced Electrochemical Energy Storage Applications

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Keywords: NaTi2(PO4)3/AC nanocomposites, energy storage materials, high-performance electrodes, sustainable energy, next-generation supercapacitor electrodes

Abstract: This study investigates a new class of high-performance energy storage electrode materials: NaTi2(PO4)3/AC nanocomposites. Through a comprehensive characterization approach, the study meticulously analyzes the crystal structure, morphology, elemental composition, and electrochemical behavior of these nanocomposites to unlock their potential for energy storage. conductivity, explained by the existence of Ti 3d orbitals in proximity to the Fermi level. . XRD analysis confirms the successful formation of the composite, revealing distinct peaks characteristic of non-layered activated carbon and crystalline NaTi2(PO4)3. Notably, specific diffraction peaks at 2θ values of 15.3°, 18.3°, 25.3°, 27.6°, 37.8°, 47.3°, and 54.0° corroborate the crystallinity of the NaTi2(PO4)3 phase. Electrochemical characterization conveys that this nanocomposite demonstrates excellent rate capability, retaining 90% of its capacitance even after 3500 cycles, while providing a high 89 Wh kg−1 density of energy across a remarkable power density of 231 W kg−1. Density functional theory (DFT) analysis indicates that the $NaTi_2(PO_4)_3$ nanoparticle is a favorable candidate applied in energy storage owing to its combined mechanical stability and good electronic. Examination of the density of states reveals positive overlap populations between Na-O, Ti-O, and P-O bonds, suggesting strong ionic and covalent bonding, aligning with oxygen 2p and phosphorus 3p orbitals dominating the valence band. In contrast, titanium 3d orbitals contribute to the conduction band, emphasizing robust bonding and good conductivity in the material. These exceptional combined properties position this novel material as a strong candidate for next-generation energy storage applications.

Modelling and Optimisation of Integrated Renewable Energy Conversion Technologies with Dual Energy Storage for Island

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Abstract: This work presents the modelling and optimisation of a hybrid solar PV-Wind-Biomass energy system for Patani island in Delta State. The hybrid system has dual energy storage technologies, namely a battery bank and hydrogen tank. A mathematical model was developed to describe the integrated system and a genetic algorithm was used to formulate the optimisation scheme to balance the energy demand, generation and battery and hydrogen energy storage. Economic models were developed to ascertain the techno-economic feasibility of the hybrid plant. The mathematical model and the optimisation scheme were implemented in high-fidelity software, MATLAB®, and the post-processing of the results was done on the MS Excel® platform. The preliminary results showed that the peak rated power of PV, WT and Biomass required to satisfy the energy demand of Patani island are 15.619 MWh, 0.012MWh and 4794.24MW, respectively. The minimum storage capacity of the battery and hydrogen was estimated at 11.033 MWh and 15.11MWh. The value of 0.45 $/kWh was obtained for the levelised cost of energy (LCOE), while the loss of load probability of the proposed energy system was estimated at 0.1086. Going forward, sensitivity analysis, validation, simulation, advanced economic analysis and policy pathway will be done to satisfy the objectives of the project.

PART 5
ENERGY ACCESS AND ENERGY SUPPLY IN AFRICA

Hybrid Renewable Energy Systems (HRES) for Nigerian Airports: An Economic Feasibility and Stakeholder Insights Assessment

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Keywords: Economic Viability, Hybrid Renewable Energy Systems (HRES), Levelized Cost of Energy (LCOE), Nigerian Airports, Stakeholder Perceptions

Abstract: Due to high electricity costs and unstable national grid power supply, Nigerian airports are challenged with issues that call for the deployment of sustainable and alternative energy sources. The economic viability of hybrid renewable energy systems (HRES) in airports as a sustainable substitute to the national grid is investigated in this study, along with stakeholder perspectives of HRES. Based on a survey conducted among 252 stakeholders in 12 Nigerian airports , the study investigates the implicit high energy costs and varying interest in HRES installations as common problems.

Descriptive and inferential statistics were used in the data analysis, and the results showed that although stakeholders are aware of the long-term cost-saving potential of HRES, clear lifecycle cost evaluations are hampered by concerns about early investment costs and a lack of data on the existing HRES installations. Interest in HRES installations is influenced by variables including potential cost savings and instability of the national grid, but then HRES adoptability are likewise influenced by other factors.

Predictive Modelling for Optimizing Wind Turbine Performance and Structural Health Monitoring: Adapting Turkish SCADA Data for Sub-Saharan Africa

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Keywords: Wind Turbine; Predictive Modelling; Structural Health Monitoring; XGBoost Algorithm; Machine Learning.

Abstract: This research investigates the application of AI-enhanced structural health monitoring (SHM) systems to predict and optimize the performance and reliability of wind turbines in Sub-Saharan Africa power generation. Supervisory Control and Data Acquisition (SCADA) systems data from a Turkish wind turbine were leveraged to develop a predictive model using the eXtreme gradient boosting (XGBoost) algorithm. Wind speed data from the Turkish wind turbine was substituted with wind speed data of some selected locations in Sub-Saharan Africa (Katsina, Nigeria; Addis Ababa, Ethiopia; Dakar, Senegal; and Cape Town, South Africa). The performance of the models was evaluated using Mean Absolute Percentage Error (MAPE) and the coefficient of determination (R^2). The findings show a 0.95% decrease in predicted power output for all the selected locations. The adapted model achieved a MAPE of 1.1% for Addis Ababa, 1.25% for both Cape Town and Katsina, and 1.17% for Dakar, while achieving a high R^2 of 0.96 for all the locations, indicating high predictive accuracy. In scenarios with high wind speed, Dakar has the highest prediction of 3691.09kW, achieving a 1.03% increase compared to Turkey with a predicted power output of 3583.69kW. Cape Town achieved better prediction accuracy, with a MAPE of 0.78% and R^2 of 0.98, while yielding a power output of 3545.67 kW. This study shows there is vast potential for employing machine learning models in enhancing the operational efficiency of wind turbines. Future study is recommended to incorporate local SCADA data across different wind farms in Sub-Saharan Africa.

Enhancing Carbon (iv) Oxide Adsorption from Flue Gas Mixture at Elevated Temperature using Composite of Nanoparticles

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Keywords: Adsorption, CO2, flue gas mixture, elevated temperature, chitosan/clay nanoparticles.

Abstract: Chitosan/clay materials from periwinkle shells and clay soil at a 50:50 ratio was made adsorbent and characterized, used for the adsorption of CO2 from flue gas at elevated temperatures (500C - 5000C) in a fixed bed column (length 1.5m, and internal diameter 0.02m). Flue gas with composition of Methane (0.003), Ethane (0.002), Hydrogen (0.05), CO2 (0.15), Water Vapour (0.02), and Nitrogen (0.76), of pressure 49KPa, temperature of 5000C, and flow rate of 75min/L from the exhaust tank; enters the fixed bed column for the adsorption process where the adsorbent is already placed. The results of the characterization of the adsorbent showed that 5.283nm, 2.64nm, 434.7m2/g, 704.2m2/g, 0.202cc/g, and 56.73% were best the values for the adsorbent' pore width, pore diameter, microspore surface area, pore volume, and porosity, obtained using Dubinin-Raduskevich (DR), density functional theory (DFT), hydraulic diameter (DH), Langmuir, DH, and scanning electron microscope (SEM) analysing techniques respectively. The Fourier transform infrared (FTIR) Spectrum showed the presence of halogen (C-Cl), 20 alcohol (C-O), Nitro (N-O), and amine (N-H) compounds in the nanoparticles, revealing a strong affinity for CO2 particles in the flue gas. Another analysis showed the presence of elements (Ca, Si, Al, and Sr) in high compositions (0.470, 0.202, 0.186, and 0.092, respectively), revealing that the adsorbent is resistant to high temperatures. X-ray diffraction (XRD) analysis of the adsorbent gave Ca (OH)2, CaCO3, and TiO2 with compositions of 0.78, 0.19, and 0.026, respectively which revealed the strong affinity of the adsorbent for CO2. The Surface morphology of the adsorbent revealed that the surface was very rough and contains variety of pores or holes with wide capacities, indicating that more CO2 was captured and accommodated within the surface. Thermal analysis using the Barrett-Joyner-Halenda (BJH) method revealed that the adsorbent could withstand high temperatures up to 9000C, at this temperature, the adsorbent is only about 18% of the amount that enters the fixed-bed column for adsorption, but 100% of it can remain in the process for temperatures ranging from 00C - 3000C. Finally, it was revealed that 95% of CO2 was adsorbed at the maximum value for the temperature (500C - 3500C), time (0.5 - 5hr), and bed height (1 - 6cm).

PART 6

RENEWABLE ENERGY SYSTEM

Harnessing Geothermal Energy for Decarbonization and Sustainable Agricultural Development using Geotto

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Keywords: Geotto, Internet of Things (IoT), HMI, PID, Geothermal Energy, Decarbonization, Artificial Intelligence (AI)

Abstract: In this paper, the cases of the use of geothermal energy are considered from the perspective of their relevance to the concept of the decarbonization of the economy efficiency, reliable, and continuous sources of energy. It presents Geotto, a comprehensive geothermal system that combines IoT, AI, and smart heat exchangers for agricultural and industrial demands. The project, already implemented in the pilot scale in the Eburu community of Kenya by using geothermal powered poultry incubation, proves the applicability of geothermal energy in crop drying, greenhouse control, and fish farming. Although this idea has attractive economic and environmental benefits, it has some technical and logistical problems such as policy limitation and lack of funds. This paper examines these challenges while portraying possibilities for future advancements, growth, and applicability in other areas of Kenya and even beyond. Through the analysis of Geotto's case, the paper emphasizes the importance of geothermal energy for the sustainable development and encourages other countries to replicate it in order to contribute to the process of decarbonization and stimulation of economic growth.

Off-grid energy solutions for Agro-rural community development in Nigeria

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Keywords: Off-grid Energy, Agro-Rural Community, Renewable Energy, Biomass Energy Hydro Energy, Solar Energy.

Abstract: Nigeria fondly regarded as the 'Giant of Africa" is the most populous country in Africa and the largest economy on the continent. However, despite the abundance of renewable energy means, Nigeria has been identified as a country with the largest energy access deficit in the world. This study therefore sought to elucidate various off-grid renewable energy opportunities that could be harnessed to engender rural electrification. The study specifically adopted exploratory research methodology to investigate the current state of the energy infrastructure of Agro-rural communities in Nigeria and identify off-grid energy solutions suitable for agro-rural communities and the potential impact of these solutions on community development and agricultural productivity. This study demonstrates that off-grid renewable energy solutions; solar, biomass, hydro and wind technologies are cost-effective alternatives to traditional energy sources that have the potential to significantly enhance agro-rural community development in Nigeria.

Design and Assessing the Effectiveness of Solar Disinfection Systems in Treating Rooftop Harvested Rainwater for Sanitation and Hygiene Purposes in Rural Maternal Health Facilities

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Keywords: SODIS, Solar UV radiation, Total coliform, Escherichia coli, Water quality

Abstract: Malawi is one of the Sub-Saharan African countries with abundant solar energy resources. Solar energy has been used for electrification, water pumping, and domestic water heating in rural and urban communities. However, the productive use of solar energy for disinfecting water is not fully utilised despite being an eco-friendly solution to achieve the Sustainable Development Goals on clean water and sanitation. The productive use of sustainable energy has the potential to supplement Malawi's government and the United Nations' efforts to accelerate universal access to affordable and clean energy, water, and sanitation. The United Nations' efforts to achieve the 2030 agenda on universal access to sustainable energy, clean water, and sanitation require affordable and environmentally friendly solutions that are socio-economically viable and easier to get. Several rural communities in the country do not have access to disinfected water. More than 85% of Malawi's population stays in remote rural areas where the majority depend on untreated water that can compromise their health. This study aimed to enhance the conventional rooftop harvested rainwater Solar Disinfection (SODIS) method to be more effective and dependable for public health facilities in Malawi and other nations worldwide. The study accomplished the 0 MPN/100 ml E. coli and 0 MPN/100 ml Total coliform water disinfection using solar UV radiation. Despite the focus on clean water for sanitation and hygiene in maternal health facilities, the study results achieved the water quality recommended by WHO's and MBS's drinking water standards.

Simulation and Experimental Performance Analysis of Portable Locally-made Solar-powered Cooler for Vaccine Storage

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Keywords: poor vaccine storage, remote areas, optimum insulation, solar-powered cooler.

Abstract: Poor storage conditions, such as exposure to extreme temperatures, compromise vaccine efficacy, rendering them ineffective or harmful. This underscores the critical need for robust storage infrastructure and monitoring systems to ensure vaccine integrity, especially in remote areas with limited access to healthcare resources. This study analyzes the performance of a locally-made solar-powered cooler for vaccine storage in remote areas. Key findings include a reduction in temperature to -14.9℃ within 180 minutes, outperforming previous models. These results highlight the cooler's effectiveness in maintaining vaccine efficacy in resource-constrained environments. The study meticulously examined factors such as pressure within the cabinet, velocity flow, temperature distribution, optimum insulation thickness, and battery discharge rates through computational fluid dynamics (CFD) simulations and experiments. The experimental results, rigorously validated from the open literature, are reliable and accurate. The literature results reported that a minimum temperature of -10 ℃ was reached after 144 minutes compared to the current experimental results, which took 140 minutes at the same minimum cooling temperature. However, the experimental results reached a minimum cooling temperature of -14.9 ℃ after 180 minutes. Furthermore, the optimum insulation thickness was 0.07 m of cooling temperature -15 ℃ of polyurethane insulation material compared to 0.129 m of the Feather Fiber, equivalent to a 45.7% increase at 42 ℃ ambient temperature. Similarly, for the ambient temperature of 32℃ of the same cooling temperature, the polyurethane has the lowest thickness of 0.066 m compared to Feather Fiber, which has a thickness of 0.117, an increase of 43.6%. Meanwhile, modeling results give guidance for the experiments and comparison results successfully.

A Framework for Sizing Solar PV Systems Adaptable to Off Grid Areas

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Keywords: Solar Photovoltaic (PV), Sizing, Framework, Off grid

Abstract. Solar PV sizing is the process of determining the quantity and capacity of solar PV system components to meet a given energy demand. This process is needed to ensure that the components are not undersized resulting in insufficient energy or oversized increasing the system cost. There are several solar PV sizing frameworks currently in use in the market such as intuitive, numerical, and analytical frameworks. However, these frameworks have neglected some key adaptability factors unique to off-grid areas such as the ability of the household to pay, the roofing structure, and the ability of the system to be relocated. This neglect has seen development of solar PV systems that are beyond the budget of most households in off-grid areas and with specifications that technically inhibit their effective use in the off-grid setup. Therefore, for enhanced adaptability, there is need to develop a new solar PV sizing framework that considers the unique adaptability factors of off grid areas.

This study identified these unique adaptability factors and investigated how they influence the size of a solar PV system. Through the modification of the existing numerical sizing framework, these adaptability factors were integrated in the sizing process within the context of this study. It was established that by integrating these factors, the resultant PV systems were more adaptable to off-grid areas in terms of cost, mobility, durability and reliability.

Optical Characterisation of Dye Sensitized Solar Cells (DSSCs) Usin Natural Dyes Obtained From Leaves of Dacrodes Edulis, Mimosa Pudica, Delonyx Regia and Xanthosoma Saggittifolium

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Keywords: DSSC, Titanium dioxide, efficient sensitizers, Solar Cell Efficiency.

Abstract: Dye sensitized solar cells (DSSCs) using TiO2 as a semiconductor material and natural dyes as sensitizer from dacryodes edulis, mimosa pudica, delonyx regia and xanthosoma saggittifolium leaves are successful produced. Photovoltaic parameters such as short circuit current density Jsc, open circuit voltage Voc, fill factor FF, and overall conversion efficiency for the fabricated cells were determined under 100 mW/cm2. The results showed efficiencies of 0.01% (ff = 0.460, Jsc = 0.62mA/cm2 and Voc = 0.372V) for dacryodes edulis, = 0.05% (ff = 0.343.Jsc = 0.05mA/cm2 and Voc = 0.258V) for mimosa pudica, (ff = 0.586, Jsc = 0.196mA/cm2 and Voc = 0.483V) for delonyx regia and (ff = 0.348, Jsc = 0.084mA/cm2 and Voc = 0.385V) for xanthosoma saggittifolium. We have successfully showed that the DSSC using these four dyes as a dye sensitizer are useful for the preparation of environmental friendly and low-cost DSSCs.

Assessing the Impact of Generator-Related Air Pollution on Stress Levels Among Printing Press Workers in Abuja, Nigeria: A Generalized Linear Model (GzLM) Analysis.

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Keywords: Air Pollution PM2.5, PM10, Stress, Energy Poverty, Nigeria.

Abstract: The impact of air pollution on public and environmental remains huge burden in Nigeria that has not been properly addressed. Poverty energy supply has further exacerbated the current situations making business to rely on generators for energy power supply. This study aims to assess the impact of generators-induced air pollution on stress levels among printing press workers in a specific setting Abuja.

This cross-sectional designed was adopted to conduct this study among printing press workers who use generators in Abuja. A total of 508 workers were selected using simple random sampling. Data on stress levels were collected using a validated perceive stress scale (PSS) 10 item scale, while exposure to air pollution from generators was assessed through on-site air quality monitoring device. A Generalized Linear Model (GLM) was employed to analyze the relationship between generator-related air pollution and stress levels, adjusting for potential confounders. Statistical analysis was performed using SPSS version 27, with significance set at $p < 0.05$. Results, shows that the mean PSS 10 scale was: >25.90 (SD 4.35), a bivariate correlation analysis indicates statistically significant positive correlation between the air pollutant variables and perceive stress, p-value 0.001. A GzLM analysis show that; In model 1, the air pollutant variable was found to have a significant positive effect on stress scale (PM2.5: $\beta = 1.029$ (95% CI; 1.024 -1.034)). In model 2, both the two air pollutants PM2.5 and PM10 were found to be significantly associated with increase in stress levels (PM2.5: $\beta = 1.568$ (95% CI: 1.397 – 1.759)) and (PM10: $\beta = 1.336$ (95% CI: 1.202 – 1.486)) separately. Contrary to model 1 and 2, most of the variables model 3 were not statistically significantly associated with increase in log odds higher perceive stress, except for PM2.5 which was adjusted In conclusion, this study demonstrates statistically significant association between air pollutants and stress scale. The findings highlighted the importance of addressing energy policy issues and air quality concerns as potential factors affecting stress and mental health.

Modelling and optimization of hybrid photovoltaic-wind turbine with Energy storage system for autonomous electricity generation

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Keywords: renewable energy, hybrid energy system, optimization, african vulture optimization algorithm

Abstract: The integration of renewable energy sources, such as photovoltaic (PV) and wind turbines, has gained significant attention due to the growing demand for reliable and clean energy solutions. This paper presents a comprehensive modelling and optimization approach for hybrid PV and wind turbine systems to maximize system performance at the same time minimizing cost and surplus energy. The proposed model incorporates detailed mathematical formulations that capture the interactions between PV modules, wind turbines, and the storage system which is a battery energy storage system (BESS). The model also considers economic factors and methods to reduce the surplus energy of the system. The optimization scheme utilized the African vulture optimization algorithm (AVOA). The AVOA is a nature-inspired meta-heuristic algorithm created based on the hunting patterns of African vultures. In addition, the AVOA was constructed to handle a multi-objective optimization with size and costs as the objective functions. The optimized system provides the best system size to support the electricity supply of a coastline town (4.7231°N, 6.77881°E). The optimized system can deliver 41.80 GWh of energy annually, meeting 98.3%of the energy demands of the community; while the optimized system has a cost savings of 45.11%, with 92.9%penetration.The work provides valuable insights for system designers, energy planners, and policy-makers in their efforts to promote renewable energy integration and address the challenges associated with the transition to a low-carbon future.

PART 7
WASTE TO ENERGY

Status Clay-based Microbial Fuel Cell System in BOD from Petroleum Contaminated Wastewater and Energy Generation

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Keywords: Biological Oxygen Demand, Clay-based membrane, Microbial Fuel Cell, Petroleum Wastewater

Abstract: This study explores the application of a clay-based microbial fuel cell (MFC) system for the treatment of biochemical oxygen demand (BOD) in petroleum-contaminated wastewater. The petroleum industry is the backbone of most industries ranging from construction and energy fields. This leads to a pollution of water resources either from transportation, refinery and usage of petroleum products. Eventhough petroleum is crucial in our day to day activities, the complex substance it contains have dire implications on the ecological stability. These pollutants compromise both the aquatic fauna and Fiona. Therefore this paper is about a study throughwhich a clay microbial fuel cell was used to removed BOD in petroleum contaminated wastewater and generate green energy. Three clay microbial fuel cells were assembled and ran at batch mode for 30 days.MFCa and MFCb were fed with a culture of micro organisms from filling station waste and MFC c had no inoculation of the microbes.A maximum removal efficiency of 91% and 89% was achieved from MFCs with microbes and only 30% from the control with no inoculation (MFCc) .A maximum of 250mV of open circuit voltage was generated from the treatment of the petroleum wastewater using the clay microbial fuel cell.

Comparison of energy recovery from organic waste from human body and primary sludge

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Keywords: Energy Recovery, Organic Waste from Human Body, Primary Sludge. Biogas.

Abstract: Increases in demand for energy have caused some waste treatment facilities to be converted to energy recovery including municipal wastewater treatment plants (MWWTPs). This study was conducted to evaluate the comparison of biogas production between organic waste from the human body (OWHB) and primary sludge (PS) from the treatment plant. The average biogas production was 1.85M3/ca.year for OWHB and 0.013M3/ca.year for PS. It can be concluded that OWHB is the best substrate for energy production compared to PS. Its production is directly proportional to the increase in human population.

Valorization of Mixed Blackwater/Agricultural Wastes for Bioelectricity and Biohydrogen Production: A Microbial Treatment Pathway

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Keywords: Blackwater, agricultural waste, Microbial treatment, Bioelectricity, Biohydrogen.

Abstract: The objective of this study was to evaluate the possibility of co-treating blackwater and agricultural wastes while co-producing bioelectricity and biohydrogen using a microbial treatment path using a dual chamber MFC and to determine the optimal feedstock ratio and pH conditions. An integrated MFC was designed to achieve this goal. The main microorganisms present included Escherichia Coli, Salmonella spp., Pseudomonas aerogunisa, Shigella sp., Klebsiella pneumonia, Enterobacter asburiae, candida guillermondii, and Pythium ultimum. The highest open circuit voltage generated was 1090 mV from MFC-4 at HRT=6 days. The maximum COD and BOD removal efficiencies were 90.87% and 76.67%, respectively, with a Columbic efficiency of 40.17%. The maximum power density was 345 mW/m2. The highest H2 yield was 483 ppm/s. The optimal feedstock ratio was cassava peel (300 g): banana peel (100 g): Tomato waste (100 g) or 3:1: 1. The optimum conditions for pH were basic medium (pH 9.35). This study highlights the potential for bioelectricity and biohydrogen production from the microbial treatment of mixed blackwater / agricultural waste in one system without the need for chemical pretreatment.

Biowaste To Bioenergy For Sustainable Energy Supply And Industrial Development In Nigeria: A Review Of Opportunities And Challenges.

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Keywords: Bioenergy, Biowaste, Sustainable Energy, Industrial Development

Abstract: The Current Industrial Crisis In Nigeria Stems From The Worsening Energy Situation – A Growing Concern Evidenced By The Recent Shutdown Of Some Industrial Companies Within The Country. This Crisis Arises Due To High Cost Of Energy Consumption, Which In Turn Inflates The Cost Of Local Production And Drastically Minimizes Profit. Despite Nigeria's Significant Oil And Gas Production Levels, Energy Sector Challenges Impede Economic Progress. Nigeria Faces A Shortage In Electricity Generation Capacity, Heavily Relying On Unsustainable Options Like Diesel-Powered Generators. These Conditions Highlight The Urgent Need For Sustainable Energy Sources To Address The Energy Crisis Effectively. Additionally, Nigeria Grapples With Mounting Agricultural Bio-Waste From Rural And Commercial Sectors. This Paper Explores The Potentials And Challenges Of Biowaste To Bioenergy (BtB) In Sustainable Energy Supply And Industrial Development In Nigeria. We Argue That Converting Bio-Waste To Bioenergy (BtB) Presents Substantial Opportunities To Combat Energy Challenges In The Country. Furthermore, Incorporating Renewable Energy Promotes Business Growth, Economic Development, And Job Creation While Combating Climate Change Effects.

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