

ICEE 2026

International Conference on Energy and Engineering

THEME

Engineering the Future: Energy, Agriculture & Infrastructure Innovations
toward Climate Resilience and Sustainable Development

**Programme Outline
& Abstracts**

30 September – 2 October 2026

University of Energy and Natural Resources
Sunyani, Ghana

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30th September – 2nd October 2026

University of Energy and Natural Resources (UENR), Sunyani, Ghana

Welcome Message from the Committee Co-Chairs

On behalf of the Organizing Committee, it is our privilege and pleasure to welcome you — our distinguished guests, keynote speakers, researchers, and industry partners — to the International Conference on Energy and Engineering at the University of Energy and Natural Resources, Sunyani, Ghana, from 30th September – 2nd October 2026.

This conference represents the culmination of many months of planning, and more importantly, it represents something larger: a gathering of minds from across many countries, united by a shared conviction that the challenges facing our energy systems, our engineered infrastructure, and our environment are best addressed together, not in isolation. Whether you have travelled a great distance or joined us from nearby, your presence here is a contribution to that shared purpose, and we thank you for it.

To our international participants in particular, allow us to extend a special welcome. You have crossed borders, time zones, and in many cases considerable distance to be part of this conversation, and that commitment does not go unnoticed. It is precisely this kind of cross-border exchange — of ideas, research, and perspective — that gives a conference like this its real value. The most meaningful breakthroughs rarely happen within the comfort of a single institution or a single country; they happen in rooms like this one, where different experiences and different ways of thinking are allowed to collide productively.

Over the coming days, you will have the opportunity to engage with cutting-edge research, hear from leading voices in energy, engineering, and environmental science, and — we would gently encourage — to spend as much time in the corridors and cocoa breaks as in the auditorium and seminar rooms. Some of the most valuable exchanges at any conference happen not at the podium, but in the conversations that follow it.

We want to take a moment to thank our keynote speakers, session chairs, reviewers, and the many volunteers who have worked tirelessly behind the scenes to bring this conference together. We also extend our sincere gratitude to our sponsors and partner institutions, whose support has made this gathering possible.

As you move through the programme ahead, we invite each of you to engage fully — ask the difficult questions, challenge assumptions respectfully, share your own work generously, and remain open to the possibility that the most useful idea you take home from this conference may come from a conversation you did not plan to have.

On behalf of the entire Organizing Committee, welcome to the International Conference on Energy and Engineering. We look forward to the ideas, connections, and collaborations that will emerge from our time together.

Thank you, and enjoy the conference.

Ing. Prof. Nana Sarfo Agyemang Derkyi, Ing. Prof. Emmanuel Kwesi Nyantakyi, Ing. Prof. Samuel Gyamfi

[Co-Chairs, Organizing Committee]

International Conference on Energy and Engineering

01

Day 1

Wednesday, 30th September 2026

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
07:30 – 09:00	Arrival & Registration	Registration Desk

Opening Session

09:00 – 11:00 • AUDITORIUM

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
09:00 – 09:05	Opening Prayer & National Anthem	MC
09:05 – 09:10	Purpose of Gathering	Ing. Prof. Nana Sarfo Agyemang Derkyi Co-Chair, ICEE 26; Dean, School of Energy, University of Energy and Natural Resources
09:10 – 09:15	Introduction of Dignitaries	MC
09:15 – 09:20	Introduction of Chairman	Dr. (Mrs.) Georgina Asi Owusu Registrar, University of Energy and Natural Resources
09:20 – 09:30	Welcome Address by Chairman	Prof. Elvis Asare-Bediako Vice-Chancellor, University of Energy and Natural Resources
09:30 – 09:35	Brief Message on Behalf of the Deans	Ing. Prof. Emmanuel Kwasi Nyantakyi Dean, School of Engineering, University of Energy and Natural Resources
09:35 – 09:45	Cultural Display	UENR Cultural Group
09:45 – 09:50	Introduction of Guest of Honour	MC
09:50 – 10:00	Address by Guest of Honour	Hon. Joseph Addae Akwaboa, Esq. Bono Regional Minister
10:00 – 10:05	Introduction of Special Guest of Honour	MC
10:05 – 10:20	Address by Special Guest of Honour	Hon. Dr. John Abdulai Jinapor Minister for Energy and Green Transition
10:20 – 10:30	Group Photograph	All Participants
10:30 – 11:00	Coffee Break / Networking	–

DAY 1 • WEDNESDAY, 30TH SEPTEMBER 2026

Plenary Keynotes

11:00 – 12:20 • AUDITORIUM

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
11:00 – 11:20	Keynote I	Ms. Adwoa Serwaa Bondzie Executive Secretary, Energy Commission
11:20 – 11:40	Keynote II	Dr. Rory Jones Associate Professor, School of the Built Environment, University of Reading
11:40 – 12:00	Keynote III	Ing. Ludwig Annang Hesse President, Ghana Institution of Engineering
12:00 – 12:20	Brief Remarks by Sponsors & Presentation of Plaques	All Sponsors

Parallel Technical Session I

12:20 – 13:20

AUDITORIUM

Session Chair: Dr. Rory Jones, Associate Professor, School of the Built Environment,
University of Reading

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 1 – Renewable Energy Systems, Energy Efficiency, DSM & Flexibility (Energy efficiency and demand-side management)		
12:20 – 12:35	An Integrated Multi-Sector LMDI–Machine Learning Framework for Decomposing and Forecasting Energy Consumption Drivers under Structural Breaks: Evidence from Ghana and Implications for Sub-Saharan Africa	Amos Somirman Kujar University for Development Studies
12:35 – 12:50	Evaluating the Feasibility of Hybrid Small Modular Reactors (SMRs) for Sustainable Power and Water Production in Aboadze–Takoradi, Ghana	Clement Kwakye University of Energy and Natural Resources Abstract • p. 23
12:50 – 13:05	Consumer Behaviour, Digital Technologies, and Demand-Side Flexibility for Sustainable Energy Systems in Developing Countries	Lawrence Ameh University of Energy and Natural Resources
13:05 – 13:20	Determinants of Household Energy Choices: Cooking Fuel Adoption in Ghana	Donatus Kuuzume University of Energy and Natural Resources <i>Virtual presentation</i> Abstract • p. 24

DAY 1 • WEDNESDAY, 30TH SEPTEMBER 2026

Parallel Technical Session I

12:20 – 13:20

LECTURE HALL 1

Session Chair: Dr. Kankam Adu Okatakyie, Lecturer, Department of Computer and Electrical Engineering, University of Energy and Natural Resources

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 1 – Renewable Energy Systems, Energy Efficiency, DSM & Flexibility (Energy, society and environment)		
12:20 – 12:35	Beyond Symptoms: Integrating the Hasevi Curative Model with Socio-Technical Frameworks to Address Root Causes of Energy Insecurity in Ghana and Africa	Prince Hasevi University of Energy and Natural Resources Abstract • p. 25
12:35 – 12:50	Developing an Integrated Financial Evaluation Framework for Renewable Energy Investment Decisions in Ghana: A Structural Equation Modelling and Risk-Based Approach	Isaac Adabire University of Energy and Natural Resources
12:50 – 13:05	Flexibility at What Cost? Governing Renewable Energy Transitions in Multi-Use Reservoir Systems	Nanabanyin Anamuah Mensah International Institute of Tropical Agriculture
13:05 – 13:20	Integrating Population Dynamics into Energy System Stability Models: A Systematic Literature Review	Prince Asabere University of Energy and Natural Resources

Lunch / Exhibition

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
13:20 – 14:00	Lunch / Exhibition	–

DAY 1 • WEDNESDAY, 30TH SEPTEMBER 2026

Parallel Technical Session II

14:00 – 16:00

AUDITORIUM

Session Chair: Prof. John-Felix Akinbami

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 1 – Renewable Energy Systems, Energy Efficiency, DSM & Flexibility (Energy, society and environment)		
14:00 – 14:15	Modelling Renewable Energy Adoption and Its Socioeconomic Impacts in Ghana: Integrating AnyLogic Simulation with Econometric Analysis	Stephen Nkrumah University of Energy and Natural Resources Abstract • p. 26
14:15 – 14:30	Quantifying and Simulating Household Food–Energy–Water Metabolism in Africa's Secondary Cities: An Integrated Assessment of Sunyani	Lewis Ofori Amankona University of Energy and Natural Resources Abstract • p. 27
14:30 – 14:45	Quantitative and Game-Theoretic Modelling of Power Purchase Agreements (PPAs) and Renewable Energy Investment Risk in Emerging Energy Markets: Evidence from Ghana	Michael Innuri Dergol-Dery University of Energy and Natural Resources <i>Virtual presentation</i> Abstract • p. 28
14:45 – 15:00	Universal Electricity Access and Renewable Energy Targets in Africa: Lessons from Ghana	Dr. Benjamin Batinge Regional Centre for Energy and Environmental Sustainability, University of Energy and Natural Resources
15:00 – 15:15	Who Cools, How Much, and How Cool? Household Profiles of Residential Air-Conditioning Demand in Urban Sahelian Africa	Dr. Komlan Hector Seth Tete 2SEDEF Project
15:15 – 15:30	Regulatory Governance and Investment in Ghana's Energy Transition: Institutional Challenges and Policy Coherence for Sustainable Energy Development	Faustina Abeka Koomson University of Energy and Natural Resources
Theme 8 – Cross-Cutting: Engineering Education, Policy, Economics & Entrepreneurship (Financing and policy frameworks)		
15:30 – 15:45	A Multi-Level Policy Framework for Sustainable Lithium Development in Ghana	Naamwinkumah Zacheous Dari University of Energy and Natural Resources Abstract • p. 29
Theme 8 – Cross-Cutting: Engineering Education, Policy, Economics & Entrepreneurship		
15:45 – 16:00	University-Induced Urban Transformation and Climate-Resilient Planning: Land-Use Change and Green-Cover Loss in Ayeduase, Ghana	Theresa Joy Kamassah Kwame Nkrumah University of Science and Technology

DAY 1 • WEDNESDAY, 30TH SEPTEMBER 2026

Parallel Technical Session II

14:00 – 16:00

LECTURE HALL 1

Session Chair: Dr. Ebenezer K. Siabi, Research Fellow, Earth Observation Research and Innovation Centre, University of Energy and Natural Resources

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 1 – Renewable Energy Systems, Energy Efficiency, DSM & Flexibility (Energy efficiency and demand-side management)		
14:00 – 14:15	Energy Consumption Characterization at Ghanaian Water Treatment Plant Pump Stations: Field Evidence from Mampong and Owabi WTPs	Stephen Aboagye University of Energy and Natural Resources <i>Abstract • p. 30</i>
14:15 – 14:30	Energy Efficiency and Demand-Side Management as Low-Cost Levers for Grid Reliability and Decarbonization in Ghana's Electricity Sector	Lartey Quao University of Energy and Natural Resources <i>Abstract • p. 31</i>
14:30 – 14:45	From Household Energy Behaviour to Targeted Demand-Side Management: A Multidimensional Framework for Urban Households in Burkina Faso	Dr. Komlan Hector Seth Tete International Institute for Water and Environmental Engineering (2iE), Burkina Faso
14:45 – 15:00	Modelling Thermal Energy Performance Reliability of a Palm Oil Mill: A Case Study in Ghana	Mathias Bennet Michael Accra Technical University <i>Virtual presentation</i>
15:00 – 15:15	The Impact of Electric Vehicle Charging Stations on Ghana's Electric Grid: A Projection from 2024 to 2045	Benedict Clifford Amekah University of Energy and Natural Resources <i>Abstract • p. 33</i>
Theme 1 – Renewable Energy Systems, Energy Efficiency, DSM & Flexibility (Grid integration of renewable energy technologies)		
15:15 – 15:30	DSTATCOM-Based Power Factor Enhancement in Hybrid PV–Wind Low-Voltage Distribution Networks: A Case Study of the Ga West Network	John Abban University of Energy and Natural Resources <i>Virtual presentation</i> <i>Abstract • p. 34</i>

DAY 1 • WEDNESDAY, 30TH SEPTEMBER 2026

Poster Presentations

16:00 – 16:40

TIME ACTIVITY / TOPIC • FACILITATOR / SPEAKER

Theme 8 – Cross-Cutting: Engineering Education, Policy, Economics & Entrepreneurship • Sustainable Infrastructure, Mining, Building, Environment & Civil Innovations

16:00 – 16:10 **Reforming Downstream Petroleum Decommissioning in Ghana: Developing an Integrated Legal, Governance and Financial Framework for Sustainable Energy Transition**

Saliu Issaka

University of Energy and Natural Resources

Abstract • p. 35

16:10 – 16:20 **Digitalization and Fiscal Policy Integration for Sustainable Energy Financing in Ghana: Mediating Effects of FinTech and Technological Innovation and the Moderating Role of Institutional Quality**

Inusah Tinama Kombet

Dormaa Central Municipal Assembly

16:20 – 16:30 **Techno-Economic Assessment and Investment Conditions for a Hybrid Small Hydropower–Rooftop Solar Photovoltaic System in Ghana**

Ali Dayinday Salifu

University of Energy and Natural Resources

16:30 – 16:40 **Assessing Non-Revenue Water Reduction through Improved Mean Time to Repair for Water Supply Systems in Ghana**

Leticia Adum

Accra Technical University

Abstract • p. 36

Closing

AUDITORIUM

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
16:40 – 16:55	UENR Anthem / Closing Remarks	Prof. Elvis Asare-Bediako Vice-Chancellor, University of Energy and Natural Resources
16:55 – 17:30	Exhibition / Networking	–

02 Day 2

Thursday, 1st October 2026

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
07:30 – 09:00	Arrival & Registration	Registration Desk

Plenary Keynotes

09:00 – 10:10 • AUDITORIUM

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
09:00 – 09:10	Welcome, Recap of Day 1 & Announcements	MC
09:10 – 09:30	Keynote IV	Ms. Lena Leumer Director, West Africa Regional Office, German Academic Exchange Service (DAAD)
09:30 – 09:50	Keynote V	Ing. Prof. Samuel Gyamfi Director, Regional Centre for Energy and Environmental Sustainability, University of Energy and Natural Resources
09:50 – 10:10	Keynote VI	Ing. Dr. Kenneth Ashigbey CEO, Ghana Chamber of Mines
10:10 – 10:40	Coffee Break / Networking	–

DAY 2 • THURSDAY, 1ST OCTOBER 2026

Parallel Technical Session III

10:40 – 12:10

AUDITORIUM

Session Chair: Ing. Prof. Nana Sarfo Agyemang Derkyi, Professor, Department of Renewable Energy Engineering, University of Energy and Natural Resources

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 1 – Renewable Energy Systems, Energy Efficiency, DSM & Flexibility (Renewable energy resources and conversion technologies)		
10:40 – 10:55	An Integrated Optimisation Model for Analysing Demand Response and Renewable Energy Integration	Eric Nyarko University of Energy and Natural Resources <i>Virtual presentation</i> Abstract • p. 37
10:55 – 11:10	Governing the Justice Gap: Energy and Environmental Justice in Ghana's Decentralised Renewable Electrification Regime	Thelma Gblorkpor University of Energy and Natural Resources
11:10 – 11:25	Techno-Economic Assessment of Rooftop Solar PV Systems with Net Metering for Residential Electricity Users in Kumasi, Ghana	Sarkodie Aboagye University of Energy and Natural Resources Abstract • p. 38
Theme 3 – Electrical, Electronic & Computer Engineering Innovations (AI and machine learning)		
11:25 – 11:40	AI-Driven Fault Detection and Classification in Low-Voltage Distribution Systems: A Framework for Emerging Smart Grids in Ghana	Abdul-Latif Ayariga Amidu University of Energy and Natural Resources Abstract • p. 39
Theme 3 – Electrical, Electronic & Computer Engineering Innovations (Electric mobility and smart charging)		
11:40 – 11:55	Framework for Sustainable Last-Mile Electric Mobility in Sub-Saharan Africa	Isaac Prempeh University of Energy and Natural Resources Abstract • p. 40
Theme 4 – Intelligent Manufacturing & Mechanical Systems		
11:55 – 12:10	Primary Barriers and Enablers of Industry 4.0 Adoption among Manufacturing Firms in Sub-Saharan Africa: A Systematic Literature Review	Worlali Kwabla. Ameevor University of Energy and Natural Resources <i>Virtual presentation</i> Abstract • p. 41

DAY 2 • THURSDAY, 1ST OCTOBER 2026

Parallel Technical Session III

10:40 – 12:10

LECTURE HALL 1

Session Chair: Ing Dr Shaibu Mohammed, Department of Petroleum and Natural Gas Engineering, University of Energy and Natural Resources

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 2 – Petroleum & Natural Gas Engineering for a Just Energy Transition (Innovations in oil and gas exploration and processing)		
10:40 – 10:55	Hybrid Joule–Thomson Valve–Turbo-Expander Operation for Flexible Cryogenic Natural Gas Liquids Recovery: A Steady-State Study of Ghana's Gas Processing Plant Train 2	Nicholas Turkson University of Energy and Natural Resources Abstract • p. 42
10:55 – 11:10	Performance Evaluation and Optimisation of the Gas Dehydration Process at the Atuabo Gas Processing Plant	Isaac Bediako University of Energy and Natural Resources
11:10 – 11:25	Evaluating the Effectiveness of the Safety Management System of the Utility Unit at the Atuabo Gas Processing Plant	Ivan Warden Nyamekye University of Energy and Natural Resources Abstract • p. 43
Theme 2 – Petroleum & Natural Gas Engineering for a Just Energy Transition (Transition pathways and policy for low-carbon petroleum sectors)		
11:25 – 11:40	An Integrated Evaluation of De-Risking Mechanisms for Natural Gas Infrastructure as a Catalyst for Ghana's Sustainable Development	Etornam Dzimenyi University of Energy and Natural Resources Abstract • p. 44
11:40 – 11:55	Life Cycle Assessment of Electricity Generation from Natural Gas in Ghana	Simon Adu Asare University of Energy and Natural Resources
11:55 – 12:10	Natural Gas Fuel Quality, CO₂ Emission Factors, and CO₂ Emissions from Thermal Power Generation in Ghana: Implications for Ghana's Climate Targets	Issah Salman University of Energy and Natural Resources <i>Virtual presentation</i> Abstract • p. 45

Lunch / Exhibition

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
12:10 – 13:00	Lunch / Exhibition	–

DAY 2 • THURSDAY, 1ST OCTOBER 2026

Parallel Technical Session IV

13:00 – 15:30

AUDITORIUM

Session Chair: Prof. Francis Kemausuor, Professor, Department of Agricultural and Biosystems Engineering, Kwame Nkrumah University of Science and Technology

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 8 – Cross-Cutting: Engineering Education, Policy, Economics & Entrepreneurship (Engineering and energy education)		
13:00 – 13:15	Development and Preliminary Evaluation of a Virtual Platform Management System to Facilitate Electrical Workshop Operations in NCE-Awarding Institutions in North-Eastern Nigeria	Abdulumuni Aliyu Cheledi Abubakar Tatari Ali Polytechnic, Bauchi, Nigeria
13:15 – 13:30	Operational Tasks and Design Requirements for a Virtual Electrical Workshop Management Platform in NCE (Technical) Institutions in North-Eastern Nigeria	Abdulumuni Aliyu Cheledi Abubakar Tatari Ali Polytechnic, Bauchi, Nigeria
13:30 – 13:45	Economic Analysis of Electricity Distribution Losses and Their Tariff Implications in Ghana: A Case Study of ECG and NEDCo	Rexford Osei Amankwaa University of Energy and Natural Resources <i>Virtual presentation</i>
Theme 8 – Cross-Cutting: Engineering Education, Policy, Economics & Entrepreneurship (Financing and policy frameworks)		
13:45 – 14:00	Governing Artificial Intelligence in Ghana's Energy Sector: Towards a Legal and Institutional Framework for Sustainable Power Systems	Felicia Borsor University of Energy and Natural Resources Abstract • p. 46
14:00 – 14:15	Green Finance, Digital Technology, and Renewable Energy as Determinants of Agricultural Value Addition in Ghana: A Cointegration and Causality Analysis, 1990–2022	Daniel Cudjoe Esimey Kporha University of Energy and Natural Resources

DAY 2 • THURSDAY, 1ST OCTOBER 2026

Parallel Technical Session IV

13:00 – 15:30

AUDITORIUM

Session Chair: Prof. Francis Kemausuor, Professor, Department of Agricultural and Biosystems Engineering, Kwame Nkrumah University of Science and Technology

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 8 – Cross-Cutting: Engineering Education, Policy, Economics & Entrepreneurship (Financing and policy frameworks)		
14:15 – 14:30	Hydropower to Mining: The Structural Anchor to Ghana's Economic Growth	Manfred Nyarko University of Energy and Natural Resources
14:30 – 14:45	Pollution, Poverty, and the Price of Clean Air: An Environmental Kuznets Curve Analysis of Household Cooking Fuel Transitions in Ghana	Cephas Egbeforme University of Energy and Natural Resources
14:45 – 15:00	Regulating the Digital Energy Transition in Ghana: Policy and Governance Frameworks for Smart Energy Systems	Marsha Owusu Saarah-Akyerekoh University of Energy and Natural Resources <i>Virtual presentation</i> Abstract • p. 47
15:00 – 15:15	The Centralisation Trap in Ghana's Energy Transition: Multi-Level Governance, Energy Justice, and Regulatory Monitoring Reform for Net-Zero Development	Frank Listowell Debrah Yeboah University of Energy and Natural Resources Abstract • p. 48
15:15 – 15:30	Financing Climate-Resilient Energy Infrastructure in Sub-Saharan Africa: Policy and Institutional Pathways for Sustainable Energy Transitions	Francis Ofori University of Energy and Natural Resources Abstract • p. 49

DAY 2 • THURSDAY, 1ST OCTOBER 2026

Parallel Technical Session IV

13:00 – 15:30

LECTURE HALL 1

Session Chair: Dr. Martin K. Domfeh, Senior Research Fellow, Earth Observation Research and Innovation Centre, University of Energy and Natural Resources

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 8 – Cross-Cutting: Engineering Education, Policy, Economics & Entrepreneurship (Gender inclusion, ethics and governance)		
13:00 – 13:15	Gender Equality in Ghana's Renewable Energy Transition: A Socio-Legal Analysis of Women's Participation in Energy Governance	Gloria Mensah University of Energy and Natural Resources
Theme 5 – Sustainable Infrastructure, Mining, Building, Environment & Civil Innovations (Resilient transport, water infrastructure systems and governance)		
13:15 – 13:30	Rainfall Extremes in the Black Volta Basin: Implications for Water Infrastructure and Climate-Smart Agriculture	Archibald Quaye Accra Technical University
13:30 – 13:45	Comparative Assessment of Groundwater Quality across Three Communities in the Akuapem North Municipality, Ghana	Thomas Agbetiame University of Energy and Natural Resources Abstract • p. 50
Theme 6 – Climate-Smart Agriculture & Engineering (Irrigation and drainage solutions for resilient food production)		
13:45 – 14:00	Drivers of Climate-Smart Irrigation Adoption for Resilient Food Production in Northern Ghana	Abubakari Sadiq Adam University of Energy and Natural Resources Abstract • p. 51
14:00 – 14:15	High Climate-Risk Awareness but Low Irrigation Resilience: Adaptation Preferences among Smallholder Farmers in Northern Ghana	Abubakari Sadiq Adam University of Energy and Natural Resources Abstract • p. 52

DAY 2 • THURSDAY, 1ST OCTOBER 2026

Parallel Technical Session IV

13:00 – 15:30

LECTURE HALL 1

Session Chair: Dr. Martin K. Domfeh, Senior Research Fellow, Earth Observation Research and Innovation Centre, University of Energy and Natural Resources

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
Theme 6 – Climate-Smart Agriculture & Engineering (Mechanization for sustainable food systems)		
14:15 – 14:30	Performance Evaluation of a Yam-Mound-Forming Implement under Different Tillage Treatments	Listowel Abugri Anaba University for Development Studies / Kwame Nkrumah University of Science and Technology
Theme 7 – Earth Observation as a Decision Tool for Socio-Economic Development		
14:30 – 14:45	Integrating Earth Observation and GIS-MCDA for Uncertainty-Aware Groundwater Recharge Potential Mapping in the Volta River Basin	Anna Amankwah-Minkah Kwame Nkrumah University of Science and Technology / University of Skills Training and Entrepreneurial Development
14:45 – 15:00	One Fire, Two Signals: Support-Aware Interpretation of MODIS Burned Area and VIIRS Active Fire in Ghana	Ing. Nana Ekow Nkwa Sey Earth Observation Research and Innovation Centre, University of Energy and Natural Resources Abstract • p. 53
15:00 – 15:15	Potential Anthropogenic Influences on Aerosol Loading Dynamics over West Africa: Evidence from MODIS and MERRA-2	Francis Kudjoe Earth Observation Research and Innovation Centre, University of Energy and Natural Resources Abstract • p. 54
15:15 – 15:30	Long-Term Spatiotemporal Variability of Aerosol Loading and Climate Interactions over West Africa: Evidence from MODIS, MISR, and MERRA-2 Observations	Francis Kudjoe Earth Observation Research and Innovation Centre, University of Energy and Natural Resources

DAY 2 • THURSDAY, 1ST OCTOBER 2026

Poster Presentations

15:30 – 16:10

TIME ACTIVITY / TOPIC • FACILITATOR / SPEAKER

Theme 1 – Renewable Energy Systems, Energy Efficiency, DSM & Flexibility		
15:30 – 15:40	Impact Assessment of Waste-to-Energy (WtE) Systems as an Alternative Decarbonization Pathway in Ghana: A Multidimensional Systematic Review Abdul Raaziq Bashiru University of Energy and Natural Resources Abstract • p. 55	
15:40 – 15:50	Advancing Vehicle-to-Grid Deployment in Developing Countries: Bibliometric Insights into Smart Charging, Grid Resilience, and Enabling Conditions Jochebed Oglie Amponsah University of Energy and Natural Resources Abstract • p. 56	
15:50 – 16:00	Decentralized Renewable Energy for Rural Electrification Kwadwo Boateng University of Energy and Natural Resources	
16:00 – 16:10	Harvesting the Sun Twice: Opportunities and Challenges of Agrivoltaics in Ghana Mark Aryee University of Energy and Natural Resources	

Closing Ceremony

AUDITORIUM

TIME	ACTIVITY / TOPIC	FACILITATOR / SPEAKER
16:10 – 16:40	Closing Remarks & Presentation of Special Awards	Prof. John K. M. Kuwornu Ag. Pro Vice-Chancellor, University of Energy and Natural Resources
18:00 onwards	Cocktail / Live Band	RCEES

03

Day 3

Friday, 2nd October 2026

EXCURSION

Kintampo Waterfalls

& Boabeng-Fiema
Monkey Sanctuary

Conference Officials

Committee Members

S/N	NAME	DEPARTMENT / UNIT	DESIGNATION
1	Ing. Prof. Nana Sarfo Agyemang Derkyi	Dean, SoEn	Co-Chair
2	Ing. Prof. Emmanuel K. Nyantakyi	Dean, SoE	Co-Chair
3	Ing. Prof. Samuel Gyamfi	Director, RCEES	Member
4	Ing. Prof. Amos T. Kabo-Bah	Head, DCEE	Member
5	Ing. Prof. Benjamin A. Weyori	Rep, DCEE	Member
6	Ing. Prof. Thomas Atta-Darkwah	Rep, DABE	Member
7	Ing. Dr. Prince Antwi-Agyei	Rep, DCEE	Member
8	Dr. Yaw A. Boakye-Ansah	Rep, PENG	Member
9	Dr. Felix Amankwah Diawuo	Rep, REE	Member
10	Dr. Gifty Serwaa Mensah	Rep, RCEES	Member
11	Dr. Rory Jones	2SEDEF Project	Member
12	Ing. Eric Osei Essandoh	Rep, DMME	Member
13	Mr. Francis Kudjoe	Rep, EORIC	Member
14	Mr. Stephen Yaw Ntiamoah	Rep, Finance	Member
15	Mr. Benjamin Gyamera	Rep, URO	Member
16	Ms. Bernice Kyei-Mensah	Registrar, RCEES	Co-Secretary
17	Ms. Abigail Amo Boatemaa	Registrar, SoEn	Co-Secretary
18	Ms. Ellen Adoma Boateng	Registrar, SoE	Co-Secretary
19	Ms. Akpene Ame Kwadzo	Assistant Registrar	Asst. Secretary

Conference Moderators

Ms. Abigail Yeboah-Kyereh

Dr. John Kwasi Annan

Technical Team

NAME	DEPARTMENT
Mr. Mathew Anabadongo Atinsia	REE, UENR
Mr. Richmond Opoku Kusi	SAA, URO, UENR
Mr. Patrick Nkansa-Kyerematen	SAA, URO, UENR
Mr. Stephen Adjei	Communications Officer, RCEES, UENR

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Day 1 • Parallel Technical Session II

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Techno-Economic Feasibility of a 77 MWe NuScale Small Modular Reactor Integrated with Seawater Reverse Osmosis Desalination for Electricity and Freshwater Production in Ghana

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Parallel Technical Session I · p. 5

The increasing demand for reliable electricity and freshwater in Ghana's coastal industrial belt has created a need for integrated energy–water solutions that can reduce dependence on fossil fuels while improving water security. This study assesses the techno-economic and environmental feasibility of a 77 MWe NuScale Small Modular Reactor (SMR) integrated with seawater reverse osmosis (SWRO) desalination for electricity and freshwater production in the Aboadze–Sekondi-Takoradi corridor. The 77 MWe configuration is treated explicitly as a single NuScale Power Module reference case rather than as a 100 MW reactor or a complete commercial VOYGR plant. NuScale's published plant architecture is modular, with 77 MWe modules assembled into multi-module configurations; therefore, the 77 MWe case provides a conservative unit-size basis for evaluating Ghanaian grid integration.

A 50-year discounted cash-flow model is used to estimate Net Present Value (NPV), Internal Rate of Return (IRR), Levelized Cost of Electricity (LCOE), and Levelized Cost of Water (LCOW), while sensitivity analysis examines the effects of capital cost, financing, capacity factor, electricity and water tariffs, and desalination performance. Under the study's base-case assumptions, the preliminary economic model indicates an NPV of approximately US\$1.2 billion, an IRR above 12%, an LCOE of about US\$65/MWh, and an LCOW of approximately US\$1.50/m³. These values are scenario results rather than vendor quotations and are intended to test feasibility under Ghana-specific assumptions.

The analysis also incorporates commercial and deployment risk. In particular, the 2023 termination of the UAMPS Carbon Free Power Project with NuScale, following difficulty securing sufficient subscription and escalating project costs, is treated as evidence that technology feasibility alone does not establish commercial viability. The economic assessment therefore includes capital-cost and financing sensitivities rather than assuming the vendor's earlier cost expectations. Grid integration is assessed against the approximately 792 MW generation capacity reported for the Aboadze–Takoradi corridor. A 77 MWe unit represents about 9.7% of this reference capacity, and the study explicitly evaluates frequency response, spinning-reserve requirements, ramping capability, and the loss-of-unit/scram contingency.

For desalination, the study evaluates SWRO energy demand and freshwater output together with seawater intake and concentrate management. Hypersaline brine, temperature effects, chemical residuals, marine dispersion, and coastal hydrodynamics are incorporated as environmental considerations rather than treating freshwater production as impact-free. Overall, the results indicate that a 77 MWe SMR–SWRO configuration can provide a technically credible basis for further Ghana-specific feasibility assessment, but its investment case is sensitive to capital cost, financing conditions, grid-reserve requirements, and brine-management arrangements. The study therefore provides an integrated framework for evaluating nuclear power and desalination as a combined energy–water infrastructure option for Ghana.

The scientific contribution of the study is the development of an integrated techno-economic framework that links SMR electricity generation, SWRO freshwater production, grid integration, and desalination constraints within a Ghana-specific energy–water context. Unlike studies that assess electricity generation and desalination separately, this study evaluates their combined performance using common technical and economic indicators. The framework also allows the effects of reactor capital cost, financing conditions, plant utilization, electricity and water prices, grid-reserve requirements, and desalination performance to be examined systematically. It therefore provides a basis for future assessment of nuclear-powered desalination and other integrated energy–water systems in Ghana and similar coastal developing-country settings.

Keywords: Small Modular Reactors (SMRs); 77 MWe; Seawater Reverse Osmosis; Energy–Water Nexus; Techno-Economic Feasibility.

Determinants of Household Energy Choices: Cooking Fuel Adoption in Ghana

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Parallel Technical Session I · p. 5

Access to clean cooking fuels remains a critical development challenge in sub-Saharan Africa, where an estimated 2.3 billion people continue to rely on solid biomass fuels, generating indoor air pollution linked to roughly 3.2 million premature deaths annually [1]. The International Energy Agency identifies sub-Saharan Africa as the region with the largest unmet demand for clean cooking access [2], with the associated health and welfare costs falling disproportionately on women and children [3]. Household fuel-switching behaviour has traditionally been explained through the energy ladder model, in which rising income drives a linear progression from biomass toward cleaner fuels [4]; however, this framework has since been challenged by evidence of fuel stacking, whereby households retain multiple fuels concurrently rather than substituting completely [5]. Ghana offers an informative case for examining these dynamics: despite sustained economic growth, biomass fuels continue to dominate household cooking in rural and northern communities, while clean fuel access remains concentrated in Greater Accra and the Ashanti Region [6]. This study analyses the socioeconomic and demographic determinants of household cooking fuel adoption in Ghana using microdata from the 2021 Ghana Population and Housing Census (10% sample; N = 765,421 household heads). Three complementary limited dependent variable models are estimated: binary logit/probit as the baseline, ordered logit as a first robustness check, and multinomial logit [7] as a second robustness and diagnostic specification. Results are consistent across all specifications. Household wealth, education, and urban residence are the strongest positive determinants of clean fuel adoption: each unit increase in the wealth index raises the probability of clean fuel adoption by approximately 9.8 percentage points, while tertiary education and urban residence are associated with increases of 26.9 and 14.7 percentage points, respectively. Household size and the age of the household head exert significant negative effects. Pronounced regional disparities persist net of household characteristics, with households in the Savannah, North East, and Northern Regions 31 to 37 percentage points less likely to use clean fuels than those in Greater Accra, consistent with prior Ghana-specific evidence [8]. The findings underscore the need for targeted LPG subsidy programmes, investment in regional fuel distribution infrastructure, and gender-responsive clean cooking policies to accelerate Ghana's household energy transition in line with Sustainable Development Goal 7.

Keywords: *Cooking fuel adoption; Household energy choice; Limited dependent variable models; Energy poverty; Ghana.*

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Beyond Symptoms: Integrating the Hasevi Curative Model with Socio-Technical Frameworks to Address Root Causes of Energy Insecurity in Ghana and Africa

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Parallel Technical Session I · p. 6

Energy insecurity across Sub-Saharan Africa represents a complex systemic failure rooted in structural political-economic distortions that conventional methodologies and frameworks inadequately capture. Despite decades of policy reform, market liberalisation, infrastructure investment, and international development assistance, countries across the continent, including Ghana, Nigeria, Kenya, and South Africa, continue to experience recurrent power shortages, utility financial crises, and governance failures. This reflects a systemic analytical gap, conventional policy frameworks focus on treating the symptoms of energy insecurity rather than diagnosing structural root causes. Root Cause Analysis (RCA) applied across engineering, healthcare, IT, and public policy on technical process failures or categorical cause-mapping rather than on the structural power asymmetries, institutional capture, and financial distortions that underpin persistent energy insecurity. The study integrated analytical framework that combines the Hasevi Curative Model (HCM), a novel diagnostic framework originally developed within the context of structural food insecurity in Africa with an ensemble of established socio-technical theories, complex adaptive systems theory, institutional and governance frameworks, political economy analysis and sustainability frameworks. The integration is structured as a qualitative, critical-realist procedure grounded in process tracing and the retroductive identification of generative mechanisms, for structural diagnosis of the drivers of energy insecurity across institutional, political, economic, technological, and social dimensions. This integrated framework is applied to Ghana's electricity sector, tracing the historical emergence of energy governance failures through process tracing and institutional analysis. The analysis identifies institutional fragmentation, contractual lock-in with independent power producers, regulatory capture, political economy distortions, fiscal imbalances in utilities, and path-dependent infrastructure as the principal root causes of Ghana's energy insecurity. The study's theoretical, methodological, and policy contributions including the HCM causal chain and the five HASEVI diagnostic dimensions (Institutional Capacity, Economic Policy Alignment, Strategic Infrastructure Development, Energy Technology Innovation, and Value Integration).

Keywords: Root Cause Analysis; Hasevi Curative Model; Energy Insecurity; Energy Governance; Africa; Political Economy

Modelling Renewable Energy Adoption and Its Socioeconomic Impacts in Ghana: Integrating AnyLogic Simulation with Econometric Analysis

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Parallel Technical Session II · p. 7

Even as access to electricity continues to increase in Ghana to 89.03% in 2024, the share of renewable energy in electricity generation still remains very low. Because in that same year solar photovoltaic (PV) energy, excluding large hydro power, contributed merely 0.71% of total electricity generation in Ghana [1]. And this shows that there is the need to better understand how renewable energy adoption can grow and how it can also improve human life as well. Studies that exist in Ghana have mostly examined what drives the adoption of renewable energy, the technical feasibility of it, or socioeconomic impacts as separate issues [2–6]. Nonetheless, the exact scientific gap is that there is still no single framework that identifies who adopts renewable energy, measures its causal socioeconomic effects, and then simulates how adoption may spread over time under different policy conditions. So to the best of our knowledge in the context of Ghana, this study is the first in the context of Ghana to combine causal econometric estimation, agent-based simulation using AnyLogic, and policy scenario analysis in one integrated framework. The study will collect primary data from about 350 households and 80 micro and small enterprises in the Greater Accra, Ashanti, and Bono Regions, and this will be supported by key informant interviews and secondary national energy data. Binary logit or probit and multinomial logit models will be used to estimate the main drivers of adoption and technology choice, while impact analysis will combine Ordinary Least Squares with causal methods like propensity score matching, inverse probability weighting, and treatment-effects models. Unlike earlier studies, the proposed framework will use these econometric results to calibrate an AnyLogic agent-based model in which households and enterprises differ by income, education, gender, location, tenure status, credit access, and awareness. The model will then capture peer influence, behavioural change, and feedback effects, and will simulate adoption pathways from 2026 to 2035 under alternative policy scenarios, including expanded pay-as-you-go financing, lower technology costs, stronger awareness campaigns, improved after-sales service, and changes in grid reliability. The study will from the scientific angle, contribute to renewable energy research in Ghana by developing an integrated framework that links causal econometric analysis with dynamic agent-based simulation for better understanding of renewable energy adoption and its socioeconomic impacts in Ghana. Hence, the results of this study will be relevant for policy makers as they will help them to know which groups are most likely to adopt which technology, who will benefit from a transition to renewable energy sources the most, who is most likely to be left behind, and what the most appropriate policy mix is to support a fast, fair and inclusive energy transition in Ghana.

Keywords: Renewable energy adoption; AnyLogic; econometric analysis; agent-based simulation; socioeconomic impacts; Ghana

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Quantifying and Simulating Household Food–Energy–Water Metabolism in an African Secondary City: An Integrated Assessment of Sunyani, Ghana.

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The household is the city's microcosm of urban food, energy, and water resource metabolism. It is the city's primary site of resource consumption and waste and emissions generation and is at the core of food-energy-water complexity. Population growth is outpacing infrastructure investment across the secondary cities of sub-Saharan Africa, concentrating food, energy, and water pressures and vulnerabilities at the household scale faster than sectorally fragmented institutions can respond.

Sunyani, a Ghanaian secondary city of 329,617 residents and 93,675 households expanding at 4.4% annually, exemplifies this condition, and no existing framework has quantified household-scale FEW resource metabolism and the feasibility of a zero-emission transition for such a city. This study characterises household resource consumption patterns and quantifies and simulates the metabolic performance of food, energy, and water flows at the household level, coupling Material and Energy Flow Analysis (MEFA) to a five-stock System Dynamics Model that projects resource and emission trajectories over 2025–2035 under baseline (So), moderate-transition (S1), and zero-emission-oriented (S2) scenarios.

The evidence base is a primary survey of 270 households, exceeding the Yamane formula-derived minimum sample size of 250 and yielding a margin of error of 6.1% ; of the total household population. Households were drawn from ten suburbs of the Sunyani East and West municipalities and purposively selected to represent the city's housing typologies, income strata, and infrastructure-access profiles. The composite household emission intensity is 1,271.075 kgCO₂e per household per year, dominated by grid electricity and cooking fuels, scaling to a city baseline of 119,038 tCO₂e annually; throughput-efficiency deficits are structural ($TE_{\text{energy}} = 0.85$, $TE_{\text{water}} = 0.70$, $TE_{\text{food}} = 0.72$). Scenario analysis reveals an asymmetry that efficiency-first prescriptions overlook: S1 reduces per-household intensity by 17.1% by 2035, yet it cannot reverse absolute city emissions given 4.4% demand growth, whereas S2, coupling efficiency gains with distributed solar generation and organic-waste recovery, achieves a 56.9% intensity reduction and an absolute decline from 119,038 to 51,358 tCO₂e per year. A simulated food–energy co-benefit invisible to sector-specific models also emerges: under S2, modelled solar deployment raises TE_{food} from 0.72 to 0.90 by reducing outage-driven refrigeration loss. The S1 and S2 gap is much more institutional than technological, and the ten-year simulation identifies a binding institutional-timing constraint on capital-intensive deployment; thus, the establishment of cross-sectoral coordination, green financing opportunities, and a workable net-metering framework is a prerequisite.

Keywords: Food–Energy–Water nexus; urban household metabolism; material and energy flow analysis; system dynamics modelling; greenhouse-gas emission intensity; throughput efficiency; Sunyani; Ghana.

Quantitative and Game-Theoretic Modelling of Power Purchase Agreements (PPAs) and Renewable Energy Investment Risk in Emerging Energy Markets: Evidence from Ghana

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Parallel Technical Session II · p. 7

Power Purchase Agreements (PPAs) play an important role in attracting private investment in renewable energy because they provide long-term contractual arrangements between governments, utilities, and Independent Power Producers (IPPs). In Ghana, however, challenges such as excess-capacity payments, exchange-rate fluctuations, and increasing fiscal liabilities have raised concerns about the financial sustainability and risk exposure associated with existing PPA arrangements. Although previous studies have examined these challenges mainly from institutional, regulatory, and policy perspectives, there is still limited use of robust quantitative models to examine the strategic and financial risks associated with PPA decisions.

This study responds to this methodological gap by focusing on two complementary quantitative approaches: Stackelberg game theory with bi-level optimization, and stochastic risk analysis using Monte Carlo simulation, Value-at-Risk (VaR), and Conditional Value-at-Risk (CVaR). The Stackelberg framework is used to examine the strategic interaction between the government or regulator and renewable energy Independent Power Producers, particularly in relation to tariff and generation-capacity decisions. The stochastic risk approach is used to assess how uncertainty in key financial variables affects the risk exposure of government and investors. These approaches are therefore selected because they address two closely connected aspects of the PPA problem: strategic decision-making and financial risk under uncertainty.

The empirical analysis will be calibrated using data from Ghana's Energy Commission, Public Utilities Regulatory Commission (PURC), Bank of Ghana, International Monetary Fund (IMF), and World Bank. The study is expected to provide quantitative evidence on tariff and capacity decisions, financial risk exposure, and potential risk-sharing arrangements within renewable energy PPAs. The findings will contribute to the energy economics and renewable energy finance literature by providing a practical quantitative framework that can support better PPA design while balancing investor confidence, consumer welfare, and fiscal sustainability in emerging electricity markets.

Keywords: Power Purchase Agreements (PPAs); Renewable Energy; Stackelberg Game Theory; Bi-level Optimization; Monte Carlo Simulation; CVaR; Investment Risk; Ghana.

A Multi-Level Policy Framework for Sustainable Lithium Development in Ghana

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Parallel Technical Session II · p. 7

As the global energy transition accelerates demand for modern energy resources, the discovery of lithium deposits at Ewoyaa positions Ghana among Africa's emerging producers of battery minerals. However, resource endowment does not automatically guarantee developmental benefit. Without coherent governance, lithium extraction risks reproducing the low-value-added, enclave patterns that have historically constrained Ghana's mineral economy, with adverse implications for industrial transformation, fiscal capture, and equitable benefit-sharing. The study adopts a qualitative research design, reviewing 53 policy-oriented studies through document and regulatory analysis, complemented by a comparative case study of mineral governance in Ghana, Zimbabwe, the Democratic Republic of Congo, Chile, and Indonesia. The study identifies persistent gaps in fiscal regime calibration, local content enforcement, inter-agency regulatory coordination, and community benefit-sharing, alongside underexploited opportunities for battery-grade value addition under the African Continental Free Trade Area (AfCFTA). The study develops a multi-level policy framework for sustainable, equitable, and green industrialisation, arguing that institutional coherence, rather than endowment alone, will determine whether Ghana's lithium sector becomes a vehicle for green industrialisation or extractive path dependency. This vision also demands engineering education, curriculum reform and industry-linked training for value-addition competencies, and entrepreneurial pathways such as SME participation, battery-manufacturing ventures, and technology commercialisation. It concludes by proposing a strengthened regulatory coordination mandate for the Minerals Commission, phased-in local value-addition obligations, and mechanisms for embedding just transition principles within Ghana's critical minerals policy.

Keywords: lithium governance; critical minerals; green industrialisation; engineering education; just energy transition.

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Energy Consumption Characterization at Ghanaian Water Treatment Plant Pump Stations: Field Evidence from Mampong and Owabi WTPs

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Water flow and energy consumption are interrelated and, in Ghana, that energy is going to waste at a magnitude that can be measured and mitigated. Two-thirds of the water treatment plant's electricity use is at the pump stations. However, Ghana Water Limited (GWL), which operates in 84 water systems supplying 14 million people, has yet to publish an energy consumption profile for any of its pump stations. The Mampong Water Treatment Plant (MWT) (peri-urban, Run of River) and the Owabi Water Treatment Plant (Owai) (metropolitan, reservoir) in Ashanti Region were surveyed to collect 12 months of metered billing records, 72 hours of dry season field campaigns and 12 structured interviews from the GWL staff. HIOKI PW3360-21 power analyzer, a Seametrics iMAG 4700 flow meter, and Keller Series 35X pressure transducers were used, which showed a cross-validation error of 2.11 and 1.81 percent, respectively. The dual-site design allows the separation of scheduling practices from the effects at the facility scale. The annual-specific energy intensity (SEI) for Mampong is 1.054 kWh/m³, which is 134 percent higher than the ESMAP benchmark of 0.45 kWh/m³ for cities of similar size and development in Africa. It has a steady load factor of 0.72–0.73. This confirms that the Public Utilities Regulatory Commission's (PURC) two-part structure of the Special Load Tariff is not being observed, which translates to at least GH¢57,524 in unnecessary costs annually, as affirmed by all the 12 operators interviewed. Owabi, which treats three times the volume at an SEI of 0.404 kWh/m³ and stays within the benchmark, still faces unmitigated peak demand charges due to a nearly flat diurnal profile of 163–250 kW. The difference in SEI of 2.6-fold between the two sites suggests that the problem with Mampong is related to the scheduling culture problem. This trend is widely experienced and is planned to increase at GWL's 61 surface water treatment systems, as peak demand cost will be increasing through 2030.

Keywords: Specific energy intensity, Special Load Tariff (SLT), peak demand charge, pump station, Ghana Water Limited, dual-site design, Public Utilities Regulatory Commission's (PURC), Energy Sector Management Assistance Program (ESMAP).

Energy Efficiency and Demand-Side Management as Low-Cost Levers for Grid Reliability and Decarbonization in Ghana's Electricity Sector

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Ghana's power sector faces a structural tension between rising peak demand, which grew from 3,952 MW in 2024 (up from 1,161 MW in 2000, a 5.2% average annual growth rate) to a projected 4,338 MW in 2025, and continued dependence on capital-intensive, foreign-exchange-exposed thermal capacity, which accounted for 61% of Ghana's 2024 electricity generation (up from 8% in 2000) against a hydro share that has fallen from 92% to 39% over the same period (Energy Commission, 2025 National Energy Statistical Bulletin; GRIDCo, 2025 Electricity Supply Plan). GRIDCo's own supply-adequacy analysis projects a cumulative generation capacity shortfall of 294 MW in 2026, rising to 593 MW by 2030, even after applying the mandated 18% operating reserve margin. This is compounded by distribution-level losses that stood at 27.1% in 2024, in sharp contrast to GRIDCo's transmission losses of 3.86% against a 4.1% PURC benchmark, and by direct exposure to fuel and exchange-rate volatility: PURC's Second Quarter 2026 tariff review shows a single 6.78%-cedi appreciation driving a GH¢499.7 million swing in the quarterly revenue requirement.

Despite this, Ghana's policy response to demand-side interventions remains underdeveloped. The National Energy Policy explicitly names weak implementation of industrial demand-side management as an unresolved issue. Still, its response stops at qualitative direction, promoting appliance standards and labelling, encouraging industrial efficiency without a quantified national EE/DSM savings target or system-level cost-benefit assessment. Ghana's existing EE labelling and standards regime, formally in place since the early 2000s, continues to suffer from weak enforcement, limited consumer awareness, and negligible integration with dynamic pricing. Existing Ghanaian and sub-regional literature separately documents individual efficiency measures or supply-side capacity sufficiency. Still, no study combines bottom-up end-use engineering modelling, electricity-demand econometrics, and system-level cost and emissions assessment into a single Ghana-specific EE/DSM evaluation framework. This study closes that gap by quantifying the extent to which coordinated interventions time-of-use (ToU) tariffs, minimum energy performance standards (MEPS), industrial DSM programmes (particularly in mining and cement, Ghana's most electro-intensive sub-sectors), and accelerated smart-meter deployment can reduce peak demand, energy consumption, system cost, and CO₂ emissions relative to GRIDCo's published 2026 – 2030 reference case.

The study applies a mixed-methods framework combining bottom-up engineering-economic modelling LEAP/ OSeMOSYS-type accounting of end-use loads, calibrated to the Energy Commission's 2024 sectoral consumption shares (residential 41.4%, industrial 42.3%, service 16.0% of 20,303 GWh total consumption) with econometric estimation of own- and cross-price electricity-demand elasticities, using secondary panel data from the Energy Commission, PURC, ECG, GRIDCo, the Bank of Ghana, the World Bank, IEA, and IRENA. The analysis is anchored theoretically in the energy-economics framework of Zweifel, Praktiknjo, and Erdmann (2017) [1].

Energy Efficiency and Demand-Side Management as Low-Cost Levers for Grid Reliability and Decarbonization in Ghana's Electricity Sector

Ghana's actual 2024 system peak (3,952 MW) and electricity consumption (20,303 GWh) provide a fully current and sourced reference case, against which GRIDCo projects a 2026–2030 system peak rising to 6,198 MW and required new generation capacity of 294–593 MW per year. Applying a savings-potential benchmark documented in Ghana-specific literature a transient-inefficiency reduction potential of approximately 5.7% of consumption, extended to an illustrative upper bound of 10% consistent with the broader sub-Saharan African efficiency-scenario literature (Adom, Kwakwa, & Amankwah, 2018) to this reference case indicates a scoping range of approximately 225–395 MW of avoided peak demand and 1,160–2,030 GWh of avoided annual energy consumption, comparable in scale to a full year of GRIDCo's projected capacity additions. At the Energy Commission's reported 2024 average electricity sale price of GH¢1.16/kWh, this corresponds to approximately GH¢1.3–2.4 billion in avoided annual electricity cost; applying the Energy Commission's published 2024 grid emission factor of 0.35 tCO₂/MWh indicates approximately 405–711 ktCO₂ of avoided annual emissions. These figures represent an initial scoping-level application of a published, Ghana-specific savings benchmark to the country's current reference case, and are being narrowed through the study's own bottom-up end-use modelling and econometric elasticity estimation, both underway.

The study's principal contribution is the combination of engineering-based end-use modelling, demand-elasticity estimation, and system-level cost and emissions assessment within a single Ghana-specific EE/DSM framework directly quantifying a policy gap the Government of Ghana has itself identified but not measured, and ranking interventions by cost per avoided megawatt, energy saved, and tonne of CO₂ abated. The framework is transferable to other electricity systems experiencing rapid demand growth, thermal-generation dependence, foreign-exchange exposure, and limited fiscal capacity for continuous supply-side expansion conditions common across much of sub-Saharan Africa and offers Ghana's Energy Commission, PURC, GRIDCo, and distribution utilities an evidence base for sequencing EE/DSM investment ahead of further thermal or grid capacity commitments.

Keywords: energy efficiency; demand-side management; peak demand; electricity demand elasticity; time-of-use tariffs; system cost; grid reliability; decarbonization; Ghana.

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THE IMPACT OF ELECTRIC VEHICLE CHARGING STATIONS ON GHANA'S ELECTRIC GRID; A PROJECTION FROM 2024 - 2045

Facilitator / Speaker: **Benedict Clifford Amekah**
University of Energy and Natural Resources

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Using software simulations, this paper examines the impact of EV charging stations on the future electricity demand of Ghana's grid, considering a 35% EV penetration projection by 2045. The findings reveal that while the grid can handle the increased demand in the short term, significant challenges are anticipated by 2045, particularly in urban centers like Accra, where EV adoption is expected to be the highest. Issues such as grid overloading, voltage drops, and power quality degradation are likely to arise without significant infrastructure enhancements. To address these challenges, the study recommends targeted upgrades to distribution infrastructure, the adoption of smart charging strategies, and increased investments in renewable energy. It also highlights the importance of establishing public-private partnerships and supportive regulatory frameworks to finance and manage these improvements. By providing valuable insights for energy planners and policymakers, this research underscores the need for proactive measures to ensure grid stability and reliability while supporting Ghana's transition to a sustainable transportation system.

Keywords: Electric vehicles, Ghana's electric grid, Electric vehicle penetration, Power generation capacity, Charging infrastructure

DSTATCOM-Based Power Factor Enhancement in Hybrid PV-Wind Low-Voltage Distribution Networks: A Case Study at GA West Network

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Increasing photovoltaic and wind generation on low-voltage feeders can create reactive-power imbalance, voltage variation, and additional network losses. This study evaluates a Distribution Static Synchronous Compensator (DSTATCOM) as a coordinated compensation option for the electricity distribution system in the GA West Municipal District of Accra, Ghana. A 26-bus representation of the local network, including solar PV and wind generation, was implemented in MATLAB/Simulink. The modelling procedure was independently benchmarked with the IEEE Low-Voltage Distribution Network. System behaviour was examined under several operating conditions using active and reactive power, power factor, voltage profile, and technical losses assessment. The simulation results show that DSTATCOM support moves the network power factor towards unity, produces a steadier voltage profile, and decreases both active- and reactive-power losses. At Bus 4, the recorded operating point was 294.6 MW of active power, -42.6 MVAR of reactive power, and a power factor of 0.99. These findings indicate that DSTATCOM-based compensation can provide effective local reactive-power regulation and improve the operating efficiency of low-voltage networks with substantial hybrid PV-wind penetration. The proposed approach therefore offers a practical power-management framework for renewable-rich distribution feeders with conditions comparable to those in GA West.

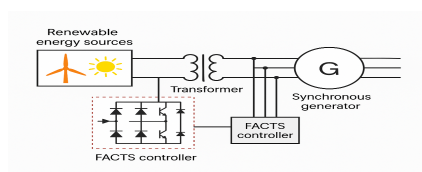


Fig. 1 – Hybrid solar PV-wind turbine and DFACTS controllers connected to the grid

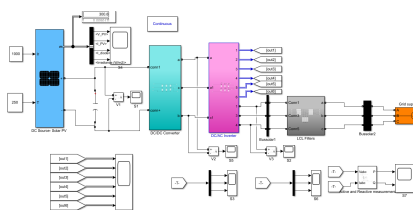


Fig.2 – Solar PV Systems. This consists of panels converter, an inverter, and filter connected to the grid

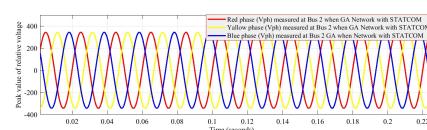


Fig.3 – "Peak value of relative Voltage obtained at Bus 2 when the GA Network with DSTATCOM

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An Integrated Legal, Governance and Financial Framework for Sustainable Downstream Petroleum Decommission in Ghana

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Ghana's downstream petroleum sector; refineries, depots, storage terminals, pipelines, liquefied petroleum gas facilities, and retail outlets has expanded steadily since the country entered commercial petroleum production, yet its governing statute, the National Petroleum Authority Act, 2005, addresses licensing, monitoring, and operational standards rather than infrastructure retirement. Ghana's upstream sector has since 2016 built statutory decommissioning plans and a dedicated Decommissioning Fund; the downstream sector has no equivalent. As ageing depots, terminals, and stations approach end-of-life, this asymmetry leaves environmental restoration, financial liability, and institutional coordination without a coherent governing framework, and existing scholarship on Ghanaian petroleum decommissioning has examined the upstream sector almost exclusively.

This study designs a comprehensive legal, governance, and financial system for sustainable downstream petroleum decommissioning in Ghana, in support of the country's energy transition agenda. Five objectives structure the work: assessing the current legal and regulatory framework and its implementation gaps; evaluating institutional governance, regulatory coordination, and accountability; examining fiscal security instruments; decommissioning funds, escrows, performance bonds, insurance, and corporate guarantees available to finance closure; benchmarking legal, governance, and financial practice in the United Kingdom, Norway, and Nigeria against Ghana's energy transition needs; and consolidating the findings into an integrated decommissioning model.

The study adopts an interpretivist, qualitative multiple-case design, with Ghana as the principal case and the UK, Norway, and Nigeria as comparator cases evidenced through legislation and regulatory documentation. Evidence from Ghana is triangulated across doctrinal legal analysis of Acts 919, 691, and 1124; documentary review of institutional and regulatory reports; semi-structured interviews with 20–35 purposively sampled officials across the Ministry of Energy, the National Petroleum Authority, the Environmental Protection Authority, the Petroleum Commission, BOST, and district assemblies; and field observation at petroleum facilities in Tema, Takoradi, and Kumasi. Data are analysed thematically following Braun and Clarke's six-phase framework, supported by NVivo 15.

The study is expected to produce an integrated framework that assigns institutional responsibility, specifies financial assurance instruments, and sets out an environmentally responsible closure pathway for downstream petroleum infrastructure. The framework offers policymakers, regulators, and petroleum operators a coordinated basis for retiring ageing infrastructure while supporting Ghana's long-term energy transition and climate resilience objectives.

Keywords: *petroleum decommissioning; downstream infrastructure; energy transition; institutional governance; financial assurance; Ghana*

Assessing Non-Revenue Water Reduction through Improved Mean Time to Repair for Water Supply Systems in Ghana

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Non-revenue water (NRW) remains a major challenge for water utilities, reducing water availability and revenue recovery. [1]. High NRW levels can undermine utility efficiency and financial sustainability, particularly where leakage losses are significant. [2]. This study investigates the extent to which improvements in the mean time to repair (MTTR) of pipe failures can contribute to NRW reduction in four water supply systems in Ghana. Quarterly records of pipe failures, MTTR, and NRW (2020 to 2023 for ABD and Nandom; 2021 to 2023 for Asiakwa and Akwadum-Nankese) were analysed. Three-dimensional response-surface visualisations, comparative statistical analyses and regression modelling were employed. The response surface analyses (Fig.1) revealed that NRW generally increased with increasing MTTR, whereas the influence of failure frequency was comparatively weaker. Comparisons between shorter and longer MTTR groups showed mean NRW increased from 28.35% to 44.68% in ABD and from 46.36% to 58.21% in Nandom, while corresponding increases were observed in Asiakwa (28.94% to 38.10%) and Akwadum–Nankese (27.73% to 31.99%). Sensitivity levels represent failure-frequency categories used to assess MTTR–NRW relationships. Correlation analyses further revealed positive relationships between MTTR and NRW, with statistically significant associations in ABD ($r = 0.81$, $p = 0.016$) and Nandom ($r = 0.69$, $p = 0.041$). The pooled model showed that NRW increased by approximately 7.75 percentage points for each additional day of MTTR ($p = 2.49 \times 10^{-7}$), while failure frequency had no significant effect. Although significant correlations were observed only in ABD and Nandom, pooling data across systems increased statistical power and revealed a consistent positive association between MTTR and NRW. The findings highlight MTTR as a key operational performance indicator associated with NRW variations.

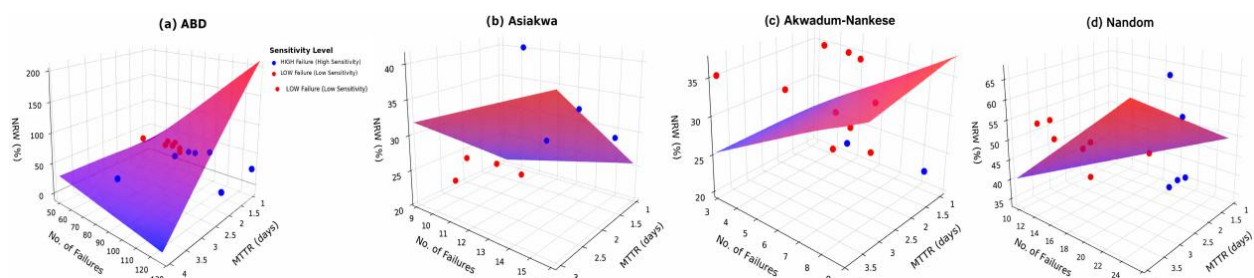


Fig.1 – 3D visualization of the interaction between MTTR, No. of pipe failures per quarter, and NRW

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An integrated optimisation model for analysing demand response and renewable energy integration

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The electricity consumption sector in Ghana faces problem of low integration of renewable energy sources, inflexible demand, exacerbated grid constraints, leading to higher generation costs, supply insecurity, and high environmental emission due large thermal component in the electricity generation system. To address these issues, several models have been developed to analyse demand response and renewable energy output independently, but they largely failed to capture the benefits of integration. The study developed an integrated optimisation model that incorporates solar photovoltaic (PV) energy and demand response dynamics to address inflexible demand response and improve renewable energy integration.

The model uses household load profile data, solar irradiance data from NASA POWER, PVGIS, and data from the Ghana Energy Commission. Applying the Mixed-Integer Linear Programming (MILP) algorithm, the model is validated using a case study of 20 households in Tema Central, Ghana. The MILP algorithm is coded in Python with the help of the Pyomo library and the GUROBI solver and operates for 168 hours to analyse the inter-day storage and demand flexibility. The results show that a medium flexibility configuration results in a cost savings of 20% compared to a base case, while a high flexibility configuration results in savings of up to 32%. In addition, self-consumption of solar energy for moderate and high flexibility increases by more than 36% and 40%, respectively. The study recommends that a solution integrating solar photovoltaic generation, battery energy storage systems, demand response, electric vehicles, and time-of-use pricing can provide a cost-effective way to optimise residential power systems in Ghana and sub-Saharan Africa.

Key Words: Ghana; demand response; renewable energy integration; Solar PV; Optimisation; Mixed-Integer Linear Programming (MILP)

Techno-Economic Assessment of Rooftop Solar PV Systems with Net Metering for Residential Electricity Users in Kumasi, Ghana

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As electricity tariffs for households rise and supply reliability issues persist, Ghanaian households are turning to distributed renewable energy solutions. However, while RSPV system costs and PURC-regulated tariffs are largely uniform across Ghanaian cities, solar resource availability and real-world performance losses from humidity, soiling, and thermal derating vary by climate zone, and no location-specific techno-economic assessment has yet quantified how these performance differences affect the payback and cost-effectiveness of rooftop PV for residential households in Kumasi's humid forest-transition climate. This study assesses the techno-economic feasibility of a 5 kWp grid-tied rooftop photovoltaic (PV) system, without battery storage, for a typical residential household in Kumasi. To determine the levelized cost of electricity (LCOE), simple payback period, and net present value (NPV), a 20-year discounted cash flow (DCF) model was developed using the following data: solar resource data for Kumasi (modeled yield of 1,650 kWh/kWp [1] [2]); current PURC residential tariffs (GHS 2.00/kWh) [4] [5]; representative system costs (GHS 25,000) [6]. Results indicate that the system can produce about 8250 kWh per year under modelled conditions, yielding a payback period of 1.5 years with an LCOE of GHS 0.40/kWh ($\approx$ USD 0.036/kWh), much lower than the current home electricity tariff of GHS 2.00/kWh. Even with the more conservative performance scenario of field measurement [3], the time to payback is still just 2.1 years, with an LCOE of GHS 0.56/kWh, which is also below the grid parity. The total savings, which will not be discounted over the system's operational period, exceed GHS 284,000. The results show that net metering is a profitable investment in the case of rooftop PV for Kumasi households, even when not backed by batteries, but the difference between the modelled and the measured yield highlights the need to consider tropical climate derating factors (humidity, soiling, thermal losses) when assessing PV feasibility. The outcomes offer locally relevant evidence to facilitate the adoption of solar energy that can drive Ghana's energy transition towards climate resilience for households, financiers and policymakers.

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AI-Driven Fault Detection and Classification in Distribution Systems: A Framework for Emerging Smart Grids in Ghana

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The increasing complexity, decentralization, and operational demand of modern electrical distribution networks have introduced significant challenges in fault detection, system reliability, and grid resilience. This study develops a reliable and data-driven machine learning (ML) based framework capable of detecting and classifying faults in electrical distribution networks. This study modelled and simulated fault scenarios on the Ashanti Region Electricity Company of Ghana (ECG) 33 kV distribution network in ETAP and utilized dataset from the IEEE 34-bus standard test feeder for benchmarking. Random Forest (RF) and Extreme Gradient Boosting (XGBoost) algorithms were implemented as ensemble learning techniques for multi-class fault classification, and model performance was evaluated using accuracy, precision, recall, F1-score, and confusion matrix analysis. Results from the Ashanti Region ECG 33 kV network achieved baseline, tuned, and optimized classification accuracies of 72.67%, 86.50%, and 98.33% respectively, while the IEEE 34-bus feeder achieved a baseline accuracy of 86.40% and an optimized accuracy of 99.17%. The findings confirm that ensemble machine learning techniques provide reliable and robust fault classification capability for modern distribution networks. The integration of practical ECG operational data with standardized IEEE benchmark systems shows a promising deployment of the model for the utilities. The framework enables near-instantaneous fault-type identification at sub-millisecond inference latency, supporting targeted switching, reduced outage durations, and direct improvements in system reliability indices without requiring additional hardware beyond existing SCADA infrastructure. These outcomes demonstrate the viability of deploying artificial intelligence (AI) driven fault classification as an operational tool in emerging smart grid environments across sub-Saharan Africa.

Keywords: Fault detection, Machine learning, Random Forest, XGBoost, Distribution network, Smart grid, Ashanti Region ECG, IEEE 34-bus feeder.

Framework for Sustainable Last-Mile Electric Three-Wheeler Mobility Transition in Sub-Saharan Africa

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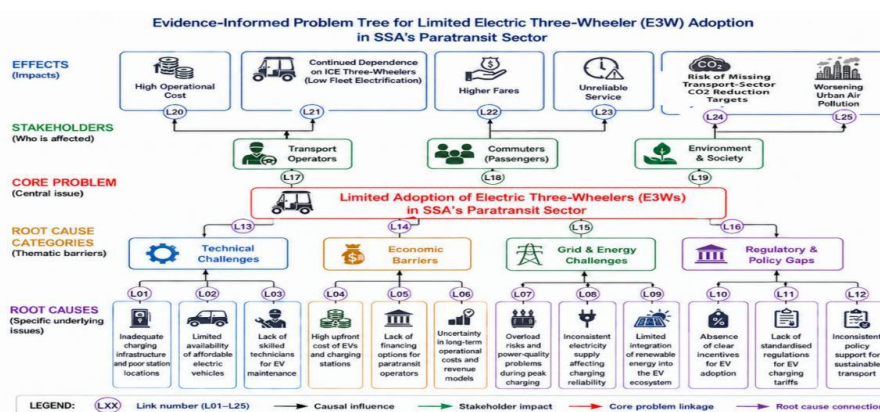
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The transition to electric mobility offers opportunities to reduce emissions. However, the electrification of last-mile electric three-wheelers (E3Ws) paratransit in Sub-Saharan Africa (SSA), remains constrained by limited charging infrastructure, high acquisition costs, grid limitations, financing barriers, and fragmented policy support. Although analytical approaches for electric vehicle deployment are well established, evidence specific to E3Ws and calibrated to SSA paratransit systems remains limited[1], [2].

This study conducts a systematic literature review and bibliometric analysis to develop an evidence informed implementation framework for sustainable E3W deployment in SSA. The review follows PRISMA 2020 using literature published between 2005 and 2026. Records were identified from Scopus, Web of Science, ScienceDirect, and relevant grey-literature sources. The screened evidence was coded against six review objectives(i.e. emissions, adoption, technical, charging infrastructure, grid impacts, and total cost of ownership). Bibliometric analysis using Bibliometrix/Biblioshiny and VOSviewer to examine research fronts, country collaboration, and co-authorship patterns. Thematic and cross objective synthesis was subsequently used to identify recurring, convergent, and divergent evidence patterns.

The findings show that E3W transition outcomes are jointly shaped by vehicle operating characteristics, charging demand, electricity network conditions, financing structures, infrastructure availability, and policy design[3], [4]. The scientific contribution of the study lies in integrating these previously fragmented evidence domains within a single implementation framework. Using a problem-tree approach, the framework provides a structured basis for planning technically feasible, economically viable, and context responsive E3W transitions in SSA paratransit systems, while also identifying priority areas for future field based research.



Evidence informed problem tree for limited electric three-wheeler adoption in SSA's paratransit sector

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Primary Barriers and Enablers of Industry 4.0 Adoption among Manufacturing Firms in Sub-Saharan Africa: A Systematic Literature Review

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Industry 4.0 is transforming manufacturing through technologies such as the Internet of Things, artificial intelligence, cyber-physical systems, cloud computing, robotics, and big data analytics, offering opportunities to improve productivity, efficiency, quality, and sustainability of manufacturing processes. However, adoption among manufacturing firms in Sub-Saharan Africa remains limited, despite ongoing industrialisation and digital transformation efforts.

This study systematically reviews the evidence on the barriers to and enablers of Industry 4.0 adoption among manufacturing firms in Sub-Saharan Africa. Following the PRISMA 2020 approach, literature was identified through Elicit and major academic databases, including Scopus, Web of Science, IEEE Xplore, ScienceDirect, SpringerLink, and the ACM Digital Library. After screening against the review's eligibility criteria, 66 studies were retained for the qualitative synthesis. The included evidence was synthesised to identify recurring financial, technological, infrastructural, human capital, organizational, and institutional factors influencing adoption.

The synthesis identified financial constraints as a major barrier, alongside weak ICT infrastructure, unreliable electricity supply, low digital readiness, cybersecurity risks, skills shortages, inadequate training, organizational resistance, weak managerial commitment, and inadequate national policy frameworks. These barriers are interconnected and vary according to firm characteristics, ownership, resource availability and policy context. Conversely, major enablers include financial incentives, investment in digital infrastructure, workforce upskilling, supportive regulations and national strategies, inter-organizational collaboration, and stronger innovation ecosystems.

The review concludes that Industry 4.0 adoption in Sub-Saharan African manufacturing is shaped not only by technological availability but also by the interaction of financial, infrastructural, organizational, human capital, and institutional conditions. Policymakers should strengthen digital and energy infrastructure, skills development programs, financing mechanisms, and coherent industrial digitalisation policies. Manufacturing firms should pursue phased, capability-based digital transformation, strengthen managerial and workforce readiness, and use collaborative innovation ecosystems to reduce adoption risk and support sustainable implementation.

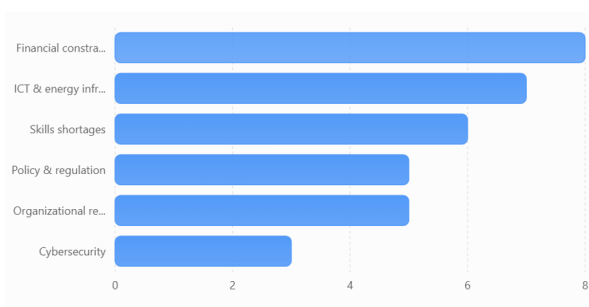


Figure 1 frequency table of Major adoption barriers



Figure 2 Overview of the nine technological pillars of Industry 4.0

Hybrid Joule–Thomson Valve–Turbo-Expander Operation for Flexible Cryogenic Natural Gas Liquids Recovery: A Steady-State Study of Ghana’s Gas Processing Plant Train 2

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The planned Atuabo Gas Processing Plant Train 2 (GPP) is a critical expansion facility designed to process gas from the Jubilee/TEN fields and recover valuable natural gas liquids (NGLs) under ethane-rejection conditions using a turbo-expander technology for maximum NGL recovery. The turbo-expander technology operation is, however, usually constrained during start-up and low-flow conditions. This study therefore evaluates a hybrid expansion strategy in which a Joule-Thomson (JT) throttling valve is presented as an isenthalpic device that provides start-up and low-flow operation. In contrast, the turbo-expander, as an isentropic-efficiency-based expansion unit, is used during normal operation. A steady-state Aspen HYSYS model was developed to represent the feed-gas conditioning, dehydration, integrated JT valve/turbo-expander expansion system, cold separation, demethanisation and NGL fractionation sections. The cryogenic section was modelled using the Peng-Robinson equation of state, and an eight-case sensitivity analysis was performed by varying the Jubilee field contribution from 10 to 100 MMSCFD while maintaining a 100 MMSCFD TEN-field baseload (total feed range of 100–200 MMSCFD). The results indicate an empirical turbo-expander stability boundary between 122.86 and 135.71 MMSCFD total feed, with 135.71 MMSCFD (35.71 MMSCFD Jubilee contribution) identified as the conservative minimum threshold for the turbo-expander engagement. At the 135.71 MMSCFD operating condition, the turbo-expander produces an outlet temperature of -81.51°C compared with -62.97°C for JT expansion, representing 18.54°C cooling advantage, with a corresponding NGL liquid fraction increase from 3.73% to 8.88%, while 2,635 kW of shaft power is recovered. A screening-level economic assessment on an electricity value of \$0.12/kWh, 8,000 operating hrs/yr and a 0.95 mechanical-to-electricity conversion factor estimated an annual energy-value saving of approximately \$2.40 million. Model validation was limited to consistency checks against literature-reported operating and performance ranges because GPP Train 2 has not yet been constructed and measured plant data were unavailable. At the flow threshold, the configured JT/turbo-expander provides certainty for cryogenic operation during low-flow conditions, enabling deeper cooling and shaft power recovery.

Evaluating the Effectiveness of the Safety Management System of the Utility Unit at The Atuabo Gas Processing Plant

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Gas processing is a hazardous operation owing to the flammable, corrosive and toxic substances utilised. This is exacerbated by the pressurised piped infrastructure, vessels and other high temperature and pressure equipment. An effective safety management system (SMS) is very important to prevent safety incidents and mitigate hazards, thereby maintaining the infrastructure and organisational reputation. The study examined the SMS of the Atuabo gas processing plant (GPP) in Ghana, identified hazards at the gas processing plant and evaluated how the SMS address these hazards using the mixed method research design approach. The preliminary hazard analysis (PHA) was the qualitative phase and fault tree analysis (FTA) and questionnaire were the quantitative phase in the study. The PHA was used to identify the hazards at the GPP, the level of the hazards and their potential consequences. From reliability databases, mean failure rates were assigned to each of these basic events identified by the PHA to find the probability of the top event in the FTA. Structured questionnaires were administered to evaluate the safety practices of workers at the GPP. Twenty workers participated in the study, and they were purposely sampled to include all departments that work directly on the Plant including Operations, Engineering, Health, Safety, Environment and Quality (HSEQ), and Maintenance. Content validity was important in the study, therefore the questionnaire was modelled around literature and two experts in academia and one from industry gave their inputs to determine how well the test items represented the subject matter. Six SMS indicators for the study included, hazard awareness, effectiveness of safety training, culture of incident reporting, safety procedure compliance, safety culture and safety climate. The Likert scale format was used where, option 1 with direct percentage (20%) represented strongly disagree; option 2 (40%) represented disagree; option 3 (60%) represented neutral; option 4 (80%) represented agree; and option 5 (100%) represented strongly agree. Avetta safety maturity index was adapted and used for the interpretation of each score where 0-25 is equivalent to option 1 on the Likert scale and it means minimal or absent evident of safety practices (the lowest safety score) and 80-100 is option 4 to 5 (highest safety score) which means there is mature safety practices and culture with continuous improvement efforts. Several identified hazards at the GPP included, gas leaks, steam line rupture, boiler explosion, hydrant malfunction among others. From the FTA, the top event probability for a major event was 4.458×10^{-6} and this falls in the as low as reasonably practical zone. The average score for the entire SMS as scored by all respondents was 84.9% and this falls within the highest safety maturity score band. The examinations of the SMS of the GPP revealed that safety climate was the weakest among all SMS indicators with a 79.4% score. The study concluded that the Atuabo GPP has an effective SMS since the safety maturity score (84.9%) falls within the highest grade of 80-100 band or 4-5 on the Likert scale. However, safety climate, maintenance management and system reliability could be improved to prevent accidents. Recommendations based on best industry practices to strengthen the SMS at the Atuabo GPP included establishing a just culture and non-punitive reporting, mitigating work pressure, preventive maintenance and risk-based inspections, and using accident reversal analysis framework as developed in this work.

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An Integrated Evaluation of De-Risking Mechanisms for Natural Gas Infrastructure as a Catalyst for Ghana's Sustainable Development

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Natural gas remains a significant fuel for electricity generation, industrial activity, and Ghana's longer-term energy transition (Government of Ghana & Sustainable Energy for All, 2023; Energy Commission, 2026a). However, gas-processing, transportation, and supply infrastructure face financial, technical, regulatory, and institutional risks that can undermine reliability, investment, and industrial use. This study assesses major risks affecting Ghana's natural gas infrastructure, evaluates de-risking mechanisms, and examines the relationship between infrastructure reliability and manufacturing viability. It also proposes an Integrated De-risking Framework to strengthen resilience and project bankability across the gas value chain. We used a mixed-method approach combining quantitative and qualitative evidence. Primary data were obtained from a targeted expert panel of 25 purposively selected industry professionals with direct experience across Ghana's natural gas value chain, supplemented by stakeholder input. Risks were assessed using mean scores, standard deviations, and the Relative Importance Index (RII), while relationships were examined using Pearson correlation and thematic interpretation. Off-taker payment default was the highest-rated risk (Mean, 4.32; RII, 0.864), followed by regulatory and institutional overlap (Mean, 4.20; RII, 0.840) and foreign-exchange volatility (Mean, 4.12; RII, 0.824). Transmission constraints and maintenance reliability were also prominent technical concerns. Among existing de-risking mechanisms, private financing received the highest effectiveness rating (Mean, 4.12), followed by public-private partnerships (Mean, 3.64) and improved governance and regulatory frameworks (Mean, 3.48). Although 88% of respondents agreed that reliable gas supply is important to manufacturing viability, the exploratory Pearson correlation between the composite infrastructure-reliability and manufacturing-viability indices was weak and statistically insignificant ($r = 0.197$, $p \approx 0.345$; $n = 25$). This difference reflects the distinction between broad expert agreement and respondent-level correlation and should be interpreted cautiously given the small expert-panel sample and other unmeasured factors. The study proposes four interrelated pillars: regulatory and governance stability, bankable payment security, blended and risk-sharing finance, and technical and operational resilience.

Keywords: Natural Gas; Risk Mitigation; Blended Finance; Infrastructure Resilience; Manufacturing Viability; Ghana

Natural Gas Fuel Quality, CO₂ Emission Factors, and CO₂ Emissions from Thermal Power Generation in Ghana: Implications for Ghana's Climate Targets

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The objective of this study is to analyze the properties of natural gas in relation to fuel quality and carbon dioxide (CO₂) emissions associated with natural gas thermal power generation in Ghana. This study employed a data set of 1,104 observations per hour of gas compositions and qualities, which were collected from online gas chromatograph. Two natural gas fuels were studied: locally produced gas (L-Gas) and Nigerian imported gas (N-Gas). Fuel-specific CO₂ emission factors were calculated using the carbon balance method and calorific value approach, whereas descriptive analysis and paired-samples t-tests were employed to compare the characteristics of both gas types. The findings show that L-Gas is composed of greater methane and lower CO₂ concentrations as compared to N-Gas, and, thus, produces a smaller average CO₂ emission factor of 0.207 kg CO₂/kWh against 0.211 kg CO₂/kWh in N-Gas ($p < 0.001$). Assuming the business-as-usual policy, thermal electricity production is expected to grow from 17.4 TWh in 2025 to 43.9 TWh in 2050, generating a CO₂ emission of 3.6 Mt to 9.1 Mt correspondingly based on L-Gas emission factor. This shows the need for the development of country-specific emission factors that take into consideration the nature of the fuel being used and the operating environment. Despite the provision of low carbon footprint compared to liquid fossil fuels in generating electricity, continued expansion of thermal electricity generation may be an obstacle to Ghana's decarbonization plans if not accompanied by more renewable energy initiatives and emission reduction strategies.

Keywords: Natural gas; CO₂ emission factors; Fuel quality; Thermal power generation; Ghana.

GOVERNING ARTIFICIAL INTELLIGENCE IN GHANA'S ENERGY SECTOR: TOWARDS A LEGAL AND INSTITUTIONAL FRAMEWORK FOR SUSTAINABLE POWER SYSTEMS

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The integration of Artificial Intelligence (AI) into electricity systems management, planning, and optimization is accelerating globally, offering pathways for improved grid stability, reduced technical losses, and progress toward SDG 7 targets on energy access [1], [2], [3]. In Ghana, sector actors, including the Energy Commission, Public Utilities Regulatory Commission (PURC), Volta River Authority (VRA), Electricity Company of Ghana (ECG), and GRIDCo, are reported to be exploring AI-enabled applications for demand forecasting, grid monitoring, and outage management [1], [2]. Ghana's core energy statutes, the Energy Commission Act, 1997 (Act 541), the Public Utilities Regulatory Commission Act, 1997 (Act 538), and the Renewable Energy Act, 2011 (Act 832), were designed to regulate conventional, non-algorithmic utility operations. None addresses the transparency, explainability, liability, or data-governance questions that opaque, self-learning systems introduce, leaving the sector without an explicit legal basis for anticipating or managing AI-related risk.

This paper addresses that gap by examining how Ghana's legal and institutional architecture can be adapted to govern AI deployment in the energy sector responsibly. Grounded in regulatory and adaptive governance theory and in layered models of AI governance [4], the study treats AI oversight as a multi-level problem spanning constitutional human-rights guarantees, sector-specific technical regulation, and institutional coordination, rather than as a matter of technical compliance alone.

The study employs doctrinal legal research and comparative legal analysis, examining Ghana's energy and data-protection statutes alongside the EU Artificial Intelligence Act, OECD AI Principles, and selected Global South regulatory experiences. These comparators are selected for their contrasting approaches to risk-based regulation, principles-based guidance, and governance under institutional and resource constraints comparable to Ghana's. This is complemented by qualitative institutional analysis, combining policy-document review with key-informant engagement across the Energy Commission, PURC, the Ministry of Energy and Green Transition, and the Data Protection Commission, to assess these bodies' readiness to assume AI-oversight functions.

The paper seeks to diagnose the specific legal and regulatory gaps constraining AI oversight in Ghana's energy sector; distill transferable governance principles from the selected international comparators; and develop a layered institutional architecture linking constitutional human-rights protections, sectoral transparency and explainability requirements, and participatory institutional coordination with implications for AI governance debates across Sub-Saharan Africa's evolving energy systems.

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Regulating the Digital Energy Transition in Ghana: A Comparative Analysis of Regulatory Gaps and Reform Pathways

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The digitalisation of energy systems is transforming electricity generation, transmission, distribution and consumption through smart grids, advanced metering, artificial intelligence, the Internet of Things and distributed energy resources [1,2]. While these technologies can improve system efficiency, renewable-energy integration and consumer participation, they also introduce regulatory challenges concerning energy data, cybersecurity, interoperability and institutional coordination [1,3]. This study assesses whether Ghana's existing regulatory framework is sufficiently equipped to govern these emerging digital energy systems and addresses two questions: first, what regulatory gaps exist in Ghana's governance of digital energy systems; and second, what regulatory reforms can be adapted from comparative international approaches to address those gaps? The study employs doctrinal and comparative legal analysis of Ghanaian energy legislation, regulatory codes and institutional mandates, complemented by an examination of regulatory approaches in the European Union and the United Kingdom. The analysis identifies three principal regulatory gaps. First, Ghana's energy regulatory framework does not yet provide an integrated sector-specific governance framework for energy data, including clear arrangements for data access, sharing, interoperability and consumer control. Although the Energy Commission has statutory responsibility for energy data and Ghana has a general data-protection regime, these frameworks are not specifically integrated into a comprehensive digital-energy governance architecture [4,5]. Second, cybersecurity obligations applicable to energy infrastructure remain principally situated within the broader national cybersecurity framework rather than being fully integrated with sector-specific energy regulation and technical requirements. The Cybersecurity Act, 2020 (Act 1038) provides for the protection of critical information infrastructure, including systems associated with public utilities, but the regulatory interface between cybersecurity governance and energy-sector regulation requires greater sector-specific coordination [6]. Third, Ghana's existing regulatory instruments address electricity networks, metering and renewable-energy integration through separate codes and regulatory mechanisms, creating potential gaps in the governance of interoperability and digitally interconnected energy resources [7,8]. Comparative analysis demonstrates that the European Union has developed more integrated arrangements linking energy data governance, interoperability, consumer protection and cybersecurity, while the United Kingdom has used regulatory mechanisms, including Ofgem's data-governance and digitalisation frameworks, to embed data access, standardisation and consumer control within energy regulation [9,10]. Drawing from these approaches, the study proposes an integrated digital-energy regulatory framework for Ghana centred on coordinated institutional oversight, sector-specific energy-data governance, mandatory cybersecurity and interoperability standards, and strengthened consumer protection. The proposed framework extends Ghana's existing energy-governance architecture by connecting energy regulation with digital governance rather than treating digitalisation as a separate technological issue. The study concludes that regulatory reform should move beyond incremental adaptation of existing electricity-sector rules towards an integrated governance model capable of supporting innovation while safeguarding energy security, data rights, consumer interests and the resilience of critical energy infrastructure.

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The Centralisation Trap in Ghana's Energy Transition: Multi-Level Governance, Energy Justice, and Regulatory Monitoring Reform for Net-Zero Development

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Paper Type: Conceptual and Doctrinal Study | Secondary-Source Analysis | Comparative Governance Review

Ghana's renewable energy sector presents an implementation paradox. A relatively robust statutory framework (based on the Renewable Energy Act, 2011 (Act 832) with the Renewable Energy (Amendment) Act 2020 (Act 1045)) is not being matched by commensurate deployment. In 2023, non-hydro renewables accounted for about 0.7% of the total electricity generation mix [48]. The Renewable Energy Master Plan (REMP) has two targets for 2030 – a 10% share of electricity generation from non-hydro renewables at the national level and 1,094.63 MW of grid-connected non-hydro renewables – which are two different indicators and are discussed separately in this paper. In turn, both are analytically distinct from Ghana's Updated Nationally Determined Contribution (NDC), which is formulated as a percentage of emissions reduction relative to business-as-usual rather than as a renewable generation or capacity target [34]. This paper suggests that one of the institutional aspects of the governance gap that has been under-documented in the literature is governance architecture, which can interact with financing, technical, resource and market constraints, and may not be mutually exclusive with these constraints. It leads to the Centralisation Trap, a conceptual proposition rather than an empirically proven causal law. The Centralisation Trap describes how vertically concentrated regulatory authority, combined with horizontally fragmented institutional mandates and weak monitoring and participation, can produce information and accountability gaps that impede effective monitoring, participation and adaptive implementation. The analysis draws on four research questions: What is the institutional allocation of governance authority at various levels in Ghana? What are the monitoring and evaluation gaps and what do they reveal about accountability for implementation? What do these monitoring and evaluation gaps imply about the energy-justice dimensions in Ghana? What institutional design lessons can be drawn, illustratively rather than causally, from Cape Verde for Ghana? The study applies purposive doctrinal analysis to five Ghanaian statutes across the governance, licensing, coordination, participation, M&E, accountability, and enforcement dimensions, complemented by documentary analysis of the REMP, NDC, and NETF, and an illustrative comparison with Cape Verde, based on its decentralised island-level energy planning and renewable-energy governance arrangements. The paper contributes a novel conceptual synthesis by distinguishing vertical centralisation from horizontal fragmentation and linking these conditions to information, accountability and energy-justice risks, while translating the diagnosis into a proposed polycentric M&E architecture with defined multi-level responsibilities, verification and feedback mechanisms.

Keywords: multi-level governance; energy justice; Centralisation Trap; renewable energy; polycentric governance; monitoring and evaluation; Ghana; net-zero development; doctrinal analysis; regulatory reform

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Financing Climate-Resilient Energy Infrastructure in Sub-Saharan Africa: Policy and Institutional Pathways for Sustainable Energy Transition.

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Sub-Saharan Africa faces the dual challenge of expanding reliable energy access while strengthening infrastructure resilience under climate-related risks. Despite substantial renewable energy potential and increasing climate-finance opportunities, many sustainable energy projects remain constrained by weak investment readiness, regulatory uncertainty, institutional fragmentation, and limited engineering delivery capacity. Existing scholarship often treats renewable energy deployment, climate finance, policy reform, and infrastructure development as separate domains, giving insufficient attention to how their interaction shapes project bankability, scalability, and sustainability.

This study examines the financing and policy conditions that enable sustainable energy and climate-resilient engineering solutions in Sub-Saharan Africa. Grounded in energy transition theory and institutional governance perspectives, it argues that successful transitions depend not only on technology availability and policy ambition, but also on the financial, regulatory, and institutional mechanisms that convert project concepts into implementable infrastructure.

The study further investigates how project-preparation systems, regulatory credibility, currency and political risk, utility performance, technical-skills capacity, and inter-institutional coordination influence investment decisions and implementation outcomes. It focuses on renewable and climate-resilient applications, including solar photovoltaic systems, decentralized mini-grids, smart energy networks, energy-efficient infrastructure, and renewable energy solutions for agriculture and rural development.

Using Ghana, Nigeria, and Kenya as comparative cases, the study adopts a mixed-methods approach that combines secondary energy and investment datasets, policy and project-document review, and semi-structured stakeholder interviews. These cases provide variation in energy-market structure, regulatory maturity, renewable-energy deployment, public-private investment experience, and climate-finance engagement. The analysis focuses on multilateral development finance, green bonds, climate and blended-finance instruments, and domestic financing models, including public-private partnerships.

This study contributes an integrated financing-policy-engineering framework that explains why many sustainable energy projects stall between planning and delivery and identifies the institutional, financial, and technical conditions required to strengthen investment readiness and long-term infrastructure performance. By linking risk-sharing mechanisms, transparent regulation, stronger project preparation, local engineering capacity, and inclusive financing models, the study provides a context-sensitive framework for equitable, scalable, and climate-resilient energy transitions aligned with SDG 7.

Keywords: Sustainable energy transition; climate finance; blended finance; renewable energy systems; institutional governance; climate-resilient infrastructure; project bankability; Sub-Saharan Africa; SDG 7.

Comparative Assessment of Groundwater Quality across three Communities in the Akuapem North Municipality, Ghana

Thomas Kofi Agbetiame

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Groundwater is a major source of domestic water in many Ghanaian communities, yet its safety may be compromised by hydrogeochemical processes, inadequate source protection, and faecal contamination. This study comparatively evaluated groundwater quality, drinking-water compliance, and potential microbial health risks in Akropong, Mampong, and Saforo in the Akuapem North Municipality, Ghana. Thirty-two boreholes were purposively selected based on spatial coverage and accessibility, comprising 12 each in Akropong and Mampong and eight in Saforo. In-situ measurements included temperature, pH, electrical conductivity (EC), total dissolved solids (TDS) and salinity. Laboratory analyses covered nitrate-N, nitrite-N, ammonium-N, fluoride, sulphate, total alkalinity, total suspended solids, colour, Pb, Fe, As and Mn, while total and faecal coliforms were quantified as indicators of microbial contamination. Analyses followed APHA/AWWA/WEF (2017) and ISO 19458:2006 within an ISO/IEC 17025:2017 quality-assurance framework incorporating blanks, duplicate analyses, and matrix-spike recovery. Results were evaluated against relevant drinking-water guideline values, and multivariate patterns were examined using Principal Component Analysis (PCA). Bartlett's test was significant ($\chi^2 = 74.59$, $df = 28$, $p < 0.001$), supporting sufficient intervariable correlation for PCA, although KMO = 0.520 indicates only marginal sampling adequacy.

Groundwater quality showed partial compliance with drinking-water requirements. All 32 boreholes complied with guideline values for TDS, nitrate-N, ammonium-N, fluoride, and arsenic, while Pb concentrations were within or at the applicable limit. However, 22 of 32 boreholes (68.8%) had pH values below 6.5, indicating widespread acidic conditions. Iron concentrations ranged from 0.001 to 1.243 mg/L, with the maximum recorded at MBH11, and 11 boreholes exceeded 0.3 mg/L. Manganese ranged from 0.001 to 0.912 mg/L, peaking at ABH7 in Akuapem; 18 boreholes (56.3%) exceeded the WHO provisional guideline value of 0.08 mg/L. Localised water-quality hotspots were also observed for turbidity (0.50–16.4 NTU; maximum at SBH2 in Saforo), apparent colour (<0.01–8; maximum at SBH2), nitrite-N (0.001–1.721 mg/L; maximum at MBH8 in Mampong), and sulphate (6–377 mg/L; maximum at MBH4). Microbiological contamination was substantial, with 16 of 32 boreholes (50.0%) positive for total coliforms and 14 of 32 (43.8%) positive for faecal coliforms. Mampong recorded the highest proportion of faecal-coliform-positive boreholes, whereas the highest faecal coliform concentration occurred at ABH1 in Akropong (1,250 CFU/100 mL).

PCA revealed spatial differentiation in groundwater chemistry, with PC1 scores differing significantly among the three communities (Kruskal–Wallis $H = 17.57$, $p < 0.001$). PC1 and PC2 explained 56.2% of the total variance, increasing to 68.0% with PC3. PC1 (35.1%) showed strong positive loadings for EC (0.87), $\text{NO}_3\text{-N}$ (0.69), sulphate (0.65), $\text{NO}_2\text{-N}$ (0.64) and Fe (0.61), supporting its interpretation as an ionic enrichment–nutrient–metal loading gradient. PC2 (21.1%) was dominated by positive loadings of pH (0.74) and Mn (0.71), with contributions from turbidity (0.44) and an inverse association with $\text{NO}_3\text{-N}$ (–0.54), reflecting a secondary geochemical–physical water-quality gradient. Mampong was associated with higher PC1 scores and greater chemical loading, Saforo with lower mineralisation and a stronger turbidity influence, while Akropong exhibited an intermediate hydrochemical profile.

The study revealed that microbial contamination, acidic conditions, and elevated manganese were the principal constraints on groundwater potability, with additional site-specific Fe, turbidity, colour, nitrite, and sulphate. The findings support strengthened borehole protection, routine sanitary and microbiological surveillance, targeted management of Mn and Fe, and treatment of contaminated groundwater before consumption.

Keywords: Groundwater quality; borehole water; faecal coliform; manganese; drinking-water compliance; principal component analysis; Akuapem North; Ghana.

Drivers of Climate-Smart Irrigation Adoption for Resilient Food Production in Northern Ghana

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Increasing climate variability and unreliable rainfall threaten agricultural productivity and food security in northern Ghana, where smallholder farming remains highly dependent on rain-fed production. Climate-smart irrigation (CSI) technologies can improve water-use efficiency and production stability, but sustained uptake depends on farmers' capacity to use the technologies and on access to dependable water sources. This study assessed the level of CSI adoption and examined factors associated with adoption among smallholder farmers in Savelugu Municipality, Northern Ghana. A cross-sectional quantitative survey was conducted among 430 smallholder farmers selected through a multistage sampling procedure. Savelugu Municipality was purposively selected, farming communities were stratified by irrigation characteristics, the sample was allocated across selected communities, and eligible households were randomly selected. The design was intended to capture farmers from contrasting irrigation settings within the municipality. CSI adoption was defined as the current use of at least one CSI technology. The principal technologies considered included drip irrigation, sprinkler systems, solar-powered irrigation pumps, and smart or soil-moisture-based irrigation scheduling. Water-source reliability was measured from farmers' survey responses and classified as reliable or unreliable. Data were analysed using descriptive statistics, chi-square tests, and multivariable binary logistic regression. For the reported odds ratios, farmers without irrigation training and those with unreliable water access served as the reference groups. Overall, 301 farmers (70.0%) had adopted CSI technologies, while 129 (30.0%) were non-adopters. After adjustment for sociodemographic, institutional, economic, and farm-level factors, irrigation training and reliable water access were associated with higher odds of adoption. Farmers who had received training had higher odds of adoption than those without training (AOR = 2.82, 95% CI: 1.68–4.74, $p < 0.001$), while farmers with reliable water access had higher odds of adoption than those with unreliable water access (AOR = 2.73, 95% CI: 1.48–5.04, $p = 0.001$). Among the variables included in the adjusted model, sociodemographic characteristics, credit access, extension support, and land tenure were not statistically significant. The overall logistic model was statistically significant (likelihood-ratio $p = 0.001$), with modest explanatory and discriminatory performance (McFadden's pseudo- $R^2 = 0.068$; AUC = 0.676) and no evidence of poor calibration (Hosmer–Lemeshow $p = 0.894$). These findings indicate that, within the variables examined, training and dependable water access were associated with CSI adoption. Programmes seeking to expand CSI should combine hands-on farmer training with investments that improve the reliability of irrigation water and provide technology-specific technical support.

Keywords: climate-smart irrigation, climate resilience, smallholder farmers, irrigation adoption, water reliability, resilient food production

Thematic Area: Climate-Smart Agricultural Engineering

Sub-track: Irrigation and drainage solutions for resilient food production

High Climate-Risk Awareness but Low Irrigation Resilience: Adaptation Preferences among Smallholder Farmers in Northern Ghana

Facilitator / Speaker: **Abubakari Sadiq Adam**
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Background: Smallholder farmers in northern Ghana face rainfall variability, prolonged dry spells, heat stress, and seasonal water shortages. Although irrigation reduces dependence on rainfall, farmers' confidence in the capacity of existing irrigation systems to remain adequate under future climate pressures is uncertain. This study assessed climate-risk perceptions, perceived changes in irrigation-water requirements, confidence in future irrigation resilience, and preferred adaptation options among smallholder farmers in Savelugu Municipality.

Methods: A cross-sectional study was conducted among 430 smallholder farmers in Savelugu Municipality. Participants were selected using a multistage sampling approach. Savelugu Municipality was purposively selected because of its agricultural importance, rainfall variability, and relevance to irrigation-based climate adaptation. Farming communities and irrigation clusters were identified and stratified according to irrigation characteristics, after which eligible farming households were selected using proportionate random, simple random, or systematic sampling as applicable. Climate-risk perception was assessed from farmers' reported experiences of changes in rainfall patterns and expectations of future climate-related hazards. Perceived irrigation-water demand was measured from respondents' reported changes in irrigation-water requirements, including the estimated percentage increase in water needed. Future irrigation resilience was assessed from farmers' confidence that their current irrigation systems would remain adequate under future climate conditions. Data were analysed using descriptive statistics, group comparisons, and multivariable logistic regression, with Benjamini-Hochberg adjustment for multiple comparisons.

Results: Overall, 88.6% of farmers perceived changes in rainfall patterns. Early rainfall cessation was reported by 48.1%, heavier storms by 45.6%, more frequent dry spells by 44.0%, and late rainfall onset by 42.3%. Seventy percent reported increased irrigation-water requirements, with a mean perceived increase of 24.5%. Only 32.6% expressed confidence that their current irrigation systems would remain resilient under future climate conditions. Preferred adaptations included improved irrigation scheduling (41.9%), drip conversion (40.2%), solar backup systems (40.2%), larger reservoirs (38.4%), and water-storage tanks (37.7%). Climate-smart irrigation adoption was associated with higher adjusted odds aOR = 1.62, 95 CI (1.10-2.31) of perceiving increased irrigation-water demand and greater confidence in future irrigation resilience.

Conclusion: Farmers reported high awareness of climate-related risks but relatively low confidence in the future resilience of their irrigation systems. Climate-resilient irrigation planning should combine farmers' preferences and perceptions with hydrological, agronomic, engineering, and climate-model evidence. The findings support diversified adaptation strategies rather than reliance on a single irrigation technology or intervention.

Keywords: Climate-risk perception; climate-smart irrigation; perceived irrigation resilience; adaptation preferences; smallholder farmers; Northern Ghana

Landscape Fire, Two Signals: Support-Aware Interpretation of MODIS Burned Area and VIIRS Active Fire in Ghana

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Satellite fire products measure distinct quantities. MODIS MCD64A1 (500 m) maps post-fire burned surfaces [1]; VIIRS 375 m active-fire data record thermal anomalies at overpass [2], while fire radiative power (FRP) characterises radiative energy release [3]. Coarse burned-area products can under-represent smaller burns in African landscapes [4,5]. Sensor integration remains an ongoing need in fire remote sensing [6], yet national-scale evidence on MCD64A1–VIIRS correspondence across district and agro-climatic settings remains limited. This study quantifies that correspondence across Ghana.

Monthly observations from February 2012 to December 2024 were linked to a 260-district framework; 249 met paired-support criteria, yielding 38,595 district-months across five agro-climatic zones. Supported district-months were classified as both-zero, VIIRS-only, MCD64A1-only or both-positive; unsupported observations remained missing. Among VIIRS-positive observations, a district-clustered penalised marginal model examined VIIRS detection count and mean FRP associations with MCD64A1 absence, adjusting for fixed BA-2012 burnable area, month, year and agro-climatic zone.

VIIRS-only, both-zero, both-positive and MCD64A1-only observations accounted for 43.6%, 40.0%, 15.9% and 0.5% of district-months, respectively. Among 22,939 VIIRS-positive district-months, 73.3% lacked MCD64A1 mapped burned-surface evidence. This represents cross-product non-correspondence, not MCD64A1 omission, because VIIRS detections are not an independent reference for true burned area. Conditional absence was 91.1% in Coastal, 85.0% in Forest, 73.1% in Transition, 44.2% in Sudan Savannah and 38.7% in Guinea Savannah. Higher VIIRS detection counts and mean FRP were associated with lower odds of MCD64A1 absence after adjustment.

Thermal-detection and mapped burned-surface evidence provide distinct, complementary views of landscape fire across Ghana. Strong geographical variation in their correspondence indicates that reliance on a single fire product may alter both the amount of fire represented and its apparent spatial pattern across agro-climatic zones. This is relevant to spatially resolved environmental monitoring and modelling and may also propagate into fire-emissions and biomass-burning carbon estimates, for which FRP and burned-area representation are consequential [3,5].

Keywords: Ghana; burned area; active fire; MODIS–VIIRS; fire-product correspondence; multi-sensor Earth observation

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Potential Anthropogenic Influences on Aerosol Loading Dynamics over West Africa: Evidence from MODIS and MERRA-2

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Anthropogenic aerosols influence atmospheric radiation, cloud microphysics, precipitation, air quality and regional climate. Previous studies on anthropogenic aerosols over West Africa (WA) were either fragmented or conducted on a short time scale or focussed on natural dust, and not sufficient enough for sub-regional climate modelling and analysis. This study assesses anthropogenic signatures in aerosol loading dynamics over WA using long-term satellite observations and reanalysis products. Aerosol optical depth (AOD) and Ångström exponent (AE) from MODIS Terra and Aqua were analysed together with MERRA-2 aerosol data and precipitation data for the period 2000–2025. AE was not used alone as a direct anthropogenic tracer. Instead, likely anthropogenic influence was inferred from the zonal and spatial coincidence of high AE with population density, urban and industrial corridors, MERRA-2 black carbon (BC), organic carbon (OC) and sulphate aerosol optical depth, and the persistence of fine-mode signatures across seasons to avoid over-attribution. Correlation analysis, aerosol-species comparison, spatial coincidence analysis and seasonal analysis were performed. The comparison between MODIS Terra and Aqua showed good consistency in AE, with a correlation (R) of about 0.71, while MODIS Terra and MERRA-2 showed moderate agreement of $R \approx 0.6$ approximately. Spatial analysis revealed persistent fine-mode aerosol signatures over the densely populated southern half of WA, particularly along the Gulf of Guinea coastal belt, where fossil fuel combustion, vehicular emissions, biomass burning, domestic fuel use and industrial activities are concentrated. In contrast, the Sahel and regions influenced by the Bodélé Depression were dominated by coarse-mode mineral dust, with low AE values. Seasonal analysis showed that aerosol loading is strongly modulated by precipitation, monsoon circulation, dry-season dust transport and biomass-burning activities. MODIS Aqua generally recorded higher AE values than Terra, suggesting enhanced fine-mode aerosol accumulation during afternoon conditions. Although mineral dust remains the dominant contributor to total aerosol loading over the Sahel, the spatial coincidence of fine-mode aerosol signatures with MERRA-2 BC, OC and sulphate maxima and densely populated coastal corridors is consistent with substantial anthropogenic contributions over the southern urban and coastal corridor. Regionally, AOD and AE were negatively correlated with $R = -0.62$, and regression slope of -0.94 . However, at the Gulf of Guinea coastal corridor AOD and AE showed positive association with R and a regression slope of 0.70 and 1.05 respectively. The positive AOD–AE association over the densely populated coastal corridor, and the relatively high amount of OC, BC and sulphate observed from the zonal profiles suggest a signature of anthropogenic pollution from the denser coastal population. The findings highlighted the need for improved aerosol source attribution, ground validation and integration of emission inventories to support climate, air-quality and public-health planning in WA.

Key words: Anthropogenic aerosols, secondary aerosols, Ångström exponent (AE), AOD, precipitation, MODIS Terra, MODIS Aqua, MERRA-2, spatial distribution and West Africa.

A comprehensive review of waste-to-energy (WtE) as a possible pathway for decarbonization in Ghana.

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Waste-to-energy (WtE) has gained increasing attention as a potential pathway for addressing municipal solid waste management, energy demand, and greenhouse gas (GHG) emissions. This study systematically reviews the evidence on WtE as an alternative decarbonization pathway, with particular emphasis on its relevance to Ghana. Following PRISMA 2020 guidelines, peer-reviewed studies published between 2010 and 2026 were identified, screened, and synthesized. A total of 150 studies were included in the review. The findings show that WtE performance is influenced by waste composition, technology configuration, system boundaries, energy substitution, and avoided emissions. Economic feasibility is affected by capital and operating costs, plant capacity, electricity revenues, tariffs, and financing conditions. Technology suitability also depends on infrastructure, technical capacity, grid conditions, and feedstock characteristics. However, policy, governance, stakeholder participation, social equity, informal-sector livelihoods, and circular-economy considerations remain comparatively underexplored. The study therefore recommends an integrated Ghana-specific assessment combining environmental, economic, technological, governance, and social sustainability dimensions to guide viable WtE decarbonization pathways.

Keywords: Waste-to-Energy (WtE); Decarbonization; Municipal Solid Waste; Greenhouse Gas Emissions; Life-Cycle Assessment; Techno-Economic Analysis; Ghana.

Advancing Vehicle-to-Grid Deployment in Developing Countries: Bibliometric Insights into Smart Charging, Grid Resilience, and Enabling Conditions

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The study is motivated by growing evidence that uncontrolled electric vehicle (EV) charging intensifies distribution-level technical challenges, including elevated line losses, severe voltage instability, and transformer overloading. Conversely, coordinated smart charging and V2G bidirectional power flow can supply vital ancillary services, enhance operational flexibility, support distributed renewable integration, and bolster grid resilience. These dynamics are acutely significant in weak radial feeders such as those characteristic of sub-Saharan distribution networks, where limited short-circuit strength increases vulnerability to load growth and system disturbances. However, the existing V2G literature remains fragmented and is predominantly centered on technically robust networks in developed-country contexts, thereby providing limited evidence on the technical, economic, regulatory, and behavioural conditions required for deployment in developing-country distribution systems. Adopting a systematic bibliometric methodology, literature was retrieved from Web of Science, Scopus and Google Scholar within the period 2010 to 2025, following deduplication and eligibility screening, a final corpus of 140 publications was analysed in VOSviewer to map publication trajectories, co-citation networks, leading research clusters, and keyword co-occurrences. The analysis reveals dominant research clusters around smart charging optimization, dynamic voltage support, microgrid resilience, and V2G market economics. Crucially, the review synthesizes persistent context-specific gaps, particularly in regulatory tariff design, distribution-level value realisation, user participation behaviour, and empirical validation, offering a tailored framework to guide grid operators, policymakers, and regulators in developing countries toward sustainable V2G deployment. This study contributes to the extant literature as it provides an integrated bibliometric mapping of the V2G-resilience knowledge domain, connecting technical, economic, and policy research streams that are often examined separately. Further, the findings of this study are interpreted through the operational realities of weak distribution networks, extending insights from predominantly developed-country V2G research to developing-country contexts.

Keywords: Vehicle-to-Grid (V2G), Grid Resilience, Radial Networks, Electric Vehicles, Smart Charging.

ICEE 2026

International Conference
on Energy and Engineering

30 September – 2 October 2026
University of Energy and Natural Resources
Sunyani, Ghana