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# Clean Energy Alternatives & Renewable Technologies

**By: Dr. Michael Kweku Edem Donkor**  
***Department of Physics, KNUST***

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***THE 2025 AFRICAN SCHOOL ON AIR QUALITY  
AND POLLUTION PREVENTION***



✉ [uro@knust.edu.gh](mailto:uro@knust.edu.gh)

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# Air Quality, Pollution & the Energy Connection

- **Pollution** *related diseases* account for a large percentage of **deaths** across the continent.
- *Most of this pollution stems directly from how we **cook, light, and power** our lives.*
- **Air pollution** is *not just* a **health** issue, *it is also* an **energy** issue.
- *As Africa **urbanizes rapidly**, energy **demand** will skyrocket. If we continue using **dirty energy**, pollution will only worsen.*



# Africa's Energy & Pollution Landscape

- 80% of Africa's electricity generation still relies on **fossil fuels** that emit particulate matter, NO<sub>x</sub> and SO<sub>x</sub>, CO<sub>2</sub>, and CO.
- At the household level, over 60% of homes rely on biomass - primarily ***traditional*** wood and charcoal technologies.
- Urban centers are becoming pollution hotspots where traffic, and industrial activities *contribute to air quality crises*.
- *As of 2025*, solar and wind account for just ~7% of Africa's total energy mix, though trends are accelerating.



# Clean Energy *to the Rescue?*:

- **Alternative primary energy sources** with **minimal** or **no pollutant emissions**.
- Is there any chance that a balance can be achieved such that **energy use** will not create the ***observable negative impacts*** while ***harvesting its benefits*** to our civilization?



***Renewables***



# Why Clean Energy?

- ***Switching*** to clean energy **cuts pollutants**, reducing respiratory diseases and health costs while **improving workforce health**.
- ***Decentralized*** clean energy - like off-grid solar - **creates jobs locally** and allows communities to **control** their energy needs.
- Renewables **curb CO<sub>2</sub> emissions** and **mitigate** extreme weather risks.
- Clean energy **helps close the rural-urban divide**, powering schools, clinics, and small businesses in underserved areas.





# Clean Energy Categories:

## Overview of Renewable Technologies

- **Solar PV:** Harnesses sunlight through photovoltaic cells or concentrated solar systems; ideal for Africa's high solar irradiance zones.
- **Wind Power:** Uses wind turbines to generate electricity; effective in coastal and highland areas with consistent wind patterns.
- **Hydropower:** Generates energy from moving water; includes large dams and small run-of-river systems.
- **Bioenergy:** Converts organic materials like crop waste or manure into electricity, heat, or biofuels; supports circular rural economies.
- **Geothermal and Ocean Energy:** Utilizes Earth's heat or marine dynamics; less common but emerging.



# Solar Power in Africa

- PV panels dominate African solar expansion due to scalability and cost declines; used in both grid and off-grid systems.
- With ~600 million Africans lacking electricity, solar mini-grids and home systems are vital for rural electrification
  - *offering a decentralized, affordable path to energy access - lighting homes, powering clinics, and running schools.*
- From 2010 to 2025, solar PV costs fell by ~85%, making it cheaper than fossil fuels in many regions.
- Countries like Morocco, Egypt, and South Africa are investing in massive solar farms, hence boosting national capacity.



# Wind Energy in Africa

- Modern wind turbines generate electricity without emissions, offering a **stable complement** to solar power.
- Countries like Kenya, Morocco, and South Africa have **strong wind corridors** ideal for utility-scale projects.
- Lake Turkana Wind Power (Kenya) and Tarfaya (Morocco) are among Africa's largest wind installations.
- *Some **challenges** include variable wind patterns, and limited grid connectivity*





# Hydropower in Africa

- **Hydropower is Africa's top renewable source:** Over 17% of Africa's electricity comes from hydro.
- Small-scale hydro (<10 MW) supports rural electrification without large-scale environmental impacts.
- **Mega-dams offer bulk power but high risk:** Raises ecological, political, and displacement concerns among others.
- Changing rainfall patterns and droughts can disrupt output, especially in regions reliant on seasonal rivers.



# Bioenergy in Africa:

## Turning Agricultural Waste into Clean Power

- **Abundant biomass resources across the continent:** Crop residues, animal waste, and forestry byproducts provide major feedstock for bioenergy.
- **Biogas and biofuel technologies can enable rural electrification:** Small-scale digesters can convert organic waste into electricity or cooking fuel, reducing indoor air pollution.
- **Supports circular economy and waste reduction:** Bioenergy systems close the loop by turning agricultural waste into value-added energy products.



# Geothermal & Ocean Energy in Africa

- **Low emissions, high reliability:** Geothermal can provide stable baseload power with minimal land use and low carbon footprint.
- **Geothermal energy thrives in East Africa's Rift Valley:** Kenya leads with over 850 MW installed; Ethiopia and Djibouti are exploring geothermal expansion.
- Wave, tidal, and thermal ocean energy remain largely untapped in Africa but hold promise for coastal nations.



# Energy Access & Security in Africa:

## Navigating the Development Dilemma

- Access remains lowest in rural areas, exacerbating inequality and limiting economic opportunity.
- Unreliable grids and fuel supply disruptions constrain businesses, health systems, and education.
- Rapid industrialization risks higher emissions unless clean energy leads the way.
- **Decentralized renewables can deliver stable, affordable, and equitable energy solutions.**



# Grid vs. Off-grid Energy Systems:

## Infrastructure Challenges and Innovation in Africa

- *Africa's energy future must be powered by **a mix** of grid and off-grid systems, each playing a vital role depending on the context.*
- Large-scale grid networks (***the backbone of electrification***) fail to reach remote areas and often suffer from underinvestment and load shedding.
- Solar home systems and mini-grids provide **flexible**, rapid deployment where national grids can't reach.
- Combining grid and off-grid solutions improves resilience, optimizes resources, and **accelerates** electrification.





# Storage & Smart Systems

- **Battery storage stabilizes renewable supply:** *Battery storage (deployed in both grid-connected and off-grid systems) key to **making intermittent renewables dependable**.*
- **Smart grids improve efficiency and reliability:** Digital sensors and real-time data allow for better grid management, outage prediction, and load balancing.
- **Smart meters empower consumers:** Prepaid, remote-managed meters offer transparent billing, usage tracking, and energy budgeting.



# Africa's Path to Inclusive Green Growth: Balancing Sustainability & Development

- Electricity **access drives** education, healthcare, industrialization, and poverty reduction.
- Africa's population will double by 2050; energy systems must **scale without** deepening emissions.
- Short-term fossil fuel fixes **can trap** countries in outdated systems with *high external costs*.
- Energy policies should link with health, environment, and industrial strategy to ensure holistic development.



# Case Studies in African Renewable Energy

- **Ghana:** 5MWp Floating Solar PV System on the Bui reservoir. It is the first of its kind in the West African sub-region.
- **Kenya: Lake Turkana Wind Power:** Africa's largest wind farm (310 MW) provides stable power to over 330,000 homes, boosting grid reliability.
- **Morocco: Noor Solar Complex:** One of the world's largest CSP plants, Noor produces 580 MW of solar power, reducing 760,000 tons of CO<sub>2</sub> annually.
- **South Africa: REIPPPP Success:** Over 100 renewable projects have been procured via competitive bidding, creating jobs and reducing blackouts.
- **Ethiopia: Grand Renaissance Dam:** Aims to generate over 6,000 MW of hydropower, transforming national energy capacity.



# Renewable Policy Models That Work:

## Lessons for Africa from Regional Successes

- **Smart frameworks** *have enabled clean energy to scale, attract investment, and deliver results.*
- **South Africa's REIPPPP model:** The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) attracted \$20B+ in investment and added 6 GW capacity.
- **Kenya's feed-in tariffs boosted geothermal:** Government-guaranteed tariffs incentivized private investment in geothermal, wind, and small hydro.
- **Morocco's state-led solar strategy:** MASEN coordinated national solar development, launching mega-projects like Noor Ouarzazate.
- **Ghana's National Energy Policy and the Renewable Energy Master Plan:**



# Empowering Africa's Next Generation for a Clean Energy Future

- **Youth are central to Africa's energy future:** 60% of Africa's population is under 25 *providing* a powerful force for climate leadership and clean tech adoption.
- **Education systems must evolve:** Curricula should integrate climate, energy, and sustainability topics across all levels of learning.
- Tech incubators and university labs must foster clean energy startups and African-designed solutions.
- **Policy support is needed to scale impact:** Grants, fellowships, and public-private partnerships can help young innovators move from idea to implementation.





# What Needs to Happen Next:

## Clean Energy Roadmap for Africa

- **Scale up investment in distributed renewables:** Focus on off-grid, mini-grid, and decentralized solar to reach last-mile communities efficiently.
- **Integrate climate, health, and energy planning:** Cross-sectoral strategies ensure clean energy solutions support wider development goals.
- **Strengthen policy frameworks and incentives:** Governments must enact supportive laws, streamline approvals, and derisk private sector entry.
- **Empower local innovation and leadership:** Youth, educators, and entrepreneurs must be central to designing and delivering energy solutions.



# A Call to Action for Africa's Clean Energy Future

- **Clean energy** needs all disciplines at the table.



- *Become a clean energy ambassador, advocate, and innovator.*





# THANK YOU

Kwame Nkrumah University of Science and Technology, Kumasi | Leaders In Change

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 [uro@knust.edu.gh](mailto:uro@knust.edu.gh)

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# Questions

