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Comparative Analysis of the Energy Transition Trends in Ghana to Other Oil and Gas – Producing Nations

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ABSTRACT *The global transition toward renewable energy has intensified debates on sustainability, particularly in oil- and gas-producing nations. Energy continues to fuel economic growth across buildings, transportation, industry, and agriculture, with much of this demand still met by fossil fuels. Although renewable energy sources such as hydropower and solar are gradually expanding, many developing economies remain dependent on hydrocarbons. This study examines Ghana's energy transition trajectory in comparison with Nigeria, the United Kingdom, and the United States. Using a comparative research design, the study assesses how global shifts from fossil fuels to cleaner energy are influencing national policies, energy diversification efforts, and long-term sustainability strategies. The analysis evaluates Ghana's policy frameworks, energy production trends, and investment patterns to determine the economic and environmental implications of the transition. A mixed-methods approach, incorporating qualitative policy analysis, quantitative statistical techniques, and case studies, is used to identify key challenges and emerging opportunities. The findings aim to highlight best practices, structural constraints, and policy recommendations that can strengthen Ghana's efforts toward a sustainable and resilient energy future. This study contributes to the broader discourse on sustainable energy planning by offering insights for balancing economic development with environmental responsibility in resource-dependent economies.*

KEYWORDS *Energy Transition, Renewable Energy, Ghana, Comparative Energy Policy, Sustainable Energy Planning.*

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I. INTRODUCTION

The global energy system is undergoing a major transformation driven by climate change mitigation, energy security concerns, and technological innovation. Advanced economies such as the United Kingdom (UK) and the United States (USA) have made substantial progress in the deployment of renewable energy technologies, supported by strong institutions, comprehensive policy frameworks, and significant investment. In contrast, developing and hydrocarbon-reliant economies including Ghana and Nigeria face financial, regulatory, and infrastructural challenges that continue to impede a seamless transition [1].

Climate change affects every area of our lives, particularly health and agriculture [2,3]. To mitigate climate change and achieve SDGs 7 and 13, restrictions on fossil fuel use and a global shift towards renewable energy are encouraged [4–6]. This might affect emerging crude oil-producing countries such as Ghana. This energy transition is affirmed at the Conference of Party (COP) 28. It is estimated that the renewable energy share will increase to 60% by 2040 [7]. Comparatively, renewables are more environmentally friendly and generate smaller carbon dioxide footprints [4,8–9].

Additionally, the price tags of renewable energy are decreasing. Solar PV cost has decreased by almost 80%, whereas the cost of wind turbines has decreased by approximately 30 to 40% [10]. Again, the tremendous increase in air quality that was observed during the COVID-19 pandemic's early lockdown period has reignited the pledges to transition to renewables [11,12]. Consequently, switching to renewable energy is unavoidable. Given the significance of renewable energy towards sustainable energy, energy policymakers must evaluate the consequences of the energy transition on emerging oil-producing economies such as Ghana [13]. The macroeconomic performance of these emerging oil-producing countries is hampered by a fall in petroleum demand since it impacts their export revenue and government budget [14,15]. These countries anticipate funding

a sizable portion of their national budgets with crude oil profits [4,16]. Despite accruing significant income from oil, [17] assert that many developing oil-producing nations lack the diversified manufacturing infrastructure and technologies needed to advance. The majority of such countries' non-oil output is imported and their non-oil output is always non-tradeable due to low-skilled labour. Furthermore, Zakaria [18] reiterate that public sector employment is supported by oil earnings in these economies, including Ghana.

Global calls for a transition to low-carbon energy systems have generated a growing body of literature examining the obstacles and opportunities associated with decarbonisation, particularly in the Global South [19,20]. In many African countries, successive governments have adopted policy frameworks outlining ambitious renewable energy targets but continue to fall significantly short of these goals due to poor implementation [21]. Consequently, Sub-Saharan Africa has one of the lowest rates of renewable energy penetrations globally [22].

Ghana, one of the first countries in West Africa to set renewable energy targets, endorse the nationally determined contributions of the Paris Agreement and pass a Renewable Energy Act in 2011 [23], the dominance of fossil fuels in the electricity generation mix has increased during the past decade. In contrast, the contribution of new sources of renewable energy remains abysmal. By the end of 2023, total installed capacity remained overwhelmingly dominated by fossil fuel-based thermal (69.1%) and hydro (28.9%) plants, while renewable capacity contributed a mere 2.0% or so. Meanwhile, the National Energy Transition Framework (NETF), published in 2022, explicitly identifies natural gas and nuclear power as the dominant energy sources for Ghana's transition strategy, designating natural gas as the country's transition fuel [24]. By contrast, renewables are expected to play a comparatively minor role, especially in terms of actual generation output [25].

Ghana, an emerging oil and gas producer, has incrementally diversified its energy mix with renewable sources; however, rapid energy demand growth, regulatory gaps, and limited financing remain persistent barriers. Nigeria, despite being Africa's leading crude oil producer with vast renewable energy potential, faces similar challenges due to long-standing structural inefficiencies and dependence on fossil fuel revenues [26].

Comparing Ghana's energy transition experiences with those of Nigeria, the UK, and the USA provides valuable insights into the determinants of successful transitions. The UK and USA have adopted aggressive net-zero targets, scaled up solar and wind energy, and established supportive regulatory frameworks [27,28].

The availability of fossil fuels often hinders renewable energy transitions, as economies dependent on fossil-fuel exports prioritise short-term economic gains over long-term sustainability goals [29]. There is some evidence to suggest that countries endowed with oil, gas and/or coal tend to invest less in renewables [30]. Pfeiffer and Mulder [31] find that fossil-fuel production is correlated with delays in renewable energy adoption in developing countries. For example, Colombia's abundance of coal has slowed its adoption of renewables [32].

Pedersen and Andersen [33] explain the uneven progress of renewable energy penetration in Ghana and Kenya mainly in terms of differences in their energy resource endowments. They argue that, while the availability of oil and gas in Ghana has negatively influenced elite commitment to non-hydro renewable energy on a significant scale, the lack of such fossil-fuel resources in Kenya, combined with the availability of geothermal resources, has successfully propelled the significant development and deployment of geothermal and other non-hydro renewable resources. Their evidence led them to conclude that 'fossil-fuel resource endowments negatively influence the prospects of introducing non-hydro renewable energy on a significant scale' [33].

Despite global efforts toward sustainable energy, Ghana's transition remains slow and uneven. Fossil fuels continue to dominate electricity generation and industrial activities, and renewable energy penetration remains below national targets. Although Ghana has introduced several policy instruments to support renewable energy deployment, progress is constrained by financing challenges, regulatory inconsistencies, and infrastructure deficits [34].

Key barriers include:

1. Insufficient Infrastructure: Limited grid capacity and inadequate technological infrastructure restrict renewable expansion.
2. Investment Barriers: High capital costs and constrained access to long-term financing limit project development [35].
3. Dependence on Hydrocarbon Revenues: Reliance on oil and gas complicates structural shifts toward low-carbon sources [36].
4. Policy and Regulatory Inefficiencies: Weak enforcement and inconsistent implementation undermine investor confidence.
5. Comparative Lag Behind Global Leaders: Unlike the UK and USA, Ghana lacks comprehensive transition roadmaps and institutional capacity to drive private-sector innovation.

These challenges necessitate a comparative assessment of Ghana's transition relative to similar and advanced oil-producing countries to identify gaps, opportunities, and policy strategies to accelerate sustainable energy development.

In order to determine best practices, obstacles, and possibilities for Ghana's energy transition, this study compares the energy transition trends in Ghana to other Oil and Gas producing nations like Nigeria, United Kingdom and United state of America. To achieve this, the following objectives were put in place;

1. To contrast Ghana's energy transition patterns with those of the united state, Nigeria, and the United Kingdom.
2. To assess how well laws and policies affecting these nations'' energy transformation are working.
3. To examine how the energy transition will affect the economy, with an emphasis on job creation, investment trends, and energy security.
4. To determine Ghana's transition to renewable energy prospects and obstacles.
5. To make policy suggestions that would improve Ghana's energy transition plan.

II. METHODOLOGY

This study adopts a comparative analytical approach supported by econometric modelling to assess the short- and long-term relationships between energy consumption, macroeconomic variables, and natural resource extraction activities in Ghana.

2.1 Econometric Approach

The Auto-Regressive Distributed Lag (ARDL) bounds testing technique was employed to analyse both short- and long-run dynamics. The model evaluates the impact of:

- Crude oil production
- Natural gas production
- Small-scale mining activities
- Timber and other natural resource extraction
- Trade openness
- Income levels

The ARDL method is suitable for time-series data with mixed integration orders and small samples common features in energy research involving developing economies.

2.2 Study Area Context

Ghana is endowed with abundant natural resources such as gold, timber, bauxite, diamonds, petroleum, and natural gas. Since the commercialisation of oil extraction, hydrocarbons have become central to the national energy mix. Ghana now ranks among emerging African producers, with daily crude oil production in the tens of thousands of barrels and rapidly developing gas prospects.

2.3 Summary of Findings from the Model

- Short-run effects indicate that crude oil extraction, small-scale mining, and timber extraction significantly affect energy consumption at the 5% level, while natural gas production shows a stronger effect at the 1% significance level.
- Long-run results reveal that natural resource extraction increases aggregate energy consumption, creating a pathway of fossil-energy dependency and raising potential risks for energy security.

III. RESULTS AND DISCUSSION

The analysis shows that Ghana's CO_2 emissions and energy consumption have risen in parallel with the expansion of its oil and gas sector. Structural challenges including limited investment in renewable infrastructure, entrenched fossil power systems, and policy inconsistencies continue to hinder transition progress [37].

Comparatively, countries such as Trinidad and Tobago exhibit similar trends in rising emissions and expanding hydrocarbon sectors. Both countries face political-economy constraints rooted in resource dependency.

Further comparative insights were drawn from Ghana and Venezuela. Despite similar timelines in discovering major petroleum reserves, the two countries diverged markedly in their policy pathways. Ghana strengthened its petroleum legal framework, licensing over 60% of available acreage by 2014. In contrast, Venezuela experienced refinery decline, rising fuel imports, and institutional instability.

Ghana's associated gas resources have a high gas-to-oil ratio (~2:1), significantly above the global average (~1:2), indicating costly treatment requirements and additional infrastructure needs. The Venezuelan case demonstrates the importance of establishing midstream institutions and reinvesting petroleum revenues into

domestic energy infrastructure. Ghana may benefit from adopting similar strategies, alongside policies that channel oil and gas revenues into renewable energy development.

Overall, findings emphasise the need for strong regulation, long-term energy planning, institutional capacity building, and substantial clean-energy investment to prevent fossil-fuel lock-in.

IV. CONCLUSION

Ghana's energy transition remains at an early stage, constrained by limited renewable energy penetration, declining hydropower share, and rising fossil-fuel dependence. Although Ghana met several Millennium Development Goals, achieving Sustainable Development Goal 7 will require accelerated investment in clean energy infrastructure, regulatory strengthening, and diversification of the national energy mix.

While hydropower and biomass remain important components of the energy system, they cannot solely ensure long-term energy security. Ghana, however, stands out as one of West Africa's most diversified electricity markets an advantage that can be leveraged for regional leadership in sustainable energy.

Policy reforms, increased renewable energy investment, and strategic use of oil and gas revenues will be essential for supporting Ghana's transition. Strengthening domestic technological capacity, improving institutional governance, and reducing dependence on fossil fuels are critical steps toward achieving a sustainable, secure, and low-carbon energy future.

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