

Decarbonizing Ghana's Petrochemical Industry: Strategic Pathways for a Sustainable Future

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Abstract

Ghana's petrochemical industry is poised for substantial growth, driven by the ambitious Petroleum Hub project, which is projected to significantly boost the nation's Gross Domestic Product (GDP) by up to 70% and generate approximately 700,000 new jobs [1]. This developmental trajectory, however, is deeply rooted in fossil fuel reliance, with oil accounting for 63% of Ghana's total CO₂ emissions from fuel combustion in 2022 [2]. This paper critically examines the inherent tension between Ghana's rapid industrialization goals and its commitment to achieving net-zero emissions by 2060 [3]. We analyze the current state of the industry, identifying its economic contributions, environmental footprint, and existing policy and infrastructural frameworks. Furthermore, we delineate the multifaceted socio-economic, technical, and institutional barriers impeding decarbonization, alongside the significant opportunities presented by renewable energy integration, energy efficiency enhancements, and circular economy principles. Drawing upon global best practices from other developing economies, this paper proposes a comprehensive, phased decarbonization roadmap for Ghana's petrochemical sector. Recommendations emphasize the critical need for policy coherence, aggressive capacity building, and a diversified financial strategy leveraging international climate finance, carbon markets, and private sector investment. This analysis provides a framework for Ghana to navigate a just and sustainable transition, offering valuable insights for other developing nations facing similar challenges.

Keywords

Ghana, Petrochemical Industry, Decarbonization, Energy Transition, Sustainable Development, Climate Policy, Circular Economy, Renewable Energy, Energy Efficiency

1. Introduction

1.1. Global Climate Imperatives and National Development Agendas

The global climate crisis necessitates an urgent and transformative shift across all economic sectors. The Paris Agreement, a landmark international accord, mandates limiting the increase in global average temperature to “well below 2°C above pre-industrial levels”, with an aspirational target of 1.5°C [4]. Achieving the 1.5°C goal requires global greenhouse gas (GHG) emissions to peak before 2025 and decline by 43% by 2030 [4]. This ambitious target places significant pressure on nations worldwide, particularly those with expanding industrial bases, to transition towards low-carbon economies.

Concurrently, the United Nations Sustainable Development Goals (SDGs) provide a holistic framework for a sustainable future, addressing interconnected global challenges such as poverty, inequality, and environmental degradation [5]. For the oil and gas industry, integrating SDGs into operational strategies is crucial for fostering environmental sustainability, social responsibility, and economic viability [5]. The petrochemical sector, a cornerstone of the global economy providing essential materials for myriad products, inherently carries a substantial environmental footprint, contributing significantly to pollution and GHG emissions [6]. Consequently, its transformation towards sustainability is a paramount global concern [6].

Ghana, with a population exceeding 33 million [7], is actively navigating this complex global landscape. The nation has demonstrated its commitment to climate action through its ambitious Energy Transition and Investment Plan (ETIP), targeting net-zero emissions by 2060, an acceleration from its previous 2070 goal [3]. This national aspiration for a green transformation is inextricably linked with Ghana’s broader economic development and industrialization plans [3]. The central challenge lies in reconciling immediate economic growth and energy security needs with long-term climate objectives, ensuring that development is both prosperous and environmentally responsible.

1.2. Significance of Ghana’s Petrochemical Industry

Ghana’s petrochemical industry is strategically positioned to play a pivotal role in the nation’s economic future and regional influence. The government’s vision to establish Ghana as a leading petrochemical hub in West Africa is a transformative undertaking, centered around the development of a Petroleum Hub in Jomoro, Western Region [8]. This ambitious project aims to revolutionize Ghana’s downstream sector, reinforcing its role as a key supplier of refined petroleum products in the region and strengthening trade relationships within the sub-region and beyond [8].

The projected economic Impact of this sector Is substantial, with estimates suggesting an Increase of up to 70% in Ghana’s GDP [1]. This economic stimulus is anticipated to be accompanied by significant employment generation, with an es-

estimated 700,000 new job opportunities across various industries, including petroleum processing, logistics, and engineering [1]. The integration of a “24-hour economy” initiative within the hub’s operations aims to maximize productivity and create continuous, shift-based employment, providing stable income for thousands of Ghanaians [8]. This strategic development underscores the industry’s perceived role as an engine for industrialization, economic resilience, and job creation, vital for Ghana’s future prosperity.

1.3. Purpose and Scope of the Paper

This paper provides an in-depth analysis of Ghana’s petrochemical industry, examining its current contributions and environmental footprint, alongside existing policy and infrastructural frameworks. It then delves into the complex challenges and opportunities for decarbonization, drawing insights from global best practices and relevant case studies from other developing economies. Finally, the paper proposes strategic pathways and actionable recommendations, encompassing a phased roadmap, policy and capacity-building measures, and financial and partnership strategies. The aim is to guide Ghana towards a sustainable, low-carbon petrochemical future that aligns with both national development aspirations and international climate commitments. The analysis is grounded in a comprehensive review of available research and policy documents.

2. Current State of Ghana’s Petrochemical Industry: A Contextual Analysis

2.1. Economic Contribution, Energy Landscape, and Employment Impact

Energy demand for the petrochemical industry is projected to grow by 8% - 10% annually over the next 15 years, driven by refinery and industrial expansion. By contrast, renewable energy supply growth, based on current REMP targets, is estimated at 5% - 6% annually. Without significant acceleration in RE deployment, a gap between industrial energy demand and clean supply may persist, reinforcing the importance of grid modernization and energy efficiency.

Ghana’s petrochemical industry is strategically positioned as a cornerstone of the nation’s economic development. The planned Petroleum Hub in Jomoro is projected to significantly boost Ghana’s GDP by up to 70% [1], aiming to solidify the country’s regional petroleum supply chain and foster broader industrialization [8]. This expansion is expected to create approximately 700,000 new employment opportunities across various sectors, including petroleum processing, logistics, and engineering [1]. The government’s “24-hour economy” initiative is integrated with the hub’s development to maximize employment and productivity through continuous, round-the-clock operations [8].

A key driver for this expansion is the pursuit of energy security and self-sufficiency. Ghana’s historical reliance on imported refined petroleum products has exposed its economy to global oil market volatility [9]. By increasing local refining

capacity, Ghana aims to ensure a stable energy supply, reduce dependence on expensive fuel imports, and enhance energy affordability [8]. The current refining capacity from the Tema Oil Refinery (TOR) and Sentuo is a combined 90,000 barrels per day (bpd) [10]. The new refineries planned for the Petroleum Hub are each designed to have a minimum processing capacity of 300,000 bpd, totaling 900,000 bpd across three complexes [8]. This expansion, alongside five new petrochemical plants and 10 million cubic meters of storage facilities [8], underscores Ghana's ambition to become a dominant supplier of refined petroleum products in West Africa [8] (Table 1).

The projected economic and employment benefits from this expansion highlight a strong national commitment to the petrochemical sector as a primary engine for development. This emphasis on fossil fuel-driven growth, however, stands in tension with Ghana's stated commitment to achieving net-zero emissions by 2060 [3] and global climate agreements necessitating rapid decarbonization [4]. This situation suggests a potential prioritization of immediate economic gains, possibly deferring significant decarbonization efforts to a later stage, with an implicit reliance on future technological advancements to offset the environmental impact of current expansion.

Table 1. Economic and employment contributions of Ghana's Petrochemical Sector.

Metric	Current State/Projection	Source
Projected GDP Boost	Up to 70%	[1]
Estimated New Employment Opportunities	700,000	[1]
Current Refining Capacity (bpd)	90,000 (TOR & Sentuo combined)	[10]
Planned New Refining Capacity (bpd)	900,000 (3 refineries, 300,000 each)	[8]
Number of Planned Petrochemical Plants	5	[8]
Storage Facilities Capacity	10 million cubic meters	[8]

2.2. Carbon Footprint and Fossil Fuel Reliance

Ghana's energy sector is characterized by a significant reliance on fossil fuels, directly contributing to its carbon footprint. In 2020, crude oil and natural gas constituted 69% of the nation's total power generation, with other renewable energy sources contributing only 1.1% [11]. This dependence is particularly pronounced in the transportation sector, where over 80% of fuel is derived from imported petroleum products, rendering the nation vulnerable to global oil market fluctuations [9]. In 2022, Ghana's fuel import expenditure reached approximately \$2.7 billion, nearly 25% of its total import expenditure [9].

Total CO₂ emissions from fuel combustion in Ghana amounted to 19.877 Mt CO₂ in 2022 [2]. Oil-based fuels are the predominant source, accounting for 63% of these emissions [2]. The transport sector is the largest consumer of oil products in Ghana, responsible for 79% of total final consumption and approximately 50%

of total energy-related CO₂ emissions in 2022 [2]. The industrial sector, while a smaller contributor, still accounts for 10.1% of energy-related CO₂ emissions [2] (Table 2).

Beyond end-use combustion, the operational activities of the oil and gas industry itself contribute to GHG emissions. Production, transport, and processing of oil and gas are responsible for nearly 15% of global energy-related GHG emissions [12]. Methane, a potent GHG, accounts for half of these operational emissions [12]. To align with a 1.5°C global warming scenario, these operational emissions must be cut by over 60% by 2030, with emissions intensity approaching zero by the early 2040s [12].

A critical discrepancy exists between Ghana's energy policy and global climate pathways. While 1.5°C compatible scenarios suggest a rapid reduction in reliance on natural gas and oil in the power mix to a maximum of 8% by 2030 and a full phase-out of fossil fuels by 2040 [11], Ghana's updated National Medium-Term Development Policy Framework explicitly promotes petroleum exploration and leveraging the oil and gas industry for national economic development [11]. The planned significant expansion of fossil fuel infrastructure, such as the Petroleum Hub, creates a substantial risk of "carbon lock-in", where long-term investments in carbon-intensive assets make future transitions economically and politically challenging. This trajectory could lead to "stranded assets" and impede Ghana's ability to achieve its net-zero targets [11]. This indicates that Ghana's current development pathway, while aiming for short-term economic gains, may inadvertently be building future environmental and economic liabilities.

Table 2. Ghana's energy mix and CO₂ emissions profile (overall and industry-specific).

Metric	Value (2022 unless specified)	Source
Fossil Fuels in Power Generation (2020)	69%	[11]
Renewables in Power Generation (2020)	1.1%	[11]
Total CO ₂ Emissions from Fuel Combustion	19.877 Mt CO ₂	[2]
Share of Oil in Total CO ₂ Emissions (Fuel Combustion)	63%	[2]
Transport Sector Share of Oil Product Consumption	79%	[9]
Transport Sector Share of Energy-Related CO ₂ Emissions	50%	[2]
Industry Sector Share of Energy-Related CO ₂ Emissions	10.1%	[2]

2.3. Existing Policies, Infrastructure, and Technologies

Ghana's petrochemical sector is characterized by a blend of ambitious planned infrastructure, existing operational facilities facing challenges, and an evolving policy and regulatory landscape.

Major Infrastructure Projects: The cornerstone of Ghana's future petrochemical landscape is the planned Petroleum Hub in Jomoro, Western Region, spanning a 20,000-acre site [13]. This undertaking aims to significantly enhance Ghana's capacity to process and utilize its petroleum resources domestically [13]. The hub will feature three refinery complexes with a combined capacity of 900,000 bpd [8], a substantial increase from current levels. Additionally, five petrochemical plants

and storage facilities with a capacity of 10 million cubic meters are planned [8]. The government is committed to providing essential supporting infrastructure, including roads, water, and electricity [14]. The Petroleum Hub Development Corporation (PHDC) manages this project, fostering a competitive and investor-friendly environment [8].

Existing Refinery (Tema Oil Refinery—TOR): Ghana's primary existing refining facility is the Tema Oil Refinery (TOR), established in 1963 [15]. TOR's processing plant includes a primary crude distillation unit (CDU) with naphtha hydrotreating and premium forming (PRF) units, and a secondary Residue Fluid Catalytic Cracking (RFCC) unit [16]. Despite its strategic position, TOR has faced persistent operational challenges, including outdated equipment, financial mismanagement, and intermittent shutdowns, leading to its underutilization [17]. Modernization efforts are underway, with a reported need for a \$25 million investment to refurbish machinery, install new equipment, and reactivate essential units to restore optimal production capacity and improve energy efficiency [18].

Gas Processing Infrastructure: To meet rising industrial demand and enhance energy security, Ghana is expanding its gas processing capacity. This includes the development of a second gas processing plant at Atuabo, which will add another 150 million standard cubic feet per day (mmscf/d) to the existing facility's capacity, potentially reaching 300 mmscf/d in future phases [19]. This expansion aims to monetize associated gas resources from offshore oil operations, reduce flaring, and improve overall energy efficiency [20].

Policy and Regulatory Frameworks:

1) National Energy Policy (2021): This comprehensive policy outlines Ghana's energy sector goals, objectives, and policy directions across various areas, including power generation, renewable energy, nuclear power, petroleum (upstream and downstream), energy transition, and energy efficiency and conservation [21]. It emphasizes promoting local content and participation and encouraging private investment in the renewable energy industry [21]. While it addresses energy transition, specific detailed provisions for petrochemical decarbonization or a comprehensive circular economy framework are not explicitly detailed within the available summaries [21].

2) Petroleum Commission: Established by Act of Parliament (2011, Act 821), the Petroleum Commission regulates and manages the utilization of petroleum resources and coordinates policies in the upstream sector [19]. Relevant legislations include the Petroleum Exploration and Production—HSE Regulations 2017 (L.I 2258), General Regulations 2018 (L.I 2359), and Data Management Regulation 2017 (L.I 2257) [22]. However, the primary focus of these regulations appears to be on production, safety, and revenue management, with limited explicit provisions addressing decarbonization or broader environmental sustainability within the petrochemical sector [22].

3) Environmental Protection Agency (EPA): The EPA is the leading public body responsible for environmental protection and improvement in Ghana [23].

It is actively engaged in developing methane guidelines for the oil and gas sector, anticipated to be enacted by 2025 [24]. These guidelines aim to reduce methane emissions from venting and fugitive sources, aligning with Ghana's commitments to the Global Methane Pledge [24]. The EPA also provides guidelines for environmental assessment and management in offshore oil and gas development, and oil waste management [23].

4) Local Content Policies: Ghana's Local Content and Local Participation Regulation (L.I. 2204) is designed to foster technology transfer, skills development, and entrepreneurship within the petroleum sector [25]. However, studies indicate that technology transfers to Ghanaian firms remain limited due to non-compliance by multinational operators and weak enforcement mechanisms, affecting the competitiveness and sustainability of local enterprises [25] (Table 3).

A significant observation arises from the contrast between Ghana's stated policy intent and its practical investment decisions. While the National Energy Policy includes "Energy Transition" and "Renewable Energy" as key areas [21], substantial investments are being channeled into the Petroleum Hub, which fundamentally represents an expansion of fossil fuel infrastructure [8]. This creates a "policy-investment discrepancy", where ambitious policy goals for a green transition may be undermined by large-scale, long-lived investments in carbon-intensive assets. This practical prioritization of traditional energy development over rapid decarbonization could lead to increased difficulty in meeting future climate targets and potentially result in stranded assets if global energy markets shift more rapidly towards low-carbon alternatives [11].

Table 3. Key policies and regulatory frameworks governing Ghana's Petrochemical Sector.

Policy/Regulation Name	Issuing Body	Year (if specified)	Key Provisions	Relevance to Petrochemical Sector
National Energy Policy	Ministry of Energy	2021	Goals for power, RE, nuclear, petroleum (upstream/downstream), energy transition, EE. Promotes local content & private RE investment.	Broad energy sector guidance, includes petroleum and energy transition [21].
Petroleum Commission Act	Parliament	2011 (Act 821)	Regulates & manages petroleum resources, coordinates policies in upstream sector.	Primary regulatory body for upstream oil & gas, influencing feedstock availability [19].
Petroleum Exploration and Production—HSE Regulations	Petroleum Commission	2017 (L.I 2258)	Health, Safety, Security, and Environment regulations for E&P.	Sets environmental standards for operational aspects, though not specific to decarbonization [22].
Petroleum Exploration and Production (General) Regulations	Petroleum Commission	2018 (L.I 2359)	General rules for E&P activities.	Governs operational aspects of petroleum extraction [22].

Continued

Petroleum Exploration and Production-Data Management Regulation	Petroleum Commission	2017 (L.I 2257)	Data management for E&P.	Supports transparency and data availability for resource management [22].
Methane Guidelines (under development)	Ghana EPA	Anticipated 2025	Reduction of methane emissions from venting and fugitive sources.	Direct impact on operational GHG emissions from oil & gas [24].
Guidelines for Environmental Assessment and Management in Offshore Oil and Gas Development	Ghana EPA	N/A	Guidance on assessing and managing environmental impacts of offshore O&G.	Addresses environmental impacts, including potential for emissions management [23].
Oil Waste Management Guidelines	Ghana EPA	N/A	Procedures and standards for managing waste from oil operations.	Addresses waste management, a component of environmental sustainability [23].
Local Content and Local Participation Regulation	Parliament	L.I. 2204	Fosters technology transfer, skills development, entrepreneurship.	Influences local capacity and technology adoption in the sector [25].
Circular Economy Framework for the Plastics Sector (CEF-PS)	MEST	2025 (Launched)	Aims to recover plastic waste, prevent marine litter, train stakeholders. Decouples plastic production from fossil fuels.	Directly relevant to the petrochemical downstream (plastics production) [17].

3. Challenges and Opportunities for Decarbonization

3.1. Socio-Economic, Technical, and Institutional Barriers

The identification of these barriers was based on a triangulated methodology combining systematic literature review, stakeholder policy document analysis, and insights from national development strategies. Ghana's trajectory towards decarbonizing its petrochemical industry is impeded by a complex interplay of socio-economic, technical, and institutional barriers.

Socio-Economic Barriers: A primary challenge is the perceived high cost and low demand for green business solutions. Existing policies and regulatory frameworks often fail to create sufficient economic incentives for businesses to adopt green products and processes, rendering them less attractive than conventional, carbon-intensive alternatives [26]. This economic disincentive can stifle innovation and investment in sustainable practices. Furthermore, an unmanaged transition to a green economy risks exacerbating existing inequalities, potentially excluding informal workers, women, and rural communities who may lack access to green skills training and financing [27]. Limited public awareness and participation can also foster mistrust and weaken public buy-in for green initiatives, hindering their successful implementation [27]. The substantial financial cost of

building and maintaining climate-resilient infrastructure, coupled with social and health vulnerabilities from climate change, could place significant fiscal pressure on Ghana's already scarce government resources [26].

Technical Barriers: The existing infrastructure, particularly at the Tema Oil Refinery (TOR), presents a significant technical hurdle. TOR has faced years of operational challenges due to outdated equipment, which inhibits its efficiency and necessitates substantial upgrades [17]. The integration of intermittent renewable energy sources, such as solar and wind, into the national grid requires considerable upgrades to accommodate increased capacity and improve transmission and distribution efficiency [3]. This grid modernization is essential for powering a decarbonized industrial sector. Moreover, a notable gap exists in the availability of a skilled workforce capable of handling low-carbon technologies [28]. While local content policies aim to foster technology transfer, their effectiveness has been limited by non-compliance from multinational operators and insufficient local capacity development [25]. The high upfront cost of acquiring low-carbon technologies is also a major concern for companies, highlighting a need for long-term payment plans or alternative financing mechanisms [28].

Institutional Barriers: Despite high political support for climate change and decarbonization, this commitment has not fully translated into an enabling business environment for climate-smart enterprises [26]. Weak policy and regulatory frameworks often fail to create the necessary economic incentives, leading to broader market, financing, and technological barriers [26]. Ghana also faces challenges related to weak regulatory enforcement and accountability. There is a recognized absence of independent green compliance audits, enforceable anti-greenwashing legislation, and adequate institutional capacity to monitor and regulate environmental, social, and governance (ESG) performance [27]. Communication gaps between government ministries and companies regarding low-carbon options further complicate policy adoption and implementation [28]. Additionally, insufficient financial and regulatory incentives hinder the promotion of investment in and adoption of renewable energy technologies [29]. Finally, Ghana's efforts to access climate finance are constrained by a complex local financial landscape marked by debt vulnerabilities, making it difficult to mobilize the necessary capital for large-scale decarbonization projects [30].

The interconnectedness of these barriers creates a systemic inertia that impedes comprehensive decarbonization. Financial constraints directly limit the acquisition of costly low-carbon technologies and necessary infrastructure upgrades. This, in turn, impacts the ability to develop a sufficiently skilled workforce and implement effective energy efficiency measures. The underlying issue of weak regulatory enforcement and insufficient incentives prevents market forces from driving green investments, perpetuating a cycle where even identified opportunities struggle to gain traction. This suggests that a piecemeal approach to addressing these barriers will be ineffective; a coordinated, multi-faceted strategy is required to break this cycle and enable a meaningful transition.

3.2. Opportunities: Renewable Energy Integration, Energy Efficiency, and Circular Economy

Despite the significant barriers, Ghana possesses substantial opportunities to advance the decarbonization of its petrochemical industry through strategic investments in renewable energy, energy efficiency, and circular economy principles.

Renewable Energy (RE) Integration: Ghana has a clear policy commitment to increasing its renewable energy footprint. The Renewable Energy Act of 2011 (amended in 2020) promotes RE for heat and power generation, supported by the 2019 Renewable Energy Master Plan (REMP) which targets 1363.63 MW of grid-connected non-hydro RE by 2030 [31]. The government has further signaled its commitment by expanding the scope of the Energy Ministry to include Green Transition. Ghana has significant untapped potential in wind energy, particularly along its coastal regions, and abundant solar resources [31]. Biofuels present a particularly promising avenue: ethanol produced from locally abundant feedstocks like corn and cassava could reduce reliance on imported fuels and cut greenhouse gas emissions by up to 70% compared to gasoline [9]. In the industrial sector, there is already a growing trend of commercial and industrial (C&I) customers installing captive solar PV capacity, reaching 61.4 MW by 2023, driven by cost savings [31]. Policies like net-metering, reinforced by the 2023 Net Metering Code, further encourage such self-generation [31]. In the long term, renewables, low-carbon hydrogen, battery electric vehicles, and clean cookstoves are projected to account for over 90% of Ghana's targeted emissions reduction by 2060 [3].

Energy Efficiency (EE): Energy efficiency is a recognized priority within Ghana's decarbonization efforts. The nation has committed to a 20% improvement in industrial facilities' energy efficiency by 2030 as part of its Nationally Determined Contribution (NDC) [7]. Progress has been made in capacity building, with the Industrial Energy Efficiency Readiness project successfully training 35 national EE consultants in ISO 50001 compliant Energy Management Systems (EnMS), leading to average energy savings of up to 9% in an initial pipeline of 10 industrial EE projects [7]. Past energy efficiency initiatives, such as the distribution of compact fluorescent lights, have demonstrated tangible benefits, saving 124 MW of peak load and reducing CO₂ emissions by 112,340 kgs [32]. A refrigerator exchange program further underscored the potential, saving 400 GWh and 1.1 million tons of CO₂ [32]. In the chemicals/plastics industry, process optimization and energy efficiency improvements, including better separation methods and heat management, are expected to contribute up to 25% of the necessary emissions reductions [33].

Circular Economy (CE): Ghana is actively pursuing circular economy initiatives, particularly in the plastics sector. The Ministry of Environment, Science, Technology and Innovation launched a \$7 million Circular Economy Project (CEF-PS) in 2025, operating under the National Plastic Management Policy [17]. This project aims to recover 93,000 tonnes of plastic waste, prevent 13,000 tonnes of marine litter, and train over 2000 stakeholders in circular economy practices

over five years [17]. Key objectives of the project include preventing environmental pollution, decoupling plastic production from fossil fuels, and establishing an effective after-use economy for plastics [17]. This initiative is also expected to generate over 10,000 direct and indirect jobs. [17] Currently, Ghana generates an estimated 840,000 tonnes of plastic waste annually, with only about 9.5% recycled [17]. This highlights a significant opportunity to accelerate waste reduction, reuse, and recycling, and to cultivate a robust domestic market for recycled plastics, thereby reducing reliance on virgin fossil-fuel-based inputs [34] (Table 4, Table 5).

Ghana has established clear policy frameworks and ambitious targets for renewable energy, energy efficiency, and circular economy. There is also demonstrated potential and early successes in areas like C&I solar PV adoption and past energy efficiency programs. However, the current penetration rates for renewables (2% of installed capacity) [31] and plastic recycling (9.5%) [17] remain low relative to the stated targets. This indicates a significant “implementation gap” where policy ambition and technical potential are not translating into sufficient on-the-ground deployment. The opportunity for Ghana therefore lies not just in identifying these areas, but in aggressively addressing the underlying barriers such as financial constraints, insufficient regulatory incentives, and capacity limitations to accelerate their adoption. Bridging this implementation gap is crucial to ensure that these opportunities contribute meaningfully and at scale to the nation’s decarbonization goals.

Table 4. Decarbonization technologies and their applicability to Ghana’s petrochemical industry.

Technology	Description	Applicability to Petrochemical Processes	Potential Benefits	Current Status in Ghana
Renewable Energy (RE)	Solar PV, Wind, Bioenergy (e.g., ethanol from corn/cassava)	Powering refinery/ petrochemical plant operations; feedstock for bio-based chemicals; blending with fuels.	Reduced GHG emissions (up to 70% for ethanol), energy security, reduced import reliance, job creation.	Policy commitment (RE Act, REMP) [31]; 2% RE in power mix (2024) [31]; C&I solar PV (61.4 MW) [31]; Biofuel potential [9].
Energy Efficiency (EE)	Process optimization, waste heat recovery, efficient equipment, Energy Management Systems (EnMS).	Reducing energy consumption in cracking, distillation, separation; optimizing heat management.	Up to 90% energy savings; reduced operational costs; lower emissions intensity.	20% EE improvement target by 2030 (NDC) [7]; trained EE consultants; 9% savings in pilot projects [7].
Carbon Capture and Storage (CCS)	Capturing CO ₂ from industrial emissions before release and storing it permanently.	Capturing emissions from large point sources (e.g., refineries, petrochemical plants).	Significant reduction of direct industrial emissions.	Ghana’s ETIP includes CCS as a decarbonization technique [3]; global interest growing (700+ projects) [33].
Green Hydrogen	Hydrogen produced via electrolysis using renewable electricity.	Fuel for industrial processes; feedstock for green ammonia, methanol, and other chemicals.	Zero emissions when burned; pathway to decarbonize hard-to-abate sectors.	Included in Ghana’s ETIP [3]; South Africa case study shows potential but also high cost/ infrastructure needs [35].

Continued

Bio-based Feedstocks	Using biomass (e.g., agricultural waste, algae) as raw material for chemicals.	Replacing fossil-based naphtha or other feedstocks in petrochemical production.	Reduced reliance on fossil fuels; lower lifecycle emissions; agricultural value addition.	Biofuel potential from corn/cassava [9]; aligns with circular economy principles [17].
Circular Economy (CE)	Reducing waste, reusing materials, recycling products, designing for longevity.	Recycling plastics; repurposing industrial by-products; closed-loop systems for water/solvents.	Reduced resource depletion, waste generation, pollution; new economic opportunities.	\$7M Circular Economy Project for plastics [17]; low recycling rates (9.5%) indicate vast potential [17].
Electrification	Replacing fossil fuel-powered equipment with electric alternatives.	Electric naphtha crackers; electric heating in industrial processes.	Reduced direct combustion emissions; shifts emissions to power sector, enabling RE integration.	Global trend in industrial decarbonization [33]; requires grid upgrades and RE expansion [3].

Table 5. Summary of barriers and opportunities for decarbonization in Ghana.

Category	Specific Barrier/ Opportunity	Description/Impact	Relevant Snippet IDs
Socio-economic Barriers	High Cost & Low Demand for Green Solutions	Green models often more expensive, lack economic incentives.	[26]
	Unequal Access & Public Awareness Gaps	Risk of excluding vulnerable groups; limited buy-in for green initiatives.	[27]
	Financial Burden on Government	Climate action infrastructure costs strain scarce resources.	[26]
Technical Barriers	Outdated Infrastructure (TOR)	Hinders efficiency, requires significant upgrades.	[17]
	Integration of Intermittent Renewables	Requires substantial grid upgrades for stability.	[3]
	Lack of Skilled Workforce & Technology Transfer	Insufficient trained workers for low-carbon tech; limited tech transfer due to non-compliance.	[26]
	High Cost of Low-Carbon Technologies	Perceived as costly, need for long-term financing.	[28]
Institutional Barriers	Unsupportive Policy & Regulatory Environment	High political support not translated into enabling business environment.	[26]
	Weak Regulatory Enforcement & Accountability	Lack of independent audits, anti-greenwashing laws, institutional capacity.	[27]
	Insufficient Financial & Regulatory Incentives	Hinders investment in RE and EE.	[29]
	Debt Vulnerabilities	Constrains access to climate finance.	[36]
Renewable Energy Opportunities	Policy Commitment & Untapped Potential	RE Act, REMP targets; abundant wind, solar, biofuel resources.	[9]
	Industrial Adoption (C&I Solar PV)	Cost savings driving captive solar installations.	[31]
Energy Efficiency Opportunities	National Commitment & Capacity Building	20% EE target; trained consultants, proven savings from past initiatives.	[7]
Circular Economy Opportunities	Plastics Sector Focus & Decoupling from Fossil Fuels	Project launched to recover plastic waste, promote bio-based plastics.	[17]

3.3. Global Best Practices Relevant to Ghana

Examining global best practices provides valuable insights for Ghana's decarbonization journey, particularly from other developing economies facing similar developmental and climate challenges.

Technological Innovations for Industrial Decarbonization:

The industrial sector is a significant contributor to global emissions, accounting for a quarter of direct global energy system emissions in 2022, necessitating a 43% decrease by 2030 to meet 2050 targets. 48 Key strategies for industrial decarbonization include:

- **Energy Efficiency:** Designing integrated systems based on energy efficiency can yield substantial savings, potentially up to 90% [33]. This involves procuring more efficient equipment and optimizing processes.
- **Carbon Capture and Storage (CCS):** This technology captures CO₂ from industrial emissions before it enters the atmosphere. Global interest in CCS is growing, with over 700 projects in various stages of development, and a predicted capture rate of 2 - 12 Gt CO₂/year [33].
- **Green Fuels:** Shifting to emissions-free fuels like green hydrogen (produced using renewable electricity) and biocharcoal is crucial [33]. While most hydrogen is currently produced from fossil fuels, decarbonizing its production through CCS or green hydrogen is a key pathway [33].
- **Electrification:** Using zero-emission electricity for industrial processes, such as electric naphtha crackers, can significantly reduce emissions [33].
- **Recycling:** Particularly in the chemicals and plastics sectors, recycling plays a vital role in reducing the use of fossil-fuel-based raw materials [33].

For the refining and petrochemical industries specifically, reducing operational (Scope 1 and Scope 2) emissions is a top priority [37]. This involves improving data collection and transparency, implementing operational improvements like equipment electrification and increased use of renewable power, and making production route adjustments, such as switching feedstocks to lower emissions intensity [38]. For instance, if half of the ammonia currently produced from coal were switched to a gas feedstock, total emissions could drop by 15% [38].

Policy and Regulatory Approaches:

Globally, there is a growing trend towards establishing carbon neutrality targets by countries, regions, cities, and companies [4]. The Paris Agreement provides a robust framework through Nationally Determined Contributions (NDCs) and Long-Term Low Greenhouse Gas Emission Development Strategies (LT-LEDS) for long-term planning [4]. The agreement also establishes a framework for financial, technical, and capacity-building support to developing countries [4].

Despite these frameworks, the oil and gas industry's engagement in clean energy transitions remains marginal, with only 1% of total clean energy investment globally coming from oil and gas producers [12]. This highlights the need for a broader coalition with more ambitious targets to significantly reduce operational emissions, which currently account for nearly 15% of global energy-related GHG

emissions [12]. A key policy priority is tackling methane leaks, which account for half of operational emissions and can be addressed cost-effectively [12]. Ghana's EPA is already developing methane guidelines, aligning with this global priority [24]. Furthermore, enhanced regulatory frameworks and technological innovations are seen as future directions for sustainability in the petrochemical sector, alongside circular economy practices like sustainable supply chain management and transparent reporting [6].

Case Studies from Developing Economies: (Table 6).

- **Brazil (Petrochemical/Refining Decarbonization):** Brazil's national oil company, Petrobras, is actively investing in decarbonization within its refining facilities. It plans to install 55.5 MW of PV solar power capacity at its oil refineries to improve operational reliability, reduce gas consumption, and cut GHG emissions [39]. Petrobras has allocated US 1.3 billion from its decarbonization fund for 34 projects, with a potential to mitigate 1.5 Mt CO₂/year, and its 2025-29 business plan includes US 16.3 billion for energy transition actions [39]. Brazil is leveraging its abundant renewable energy resources (solar and wind) for low-carbon hydrogen production [40]. The state of Pernambuco, a region with a large oil and gas refining industry, is also developing its own decarbonization strategies, including expanding renewable electricity generation [41].
- **Egypt (Industrial Energy Transition—Benban Solar Park):** Egypt's Benban Solar Park serves as a powerful example of large-scale renewable energy integration. It is one of the largest solar parks globally, with 1.465 GW of contracted capacity, significantly increasing Egypt's renewable capacity by 165% from 2017 levels [42]. The park generates clean, reliable energy for over a million households and annually limits approximately 2 million tonnes of carbon emissions [43]. This project attracted substantial private sector investment and created tens of thousands of jobs during construction and operation [43]. It has enhanced Egypt's energy security by diversifying sources and reducing dependence on fossil fuels [43]. Egypt's success led to its selection for the Climate Investment Funds' (CIF) \$1 billion Industrial Decarbonization Program and its joining of the Industrial Transition Accelerator (ITA) program, highlighting international confidence in its climate policies and green transformation agenda [44].
- **South Africa (Green Hydrogen Strategy):** South Africa is positioning itself as a leader in green hydrogen production, capitalizing on its abundant solar, wind, and water resources [45]. Green hydrogen has applications in the petrochemical industry, including the production of ammonia and methanol as feedstocks for chemicals and fertilizers, and for green steel production [45]. The South African government has enacted climate-forward policies, an investment plan for a just energy transition (ZAR 1.5 trillion), and is developing strategic hydrogen hubs [45]. However, challenges persist, including the high costs of green hydrogen production and transportation (up to five times that

of fossil fuel alternatives), the lack of charging infrastructure for green hydrogen vehicles, and the need for entirely new specialized pipelines [46].

These global examples demonstrate that while the technical solutions for decarbonization are increasingly available, their successful implementation in developing economies requires careful adaptation to local contexts. The case studies from Brazil, Egypt, and South Africa illustrate that success often hinges on significant international financial support, strategic government-led investments, and overcoming specific local challenges such as water scarcity or grid integration. This indicates that Ghana must not merely adopt these technologies but adapt them to its unique socio-economic, technical, and institutional circumstances. This adaptation necessitates detailed feasibility studies, context-specific policy design, and a clear understanding of which solutions best align with Ghana's resource endowments and address its particular barriers.

Table 6. Comparative summary of global best practices and applicability to Ghana.

Country	Key Decarbonization Strategy	Applicability to Ghana	Required Adaptation
Brazil	CCS & solar in refineries	High—similar refinery base	Requires tech transfer & financing
Egypt	Large-scale solar deployment (Benban Park)	High—Ghana's solar potential is similar	Needs utility-scale grid integration
South Africa	Green hydrogen strategy	Medium—future pathway	Needs infrastructure & cost support

4. Strategic Pathways and Recommendations for a Sustainable, Low-Carbon Petrochemical Industry

Ghana's transition to a sustainable, low-carbon petrochemical industry requires a comprehensive and phased strategic roadmap, supported by robust policy, capacity building, and diversified financial mechanisms.

4.1. Decarbonization Roadmap (Short-Term, Mid-Term, Long-Term)

A phased approach is crucial for managing the complexity and investment required for decarbonization, allowing for learning and adaptation as technologies evolve and economic conditions change.

Short-Term (0 - 5 years):

Immediate actions should focus on high-impact, cost-effective measures. A top priority is the reduction of methane emissions from existing oil and gas operations. This involves the full implementation of Ghana's new methane guidelines, anticipated by 2025 [24], coupled with the establishment of robust leak detection and repair (LDAR) programs and minimizing routine flaring and venting [12]. These measures are recognized as highly cost-effective and can yield significant immediate emission reductions [12]. Simultaneously, intensive energy efficiency upgrades at the Tema Oil Refinery (TOR) and other industrial facilities are essential. This includes modernizing outdated equipment [18] and adopting ISO 50001

compliant Energy Management Systems (EnMS) to achieve tangible energy savings [7]. Furthermore, scaling up pilot projects for biofuel production, particularly ethanol from locally abundant corn and cassava, should be pursued for blending with transportation fuels, offering a pathway to reduce imported fuel reliance and emissions [9]. Enhancing data collection and transparency, especially for Scope 1 and 2 emissions in the petrochemical industry, is critical to accurately quantify baseline emissions and identify further near-term reduction opportunities [38].

Mid-Term (5 - 15 years):

This phase should focus on substantial infrastructure modernization and initial integration of advanced low-carbon technologies. Full modernization of TOR's facilities should be completed [18], exploring the economic viability of integrating initial carbon capture technologies for specific high-emitting units [33]. Concurrently, Ghana must accelerate the integration of utility-scale solar and wind power into the national grid to decarbonize electricity supply for industrial processes [31]. This should be complemented by strengthening net-metering policies to further encourage captive solar PV installations by commercial and industrial customers [31]. The Circular Economy Framework for the Plastics Sector (CEF-PS) [17] needs to move beyond pilot projects to establish a robust domestic market for recycled plastics and actively explore alternatives to fossil-fuel-based plastics [34]. Initial pilot projects for green hydrogen production should be launched, targeting industrial applications where electrification is challenging, such as ammonia production [45], and prioritizing local value chains to mitigate high transportation costs [46].

Long-Term (15+ years):

The long-term vision centers on a fully decarbonized petrochemical industry integrated within a net-zero national energy system. This requires ensuring that the newly developed Petroleum Hub incorporates advanced decarbonization technologies from its inception, including large-scale Carbon Capture and Storage (CCS), significant green hydrogen production capabilities, and extensive electrification of processes, aiming for near-zero emissions intensity [12]. The national power sector must transition to a near 100% renewable energy mix by 2040 [11], providing a clean and reliable energy source for an increasingly electrified industrial sector. Comprehensive circular economy principles should be implemented across the entire petrochemical value chain, encompassing advanced recycling techniques, chemical recycling, and widespread adoption of bio-based feedstocks [6]. Finally, the full implementation of carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, will be crucial to provide sustained economic incentives for low-carbon transitions across all sectors of the economy [29] (Table 7).

This roadmap necessitates a phased approach, starting with readily achievable measures like energy efficiency and methane reduction. However, the long-term vision, particularly for the Petroleum Hub, implies a continued reliance on fossil fuels for several decades. This highlights the need for the roadmap to be dynamic and adaptive, incorporating mechanisms for continuous monitoring of techno-

logical advancements in areas like CCS and green hydrogen, as well as shifts in global energy markets and climate policy. This “adaptive capacity” is crucial to avoid locking into outdated technologies or development pathways, especially given the inherent tension between Ghana’s current growth ambitions and its long-term climate goals. The strategy must explicitly build in regular review points and flexibility to adjust investments and priorities based on evolving global technological landscapes and policy developments.

Table 7. Proposed decarbonization roadmap for Ghana’s petrochemical industry.

Timeframe	Key Decarbonization Initiatives	Specific Actions/ Technologies	Expected Outcomes	Responsible Stakeholders
Short-Term (0 - 5 years)	Methane Emission Reduction	Implement new methane guidelines; establish LDAR programs; minimize flaring/venting.	Significant reduction in operational GHG emissions; enhanced environmental compliance.	EPA, Petroleum Commission, Oil & Gas Operators [12]
	Energy Efficiency at Existing Facilities	Invest in TOR upgrades; implement ISO 50001 EnMS; optimize industrial processes.	Reduced energy consumption & operational costs; improved competitiveness.	Ministry of Energy, TOR, Industrial Companies, Energy Commission [7]
	Biofuel Pilot Projects	Scale up ethanol production from corn/cassava; promote blending.	Reduced reliance on imported fuels; lower transport emissions; rural economic development.	Ministry of Agriculture, Ministry of Energy, Biofuel Producers, Private Sector [9]
	Data Transparency & Baseline	Improve data collection for Scope 1 & 2 emissions; utilize monitoring systems.	Accurate emissions baseline; identification of immediate reduction opportunities.	EPA, Petroleum Commission, Industry Associations [38]
Mid-Term (5 - 15 years)	TOR Modernization & Integration	Complete TOR upgrades; explore initial CCS integration; optimize operations.	Enhanced refining efficiency; early stage emissions reduction from processes.	TOR, Ministry of Energy, Private Investors [18]
	Renewable Energy for Industrial Processes	Accelerate utility-scale solar/wind; strengthen net-metering for C&I.	Decarbonized electricity supply for industry; reduced grid strain.	Ministry of Energy, Energy Commission, GRIDCo, Private RE Developers, C&I Businesses [31]
	Circular Economy Scale-Up (Plastics)	Expand CEF-PS; establish domestic market for recycled plastics; explore alternatives.	Reduced plastic waste & pollution; decoupling from fossil fuels; new jobs.	MEST, SMEs, Industry, Local Authorities [17]
	Low-Carbon Hydrogen Pilots	Initiate green hydrogen production pilots for industrial use (e.g., ammonia).	Feasibility assessment for large-scale green hydrogen economy; initial decarbonization of specific processes.	Ministry of Energy, Research Institutions, Private Sector, International Partners [45]
Long-Term (15+ years)	Decarbonized Petroleum Hub	Integrate large-scale CCS, green hydrogen production, electrification into new hub.	Near-zero emissions intensity for new petrochemical facilities.	PHDC, Ministry of Energy, International Investors, Technology Providers [3]

Continued

Full Renewable Energy Grid	Achieve 92% - 99% RE in power mix by 2030, 100% by 2040.	Fully clean energy supply for all sectors, including petrochemicals.	Ministry of Energy, Energy Commission, GRIDCo, IPPs [11]
Advanced Circular Economy	Implement comprehensive CE across value chain (advanced recycling, bio-based feedstocks).	Maximized resource efficiency; minimal waste; sustainable material cycles.	MEST, Industry, Research Institutions, Consumer Groups [6]
Carbon Pricing Mechanisms	Fully implement carbon taxes or cap-and-trade systems.	Broad economic incentive for decarbonization across all sectors.	Ministry of Finance, EPA, PURC [29]

4.2. Policy and Capacity Building Recommendations

Achieving Ghana's decarbonization objectives requires a robust and coherent policy framework coupled with significant investments in human and institutional capacity.

While the EPA and Petroleum Commission are the most likely institutional enforcers of green compliance audits and anti-greenwashing legislation, both currently face capacity and resource constraints. Strengthening these agencies through targeted funding, staff training, and legislative mandate expansion is essential for effective enforcement.

Policy Coherence and Enforcement: It is imperative to develop a comprehensive "National Industrial Decarbonization Strategy" that explicitly integrates the petrochemical sector. This strategy must align seamlessly with the broader Ghana Energy Transition and Investment Plan [3], ensuring that industrial growth is synchronized with climate goals. A critical step involves strengthening regulatory enforcement mechanisms. This includes establishing independent green compliance audits and enacting enforceable anti-greenwashing legislation with meaningful penalties to ensure accountability and prevent misleading environmental claims [27]. Furthermore, the government must establish clear, long-term policy frameworks and economic incentives, such as targeted tax breaks, production incentives, and competitive tariff structures, to stimulate private sector investment in renewable energy, energy efficiency, and other low-carbon technologies [29]. Introducing carbon pricing mechanisms, whether through carbon taxes or cap-and-trade systems, would internalize the social cost of carbon emissions, providing a powerful economic signal to incentivize low-carbon transitions across all sectors [29].

Capacity Building and Human Capital Development: A successful green transition hinges on a skilled and adaptable workforce. Ghana must therefore roll out national green skills development programs, tailored to both urban and rural populations, with a strong emphasis on critical areas such as renewable energy technologies, waste management, eco-construction, and circular economy practices [27]. It is crucial to prioritize the retraining of workers displaced from fossil fuel-dependent sectors to ensure a just transition and minimize socio-economic

disruption [27]. Expanding STEM education for girls and youth is also vital to build a pipeline of future talent and ensure long-term gender equity in emerging green industries [27]. To address financial sector limitations, efforts must be made to enhance the skills of consultants and bank staff in energy efficiency and project assessment, thereby bridging the expertise gap necessary for attracting and deploying green finance [7]. Finally, strengthening the institutional capacity within key regulatory bodies, such as the EPA and the Petroleum Commission, is essential to effectively monitor, regulate, and facilitate the adoption of green technologies and practices across the industry [27].

The repeated identification of an “unsupportive policy and regulatory environment”, “weak enforcement mechanisms”, and “insufficient financial and regulatory incentives” as major barriers [26] highlights a crucial point: a robust and coherent governance framework is the fundamental prerequisite for market transformation towards decarbonization. Policy and capacity building are not merely about setting rules; they are about actively shaping the market by reducing investment risks, creating clear and predictable signals for green investments, and fostering an ecosystem where sustainable solutions are both attractive and feasible. Without strong governance, even the most promising financial and technological solutions will struggle to gain widespread traction and deliver their full potential.

4.3. Finance and Partnership Strategies for Implementation

The scale of Ghana’s decarbonization ambition necessitates a robust and diversified financial strategy, complemented by strong domestic and international partnerships.

Addressing the Financing Gap: Ghana’s Energy Transition and Investment Plan is estimated to cost a staggering \$550 billion by 2060 [3]. However, an analysis of climate finance flows in Ghana revealed that in 2019-2020, only an annual average of \$830 million was tracked, representing a mere 5% - 9% of the estimated \$9.3 - 15.5 billion required annually to achieve Ghana’s NDCs [47]. This massive financing gap underscores the urgent need for innovative and diversified funding mechanisms that extend beyond traditional public finance [36].

Ghana’s ability to raise \$550 billion by 2060 faces significant constraints given current macroeconomic vulnerabilities, including a debt-to-GDP ratio exceeding 70% and declining access to concessional loans. This necessitates innovative financing structures such as blended finance, debt-for-climate swaps, and strengthened domestic revenue assurance as well as strategic partnerships with MDBs and climate funds to close the gap.

Attracting Private Sector Investment: To bridge this gap, Ghana must cultivate an environment highly attractive to private capital. This involves creating a clear and stable regulatory environment, ensuring transparency in investment processes, and actively building investor confidence to attract both domestic and foreign private investments [36]. Providing targeted fiscal incentives for en-

ergy-efficient products and for the local manufacturing and assembly of green technologies can stimulate private sector engagement [33]. Furthermore, actively encouraging financial institutions to develop and offer financial products that support energy conservation and efficiency initiatives is crucial [33]. Leveraging Public-Private Partnerships (PPPs) can be an effective mechanism for securing funding for critical infrastructure projects, distributing risk, and mobilizing expertise [14].

International Collaboration and Climate Finance: Ghana must aggressively engage with international organizations and multilateral development banks (MDBs) to access concessional financing, grants, and technical assistance [12]. Exploring innovative financial instruments such as debt-for-climate swaps can free up fiscal space for green investments [21]. Ghana's recent selection for the Climate Investment Funds' (CIF) \$1 billion Industrial Decarbonization Program and its joining of the Industrial Transition Accelerator (ITA) program are positive steps, highlighting international confidence in its climate policies and providing access to critical funding and expertise [44]. The international carbon market under Article 6 of the Paris Agreement presents a significant opportunity for revenue generation and investment. Ghana has already authorized three carbon market projects for international transfer, amounting to 5.9 metric tons of carbon dioxide (Mt CO₂), and has a pipeline of 68 projects with a potential for 402 metric tons of carbon dioxide (Mt CO₂) credits [48]. Capitalizing on these mechanisms will be vital [4].

Domestic Resource Mobilization: While international finance is critical, domestic resource mobilization is equally important for long-term sustainability and ownership. Reinvesting a portion of Ghana's oil revenues directly into the petroleum hub and other green transition initiatives through sovereign wealth fund allocations can provide a consistent funding stream [13]. Strengthening revenue assurance programs in the petroleum sector to curb leakages and enhance tax revenue mobilization can also free up significant domestic capital for these investments [49].

The overwhelming financial requirement for Ghana's decarbonization, coupled with the severe existing funding gap, indicates that finance is the single most critical bottleneck. While policy and technology are undeniably crucial, their effective deployment and scale-up are largely contingent on securing adequate and sustainable funding. Therefore, the financial strategy must be a central pillar of Ghana's decarbonization plan, actively exploring diverse funding sources including domestic public funds, private investment, multilateral development banks, dedicated climate funds, and carbon markets and innovative financial instruments. (Table 8). Without a robust and successfully executed financial mobilization plan, even the most well-designed roadmap and policies will remain aspirational. This situation highlights the imperative for Ghana to become an exceptionally attractive destination for green investment, potentially requiring broader economic and governance reforms beyond the energy sector.

Table 8. Financing and partnership opportunities for decarbonization initiatives.

Funding Source/ Mechanism	Description	Potential Contribution/Role	Examples/Relevant Snippet IDs
Domestic Public Funds	Government budget allocations, sovereign wealth fund reinvestment.	Provides foundational capital, signals government commitment, can de-risk private investment.	Reinvest Ghana's oil revenues into Petroleum Hub & green transition [13]; Public actors accounted for 87% of climate finance (USD 722M) in 2019-2020 [47].
Private Investment (Domestic & Foreign)	Equity, debt, and direct investments from companies, financial institutions.	Crucial for large-scale project financing, technology transfer, and operational expertise.	Private finance only 13% (USD 106M) of climate finance in Ghana (2019-2020) [47]; Ghana seeks to attract investors for \$550B ETIP [36].
Multilateral Development Banks (MDBs)	Concessional loans, grants, technical assistance from institutions like World Bank, AfDB, EBRD.	Provides significant capital, de-risks projects, offers technical guidance, enhances debt sustainability.	MDBs provided USD 248M in climate finance (2019-2020) [47]; EBRD invested \$1.1B in Benban Solar Park [42]; Partners in Egypt's industrial decarbonization [44].
Global Climate Funds	Dedicated funds like Climate Investment Funds (CIF), Global Environment Facility (GEF).	Targeted funding for climate action, often with concessional terms.	Ghana selected for CIF's \$1B Industrial Decarbonization Program [44]; GEF funded Ghana's Circular Economy Project for plastics [17].
Carbon Markets (Article 6 of Paris Agreement)	Trading of carbon credits (ITMOs) generated from emission reduction projects.	Revenue generation for green projects, incentivizes low-carbon development.	Ghana authorized 3 projects (5.9 Mt CO ₂) for international transfer; pipeline of 68 projects (402 Mt CO ₂) [48].
Public-Private Partnerships (PPPs)	Collaborative arrangements between government and private sector.	Leverages private capital and expertise for public infrastructure; shares risks and rewards.	Proposed for securing funding for critical infrastructure in Jomoro Petroleum Hub [13]; South Africa uses PPPs for green corridor development [45].
Innovative Financial Instruments	Debt-for-climate swaps, green bonds, blended finance.	Tailored solutions to address specific financing challenges and attract diverse investors.	Ghana's Energy Policy mentions exploring emissions trading and debt carbon swap [21]; Petrobras uses decarbonization fund [39].

5. Conclusions

Ghana's petrochemical industry is at a pivotal juncture, embodying a complex interplay between ambitious economic development and the pressing global mandate for decarbonization. The nation's strategic vision to become a regional petroleum hub, promising substantial GDP growth and extensive job creation, reflects a deep national commitment to this sector as a primary engine for prosperity. However, this growth trajectory is currently underpinned by a heavy reliance on fossil fuels, creating a significant carbon footprint and posing a direct challenge

to Ghana's net-zero emissions target by 2060. The existing infrastructure, notably the Tema Oil Refinery, faces operational inefficiencies and requires modernization, further complicating the decarbonization pathway.

The analysis reveals that Ghana's decarbonization efforts are hindered by an intricate web of interconnected barriers. Socio-economic challenges, such as the high cost of green solutions and potential social exclusion, intertwine with technical limitations like outdated infrastructure and a shortage of skilled labor. These are compounded by institutional weaknesses, including an unsupportive policy environment, weak regulatory enforcement, and a substantial climate finance gap. The current policy-investment discrepancy, where significant capital is directed towards fossil fuel expansion despite green transition aspirations, risks carbon lock-in and the creation of stranded assets.

Despite these formidable obstacles, Ghana possesses considerable opportunities for a sustainable transition. The nation's abundant renewable energy resources, coupled with existing policy frameworks for energy efficiency and emerging circular economy initiatives, offer viable pathways for emissions reduction. Learning from global best practices, particularly from developing economies like Brazil, Egypt, and South Africa, demonstrates that tailored adaptation of technologies and policies, supported by robust financial mechanisms, is key to successful decarbonization.

5.1. Forward Outlook and Call to Action

The path forward for Ghana's petrochemical industry necessitates a balanced and pragmatic approach that acknowledges the nation's developmental needs while aggressively pursuing a low-carbon transition. This requires moving beyond aspirational targets to concrete, integrated action across all levels of governance and industry.

a) Integrated Policy and Regulatory Coherence: Ghana must develop a cohesive national industrial decarbonization strategy that fully integrates the petrochemical sector within its broader Energy Transition and Investment Plan. This strategy must be supported by strengthened regulatory enforcement, clear economic incentives for green investments, and the progressive implementation of carbon pricing mechanisms.

b) Aggressive Capacity Building and Technology Transfer: Prioritizing human capital development through national green skills programs and retraining initiatives is paramount. Simultaneously, fostering genuine technology transfer through improved local content enforcement and strategic international partnerships will be critical for adopting advanced low-carbon solutions.

c) Diversified Financial Mobilization: Bridging the substantial climate finance gap requires a multi-pronged approach. Ghana must actively engage with international climate funds and multilateral development banks, leverage the international carbon market, and create an exceptionally attractive environment for private sector investment through transparent governance and de-risking mecha-

nisms. Domestic resource mobilization, including strategic reinvestment of oil revenues, will also be essential.

d) Phased and Adaptive Implementation: The proposed decarbonization roadmap, from immediate methane reductions and energy efficiency gains to long-term large-scale renewable energy integration and circular economy adoption, must be implemented with flexibility. Continuous monitoring of technological advancements and global market shifts will enable adaptive adjustments, preventing lock-in to outdated pathways.

Ghana's journey towards a sustainable, low-carbon petrochemical industry is not merely an environmental imperative; it is a strategic economic opportunity. By proactively addressing its unique challenges and leveraging its inherent strengths, Ghana can transform its energy landscape, enhance long-term economic resilience, and emerge as a compelling model for other developing nations navigating similar transitions. The time for decisive and coordinated action is now to secure a prosperous and sustainable future.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

- [1] PHDC (n.d.) Positioning Ghana as a Leading Petrochemical Hub: The Role. <https://phdc.gov.gh/positioning-ghana-as-a-leading-petrochemical-hub-the-role-of-phdc/#:~:text=With%20an%20estimated%20700%2C000%20new,the%20regional%20petroleum%20supply%20chain>
- [2] IEA (n.d.) Emissions-Ghana-Countries & Regions-IEA. <https://www.iea.org/countries/ghana/emissions>
- [3] Trade.gov (n.d.) Ghana Energy Transition Plan. <https://www.trade.gov/market-intelligence/ghana-energy-transition-plan>
- [4] UNFCCC (n.d.) The Paris Agreement. <https://unfccc.int/process-and-meetings/the-paris-agreement>
- [5] ResearchGate (2021) Economic Benefits of Energy Efficiency to the Petroleum Refineries in Ghana: A Case of Tema Oil Refinery (TOR). *Open Journal of Energy Efficiency*, **10**, 121-135. https://www.researchgate.net/publication/356353066_Economic_Benefits_of_Energy_Efficiency_to_the_Petroleum_Refineries_in_Ghana_A_Case_of_Tema_Oil_Refinery_TOR
- [6] Petrochem Expert (n.d.) Sustainability in the Petrochemical Sector: Initiatives and Best Practices. <https://petrochemexpert.com/sustainability-in-the-petrochemical-sector-initiatives-and-best-practices/>
- [7] Green Climate Fund (n.d.) Ghana's Industrial Energy Efficiency: Forging a Path to Decarbonisation. <https://knowledge.greenclimate.fund/readiness/stories/ghana-success-story/>
- [8] Boadi, S. and Armah, B. (2025) Socioeconomic Impact of Downstream Oil Infrastructure in Ghana. *West African Journal of Energy Development*, **11**, 88-104.
- [9] Abudu, H. and Tagoe, D. (2024) Evaluating Bioethanol Feedstock Potential in

- Ghana's Agro-Industrial Sector. *Renewable Energy Research in Africa*, **18**, 44-61.
- [10] AllAfrica (2025) Ghana: Three Oil Refineries, Five Petrochemical Plants to be Constructed. <https://allafrica.com/stories/202504230010.html>
- [11] Climate Analytics (2022) Power Sector in 2030. <https://1p5ndc-pathways.climateanalytics.org/countries/ghana/sectors/power>
- [12] IEA (n.d.) The Oil and Gas Industry in Net Zero Transitions. <https://www.iea.org/reports/the-oil-and-gas-industry-in-net-zero-transitions/executive-summary>
- [13] Akpalu, A. (2025) Jomoro Petroleum Hub: Ghana's Path to Energy Sovereignty and Economic Transformation. *Modern Ghana*. <https://www.modernghana.com/news/1408793/jomoro-petroleum-hub-ghanas-path-to-energy-sover.html>
- [14] B&FT Online (2025) Three oil Refineries, Five Petrochemical Plants to be Constructed. <https://thebftonline.com/2025/04/22/three-oil-refineries-five-petrochemical-plants-to-be-constructed/>
- [15] Springer Nature Communities (2025) Sociological Impacts of Energy Management at Tema Oil Refinery. *Discover Environment*. <https://communities.springernature.com/posts/arthur-j-l-2024-sociological-impacts-of-energy-management-at-tema-oil-refinery-discover-environment-2-1-114>
- [16] Tema Oil Refinery Ltd. (n.d.) What We Do. [https://torghana.gov.gh/what-we-do/#:~:text=As%20a%20downstream%20oil%20and,premium%20forming%20\(PRF\)%20unit](https://torghana.gov.gh/what-we-do/#:~:text=As%20a%20downstream%20oil%20and,premium%20forming%20(PRF)%20unit)
- [17] Mensah, R.A. and Asare, E. (2023) Circular Economy Integration in Ghana's Industrial Policy. *Journal of African Sustainability Studies*, **12**, 155-174.
- [18] Ornoir Africa (2025) Ghana: A USD 25 Million Investment to Relaunch the Tema Refinery. <https://ornoirafrika.com/en/ghana-an-investment-of-usd-25-million-to-re-launch-tema-refinery/>
- [19] World Oil (2025) Ghana's Petroleum Commission to Outline Upstream Investment Opportunities. <https://www.worldoil.com/news/2025/4/7/ghana-s-petroleum-commission-to-outline-upstream-investment-opportunities/>
- [20] African Energy Chamber (2025) AEC Commends Ghana's Commitment to Boost Energy Security with Second Gas Processing Plant. <https://energychamber.org/aec-commends-ghanas-commitment-to-boost-energy-security-with-second-gas-processing-plant/>
- [21] FAO (2021) Ghana's National Energy Policy (2021). <https://www.fao.org/wood-energy/search/detail/en/c/1734090/>
- [22] Ghana Petroleum Register (n.d.) Legislations. <https://ghanapetroleumregister.com/legislations/>
- [23] Environmental Protection Agency Ghana—Oil & Gas Division (n.d.) Guidelines or Regulations for Petrochemical Industry Emissions and Environmental Management. <https://epaoilandgas.org/>
- [24] Climate & Clean Air Coalition (n.d.) Training and Capacity Support to Implementing Ghana's Petroleum Regulation and Supplementing It with Methane Guidelines. <https://www.ccacoalition.org/projects/training-and-capacity-support-implementing-ghanas-petroleum-regulation-and-supplementing-it-methane-guidelines>

- [25] Sikaman Times (2025) Local Content Policies Key to Ghana's Upstream Petroleum Growth, Entrepreneurial Development, Skills and Technology Transfer, Study Finds. <https://sikamantimes.com/local-content-policies-key-to-ghanas-upstream-petroleum-growth-entrepreneurial-development-skills-and-technology-transfer-study-finds/>
- [26] Ghana Climate Innovation Centre (2024) Identifying the Enablers and Barriers to a Supportive Business Environment for Green Businesses in Ghana. <https://ghanacic.ashesi.edu.gh/wp-content/uploads/2024/12/Identifying-the-Enablers-and-Barriers-to-a-Supportive-Business-Environment-for-Green-Businesses-in-Ghana.pdf>
- [27] (2025) Ghana's 24-Hour Economy: A Strategic Pathway to the Nine Trillion Dollar Global Green Transition Market. <https://cedirates.com/news/ghanas-24-hour-economy-a-strategic-pathway-to-the-nine-trillion-dollar-global-green-transition-market/>
- [28] MDPI (2024) Investigating Barriers to Low-Carbon Policy Implementation among Mining Companies in Ghana. *Sustainability*, **16**, Article 1798. <https://www.mdpi.com/2071-1050/16/5/1798>
- [29] PURC (2024) Regulatory Brief. <https://purc.com.gh/attachment/750265-20240911010919.pdf>
- [30] Yeboah, S.A. (2025) Innovative Climate Finance in Ghana: A Systematic Review of Green Bonds, Blended Finance, and Climate Funds (MPRA Paper No. 124517). Munich Personal RePEc Archive. <https://mpra.ub.uni-muenchen.de/124517/>
- [31] Climate Policy Lab (2025) The Case for Ghana's Renewable Energy Transition: A Path to Sustainability and Economic Resilience. <https://www.climatepolicylab.org/climatesmart/2025/3/7/the-case-for-ghanas-renewable-energy-transition-a-path-to-sustainability-and-economic-resilience>
- [32] RMI (n.d.) The Energy Efficiency Journey in Ghana. <https://rmi.org/the-energy-efficiency-journey-in-ghana/>
- [33] CAS (2025) Industrial Decarbonization. <https://www.cas.org/resources/cas-insights/industrial-decarbonization>
- [34] World Economic Forum (2024) Trade and the Circular Economy: A Deep Dive into Plastics Action in Ghana. https://www3.weforum.org/docs/WEF_Ghana_NPAP_Trade_and_Circular_Economy_2024.pdf
- [35] MDPI (2024) South Africa Green Hydrogen Petrochemical Industry. *Sustainability*, **17**, Article 901. <https://www.mdpi.com/2071-1050/17/3/901>
- [36] Gas Outlook (2023) Ghana Energy Transition Plan Faces Roadblocks: Experts. <https://gasoutlook.com/analysis/new-550bn-ghana-energy-transition-plan-faces-challenges-experts/>
- [37] New Producers Group (2022) Minimising Greenhouse Gas Emissions in the Petroleum Sector. <https://www.newproducersgroup.online/wp-content/uploads/2022/11/Minimising-Greenhouse-Gas-Emissions-in-the-Petroleum-Sector.pdf>
- [38] RMI (2022) Decarbonizing Refining and Petrochemicals: Big Challenges, Big Opportunities. <https://rmi.org/decarbonizing-refining-and-petrochemicals-big-challenges-big-opportunities/>
- [39] BNamericas (2025) Why Petrobras Is Investing in PV Solar Power. <https://www.bnamericas.com/en/features/why-petrobras-is-investing-in-pv-solar->

[power](#)

- [40] Rolim, M. J. C. P. and de Oliveira, V. M. (2023) Developing a Sustainable Hydrogen Economy in Brazil: Tracking Some Legal and Regulatory Paths (Report). Sabin Center for Climate Change Law, Columbia Law School.
https://climate.law.columbia.edu/sites/climate.law.columbia.edu/files/content/docs/Develop-ing%20a%20Sustainable%20Hydrogen%20Econ-omy%20in%20Brazil_November%202023.pdf
- [41] Pereira, A.O., Pereira, A.S., La Rovere, E.L., Barata, M.M. de L., Villar, S. de C. and Pires, S.H. (2011) Strategies to Promote Renewable Energy in Brazil. *Renewable and Sustainable Energy Reviews*, **15**, 2954-2963.
<https://doi.org/10.1016/j.rser.2010.09.027>
- [42] Elba, H., Mahdi, I., Abdel Rashid, I. and Hassan, H.M. (2024) Implementing Renewable Energy in Egypt: State of the Art Review, Challenges, and Opportunities. *International Journal of Research in Engineering and Management*, **7**, 22-31.
<https://doi.org/10.13140/RG.2.2.11128.05125>
- [43] Energy-Utilities (2024) Harnessing Solar Power in Egypt: The Rise of Benban Solar Park.
<https://energy-utilities.com/harnessing-solar-power-in-egypt-the-rise-of-news124897.html>
- [44] Business Today Egypt (2025) Egypt Chosen among 7 Nations for \$1B Global Industrial Decarbonization Initiative.
<https://www.businesstodayegypt.com/Article/1/6443/Egypt-chosen-among-7-nations-for-1B-Global-Industrial-Decarbonization>
- [45] World Economic Forum (2024) Decarbonizing South Africa's Shipping and Trucking Sectors.
https://www3.weforum.org/docs/WEF_Decarbonizing_South_Africas_Shipping_and_Trucking_Sectors_2024.pdf
- [46] Wits University (2025) Why SA Is Not Ready to Produce Green Hydrogen.
<https://www.wits.ac.za/news/latest-news/opinion/2025/2025-02/why-sa-is-not-ready-to-produce-green-hydrogen.html>
- [47] Climate Policy Initiative (2023) Climate Finance in Ghana.
<https://www.climatepolicyinitiative.org/publication/climate-finance-in-ghana/>
- [48] Environmental Protection Agency Ghana (2025) 2024 Annual Progress Report. Ghana Carbon Market Office, Environmental Protection Agency Ghana.
https://cmo.epa.gov.gh/wp-content/uploads/2025/03/2024-Annual-Progress-Report_final-version_21325.pdf
- [49] Anomah, S., Ayebofo, B., Aduamoah, M. and Agyabeng, O. (2024) Blockchain Technology Integration in Tax Policy: Navigating Challenges and Unlocking Opportunities for Improving the Taxation of Ghana's Digital Economy. *Scientific African*, **24**, e02210. <https://doi.org/10.1016/j.sciaf.2024.e02210>