

# Climate Change, Energy Transition and Global Industry's Challenges and Opportunities: Roadmaps for a Sustainable Industrial Future

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## ARTICLE INFO

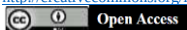
### Keywords:

Climate Change,  
Energy Transition,  
Industry,  
Impacts,  
Roadmaps.

**Vol.01, No.03, 2026**

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## ABSTRACT

There is a growing intensity of global pressures on industry and economic competitiveness as a result of the increasing climate change. This tends to propel global energy transition away from fossil fuels to renewable and low-carbon energy systems. This is the reshaping pedestal upon which industrial operations, investments and policy frameworks are placed. However, this transition is accompanied by disruptive challenges and transformative opportunities for industry. This paper presents a descriptive and position-based analysis of secondary data to assess the relationship between climate, energy transition and industry. Therefore, the study assesses impacts, strategies of adaptation and policy roadmaps for a paradigm shift to clean or renewable energy in the industry. Findings revealed that carbon pricing and technological lock-in remains the highest transition risks faced in industries that use energy intensively like steel, cement and chemical industries. Despite the risks and vulnerabilities, opportunities present circular economy, green hydrogen, electrification and digitalization. These opportunities have the capacity to reduce the level of industrial emissions up to 50% by 2030. Data were collated and synthesised from IEA World Energy Outlooks, UNFCCC, Peer-reviewed journals, IRENA, and IPCC Reports. Regional differentials showed that while developing economies contends with financing, technology and infrastructural deficits to green their environment, developed economies thrive better in the deployment of renewable technology, policy and innovation. It is on this note that this paper concludes that a well-managed energy transition that is just in implementation remains the pathway to a green environment and sustainable economy. This could be achieved through collaboration of government and the industry as well as a strong financial backup and blue-print applicable to specific sectors. There is an inevitable need to embrace proactive adaptation measures to mitigate the climate shocks resulting in supply chain disruptions and cost of operations in the industry.

## Introduction

Climate can be viewed as both a resource and a major challenge as it has influence on all areas of life. Any unique change in climate presents a unique challenge. Olanrewaju, Akpan, and Buku (2017) see climate change as a reality based on existing evidences and its attendant consequences seen and felt everywhere. As observed by the National Research Council (NRC, 2010), the rapidity, frequency and severity of the consequences of climate change in the last few decades are alarming. Jackson (2017) and Turner (2018) ranked climate change first among the 10 most serious problems facing the world. According to IPCC AR6 2023 Report, global average temperature has risen by 1.2°C above pre-industrial levels, with industry accounting for approximately 24% of global CO<sub>2</sub> emissions. However, the need to limit warming to 1.5°C pursuing net-zero emissions by 2050 put the industrial sector under serious pressure.

The World Meteorological Organization (WMO) according to Nigerian Meteorological Agency, NiMET (2019) defined climate change as “a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period”. The trapping of heat within the lower portion of the earth makes the Earth's surface hotter (warmer) and this is known as the greenhouse effect being responsible for global warming. According to Intergovernmental Panel on Climate Change (IPCC,

2018), global warming is the increase in the average surface temperature of the whole planet. In other words, it is the sustained increase or steady rise in the mean temperature of the earth's climate system over a relatively long period. Energy transition is the global shift from fossil fuels to renewable energy otherwise referred to as clean energy being not carbon-intensive technology for energy efficiency. The Industry transition is influenced by an interplay of forces including risks of heatwaves, floods and scarcity of water which disrupts production, supply chains and workforce productivity. Changing consumer market demand, carbon taxes, and ESG conditionalities are also major transition risks including the use of AI for energy management, CCUS, and green hydrogen as technology opportunities gave impetus to initiate and embrace new market models.

Despite the high vulnerability of heavy industries as a result of their high emissions level, they remain central to the solution. This is so because these industries produce the requisite materials for solar panels, batteries and wind turbines. The developing economies seems to be hit harder based on the matching order to industrialize for poverty reduction yet prevent high carbonized ways of the developed economies. As a result of the foregoing, this paper provides answers to how climate change impacts operations in the industry, the roadmaps and constraints to energy transition in industry and the policies that can globally enhance competitive position for the industry.

## **Materials and Methods**

### **Research Design**

Rather than the collection of primary data and generating new empirical data, this study adopts descriptive and interpretative research design entirely based on secondary data. It synthesized existing literature as the basis for interpreting and providing overview of the current trends and proffers future blueprint.

### **Instrument and Data Sources**

Data were sourced from institutional secondary materials including current international reports, policy documents, industry reports and peer reviewed journals. Among the international reports are IPCC AR6 2021–2023, IRENA Global Energy Transition Outlook 2023–2024 and IEA World Energy Outlook 2021–2025. Nigeria Energy Transition Plan 2022, US Inflation Reduction Act 2022, EU Green Deal and UNFCCC are some of the policy documents utilized. The industry reports include Global Cement and Concrete Association, McKinsey, BloombergNEF, World Steel Association and Nigeria's oil and gas industry report while the peer-reviewed journals comprised Nature Climate Change, Energy Policy and Journal of Cleaner Production. These authoritative materials were published up till 2021 and 2026.

### **Objectives of the Study**

#### ***The objectives of the study are to:***

- (i) evaluate the impacts of climate change on performance of industry.
- (ii) analyze roadmaps, opportunities and constraints in energy transition in industry.
- (iii) recommend policy and financing windows for decarbonization in industry.

### **Methods of Data Analysis**

The study adopts thematic content analysis by coding data into themes including climate change impacts, transition technologies, policy, finance and just transition. There was no primary statistical analysis conducted as descriptive statistics and trends from reports summarized in text essentially formed the core of the study. A comparative synthesis across regions and sectors was also systematically employed.

## **Results and Discussion**

### **The Impacts of Climate Change on Industry**

Climate change has continue to influence the occurrence, geographic spread, frequency and intensity of disasters such as floods, tsunamis, wildfires, heatwaves, droughts, earthquakes, volcanic eruptions etc. around different parts of world (United Nations International Strategy for Disaster Reduction, UNISDR, 2015; Oxfam, 2017). Their consequences are reflected both in the developed and developing economies, though with different varying risks and vulnerability levels. The raging wildfires in Southern France, Canada, Spain and Scotland which made Spain declare a national emergency, Massive wildfires in Oregon and extreme heat in Northern Africa, Algeria and North African heatwaves with temperature rising to 49°C resulting in serious dehydrations, extreme heat in Northern Algeria,

Tunisia heatwave causing water shortages, blackouts and struggling economy and the heatwave that swept across Western Libya with temperature rising up to 50°C are all recent occurrences in July, and August, 2026 which impacted greatly on virtually every aspect of life including the industry. The ravaging fires, referred to as the worst fire disaster in history was on a scale never seen before because it became increasingly more ferocious and yet kept escalating. Over 250,000 were said to have been evacuated in Southern France in the ensuing incidents according to China Global Television Network (CGTN), World Today July 2026.

Specifically in the industry, there are incessant physical and economic risks. According to the World Bank (2024), extreme weather caused 280 billion dollar supply chain losses in 2022–2023. The International Energy Agency (IEA) reported that globally, water stress threatens 40% of thermal power plants and refineries. International Labour Organization (ILO) in 2023 and 2021 reported that heat stress is projected to reduce labour productivity in manufacturing by 10–15% in tropical regions by 2030. Global emissions drives climate change as transition risks keeps accelerating. World Bank 2025 declared that over 70 carbon pricing schemes now cover 23% of global emissions. Exporters in Asia and Africa are in for hard times due to the European Union (EU) Carbon Border Adjustment Mechanism starting in 2026 levies tariffs on steel, cement and aluminium imports.

The mutual relationship between man, weather and climate often lead to positive and negative consequences. Banis (2019) examined the report given by United Kingdom Charity Organization “Christian Aid”, titled “Counting the Cost: A Year of Climate Breakdown”, published in 2018. Financial implications of climate change-driven weather events over the past years in various parts of the world was the main focus of the report. According to the report, the 10 Most-expensive climate change related disasters in 2018 alone by area are:

1. United States, where Hurricanes Florence and Michael gulped 17 and 15 billion dollars respectively.
2. California, United States where Fire cost 7.5–10 billion dollars and Woolsey Fire cost 1.5–3 billion dollars.
3. In Europe, drought caused 7.5-billion-dollar damage.
4. Japan, June to July floods cost 7 billion dollars while Typhoon Jebi cost 2.3–5.3 billion dollars.
5. Argentina drought’s estimate was 6 billion dollars.
6. China – floods 3.9 billion in July floods while the Tropical Storm Rumbia floods cost 5.4 billion dollars.
7. The Australia drought cost 5.8–9 billion in dollars.
8. Kerala in India whose floods cost 3.7 billion dollars.
9. Drought in Cape Town, South Africa was estimated to cost 1.2 billion dollars; and
10. The Philippines and China Typhoon Mangkhut cost 1–2 billion dollars.

These disasters are most terrific and catastrophic of unimaginable proportions. Mulla (2019) while quoting the Bank of International Settlement (BIS) added that climate-related risks have the potentials to inflict massive damage on global financial markets. All these major challenges are perhaps why Jackson, 2017 and Turner, 2018 ranked climate change first amongst the 10 most serious problems facing the world. The dare-devil powerful hurricane that swept through Latin America in October, 2025 that killed 45 people, displaced 45,000 across 43 communities and destroyed 90% of buildings with a consequent cost of 9B dollars remains a concrete reminder of a climate change impacts. Hence, climate change adaptation, mitigation and disaster management becomes imperative in building a robust globally competitive roadmaps.

### **Impact of Climate Change on the Oil and Gas Industry**

The impact of climate change on the oil and gas industry cannot be overemphasized. The findings in the study revealed that climate change has a far-reaching impact on the socio-economic and the environmental ecosystem and livelihood. This has significant implications for the oil and gas industries. These industries are not immune from the drastically changing weather patterns and increasing temperatures as it affects their operations thereby leading to increasing cost of productions. This justified the position of the World Bank (2020). Increased costs of production from the oil and gas industries have spiral effect on the price making it too high for the final consumer to bear. For instance, despite the climate change effect, the removal of oil subsidy in Nigeria, the Ukraine/Russian war in the last 5 years

and the current Iran/US-war also impacts substantially on the industry. All these no doubt have negative influence on the price module, availability, affordability which impacted on people's livelihood.

Consequently, the industry's supply chain is also distorted thereby attesting to the submission of United Nations Development Programme, UNDP (2020). The sustainability of the energy sector is central to other sectors of the economy including manufacturing, transportation, agriculture, construction and tourism to mention just a few. However, when the energy supply is being hampered, the wisest alternative option is to transit. This is aimed at mitigating the negative effects of climate change on oil and gas industry. Hence, renewable energy for instance, is gradually being seen as the best option to sustaining and increasing energy supplies in the oil and gas sector of the Nigerian economy. The International Renewable Energy (IRENA, 2020) subscribed to this initiative and it is currently the novel trends globally. This same position was highlighted in the United Nations Framework Convention on Climate Change (UNFCCC, 2019). Findings also revealed that most oil and gas industries are adopting the use of solar energy and in a few instances, wind energy as sustainable alternative sources of power.



Figure 1



Figure 2



Figure 3



Figure 4



Figure 5



Figure 6

**Figure 1-6: on the spot view of the impact of Climate-induced Heatwaves, Wild fires, and Drought in Europe, Americas and Africain July/August 2026.**

*Source: CGTN, Formerly CCTV English WORLD TODAY July/August Editions, 2026*

### Specific Areas of Interventions in the Oil and Gas Industry in Nigeria

i. **Flare gas digital infrastructure project:** In order to advance Nigeria's energy transition, flare gas commercialization as opposed to waste, compressed natural gas adoption, and greenhouse gas reduction initiatives were encouraged and supported. This was aimed at addressing complex operational

challenges, enhance sustainability and benefit from the inexhaustible energy value chain. This was particularly predicated on emissions accounting, gas utilization, hydrocarbon measurement and petrochemical downstream opportunities assessments. In concrete terms, the flare gas digital infrastructure project sought to make emissions reduction with data-driven industrialization as a strategic move with both climate and economic benefits.

**ii. Compressed Natural Gas Developments:** This operated under the auspices of the Presidential Compressed Natural Gas (CNG) initiative. In this regard, over 400,000 vehicle conversions from the traditional Premium Motor Spirit (PMS) usage was activated. Clean energy training programmes such as CNG technician training for polytechnics students and rural electrification agency's NextGen RESCO leadership program were actualized. This strategic move have guided job creation, capacity building and local content efforts.

No gains saying that these strategic interventions have resulted in steady progress. Key areas in the energy sector including clean energy use, decentralized energy access and investment in resilient infrastructure have been sustainably enhanced. Presently, the clean transport advancements have been adopted by Lagos, Enugu and Benue states with substantial investments. Benue launched clean energy powered taxis with zero emissions to promote eco-friendly transportation and to create not less than 8,500 direct jobs in the state by December, 2025. Dangote Group announced plans to convert 6,500 additional trucks to CNG. Eventually, a 40% fare cut was enforced for CNG-powered commercial vehicles in Abuja.

On investment and infrastructure front, new investment that support a wide array of energy facilities developments were brought to life in areas such as Liquefied Natural Gas (LNG), Compressed Natural Gas (CNG), and Solar mini-grids. The Economic Community of West African States (ECOWAS), World Bank and Eco Bank invest \$800,000 in Nigerian Small, Medium Enterprises (SMEs) to promote solar energy solutions. Lagos State launched electric tricycle operations by Bolt. This can be likened to the front lining and pace-setting innovations in electric vehicles by China which is presently making waves in Mexico engendering clean environment and substantial cost reduction. This was premised on evolving building transport solutions for lower operational costs and also to create more accessible way to vehicle ownership. Financial call inclusion premium spirit usage to Compressed natural gas was operationalized while 255 operational centers were established involving 40 filling stations in use while 172 others are under construction.

**iii. Renewable Energy and Electrification Initiatives:** The Rural Electrification Agency (REA) through the World Bank-supported Distributed Access through Renewable Energy Scale (DARES) project signed agreements with 8 companies to deliver clean energy targeting more than 17.5 million people in Nigeria. In a bid to retain a larger share of the \$40 Billion electricity access investment within Nigeria, REA emphasized local solar manufacturing.

**iv. Sub-national and Institutional Projects:** For the purpose of deepening energy access and infrastructure modernizing, a wide range of projects were initiated across the country. References abound in clean energy initiatives in Adamawa, Katsina, Kano, Abia states of Nigeria including renewable-powered transport and refrigeration systems launched in Benue state by Koolboks. Not less than 24 Federal educational institutions have been powered by solar energy.

**v. Workforce Development and Capacity Building:** Implementation of various workforce development, income growth and long term sustainability were put in place. In the same vein, the United Arab Emirate (UAE) is focused on financing a \$25 Billion Nigeria-Morocco gas pipeline with the goals of diversifying export routes, reducing gas flaring and transforming the regional energy opportunities significantly.

### **Roadmaps for Industrial Energy Transition**

After a comprehensive dissection of the literature, four key roadmaps are synthesized as core leeway for industrial energy transition. These are: Firstly, a viable option that is for low-heat processes discovered is the electrification combined with the renewable energy sources. According to the International Renewable Energy Agency (IRENA), direct electrification have the capacity to address 50% of industrial energy demand by 2050 confirming that costs of solar and wind PV dropped 85% since 2010. China leads in 80% of solar panel and battery manufacturing (BNEF, 2024).

Secondly, green hydrogen cost is projected to fall to an average of 1.5 dollar per kilogram by 2030 according to the International Energy Agency (IEA) as this is critical for steel and chemicals production. This is an economic booster that gives impetus to over 50 steel projects in pilot phase globally using green hydrogen (H<sub>2</sub>). Thirdly, the Carbon Capture, Utilization and Storage (CCUS) is essential in the cement industry in its production where 60% of emissions are process-based. Only 30MtCO<sub>2</sub> per year current capacity exists. This is against the 1.2 Gt needed by 2030 according to the IEA. The high point here is that the CCUS option has the capacity to reduce global carbon dioxide emissions to the barest minimum which is an elixir to a clean and greener environment. Fourthly, the Circular economy and digitalization transition are innovative means of improving material efficiency, recycling and Artificial Intelligence AI-driven energy management. This innovative initiative has the capacity to 15–20% of emissions in the industry according to McKinsey (2024).

These roadmaps are considered sacrosanct in the emissions control and management in those industries. This is in tandem with Alfred (2017) when he likened disaster management to more of measures of mitigation against the various threats that arise due to the occurrence of a disaster so as to lower the amount of total damage it can cause. In other words, disaster management is concerned with analysis of threats, protecting against those threats, evolving contingency plans and a system to repair possible damage from the disaster which sums up to preparedness, response and recovery.

However, it is noteworthy that there are regional disparities and constraints to the industrial energy transition. In the developing economies, high cost of capital, weak energy grids, energy access deficits and poverty remains the major stumbling blocks. This is in the face of the industrial energy demand that is projected to triple by 2050 in sub-Saharan Africa but 600 million people still lacking electricity according to IEA. The Federal Government of Nigeria FGN (2024) submitted that Nigerian Energy Transition Plan requires 10B dollars annually to 2060. Whereas, developed economies takes advantage of subsidies in various forms to cushion the effects of climate change and to upscale production capacity. For instance, European Union (EU) Green Deal benefits to the tune of 1T pounds, while the US IRA is rescued in the region of 369B dollars according to the BNEF (2024).

### **Conclusion**

Climate change and energy transition are basic phenomena that are critical to redefining and reshaping the industry in the 21st century. The beneficial outcome of energy transition far outweighs the recalcitrance to change in the annihilating dimensions of climate change. There is the need to adhere strictly to the roadmaps in electrification, hydrogen, CCUS and circular economy as necessary equity to mitigate palpable risks. Although, it is incumbent on government to provide the enabling environment in terms of consistent policy direction and financial backup in form of subsidies, the industry itself must be in the lead towards a just transition.

One of the main panacea needed in the developing economies is technology transfer and capacity building in their bid to industrialize with manageable level of carbon emissions. This is against the backdrop that they are contending with infrastructure deficits, policy inconsistencies and financial shortfalls. Achieving net-zero emissions in the industry by 2050 is a herculean task because of the huge financial commitments which according to IEA require 4.3T dollars. This can only be feasible through tripartite partnership and effective collaboration between the governments, financial institutions and the industry itself. The Energy transition mechanism must also take cognizance of peculiar and specific sectoral needs. Regional perspectives remains a formidable means to confront climate issues in its governance.

### **Recommendations**

The following recommendations were the products of expert opinions in the industry and various policy documents consulted in this study. These are:

1. Policy Consistency on the part of government to implement clear cut decarbonization roadmaps through 2030–2050 which takes adequate care of carbon pricing and universal standards especially for heavy industry.
2. Financial stability window must be mobilized in the form of Industrial Transition Fund to facilitate proper de-risking of hydrogen and CCUS projects, in particular, those in the developing economies. This will encourage them to frontally confront the barriers towards the journey of energy transition.

3. To drive a sustainable energy transition project, technology and infrastructure must be a first line charge through huge investments in industrial clusters in hydrogen and CO<sub>2</sub> facilities. There is the need to scale up Research and Development especially in the difficult or hard-to-abate industrial sectors.
4. Need to ensure energy access in juxtaposition with the process of decarbonization. Workers in fossil-based industries requires renewed skills acquisition through funds to raise the bar of competence and compliance with necessary tools to operationalize a just energy transition prerequisites.
5. Industries should integrate climate risk into their investment decisions through setting science-based targets and the adoption of TCFD disclosures as a corporate strategy for implementing their energy transition to guarantee energy efficiency because the transition is a necessity.
6. Identifying appropriate climate change result metrics for use in the project result management framework including strict compliance with international protocols and cooperation, climate summits, agreements, climate conferences, action initiatives and acceleration agenda through a pragmatic global governance initiative.
7. Projects to be invested in should be such that will promote job creation and benefit the vulnerable populations and ensure that projects always align with climate change objectives.

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