2023

NIGERIA'S LONG-TERM LOW-EMISSION DEVELOPMENT STRATEGY – 2060

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Nigeria's Long-Term Low-Carbon Development Strategy

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Statement by the Nigeria President

Foreword by DG NCCC+Hon Ministers of FMenv and Finance

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Abbreviations

Abbreviations and Acronyms

AAAP	Africa Adaptation Acceleration Program
ACE	Action for Climate Empowerment
ACReSAL	Agro-Climatic Resilience in Semi-Arid Landscapes
AFD	French Development Agency
AfDB	African Development Bank
AFOLU	Agriculture, Forestry, and other land use
BAU	Business-As-Usual
BNRCC	Building Nigeria's Response to Climate Change
BRT	Bus Rapid Transit
CBN	Central Bank of Nigeria
CCS	Carbon Capture and Sequestration
CCUS	Carbon Capturing, Utilization and Storage
CE	Circular Economy
CER	Certified Emissions Reduction
CGE	Computable General Equilibrium
CIDA	Canadian International Development Agency
CNG	Compressed Natural Gas
CO2	Carbon Dioxide
COP	Conference of the Parties
CPS	Current Policy Scenario
CRI	Climate Risk Index
CSOs	Civil Society Organisations
CSP	Concentrated Solar Power
DAPP	Dynamic Adaptive Policy Pathways
DDP	Deep Decarbonisation Pathways
DFID	Department for International Development
EbA	Ecosystem-based Adaptation
EnMS	Energy Management System
ETP	Energy Transition Plan
ETS	Emission trading system
EVs	Electric Vehicles
FAO	Food and Agriculture Organisations
FCDO	Foreign, Commonwealth and Development Office
FiT	Feed-in-tariff
FMARD	Federal Ministry of Agriculture and Rural Development
FMEnv-DCC	Federal Ministry of Environment, Department of Climate Change
GCA	Global Centre on Adaptation
GCRI	Global Conflict Risk Index
GDP	Gross domestic product
GES	Gas Economy Scenario

GHG	Green House Gas
GIZ	Gesellschaft für Internationale Zusammenarbeit
GRADE	Global Rapid Damage Estimation
GW	Giga Watt
GWP	Global Warming Potentials
HDI	Human Development Index
HDV	Heavy-Duty Vehicle
IDDRI	Institute for Sustainable Development and International Relations
IMF	International Monetary Fund
IPCC	Inter-Governmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
KLEM-NGA	Capital, Labour, Energy and Material for Nigeria
LCOE	Levelized Costs of Electricity
LDV	Light Duty Vehicle
LEAP- NGA	Low Emissions Analysis Platform for Nigeria
LPG	Liquefied petroleum gas
LT	Long Term
LT-LEDS	Long-Term- Low Emission Development Strategy
LTS	Long Term Strategy
LTV	Long Term Vision
LULUCF	Land-Use Land -Use Change and Forestry
MAP	Mass Agricultural Programme
MDAs	Ministries, Departments and Agencies
MHP	Mass Housing Programme
MMTCO2e	Million Metric Tons of Carbon dioxide
MRV	Measurement, Reporting, and Verification
MT	Medium Term
MYTO	Multi-year Tariff Order
NAMAs	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plan
NASPA-CCN	National Strategy and Plan of Action for Climate Change in Nigeria
NBS	National Bureau of Statistics
NbS	Nature-based solution
NCCC	National Climate Change Council
NCCP	National Climate Change Policy
NDC	Nationally Determined Contributions
ND-GAIN	2021 Notre Dame Global Adaptation Index
NEC	Natural Eco Capital
NEEAP	National Energy Efficiency Action Plan
NESP	Nigeria Economic Sustainability Plan
NESREA	National Environmental Standards and Regulations Enforcement Agency
NEWMAP	Nigeria Erosion and Watershed Management Project
NGECP	National Generator Emission Control Programme
NIIA	Nigerian Institute of International Affairs
NMT	Non-Motorized Transport
NREEEP	National Renewable Energy and Energy Efficiency Policy

NVECP	National Vehicular Emission Control Programme
OCEL	Oando Clean Energy Limited
PCNGI	Presidential Compressed Natural Gas Initiative
PES	Payment for ecosystem service
PEWASH	Partnership Expansion for Water Sanitation and Hygiene
PIA	Petroleum Industry Act
PV	Photovoltaic
REDD+	Reducing Emissions from Deforestation and forest Degradation,
REER	Real Effective Exchange Rate
REMP	Renewable Energy Master Plan
RES	Renewable Energy Scenario
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SEC	Stock Exchange Commission
SMEs	Small and Medium-sized Enterprises
SSP2	Shared Socioeconomic Pathways
ST	Short Term
UN	United Nation
UNDP	United Nation Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNSEEA	United Nation System of Environmental-Economic Accounting
USAID	United States Agency for International Development
USD	United States dollar
VER	Voluntary Emissions Reduction

EXECUTIVE SUMMARY

1. Introduction

Nigeria has prepared this Long-Term Low Emission Development Strategy (LT-LEDS) as part of its commitment to the Paris Agreement (PA). The Paris Agreement commits the world to decarbonising its development process with a long-term objective of avoiding dangerous levels of global warming from human-induced greenhouse gas (GHG) emissions. This commitment takes into account the principle of "common but differentiated responsibilities," while also considering respective capabilities in the light of national circumstances. In addition, the Paris Agreement introduced Nationally Determined Contributions (NDCs) as a way for Parties to convey their near-term actions in reducing emissions and adapting to the impacts of climate change.

In 2021, Nigeria submitted its updated NDC and LTV 2050 (Long-term Vision 2050) as a first contribution towards elaborating this LT LEDS) to the UNFCCC. The country also pledged to achieve net-zero emissions by 2060 as part of its commitment to the PA. The LT-LEDS presented here has been elaborated to explore how Nigeria can meet its net-zero carbon goal while ensuring sustainable socioeconomic development and enhancing climate resilience. The LT-LEDS links Nigeria's NDC, the short-term development planning tool, to the country's long-term objectives, providing a framework for policy development. Thus, the LT-LEDS will help strengthen and guide the NDC by providing a long-term vision that gives coherence and direction to the country's aspiration for sustainable, low-carbon, and climate-resilient development.

2. Nigeria's LT-LEDS Development Process

Nigeria's LT-LEDS process was led by the National Council on Climate Change (NCCC) with the support of the 2050 Pathways Platform. Natural Eco Capital acted as the National Project Coordinator, whilst the technical support for developing the scenarios, GHG emissions and macro-economic modelling was provided by Nigeria's Deep Decarbonization Project (DDP-Nigeria). The latter was led by the Center for Climate Change and Development Alex Ekwueme Federal University (CCCD-AE-FUNAI) in collaboration with the Institute for Sustainable Development and International Relations (IDDRI) and funded by the French Development Agency (AFD). Natural Eco Capital carried out the vulnerability and adaptation modelling with the support of Nelen & Schuurmans of the Netherlands.

The essential tasks in developing the LT-LEDS included governance/project coordination and management, modelling and scenario generation, stakeholder engagement, implementation planning, and report preparation. A series of inclusive stakeholder engagements were carried out to include government Ministries, Departments and Agencies (MDAs), the private sector, civil society organisations, academia, and development partners. The development process was carried out to ensure proper alignment with key national development policies (e.g. National Climate Change Policy (2021-2030) and legal frameworks (Nigeria Climate Change Act, 2021). It also aligned programmes (e.g. National Climate Change Programme (2021-2030), strategies and plans (e.g. the NDC, National Development Plan (2021-2025), Agenda 2050, Energy Transition Plan) as well as relevant tools (e.g. Nigeria Energy Calculator 2050).

The elaboration of Nigeria's LT-LEDS was built on an initial visioning process for achieving low-carbon and climate-resilient development by 2050 (LTV 2050). The resulting **Vision Statement was:**
"By 2050, Nigeria will be a country of low-carbon, climate-resilient, high-growth circular economy that reduces its current level of emission by 50 %, moving towards having net-zero emissions across all sectors of its development in a gender-responsive manner."

Following the elaboration of the full-blown LT-LEDS, which is built on relevant enabling legal frameworks, policies, strategies, and plans, as well as tools that set the tone for decarbonisation scenarios and the adaptation and resilience pathways for Nigeria as against its 2050 aspirations, the Vision Statement for the country was reformulated:

"By 2060, Nigeria will be a country of net-zero emissions across all sectors of its development and climate-resilient with high-growth circular economy in a gender-responsive manner."

3. Outline of the LT-LEDS

Following the introduction in Section 1, Section 2 of the LT-LEDS highlights Nigeria's efforts towards decarbonisation and associated enabling policies. Section 3 presents the National Emission Profiles and LT-LEDS Decarbonisation Scenarios for various sectors of the economy. The sectoral mitigation measures and development strategies that can be implemented to guide a transition to a low-carbon and sustainable economy are outlined in Section 4. Section 5 discusses the adaptation measures and resilience-building strategies. Section 6 highlights the enabling innovations for effective and result-oriented implementation of the LT-LEDS for Nigeria. Some elements of the implementation framework for the strategy are also highlighted in the last section of the report (Section 7).

4. National Emission Profiles and LT-LEDS Decarbonisation Scenarios

a. *Decarbonisation Scenarios for Nigeria's LT-LEDS*

Four scenarios were developed for the LT-LEDS, using the LEAP-NGA model architecture. They took into consideration Nigeria's development aspirations to achieve net-zero emission by 2060, energy access, economic competitiveness, poverty elimination (through employment), food security, sanitation, economic growth, and advancement in innovation, among others:

i. ***Business As Usual (BAU):*** This scenario is based on the premise of a significant increase in Nigeria's emissions from all sectors due to increasing socio-economic development and population without substantial mitigation efforts. ***Current Policy Scenario (CPS):*** This scenario assumes an economy guided by the ambition of the ETP (Net-Zero by 2060) and the NDC. By 2060, renewable energy sources (RE) provide over 90% of power generation, CCS is deployed in industry; electric vehicles account for 85% of the car and bus fleets; energy efficiency is boosted, and gas flaring is ended by 2030.
ii. ***Gas Economy Scenario (GES)*:** The basis for this scenario is that Nigeria's aggressive exploitation and utilization of gas resources will account for 58% of power generation by 2060. Efficient appliances are the norm in the residential sector, as well as clean and more efficient cookstoves. Natural gas is combined with CCS in energy-intensive

industry. A modal shift to public modes of transportation is operated, with cars and taxis accounting for only 30% of transport needs by 2060. Carbon sinks are deployed through massive reforestation (5% annually), supported by the global mechanism of reducing emissions from deforestation and forest degradation (REDD+). This scenario allows Nigeria to meet its objective of net-zero by 2060.

iii. ***Renewable Energy Scenario (RES)*:** This scenario presents Nigeria's ambitious emission reduction goal of net-zero by 2060. In addition to a massive deployment of RE, the scenario reaches the goals set by the Nigerian Nuclear Power Programme: 98% of electricity is carbon-free. Electrification reaches all energy end-uses, combined with more efficient appliances, and modal shift in transport. Enteric fermentation will be reduced by respectively 5%, 8%, and 10% by 2030, 2050, and 2060. In addition, a moderate reforestation rate, at 2.3% annually, is assumed to support nature-based carbon sinks, again relying on REDD+.

The BAU, CPS, GES, and RES emissions by 2030 stood at 514, 416, 327, and 242 MtCO2e, respectively, to be compared with 2018 base-year emissions of 424 MtCO2e (respectively 2%, 23%, and 43% below 2018 levels for the three mitigation scenarios). The results indicate that the CPS, GES, and RES, respectively, could be 24.5%, 38.3%, and 61.5% lower than base-year emissions in 2050 and 37%, 78%, and 97% in 2060. In this regard, only the RES passed the vision of Nigeria's LTV-2050 of cutting emissions by 50% by 2050, with firewood and charcoal dominating the energy space in 2030, while electricity will dominate beyond 2050.

5. Mitigation Strategies and Policy Measures

This section lists mitigation options and strategies that need to be implemented to achieve sectoral changes in line with the country's net-zero by 2060 objective.

a. *Agriculture, forestry, and other land use (AFOLU) sector*

- Adoption and implementation of climate-smart crop production, livestock, and fishery practices
- Promotion of afforestation and reforestation activities to increase Nigeria's forest cover to a minimum of 25 % by 2060,
- Deploying cooling hubs based on renewable energy to mitigate post-harvest losses.

b. *Power generation*

- Increasing the renewable energy mix in the power sector to a minimum of 60%.
- Promoting smart grid technology to reduce transmission and distribution losses by at least 5%.
- Introducing and accelerating the uptake of carbon capture utilisation and storage (CCUS) technologies
- Accelerating the adoption of energy efficiency and energy management measures across all sectors.
- Introducing nuclear energy where possible.
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c. ***Buildings and residential sector***

- Improving access to clean and affordable energy in residential buildings, which includes 90% of households in the urban areas and 80% of households in the rural areas using electricity from clean sources by 2060.
- Ensuring massive penetration of renewable energy technologies for household use
- Replacing inefficient technologies by 100% with efficient ones by 2060.
- Encouraging private sector participation in supporting households in acquiring the appropriate renewable energy technology that includes a share of clean cooking to 50% in 2030 and 95% in 2060.
- Providing subsidised renewable energy materials and equipment and ensuring a pricing structure and feed-in-tariff (FiT) for the household renewable energy equipment.
- Encouraging the construction of green buildings through the development/implementation of relevant policies.

d. ***Oil and gas***

- Introducing and/or accelerating the uptake of carbon capture storage technologies at a 10% annual growth rate
- Improving emission management in the oil and gas sector to attain a 97.5 % reduction in process losses, mainly methane leak containment through carbon capture technologies.
- Eliminating gas flaring by 2030 through the adoption of industry standards to reduce GHG emissions.
- Deploying advanced fugitive emission curtailment technologies to achieve at least an 85% reduction in methane leakage by 2050 and progressively to 98% by 2060 through effective regulatory measures.
- Incorporating renewable energy technology into the sector to meet at least 50% of operations' energy demand by 2050.
- Using gas in the form of LPG as a transition fuel in the short term to facilitate the establishment of low-carbon energy.
- development to address the nation's clean cooking deficit.

e. ***Industry***

- Developing and adopting CCUS technologies, including pre- and post-combustion capturing processes.
- Increasing renewable energy mix in the power sector to a minimum of 60%.
- Promoting smart grid technology to reduce transmission and distribution losses by at least 5%.
- Immediate shifting to the use of bioenergy sources and adoption of cleaner energy sources in production processes

- Using gas as a transition fuel in the short term to facilitate the establishment of low-carbon energy development to address industrial needs

f. ***Transport***

- Wide adoption of electric vehicles (EVs) and ethanol vehicles.
- Promoting the massive deployment of CNG and LPG vehicles up to 2060
- Promoting the aggressive adoption of measures to reduce or avoid travel
- Promoting the shift to low-carbon modes of transport.
- Introducing EURO IV efficiency standards for all road vehicles,
- Adopting up-to-date Transport Information Technology for efficient management of transport infrastructures
- Strengthening the adoption of Circular Economy principles, such as sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible.

g. ***Waste***

- Adoption of the circular and bio-economy approach in waste management
- Encouraging and promoting waste-to-energy technologies to support the power sector
- Improving the waste management process, including the promotion of waste reduction through efficient material designs

h. Macro-economic Implications of Mitigation Scenarios

The four scenarios modelled and an additional scenario that considers the RES evolution of the Nigerian energy system that relies on international aid to fund the incremental energy supply investment required to shift from the CPS to the RES energy trajectory (RES+) were further subjected to macro-economic analysis. RES+ marks the benefits of the presumed international support that differentiates it from RES: it dominates all other scenarios up to 2054 when it roughly falls in line with the more macro-economically favorable of them (first with CPS, then with GES).

Based on the analysis, the critical requirement for Nigeria's economic (and by extension LT-LEDS) future is a structural transformation that induces local production and consumption of otherwise imported non-energy goods and positive trade shock that doubles her export potential by 2035 compared to current levels. Overall, the RES+ holds the most promise as it achieves a low emission rate that is the same as the RES scenario in 2060, compared with BAU, and real GDP growth and unemployment rates of 5.52% and 6.00%, respectively. Over the 38 years, the cumulated international financial aid to achieve the RES+ amounts to 859 billion USD. Thus, Nigeria will subsequently engage in global resource mobilisation to successfully implement this Strategy.

6. Strategic Priorities and Policy Measures Under Adaptation

a. Imperative for Adaptation and Strategies

Climate change adaptation is a development challenge that impacts the livelihoods of Nigerians. The LT-LEDS encompasses adaptation strategies, combining short-term measures to address immediate threats and long-term actions for fostering climate-resilient development within Nigeria. The short-term measures deal with existing climate

vulnerabilities. At the same time, the long-term strategy focuses on monitoring and understanding the country's sustained vulnerabilities, employing best practices to address uncertain threats in complex systems. The outcome of the modelling adaptation strategies in this LT-LEDS report provides valuable insights into timelines and the potential consequences of adaptation shortcomings. The results from the adaptation scenario assessment offer multiple options that can be aligned with national development priorities, as well as with adaptation projects and initiatives across various sectors to provide numerous benefits to the country on the path to achieving a net-zero, low-carbon, and climate-resilient development.

b. Macro-economic impacts of key adaptation measures

With regard to the macro-economic impacts of key adaptation measures, the agriculture sector, using a Computable General Equilibrium (CGE) modeling framework, was found to be the most vulnerable. The LT-LEDS empirical evidence on the impacts of adaptation strategies on crop yields showed simulation results that indicate that overall, the country's GDP is expected to be lower in the climate change scenario by 4.92% when compared with the business-as-usual scenario over the long-term period [2050] due to damage to the economy by climate change. The agriculture sector is expected to endure the most severe shock, and the resulting output damage in the sector will contribute the largest share to the expected GDP decline, accounting for 64% of the total decline from the business-as-usual scenario. The industry sector, which has a stronger backward linkage with the agriculture sector compared to the services sector, is expected to contribute 20% to the simulated GDP decline over the long-term period. This is followed closely by the services sector, which is expected to contribute 16% to the simulated GDP decline.

The adaptation measures will help answer the question of how much adjustment in behaviour or investment in real terms will be required by the country to recover from or compensate for the expected GDP decline due to climate shocks. The government is expected to expand the use of Climate Smart Agricultural practices of reduced tillage, terracing, ridging, bunds, and mulching to cover an additional 58% of the cultivated area to recover from the damage to GDP due to climate shocks. A complementary adaptation measure is to increase the cultivation of improved varieties, including drought-tolerant and early-maturing crop varieties. The simulation results indicate that the country needs to cultivate these improved varieties on an additional 50% of the cultivated area to reverse the expected GDP loss due to climate change. Similarly, irrigated land should be expanded to cover an extra 38% of cultivated area in the country to recover from the damage to GDP due to climate change. Finally, organic fertiliser should be expanded to cover an additional 25% of the cultivated area to recover from the expected decline in GDP due to climate change.

In all, the simulation results suggest that the selected adaption measures for the LT-LEDS are consistent in recovering the Nigerian economy from a climate-induced GDP loss over the long-term period. The agriculture sector will undoubtedly play a central role in climate adaptation efforts. The roles of the agriculture and industry sectors will be mutually reinforced in this respect due to the strong linkages between these two sectors of the economy.

The strategies embed using nature-based solutions (NbS) that can contribute to the country's climate change mitigation and adaptation objectives by helping to strengthen climate resilience while also contributing to climate change mitigation through functions such as carbon sequestration. The NbS actions will protect biodiversity and sustainably manage and restore ecosystems while simultaneously contributing to achieving multiple sustainable

development goals, including national goals for climate, food security, water security, disaster risk reduction and livelihoods. These will also provide additional co-benefits linked to reducing exposure to the vulnerability building resilience and adaptation in priority sectors.

7. *Mitigation and Adaptation Measures Synergy*

Nigeria recognises mitigation and adaptation strategies are crucial to address the country's climate crisis holistically and comprehensively. Recognising the potential interlinkages between climate change impacts, mitigation and adaptation activities, and developmental outcomes is essential for identifying pathways toward climate-resilient development. Thus, this LT-LEDS emphasises that the synergies between adaptation and mitigation actions in sectors related to terrestrial and wetland ecosystems, food security and production, and energy, with their adaptation and resilience efforts, must be undertaken jointly with mitigation efforts. This section considers the mitigation and adaptation synergies in the three most significant sectors responsible for the highest national emissions: energy, AFOLU, and transport.

8. Cross-Cutting Sectors' Measures and Instruments

These include measures for a carbon tax, removing inefficient subsidies, gas transformation, carbon budget, carbon market, blue economy, health, youth, people with disabilities, and gender as well as just transition. The LT-LEDS will play a critical role in aligning climate goals and targets with national and sub-national sustainable development objectives and the international objectives of addressing the global challenge of climate change. Its implementation will also be considered within the imperative of balancing emission reduction and economic development, as well as other sustainable development indicators and supporting issues such as just transition, fairness and equity, healthy living, climate resilience, gender responsiveness, inclusivity, intergeneration, and vulnerable groups.

9. Key Enablers for Implementing Nigeria's LT-LEDS and Challenges

a. Key Enablers

The implementation of LT-LEDS, aimed at achieving net-zero emissions and enhancing resilience, is anchored on the profound transformation of the national development agenda. This transformation is anchored on new strategic approaches that can attract significant investments to support delivering a wide range of products and services. To carry out this transformation effectively, Nigeria will implement critical enabling innovations related to policies, economic and social development, finance, technology, and research and development.

Relevant policies from the plethora of national sectoral policies will be knitted together into a robust, coherent, and inclusive policy framework to support systemic transformations for the implementation of the LT-LEDS. Economic innovation will include transitioning to low-carbon economies, investing in sustainable infrastructure, and promoting green jobs. Successful implementation of Nigeria's LT-LEDS will require significant changes in social behaviour and norms to ensure inclusiveness and community-based approaches that prioritize local knowledge, culture, and values in implementing LT-LEDS. The technological innovations that will be introduced for the implementation of the LT-LEDS will include adopting and investing in up-to-date technological innovations, particularly in areas of renewable energy, energy storage, carbon capture and storage, and digital technologies.

Nigeria will explore innovative financing mechanisms such as carbon pricing, green bonds, and climate risk insurance and prioritize public investment in LT-LEDS and encourage private investment in sustainable development. Demand-driven research partnerships with research users across the public and private sectors that can lead to innovation in mitigation and adaptation research and scaling will be promoted.

b. Possible Challenges/Risks in the Implementation of the LT-LEDS

The successful implementation of this LT-LEDS, which requires a significant reduction in fossil fuel for development, could face some challenges for Nigeria. A considerable challenge is how Nigeria will balance the need for rapid economic growth with the global transition that emphasises less dependence on oil and gas. The oil and gas industry accounts for 70 per cent of budget revenues and 95 per cent of foreign exchange earnings, though the oil industry consistently delivered less than 10% of Nigeria's GDP since 2018. Before the coronavirus (COVID-19) pandemic, Nigeria's oil sector generally accounted for about nine (9)per cent of the country's gross domestic product (GDP) and in the second quarter of 2023, the contribution of the oil sector to the country's GDP was 5.34 per cent.A critical question is what happens by 2040-60 if prices of oil and gas drop as a result of a global reduction in the use of oil and gas that can transform these resources into stranded assets? Would continual investments in fossil fuel-intensive systems delay or obstruct the transition to low-carbon alternatives – which would put the country's climate efforts in danger and potentially cause higher costs for the transition to a low-carbon economy? Would continual fossil fuel-intensive investments be neutral for Nigeria's ability to meet its future development aspiration for a rapidly growing population with lower global demand? What alternative measures does Nigeria count on to pick up the corresponding loss of government revenues? What additional fiscal revenues to meet development objectives and push mitigation and adaptation measures simultaneously? These questions remain critical and need further analysis as we advance to adequately situate these within Nigeria's climate efforts and avert the danger that could potentially cause higher costs for the transition to a low-carbon economy.

10. Way Forward - Implementation Framework for the LT-LEDS

The implementation of this LT-LEDS for realising net-zero emissions by 2060 and building a climate resilience society will be guided by the following key elements:

- § **Well-formulated action plan**: The strategic mitigation and adaptation measures of such a plan are summarised in the action plan outlined in the immediate, short-term, and long-term initiatives presented in the relevant appendices to this LT-LEDS. This will be further elaborated to properly indicate the responsibilities and performance indicators, taking into cognisance the multi-sectoral nature of the LT-LEDS.
- § **Governance Structure and Roles and Responsibilities:** Establishing the National Council on Climate Change, along with its secretariat serving as the UNFCCC Focal point and overseeing climate change response in Nigeria, provides the country with formal institutional arrangements. These arrangements will be effectively strengthened to ensure the national integration of climate and development priorities at all levels of governance (Federal, State and Local Governments). It also secures a high-level endorsement of the LT-LEDS, positioning climate change at the Centre of government decision-making. The latter already has an overarching vision for enhancing institutional capacities at all levels, preventing and minimising possible

challenges and trade-offs through coordination, ensuring effective coordination, and providing strategic orientation in achieving the long-term goal.

- § **Finance Strategy:** The cost of addressing the development challenge of climate change in Nigeria is extensive. For example, the cost of managing the mitigation and adaptation measures in the updated 2021 NDC to achieve 47% emission reduction by 2030 is estimated at USD 177 billion. This is expected to be higher when comprehensive investment plans for all sectors of the country's development are developed. Thus, consistent financial flows with a pathway towards low-emission and climate-resilient development are vital to implementing this LT-LEDS. In this regard, Nigeria requires a robust financial management plan to address the mitigation and adaptation measures enumerated in the Strategy. Thus, an LT-LEDS Investment Strategy and Plan will be created for the LT-LEDS implementation. The investment plan will explore all national, regional, and international climate finance mechanisms and instruments, and also benefit from the National Climate Change Fund established under the Nigeria Climate Change Act 2021 once made operational and ensure its effective implementation.
- § **Action for Climate Empowerment (ACE) and Capacity Building**: ACE elements such as climate education, public awareness, training, participation, and access to relevant information will be developed to build the capacity and skills required for the long-term management of LT-LEDS mitigation and adaptation measures. An integrated approach to capacity development at all levels would ensure inclusive growth towards the pathway to net zero emissions and a climate-resilient economy.
- § **Technology Development and Transfer with International Partnership:** Technologies and innovation are fundamental to addressing climate change and the economic growth of Nigeria. They assist in creating jobs, increasing competitiveness, supporting sustainable development, and enhancing living standards. A well-designed mix of policies is relevant as these reduce costs, including public research and development, demonstration and pilot projects, and demand-pull policies, which create incentives and market opportunities.
- § **Policy and Regulatory Changes:** Relevant policy and regulatory frameworks for the implementation of the LT LEDS will be updated regularly to put the country on track to achieve its long-term objectives with regard to low-emission development.
- § **Monitoring Reporting and Verification:** To enhance monitoring, support policymaking, and prioritise mitigation and adaptation measures, Nigeria will establish a dedicated Climate Data centre. This Centre will serve as a regional hub for comprehensive information on water, land use, climate change, education, outreach, and support of specialised studies and research projects informing decisions and investments in the region. A data governance framework, business model, and sharing policy will be set up to ensure data availability, benefitting both commercial and non-commercial stakeholders. Indicators and reporting elements shall include quantified data such as GHG emissions, sink capacity, current economic and energy statistics, and intermediate and long-term targets. Qualitative descriptions by sector, including but not limited to agriculture, buildings, energy, industry, LULUCF, transport and waste, will inform the achievement of domestic policies and measures.
- § **LT-LEDS Update:** This LT-LEDS builds to the best extent possible on the latest data, analysis, and future scenarios to support global climate action in line with the Paris Agreement and Nigeria's development agenda. Given Nigeria's limited contribution to global GHG emissions (less than 4%) and its limited adaptive capacity, the country will likely experience dynamic changes that may impact the current conditions on which the report is based. Thus, implementing the LT-LEDS

will involve ongoing monitoring, review, and necessary updates at needed intervals to strengthen and guide the NDC review process as circumstances evolve.

11. Conclusion

Overall, Nigeria's ability to achieve the LT-LEDS lofty goals will be contingent, among others, on the maturity of the available decarbonisation technologies and practical and effective international cooperation, even concerning building a climate-resilient society.

INTRODUCTION

1.1 Global Context

Numerous initiatives are focused on achieving decarbonization to prevent dangerous level of global warming. In pursuit of this objective, an expanding coalition of nations and institutions is committing to achieve net-zero emissions by the middle of the century. At least fifty-eight (58) countries including major emitters such as China, India, the United States of America (USA), and the United Kingdom (UK), have set net-zero targets representing a little above three-quarters of global emissions *(LTS- UNFCCC).*

The Paris Agreement adopted in 2015, resolved to limit global warming to well below 2, and pursue efforts to limit temperature increase to 1.5 degrees Celsius, compared to pre-industrial levels. In addition to establishing the Nationally Determined Contributions (NDCs) as a means for Parties to communicate their effort to reduce national emissions and adapt to the impacts of climate change, the Paris Agreement, in Article 4, Paragraph 19, also requested all Parties to strive to formulate and communicate Long-Term Low Emission Development Strategies (LT-LEDS) taking into account their common but differentiated responsibilities and respective capabilities, in the light of national circumstances. Therefore, LT-LEDS are development plans that support sustainable social and economic development while reducing greenhouse gas emissions over the medium to long term. It ideally defines the long-term vision, strategies, and system arrangements for countries to achieve green and low-carbon transformation in sustainable development.

As a Party to the Paris Agreement, Nigeria has committed in her NDC, to a substantial reduction in emission by the year 2030. Additionally, Nigeria has set a target to achieve a carbon-neutral economy by 2060. The elaboration of this Long-Term Low Emission Development Strategy (LT-LEDS) in line with these commitments and in particular the net-zero pledge. The LT-LEDS is a tool and approach for exploring the Green House Gas (GHG) emissions implications of the country's development aspiration, as well as options for

decoupling economic growth from emissions and bridging sustainable development and climate goals.

1.2 National Context

Nigeria is the most populated country in Africa with over 200 million people and the largest economy in sub-Saharan Africa, with a nominal Growth Domestic Product (GDP) of about US$504 billion. The country's GDP annual growth rate averaged 2.67 per cent from 2011 until 2022, reaching an all-time high of 6.88 per cent in the first quarter of 2011 and a record low of -6.10 per cent in the second quarter of 2020. The International Monetary Fund (IMF) recently projected a growth rate of 3.2 per cent in 2023 for the country *(IMF report).* Much of this growth is driven by fossil fuel export and use.

Nigeria is richly endowed with energy resources - renewable sources as well as fossil fuel-based. The latter's significant natural endowment implies that the country's economy is driven mainly by exploiting its oil and gas reserves, creating a strong dependency on associated revenues. This situation, therefore, exposes Nigeria to fluctuations in global energy prices and international geopolitical tensions, as well as to the rapid evolution in low-carbon technologies and resources driven by the climate crisis. Nigeria's vulnerability to fluctuations in global energy prices became more pronounced between 2014 and 2020, as annual GDP growth rates mirrored the trajectory of oil rents; (**Figure 1.1.)**

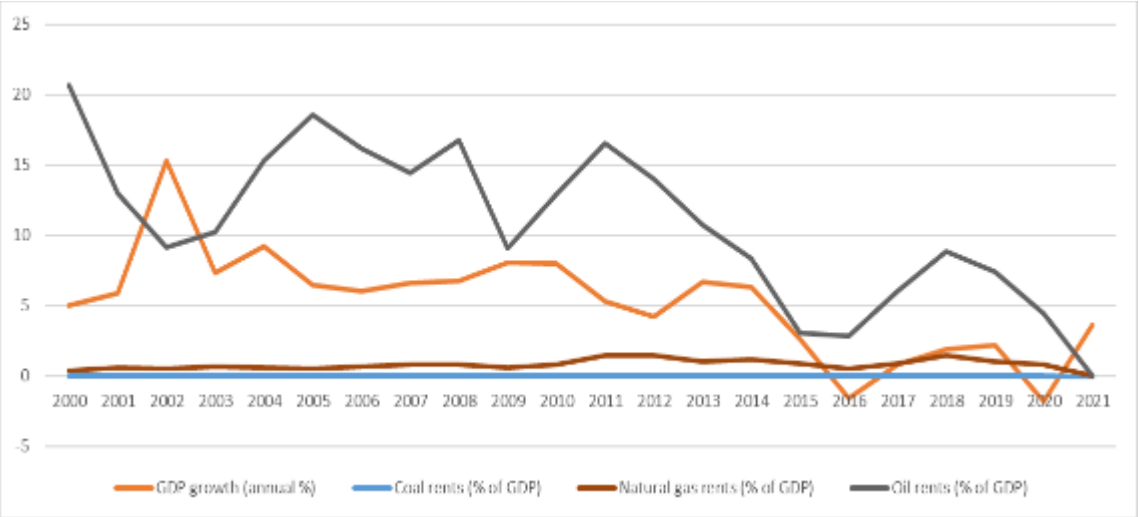


Figure 1. 1: Nigeria Fossil Economy Outlook (2000-2021)

Despite posting an average modest growth rate in the past decade, development in Nigeria continues to face many challenges. Although Nigeria's economy is diversifying and became the largest economy in sub-Saharan Africa and the world's 26th biggest economy in 2014, the country is still a lower-middle-income developing country with an income per capita of about $4,790 in 2021. The economy is still characterized by structural challenges that limit its ability to sustain growth, create jobs and achieve real poverty reduction. Nigeria has a low human development index (HDI)[1] score of 0.535 and is ranked 163 of 191 in the world, with a life expectancy of 52.7 years in 2021. The recent report of the National Bureau of Statistics (NBS) indicates that about 133 million (about 63% of the total population) are multidimensionally poor *(National Bureau of Statistics (2022).*

The country has also been confronted with inadequate power supply, inadequate infrastructure, and insecurity, among other challenges. Further compounding these development challenges is the global climate change crisis that is negatively impacting all sectors of the country's national development. Fighting poverty and insecurity and tackling climate change remain three critical development challenges for Nigeria, as they all impact the utilization of its human and natural resources for meaningful and sustainable development. Meeting these challenges, particularly tackling the climate change challenge, requires fresh ideas and a radical new way of thinking.

Climate change continues to compound the development challenges of Nigeria, making attaining national sustainable development goals, particularly in the

[1] HDI is a development indicator which measures health, education, and standard of living and reported by the UNDP in its annual Human Development Reports since 1990 (see UNDP (2021-2022): Human Development Report - Uncertain Times, Unsettled Lives: Shaping our Future in a Transforming World

short-term, difficult for the country. This is because the country's largely fragile economy is strongly vulnerable to the impacts of climate change as much of it, particularly the agriculture sector, which contributes about 24% to its GDP, is climate sensitive. Other sectors of the economy are also vulnerable to the impacts of climate changes.

The physical manifestations of climate change are increasingly visible across the co… affected

… a decade in… Rapid (Post Disaster) Damage Estimation (GRADE)[3] Assessment report presented by the Minister of Humanitarian Affairs, Disaster Management and Social Development on the 2022 flood situation indicated that all 36 states and the Federal Capital Territory were affected by the floods, with varying degrees of damages and over three million people affected *(UNICEF, 2022*). Nigeria reportedly lost an estimated $6.68 billion to this flooding incident. The impacts included damages to croplands, infrastructure, and residential and non-residential buildings, among others [4].

The 2019 Climate Risk Index (CRI)[5], which indicates a level of exposure and vulnerability to extreme events, which countries should understand as warnings to be prepared for more frequent and/or more severe events in the future ranks Nigeria 73 out of 180 countries surveyed. This ranking makes Nigeria one of the most moderately affected countries in the world in terms of the level of exposure and vulnerability to extreme events.

… purely economic terms, DFID (2009) …imated that climate change could result …loss in GDP of between 6% and 30% …50, worth an estimated US$ 100 to …lion dollars. Similarly, Kompas et al … indicated that, with a 3°C rise in … temperature, Nigeria will, in the …erm (beyond 2067), experience up …% reduction in its GDP.*(Kompas, T., Ha, … and Che, T. N. (2018)* Climate change …mpact is expected to result in crop yields declining by 7% in the short term (2006–35) and by 25% in the long term (by 2050). According to the economic outlook for Nigeria by the African Development Bank (AfDB), increases in annual maximum temperature of 3–4°C between 2050 and 2070 could further undermine agricultural productivity and cause greater water stress in the country *(AfDB (2022*). Already, shortages of water and grazing land are generating communal conflicts. Nigeria is 73 on the 2021 Global Conflict

[2] Drying Lake Chad Basin gives rise to crisis - https://www.un.org/africarenewal/magazine/december-2019-march-2020/drying-lake-chad-basin-gives-rise-crisis

[3] GRADE is developed by the World Bank's Disaster-Resilience Analytics and Solutions (D-RAS) Team

[4] Nigeria lost $6.68 billion to flooding in 2022: Minister available at https://gazettengr.com/nigeria-lost-6-68-billion-to-flooding-in-2022-minister/

[5] Developed by German watch analyses quantified impacts of extreme weather events10 – both in terms of the fatalities as well as the economic losses that occurred - https://www.germanwatch.org/en/cri.

Risk Index (GCRI)[6]. Climate projections for the coming decades also reveal a significant increase in temperature over cities across all the ecological zones *(Akande, A., Costa, A.C., Mateu, J. and Henriques, R (2017).*

Nigeria is a relatively small contributor to worldwide greenhouse gas (GHG) emissions, contributing only 336 million tons of CO^2-equivalent in 2018 *(NDC update*) with per capita of
0.57 metric tons CO_2 equivalent in 2019[7]. However, in its current National Development Plan (2021 – 2025), Nigeria targets an annual average of 4.6 percent annual economic growth to cumulatively lift 35 million people out of poverty and create 21 million full-time jobs. To achieve these development objectives and in addition meet the demands of its large population that is projected to increase to about 402 million by 2050, Nigeria is expected to emit more GHGs in the short-term. This calls for a more ambitious future mitigation efforts in keeping with the country's international climate commitments and national commitment to net zero emission by 2050.

As pointed out in its 2050 Long-Term Vision report (2021) *(LTV-2050),* climate change phenomena in Nigeria is further complicated because the country runs a mono-economy by nearly wholly dependent on oil exploration, mining, and export. This not only makes it difficult for the country to decouple emissions from its economic growth trajectory but also leaves Nigeria, in the short-term, in a precarious and vulnerable fiscal and macro-economic condition with high fluctuations in global oil price linked to the global transition to the green economy and other factors driving energy demand.

[6]GCRI expresses the statistical risk of violent conflict in each country in the coming 1-4 years and is exclusively based on quantitative indicators from open sources.

[7] https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?locations=NG

Nigeria, nevertheless, recognizes that global trends suggest that ambitious transitions towards low emissions development will further skew the energy outlook with devastating impacts on Nigeria's economy if there are no significant efforts to diversify the economy to make it less dependent on fossil fuel exports or tune the economy in the path of sustainable low carbon development.

The LT-LEDS has been developed to explore the links between economic growth and GHG emission across vital economic sectors based on different scenarios and to offer guidance on the measures to help steer Nigeria's development in a climate-resilient and climate-compatible path for shared socioeconomic prosperity. It offers a guide to enable the country to meet its medium to long-term climate objectives, including attaining the net-zero emissions target by 2060.

This LT-LED for Nigeria is structured as follows:

Section 1	Provides the background information leading to the development of the LT-LEDS.
Section 2	Provides Nigeria's efforts towards decarbonization and the enabling policies.
Section 3	Presents the National Emission Profiles and LT-LEDS Decarbonisation Scenarios s for various sectors of the economy: agriculture, forestry, and other land use (AFOLU); energy; oil and gas; industry; transport, building, waste, and some cross-cutting sectors. The section also examines the country's economic and development aspirations and challenges
Section 4	Outlines sectoral mitigation measures and development strategies that can be implemented to guide a transition to a low-carbon and sustainable economy.
Section 5	Discusses the adaptation measures and resilience-building strategies,
Section 6	Highlights the enabling innovations for effective and result-oriented implementation of the Nigeria LT-LEDS
Section 7	Highlights the implementation framework for the LT-LEDS

1.3 The Imperative of Carbon Neutrality Development

The world is facing a real climate crisis, that is redefining development pathways globally and extreme weather may become the "new normal". Climate change is perhaps the most significant risk multiplier facing humanity today. The lingering effects of the heat-trapping greenhouse gases (GHGs) and climate inertia portend a high probability that the current global warming trends may persist even if the world succeeds in stabilising the emissions to an acceptable level globally. The worsening situation was succinctly captured by the UN Secretary-General at the High-level Opening of the UNFCCC Conference of Parties (COP) in Sharm El Sheik in Egypt on 7th November 2022 with a warning that the world is on "a *highway to climate hell*", which, if not checked, will make climate chaos irreversible and may eventually consign the coming generations to absolute climate catastrophe.

By 2020, the global average atmospheric CO_2 concentration had rapidly increased to 415ppm from a pre-industrial level of 285 ppm around 1850. As a result, the global average surface temperature increased by about 1.2^{O}C over the period 1850 – 2020. As indicated, the CO_2 already in the atmosphere will continue to produce a greenhouse effect and global warming even if we stop carbon emissions immediately *(Chen, J. M. (2021)*.

The global concern about GHG emission-induced high temperatures in the very near future under the current business-as-usual development scenario has called for the need to pursue carbon neutrality or net-zero CO_2 emissions development, which is attained by balancing the emission of CO_2 with its removal to stop its build-up in the atmosphere. The goal of its attainment by 2050 is to limit the average global temperature increase by 2100 to 1.5°C–2.0°C from its preindustrial level. The attainment of carbon neutrality by 20250 is expected to greatly slow global warming with accompanying benefits to air quality and enhancement of quality of life and health, if done in a sustainable manner.

As the global climate crisis worsens, carbon neutrality is expected to be a central aspect of the solution to the climate crisis. As enumerated by Chen (2021), to achieve carbon neutrality, the reduction of carbon emissions would need to be approached in a multi-faceted manner, including (i) replacing fossil fuels with carbon-free renewable energies, hydropower, and nuclear power; (ii) industrial CO_2 capture, removal, storage, and utilization; (iii) reuse of solid wastes; and (iv) reducing energy consumption and increasing energy use efficiency. There is also the need to enhance carbon sinks in land and possibly the ocean. Countries across the world have seen the need for massive-scale transformation of their economies well beyond incremental change as a challenge for the transition to low-emission development pathways or net zero. Nigeria is one of the 137 countries that has pledged to achieve carbon neutrality by 2060[8] as part of its commitment to achieving the long-term temperature goal of the 2015 Paris Agreement and the realization that the current highly carbonised economic model is not in congruence with the global trend of decarbonization.

1.4 Importance of the Long-term Low Emission Development Strategy to Nigeria

Long-term Low Emission Development Strategy (LT-LEDS) provide a pathway to a whole-of-society transformation and a vital link between shorter-term NDCs and the long-term objectives of the Paris Agreement[9]. Leveraging its Nationally Determined Contributions (NDC), Nigeria is integrating a transition to a low-carbon development pathway into its national development agenda because of its tremendous benefits for sustainable national development. An LT-LEDS is vital for Nigeria as it enables the country to:

1. Carve out a national vision for a climate-resilient society that will help integrate and coordinate critical action programmes on economic, environmental, health, and other sectors, as well as turn programmes, strategies, and plans into concrete actions.

2. Establish a clear direction for achieving a low carbon development and the economic opportunities it brings.
3. Set the pillars for such a vision and the policies and measures that will help actualise the vision.
4. Establish implementable policy and financing priorities for low-emission green growth.
5. Realign its national policy on climate change to help meet the overarching goal of the country's long-term national economic and sustainable development.
6. Understand and inform strategies to manage trade-offs of measures required to achieve net zero (e.g., jobs affected, new skills required, fiscal policy transition to a green base, etc.).
7. Inform public economic and sectoral planning processes over time.

[8] Race to Net Zero: Carbon Neutral Goals by Country - https://www.visualcapitalist.com/sp/race-to-net-zero-carbon-neutral-goals-by-country/
[9] What is a Long-term Strategy - https://www.wri.org/climate/what-long-term-strategy

8. Build on governance partnerships that will strengthen the economy and climate by bringing together government, business, and economic leaders to enhance the global and national understanding of how climate action can drive economic, social and development objectives.

It should be noted that the LT-LEDS is **central to national climate and development planning processes.** It is expected to be regularly reviewed and updated to remain relevant over 30 years. With such updates, it will be very appropriate to update successive short-term NDCs. It will also guide Nigeria toward avoiding costly investments in high-emissions technologies, supporting just and equitable transitions, promoting technological innovation, planning for new sustainable infrastructure considering future climate risks, and sending early and predictable signals to investors about envisaged long-term societal changes. Furthermore, with updates, the LT-LEDS will continually offer a framework for identifying mitigation, adaptation and resilience plans that must be integrated simultaneously with national development plans and agendas to ensure a just transition to a low-carbon society. In the long term, Nigeria's LT-LEDS will facilitate the alignment of critical national development policies, strategies, and plans for building a climate-resilient economy.

> LT-LEDS is central to national climate and development planning processes

1.5 National Long-Term 2050 Vision (LTV-2050)

To set the framework for the development of the LT-LEDS, Nigeria initially developed a long-term visionary approach for achieving low-carbon and climate-resilient development by 2050 (LTV 2050).

The development of the vision was country-driven and based on country-specific climate change interventions and responses. It was guided by several principles, which include:

1. Building a sustainable and resilient economy and social development with adequate adaptation response.
2. Effective citizenship participation.
3. Shared vision, social inclusion, and responsibility among stakeholders.
4. Identification of low-carbon transition enabling activities.
5. Promotion of environmental quality and ecological equilibrium.

6. Transparency, accountability, and equity.
7. Effective monitoring, evaluation and reporting of all climate change interventions and lessons.
8. Building international partnership and cooperation for implementation.

The national Long-Term 2050 Vision states that:

By 2050, Nigeria will be a country of low-carbon, climate-resilient, high-growth circular economy that reduces its current level of emission by 50%, moving towards having net-zero emissions across all sectors of its development in a gender-responsive manner.

The Nigeria LTV-2050 covered many sectors (agriculture, forest, and other land use (AFOLU), energy, fresh water and coastal wetlands, industry, urban settlements, oil and gas, transport, waste and cross-cutting including for instance, gender) with their specific visions is cascaded into sectoral visions.[10]

Nigeria through the LTV 2050 and now the LT-LEDS hopes to promote sustainable development and guarantee climate-proofed economic development through multi-stakeholder engagement across multiple sectors and aligned with medium-term (2021-2025) and long-term (Agenda 2050) national development plans. It lays a solid foundation for Nigeria to contribute to the global goal of climate neutrality and to be a climate-resilient society with a knowledge-driven economy that is globally competitive and compliant with Africa's Agenda 2063, enabling the country to play its leadership role in Africa effectively. This LT-LEDS document translates the Vision into measurable and implementable strategies.

[10] Please, for the Sectoral Visions, see https://unfccc.int/documents/386681.

1.6 Scope and Elements of the LT-LEDS

In the context of the global climate change discourse and in line with the expressed intention in the Paris Agreement, this LT-LEDS comprises Nigeria's long-term low-carbon development options and pathways. In keeping with the country's pledge to achieve carbon neutrality by 2060, much of the quantitative aspects of the LT-LEDS projections up to 2060 computed based on different emission and development scenarios, including Business as Usual Scenario (BAU), Current Policy Scenario (CPS), Gas Economy Scenario (GES) and Renewable Energy Scenario (RES) (see Section 3.2), a modelling effort championed by Nigeria's Deep Decarbonisation Pathways (DDP) project funded by the French Development Agency (AFD). The computations involve the establishment of the balance between generation and demand from various fuel sources in critical sectors, including the residential, industrial, transport, AFOLU, as well as the oil and gas sectors alongside associated emissions with due consideration of generation methods, technologies, and efficiencies by populating the Low Emissions Analysis Platform (LEAP) model with sensitive country data to create the "LEAP Nigeria".

The LEAP model for Nigeria provides quantitative information about the energy mix and emissions of the country under different scenarios. The LEAP model relies on Nigeria's context-sensitive data – the most comprehensive yet assembled for the country. It tracks energy mix, consumption pattern, production, resource extraction and emissions under different scenarios**.** The LEAP model was accompanied by assumptions on critical social and economic variables such as projected population and GDP **t**hrough the linkage and iteration using the **Macroeconomic model (KLEM)**. This hybridization (of the LEAP and KLEM models) enabled and allowed for the computation of the labour productivity gains of the various economic development scenarios. The coupling method is based on an exchange of inputs and outputs of the two modelling systems. In the case of KLEM and LEAP, this exchange focuses on the energy system variables (prices and physical flows) forced into KLEM from LEAP, and the growth of the real GDP calculated by KLEM, which is the primary driver of the growth of energy consumption, feed back into the LEAP model.

While the LEAP Nigeria projection has a 2060 end date, a number of the qualitative elements considered in the LT-LEDS can apply well beyond the 2060 date. Some consideration is given to understanding how the long-term goals covered in the LT-LEDS align with other national climate and development plans socially, the NDC and the Energy Transition Plans (ETP). However, direct comparison or alignment with these other important documents is outside the scope of work. The LT-LEDS covers all the critical economic sectors **(**agriculture, forestry, and other land use (AFOLU); energy; oil and gas; industry; transport, building, waste, and some cross-cutting sectors) and emphasises mitigation and adaptation. The LT-LEDS goes beyond a narrow focus on mitigation and adaptation and covers broader issues relevant to the country's sustainable and equitable economic development, such as gender inclusion, social innovation, and financing strategies.

1.7 Process for the Development of the LT-LEDS

The elaboration of the LT-LEDS was structured around five key areas, namely: (i) governance/ project coordination and management, (ii) modelling and scenario generation, (iii) stakeholder engagement, (iv) implementation planning; and (v) report elaboration (Appendix 1). Suffice it to say the LT-LEDS elaboration were based on some key elements shown in Box 1. These guided the meetings with relevant stakeholders at different times (inception workshop, roadmap and baseline development workshops) and online stakeholder review meetings. The LT-LEDS document has been further subjected to a technical working group (TWG) review meeting with international and National consultants and a final stakeholders' validation workshop held in November,2023. The LT-LEDS properly align key national development policies, strategies, and plans for coherence which began during the preparation of the LTV 2050.[11]

Box 1: Key elements of Nigeria's LT-LEDS elaboration

[11] In addition, during the LT-LEDS elaboration, the document: *Nigeria-Aligning Energy Transition Plan, NDC and Long-Term Strategy Targets* was prepared.

Nigeria's Efforts Toward Decarbonization

This Section presents Nigeria's efforts and commitments toward net-zero carbon development and resilience buildings. The Section also highlights the enabling policies imperative for the 2060 net-zero sustainable development.

2.1 Nigeria's Net-zero Commitment at Glasgow

At the 26th Conference of Parties (COP26) held in Glasgow in 2021, the Federal Government of Nigeria made three significant pledges, which include the net zero pledge, the global methane pledge, and the declaration on forest and land use. President Muhammadu Buhari pledged that Nigeria will cut down its emissions and reach net zero by 2060. The role of gas role in supporting renewable energy-based systems in the country's energy transition roadmap is at the heart of this pledge. Furthermore, the President explained that 7GW of renewable energy would be added annually to address the country's clean energy shortage and that the government is committed to electrifying 5 million households with decentralized solar solutions by 2030. Also, the government joined other countries in pledging to reduce global methane emissions by 30% by 2030, below 2020 levels. Regarding forest and land use, 141 countries, including Nigeria, pledged to conserve and restore forests over the next 10 years. These pledges are very ambitious and require that many sectoral strategies be put in place and policies enforced to attain them.

2.2 Nigeria's Nationally Determined Contributions (NDC)

Nigeria submitted its Nationally Determined Contribution (NDC) in 2015 and updated it in 2021. The GHG assessment of Nigeria's emissions profile in the updated NDC is estimated at 347 $MMTCO_{2e}$ in 2018, with energy, Agriculture, Forestry, and other Land Use (AFOLU), waste and Industrial Processes and Other Product Use (IPPU) contributing approximately 60% (208.2 $MMTCO_{2e}$), 25% (86.8 $MMTCO_{2e}$), 9% (31.2 $MMTCO_{2e}$) and 5% (17.4 $MMTCO_{2e}$), respectively. If nothing is done, the emissions are expected to grow to an estimated value of 452.7 MMTCO2e by 2030. Nigeria's NDC targets a reduction in its Business as Usual (BAU) emissions by 20% under the "Unconditional NDC" – if no external support is received. However, with the intervention of international assistance, Nigeria pledges a 47% emissions reduction below.

BAU by 2030. Strategic measures that the revised NDC enshrined to meet the target include: (i) ending gas flaring by 2030, (ii) elimination of diesel and petrol generators by 2030, (iii) 48% and 13% penetration of

LPG and improved cookstoves, respectively, in the household sector, (iv) reduction in energy intensity by 2.5%, annually, across all sectors (v) 30% of grid-connected electricity generation from renewable energy, (vi) installation of 13GW of off-grid renewable energy, (vii) elimination of kerosene lighting by 2030, (viii) reducing transmission and distribution losses to 8% by 2030, (ix) all vehicles to meet EURO IV emission limits by 2030, and (x) Bus Rapid Transport to account for 22.1% of passenger-km by 2035, while, 25% of trucks and buses to use CNG by 2030.

2.3 Nigeria's Energy Transition Plan (ETP)

Like the NDC, the Energy Transition Plan (ETP) provides a pathway for Nigeria to lower its emissions. The GHG assessment of Nigeria's emissions in the ETP is estimated at 275 $MMTCO_{2e}$ in 2020, with approximately 65% (179 $MMTCO_{2e}$) attributed to energy consumption and industrial processes. If there are no decarbonization efforts, the emissions from energy consumption and industrial processes could reach 216 $MMTCO_{2e}$ and 322 $MMTCO_{2e}$ by 2030 and 2050, respectively. However, there is a significant difference between the emissions profile presented in the NDC and the ETP, possibly because of the ETP's scope (focusing only on energy consumption sectors) and methodology. Unlike the NDC, the ETP provides a long-term path to achieving a net-zero by 2050. The ETP provides two scenarios, the NDC-guided and net-zero scenarios. The net-zero scenario proposes that electric vehicles will make up 80% of vehicle fleets, while clean cooking will penetrate over 80% of households. In addition, the net-zero scenario also showed that the electricity installed capacity will be 250 GW by 2050, with renewables taking a share of more than 90% of the electricity capacity.

2.4 Nigeria Existing Policies for the 2060 Net-Zero Emissions

The national path towards net-zero emission in 2060 will be effectively driven by the implementation of appropriate policies in the various sectors that have been analysed by LEAP-NGA. Nigeria has many policies, strategies and plans which have some relevance to national mitigation response to the challenge of climate change in sectors of national development. They constitute potential instruments that are imperative for the facilitation of an enabling environment for the strengthening of national resolve to drastically reduce the country's GHG emissions, while still ensuring the sustainability of national development that is imperative for poverty reduction, job creation and inclusive social development.

2.4.1 Nigeria's Climate Act, 2021

The Climate Act 2021 provides the legal framework for achieving low greenhouse gas emissions that is inclusive of green growth and sustainable economic development. The Act was signed into law in November 2021 by President Buhari. The Act demonstrates a commendable first step that Government has taken to meet its obligations to combat climate change under the various treaties it has subscribed. The Act provides a comprehensive regulatory framework to achieve its long-term climate goals, encompassing a net-zero target, funding, environmental and economic

accountability, and championing climate actions. The Act ensures that Nigeria formulates programmes for achieving ~~its~~ long-term climate change mitigation and adaptation targets. The Act sets a target of 2050-2070 to attain net-zero greenhouse gas emissions, in line with Nigeria's international climate action commitments. Some important highlights of the Act are establishing the National Council on Climate Change, establishing a Climate Change Fund, providing a carbon budget and national climate change action plan, and undertaking vulnerability and risk assessment.

2.4.2 Nigeria's Agenda 2050 and National Development Plan (2021-2025)

The LT-LEDS leveraged Nigeria Agenda 2050 and Nigeria's National Development Plan (2021-2025).

The Agenda 2050 is Nigeria's long-term development plan, which replaced the Vision 2020—the country's plan to be among the 20 most developed economies by 2020. The Agenda 2050 is aimed at repositioning Nigeria as one of the leading countries of the 21st Century.

Nigeria's National Development Plan (2021-2025) is one of the medium-term plans. It is the successor plan to the Economic Recovery and Growth Plan, ERGP, 2017-2020, whose implementation ended in December 2020. The plan is underpinned by a macro-economic framework, which projects an average GDP growth of 5% over the plan period.

2.4.3 National Climate Change Policy (2021-2030)

Nigeria's National Climate Change Policy (NCCP) of 2021 is a comprehensive policy that seeks to foster a low-carbon, climate-resilient and gender-responsive sustainable socio-economic development (Federal Ministry of Environment, 2021). The policy sets out several targets and objectives that Nigeria must meet to fulfil its obligations under the Agreement. The policy focuses on several key areas: mitigation, adaptation, finance, research and development, institutional capacity-building, and global and regional cooperation. It includes plans to reduce emissions from energy production (including oil and gas), agriculture, forestry, and other land use (AFOLU), industry, transportation, waste, as well as to strengthen climate resilience through initiatives such as improved early warning systems, climate-smart agriculture, and the promotion of clean energy and renewable sources. The policy also includes plans to build capacity and strengthen institutional frameworks for effective climate change management, as well as putting in place innovative finance mechanisms to support climate action, such as the green bond market and the establishment of a carbon tax, with effective support from the private sector.

2.4.4 National Climate Change Programme for Nigeria (2021-2030)

To foster a comprehensive and broad result-oriented national response to climate change, several critical action programmes were developed to guide the implementation of the National Climate Change Policy. These programmes will further consolidate climate change-related ongoing initiatives and processes to enhance the country's adaptive capacity to respond to different levels of impact of climate change and its opportunities. The programmes represent measures and actions that will be implemented in a programmatic manner to address most, if

not all, of the challenges posed by climate change and climate vulnerability in the country. Within the strategic policy response framework of fostering a low-carbon, high-growth economic development path and building a climate-resilient society to enable Nigeria to meet the challenge of climate change, these priority actions will be implemented for the next 8 years (ending 2030). Programme focus areas are targeted at (i) managing resilience in ecosystems, infrastructure and human communities through mitigation and adaptation strategies and initiatives; (ii) addressing current risks, vulnerabilities, policies, capacities, and gaps in knowledge; (iii) facilitating internal and external resources for climate financing; and (iv) engaging internal and external partners in seeking solutions.

2.4.5 The Nigerian Economic Sustainability Plan

The Nigeria Economic Sustainability Plan (NESP) was approved by the Federal Government in June 2020 and aims to chart a clear course out of the Covid-19 pandemic, by stimulating and diversifying the economy, retaining, and creating jobs and extending more protections to the poor. The aim is to lift 100 million Nigerians out of poverty over the next 10 years. key interventions centre around 10 core projects which include a Mass Agricultural Programme (MAP), an Extensive Public Works and Road Construction Programme, a Mass Housing Programme (MHP). Installation of Solar Home Systems, Strengthening the Social Safety Net, Support for Micro Small and Medium Enterprises, Survival Fund, Promotion of Domestic Gas Utilization, and Digital Technology. The updated NDC is also aligned with the plan and some of the actions specifically targeted to this agenda. For example, the installation of Solar Home Systems targets 5 million households, serving about 25 million individual Nigerians who are currently not connected to the national grid.

2.4.6 *The Nigeria 2050 Calculator (NECAL 2050)*

This is a tool to plot and explore Nigeria Pathways for Climate Change mitigation. It is an integrated energy, emission and energy-related land use calculator that supports different energy scenarios.

2.5 Vision Statement for Nigeria's LT-LEDS

Based on the review of the relevant policies provided in the preceding subsection of this Section 2 and decarbonisation scenarios as well as the adaptation pathways, as against the LTV 2050, the LT-LEDS has been adjusted to now read:

"By 2060, Nigeria will be a country of net-zero emissions across all sectors of its development and climate-resilient with high-growth circular economy in a gender-responsive manner."

National Emission Profile and LT-LEDS Decarbonisation Scenarios

This section presents Nigeria's emission profiles and the decarbonisation scenarios. It also highlights the national GHG emissions under LT-LEDS scenarios or pathways for various sectors of national development (agriculture, forestry, and other land use (AFOLU); energy; oil and gas; industry; transport, waste, and some cross-cutting elements). The section concludes by examining the country's economic and development aspirations and challenges *to ensure Nigeria becomes a low-carbon, climate-resilient and economically prosperous country.*

3.1 National Emissions Profile under the LT-LEDS BAU

The total GHG emission from the Nigeria's Low Emissions Analysis Platform (LEAP) model analysis for 2018 which serves as the base year (same as the updated NDC), is 424.30 $mtCO_{2e}$. The emissions were aggregated from all the sectors, namely Residential, Agriculture, Forest, and Other Land Uses (AFOLU), Oil and Gas, Power, Industry, Transport, Services, and Waste and emissions from other sources (indirect N_2O emissions), as shown in **Figure 3.1**. The estimated emission in 2018 is higher than the value (347 $mtCO_{2e}$) estimated in the NDC by about 22%, which could be attributed to the expansive and detailed consideration of emissions data in the AFOLU and transport sectors. The analysis indicates that the energy sector emissions (i.e., from oil and gas extraction, power, building and residential, and transport subsectors) account for 54.3% (229.4 $mtCO_{2e}$) of the total emissions. However, at the subsector levels, AFOLU sector dictates the emission at 125.70 $mtCO_{2e}$, which is equivalent to 29.6% of the total emissions in 2018. The high emissions from AFOLU are driven mainly by enteric fermentation, and land use, land-use change, and forestry (LULUCF). The share of AFOLU emission is followed by oil and gas extraction, transport, waste, residential, Industrial Processes and Product Use (IPPU), power, others, and services at 29.4%, 16.2%, 10.6%, 5.9%, 4.6%, 2.6%, 0.8% and 0.3%, respectively, as shown in **Figure 3.2**. In addition, the share of emissions by the energy, AFOLU, waste, IPPU and other sectors are at 54.3%, 29.6%, 10.6%, 4.6% and 0.8 %, respectively, as shown in **Figure 3.3**. It is shown that more than 50% of the emissions from the energy sector are from the oil and gas subsector.

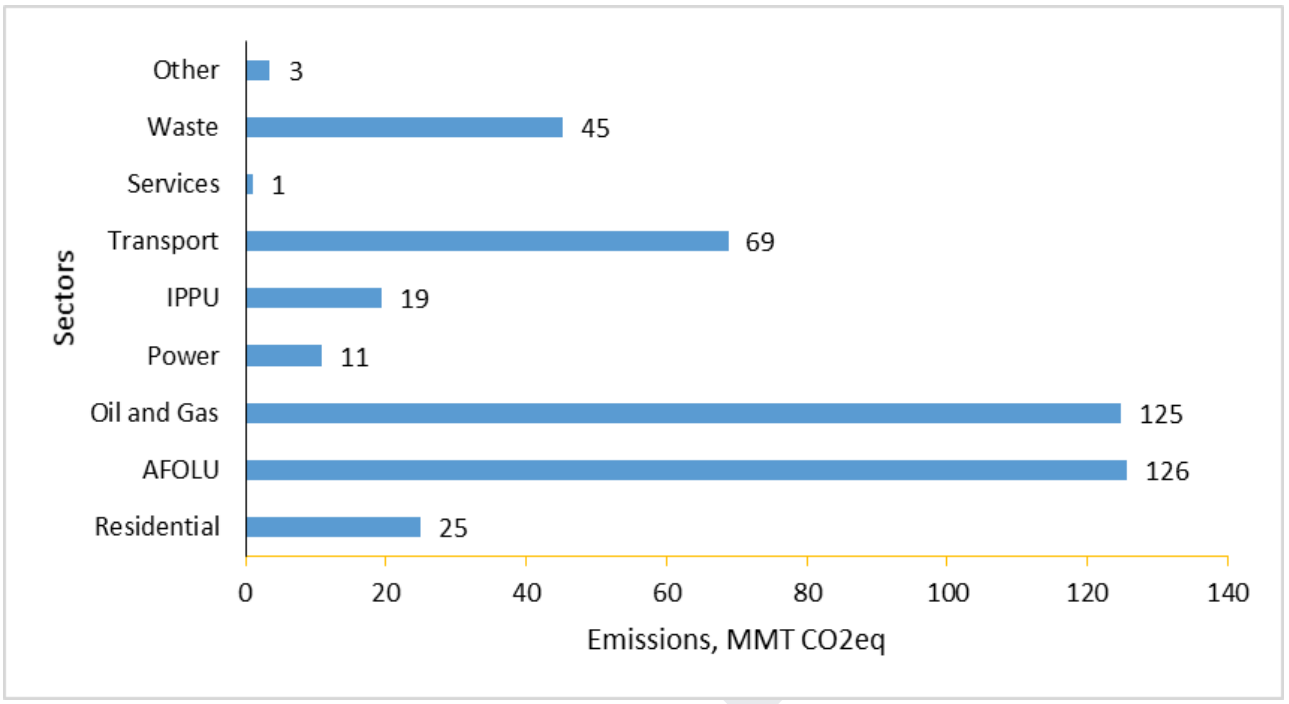


Figure 3.1: Sectorial Emissions Profile

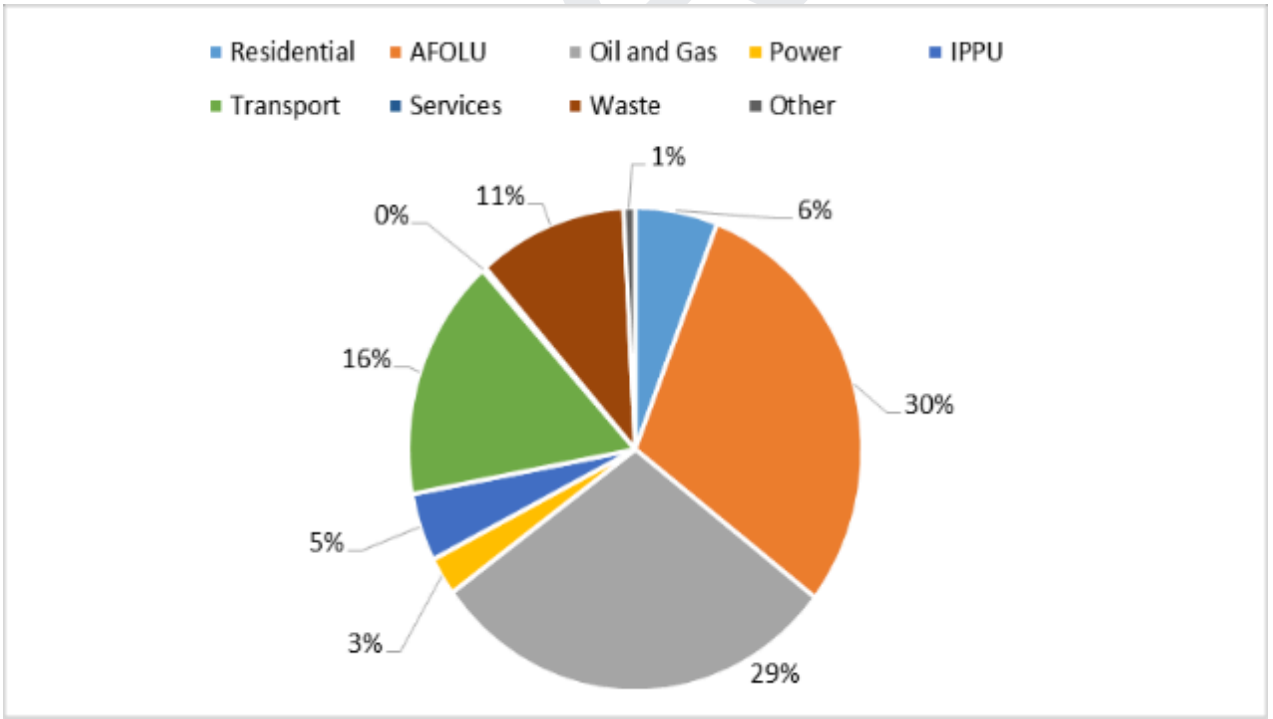


Figure 3. 2: Sectorial emissions contribution by a percentage in 2018

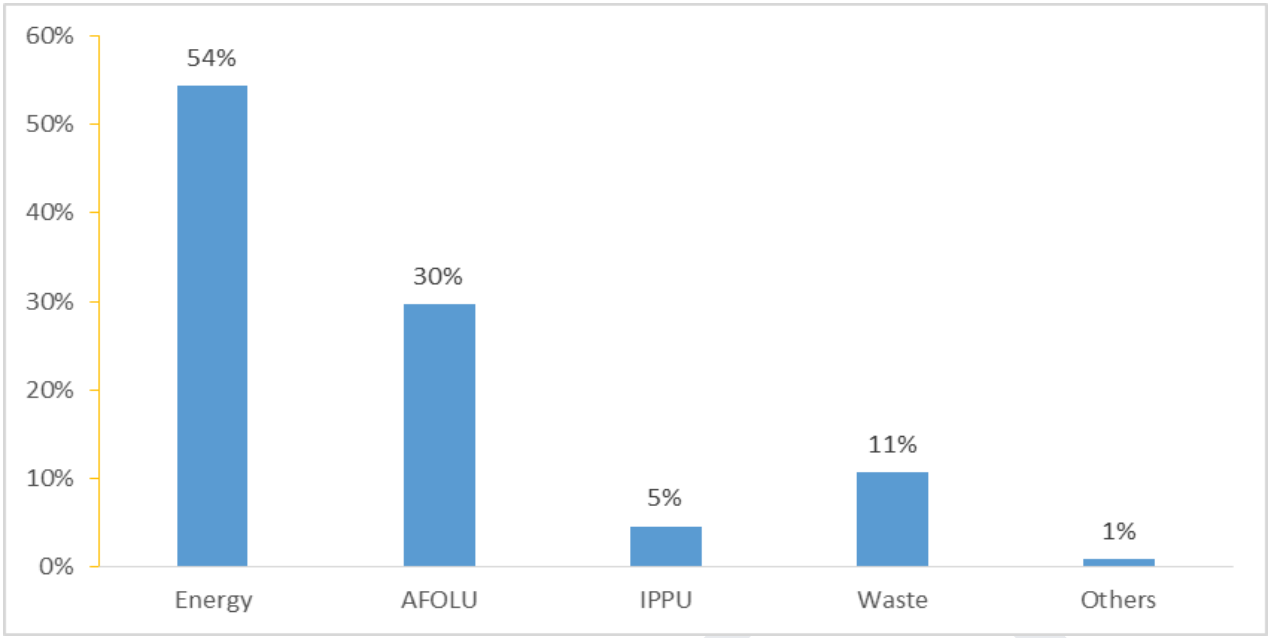


Figure 3.3: Aggregated percentage emission contribution in 2018

3.2 Decarbonization Scenarios for Nigeria's LT-LEDS

The scenario thinking provides the opportunity to explore different future trajectories and to analyse the consequences of these alternative futures at different time horizons in order to inform decisions. However, scenarios are not designed for the prediction of the future. Four scenarios are developed to support the LT-LEDS which were formulated under Nigeria's Deep Decarbonization Pathways (DDP-Nigeria) project, in collaboration with the Institute for Sustainable Development and International Relations (IDDRI), funded by the French Development Agency (AFD) and elaborated on by critical stakeholders (government ministries, civil society organisations, and academia). The project provides a coupling of bottom-up and top-down modelling frameworks that allows analysing the technical details of sectoral transitions as well as their cross-cutting socio-economic consequences. This allows the analysis to explore how to deeply decarbonize Nigeria by 2060 while encouraging aggressive improvement in macroeconomic indicators, e.g., employment, increased GDP, reduced poverty level and others. The Nigeria DDP project considers all forms of emissions, considering energy and non-energy induced emissions.

The four LT-LEDS scenarios are depicted by **Figure 3.4**. The scenarios are implemented within Nigeria LEAP model architecture, which is anchored on bottom-up and top-down modelling structures constructed on the premise of extensive Nigeria context-sensitive data.[12] However, there is a wide space to accommodate emerging policies, technologies, and economic variables with established Nigeria context-sensitive data to better model

[12] As part of the general context development, Nigeria Energy Calculator 2050 was reviewed.

and understand the energy and macroeconomic implications of deep decarbonisation pathways for Nigeria.

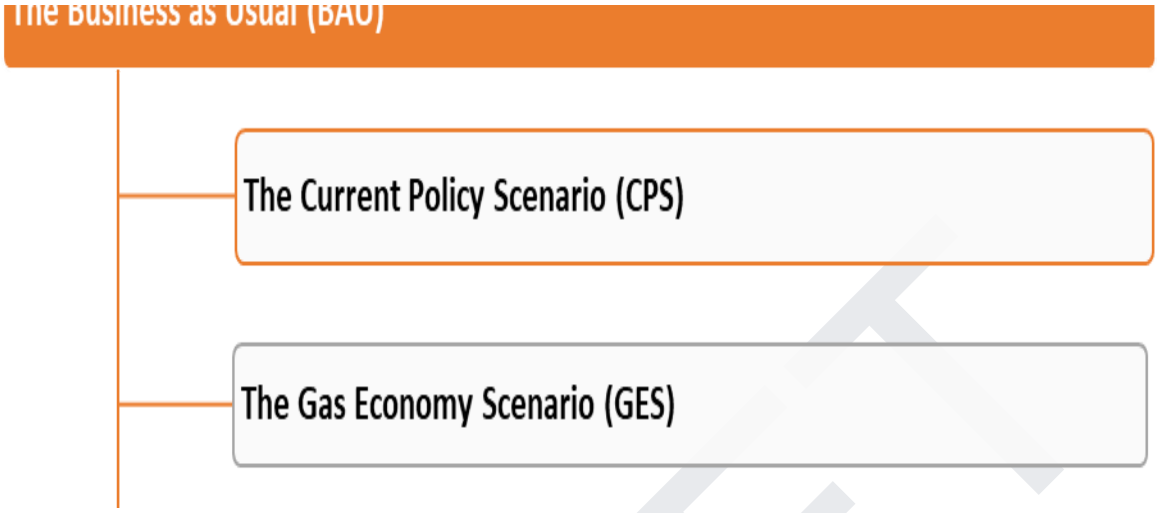


Figure 3. 4: LT-LEDS Scenarios

In formulating the four LT-LEDS scenarios, consideration was given to Nigeria's development goals of universal energy access, economic competitiveness, poverty eradication (through employment), food security, improved education quality, and other key development priorities . Also, Nigeria's net-zero commitment by 2060 was considered through aggressively utilising renewable energy and adopting energy efficiency and management measures across all sectors along with agro-waste and forest management measures (e. g. reforestation and afforestation). Therefore, the scenario analysis involved elaborating scenario pathways, including required technologies, fuel switching, renewable and non-renewable energy penetration, deforestation, and forest degradation (REDD+) and economic implications. The storylines supporting the scenarios are presented as follows.

(i) *Business As Usual (BAU):*
This scenario imagines a significant increase in Nigeria's emissions from all sectors due to increasing socioeconomic development and population without substantial mitigation efforts. The key BAU assumptions are presented in Table 3.1

Table 3. 1: Key BAU assumptions

Key Parameter	Assumption					
Study Base Year	2018					
Gases Covered	CO2, CH4, N2O, CO, NMVOC, NOX, PM10, PM2.5, BC, OC, SO2, NH3					
Base Year Population	195.88 million People					
Household Size	National = 6.8		Urban = 6.3		Rural = 7.2	
Annual Population Growth rate	2030 = 2.5%	2040 = 2.3%	2050 = 2.0%	2060 = 1.7%		
Base Year GDP	649.13 billion US$					
Sectoral Value Added	Agriculture = 21.4%		Services = 52.6%		Industry = 26.0%	
Annual GDP Growth Rate	Stats & SSP:	2020 = -1.79%	2021= 3.64%	2022 = 6.2%	2023 = 5.8%	2024 = 5.5%
		2025 = 5.2%	2030 = 5.0%	2040 = 4.7%	2050 = 4.5%	2060 = 5.0%
Base Year Urbanisation Rate	43.5%					
Electrification Rate	National = 56.5%		Urban = 83.9%		Rural = 25.5%	
Existing Generation Plants	Grid generation (7,228 MW):		Large Hydro Plants = 1383 MW,		Gas Turbines = 5,845 MW	
	Off-grid generation (25,056 MW):		Standalone Solar PV (20 to 200W) = 1 MW		Rooftop Solar PV (200W to 20 KW) = 10 MW	
			Small Hydro = 45 MW		Fossil fuel-based self-generation = 25,000 MW	
Household Cooking and Lighting Shares	Cooking:			Lighting:		
	Electricity Wood LPG X Charcoal Kerosene Vegetable waste Animal waste Coal No cooking	= 1.3% = 65.7% = 65.7% = 5.9% = 15.6% = 0.1% = 0.1% = 0.5% = 0.5%		Grid electricity Off-grid electricity Kerosene Wood Natural gas	= 44.8% = 31.2% = 16.6% = 6.6% = 0.2%	
Household Appliances	Stock of appliances (No. Units in millions):		Electricity use (GWh):		Energy intensities (kWh/Unit):	
	Motors Fridges/freezers TVs	= 1.8 = 16.4 = 15.7	Motors Fridges/freezers TVs	= 5,145 = 557.4 = 190.9	AC Fans Motors Fridges/freezers TVs	= 448.67 = 16.32 = 2858.3 = 34 = 12.16
Transport	Road (Number and volumes) Number of vehicles = 12.8 million			Rail (volumes)		
				Passenger Freight	1,664.9 million pkm 186.4 million tkm	

	Car Motorcycle Bus LDV HDV	45.9% 8.9% 16.2% 11.5% 9%	68 billion pkm 5.5 billion pkm 36 billion pkm 29 billion tkm 17 billion tkm	Domestic Air (volumes)	
				Passenger Freight	9,076.9 million pkm 19.8 million tkm
Household and transport demand	Household and Transport demand has been projected based GDP				
Sectoral GVA projections	Agriculture, services, and industry projected based on GDP growth rate				
Non-Energy sector	**Subsector**				
Fugitive Emissions from the Energy Sector	• Fugitive emissions from solid fuels • Fugitive emissions from oil and gas				
Industrial Processes and Product Use (grows with GDP growth rate)	• Cement production • Lime production • Glass production • Other processes • Production of chemicals • Production of metals • Non-Energy Products from fuels and solvent • Refrigeration and air conditioning • Foam blowing			• Fire extinguishers • Aerosols • Solvents • Semiconductor and electronic manufacturing • Electrical equipment • Other F gas use • Other product manufacturer and use	
Agriculture, Forestry and Other Land Use (grows with population and GDP growth rate)	• Enteric fermentation • Manure management • Manure in pasture range and paddock • Land Use and Land Use Change and Forestry • Direct N20 emissions from managed soils			• Other direct soil emissions • Indirect N2O from managed soils • Indirect N2O emissions from manure management • Rice cultivation and other	
Waste (grows with the population growth rate)	• Solid waste disposal • Biological treatment of solid waste			• Waste incineration & open burning • Wastewater handling	
Other	• Indirect N2O emissions from atmospheric deposition of nitrogen in NOx and N • Other				

(ii) Current Policy Scenario (CPS):

This scenario imagines an economy that is guided by the ambition of the Energy Transition Plan (Net-Zero by 2060) and the Nationally Determined Contribution. Thus, over 90% of power generation is attributed to renewable energy, bioenergy with carbon capture and storage accounts

for 50% of cement production, electric vehicles replace more than 85% of fossil fuel-powered cars and buses and 85% replacement of inefficient household technologies by 2050, and end of gas flaring by 2030. In addition, the scenario assumes that backup fossil fuel generators will be eliminated by 2050. Appendix 4 for the key policy assumptions supporting this scenario.

(iii) Gas Economy Scenario (GES):

This scenario imagines Nigeria's aggressive exploitation and utilisation of gas resources. This scenario assumes that by 2060, 58% of power generation will be from natural gas with carbon capture and sequestration (CCS). In the residential sector, 100% of inefficient lighting, refrigeration and air conditioning technologies will be replaced by 2060, and clean cooking (LPG, natural gas, and electricity) will account for 90% of the share of cooking energy by 2060 and improved cook stove (biomass cook stove) will account for the remaining 10%. Natural gas with CCS will account for 57% of the energy-intensive industry and gas flaring will be ended by 2030. A modal shift to public modes of transportation with buses and three-wheeler vehicles accounting for 50% and 20%, respectively, by 2060, and cars and taxis accounting for the remaining 30%. Furthermore, an aggressive reforestation rate, at 5% annually, is assumed to support nature-based carbon sinks, and forestry management practices are in line with the global mechanism of reducing emissions from deforestation and forest degradation (REDD+). Also, emissions from waste will decrease by 2%, annually **(Appendix 5)** for the key policy assumptions supporting this scenario.

(iv) Renewable Energy Scenario (RES):

This scenario envisages ambitious Nigeria's emission reduction to net-zero by 2060. The scenario assumes about 98% zero-emission energy penetration in the power sector comprising of renewable energy and nuclear power to align with the Nigerian Nuclear Power Programme. *(Ibitoye, F. (2014)*) Clean cooking accounts for 95% of cooking energy, and efficient technologies will replace inefficient household technologies by 2060. Electricity will account for most energy use in the service, transport, and industrial sectors. By 2060, the shift to buses and three-wheelers will be 50 and 20%, respectively. Enteric fermentation will be reduced by 5, 8, and 10%, respectively, by 2030, 2050, and 2060. In addition, a moderate reforestation rate, at 2.3% annually, is assumed to support nature-based carbon sinks, and forestry management practices are in line with the global mechanism of reducing emissions from deforestation and forest degradation (REDD+). Furthermore, emissions from waste will decrease by 5, 10, 15, and 20%, respectively, by 2030, 2040, 2050, and 2060 due to improved waste management and waste-to-energy practice. **(Appendix 5).**

3.3 Scenarios Construction

As previously noted, the Nigeria LEAP was used to quantitatively chart a road map for Nigeria's decarbonisation journey. The LEAP model is the tool of choice for energy calculations. The Nigeria LEAP (LEAP-NGA) model structure was designed to reflect the sector-tailored integrated scenarios. As a result, the LEAP-NGA model, which is anchored on the low emissions analysis platform (LEAP) bottom-up model architecture, can provide

quantitative information about the energy mix and emissions of the country under the various LT-LEDS scenarios. LEAP-NGA structure was developed by integrating all the country's sectors: energy, Agriculture, Forestry, and other Land Use (AFOLU), industry, services, and waste. The energy sector comprises residential and building, power, transport, and oil and gas subsectors. The Nigeria LEAP model relies on the key policy assumptions supporting each of the four LT-LEDS scenarios and Nigeria's context-sensitive data presented in (Appendix 5) showing the data sources. The Nigeria LEAP model is used to track energy mix, consumption pattern, production, resource extraction and emissions under featured scenarios.

The Nigeria LEAP structure was extended to incorporate endogenous Nigeria's context-sensitive macroeconomic data through the KLEM (Capital, Labour, Energy, Materials and Services) macroeconomic model (KLEM-NGA), which is a top-down modelling **architecture (**Figure 3.5).

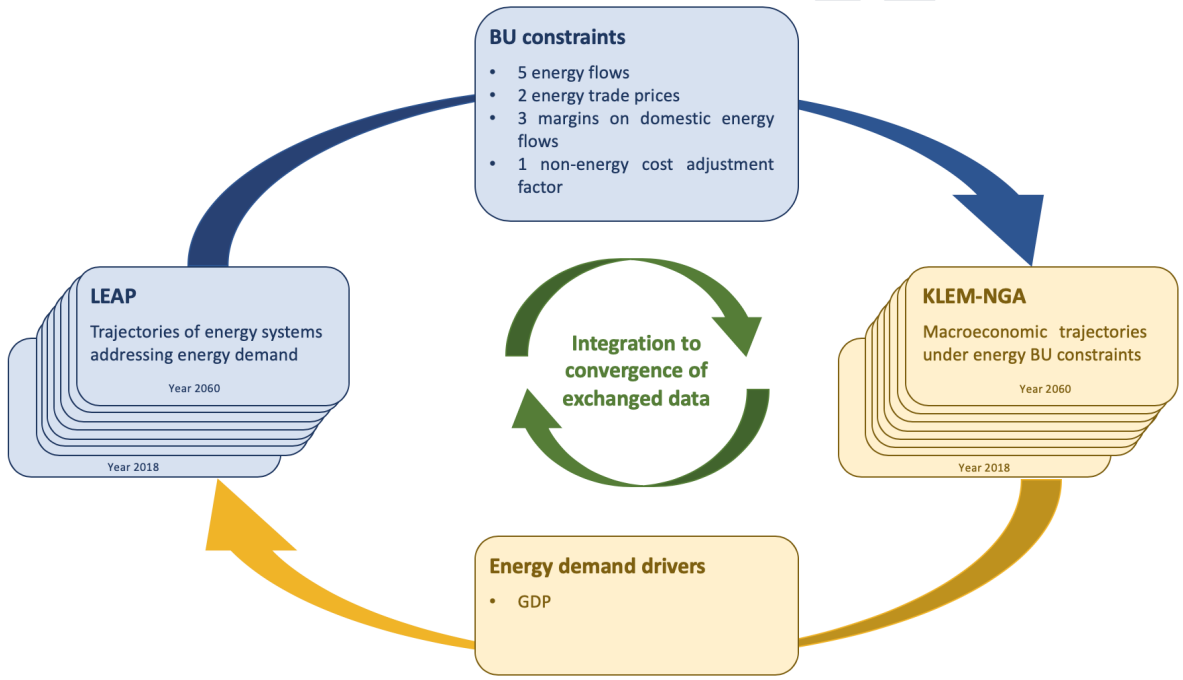


Figure 3. 5: Dynamic Calibration of NGA LEAP-NGA KLEM

The KLEM is designed to compute macroeconomic trajectories under the constraint of exogenous energy flows and prices. The focus of the KLEM is on overall macroeconomic impacts. The model aggregates the economy into two sectors only – energy and non-energy. It was assumed that further sectoral specificities in the non-energy sector do not significantly influence the simulation results. This assumption allows a two-sector KLEM-NGA model, with one sector representing energy branches and the other sector the rest of the economy. The energy branches are derived exogenously by soft-linking the LEAP-NGA and KLEM-NGA models. The exchange concerns the variables of the energy system (costs/prices and physical flows), calculated by LEAP, and the growth of the real gross domestic product (GDP)

calculated by KLEM, the main driver of energy consumption growth in LEAP.

The coupled implementation of both models (Nigeria LEAP-Nigeria KLEM) allows the production of outlooks that offer a consistent description of the Nigerian energy system and the aggregate economic activity it is servicing.

It is important to note that, the result obtained using these models were computed based on the 100-Year global warming potential (GWP), which is consistent with the Intergovernmental Panel on Climate Change (IPCC).

3.4 Emissions from the Scenarios

The analysis of the scenarios on the Nigeria LEAP model yielded important aggregated national emissions profiles for the scenarios, as shown in **Figure 3.6**. In 2030, the emissions of the BAU, CPS, GES and RES stood at 513.7, 415.98, 326.8 and 242.0 $mtCO_{2e}$, respectively. The results for 2030 show that the CPS, GES, and RES can reduce emissions by 1.96%, 22.99% and 42.96%, respectively, compared to 2018, the base year, with emissions of 424.30 $mtCO_{2e}$. Again, the LT-LEDS BAU is higher than the NDC BAU's value (452.7 $mtCO_{2e}$) by about 13% in 2030. The difference between the LT-LEDS BAU and NDC BAU could be attributed to the more granular analysis of activities in the AFOLU and the transport sectors in the LT-LEDS modelling approach. The emission from the energy sector (265 $mtCO_{2eq}$) in 2030 is higher than the updated NDC's value (252 $mtCO_{2e}$) and ETP's value (216 $mtCO_{2e}$) by about 5% and 18%, respectively.

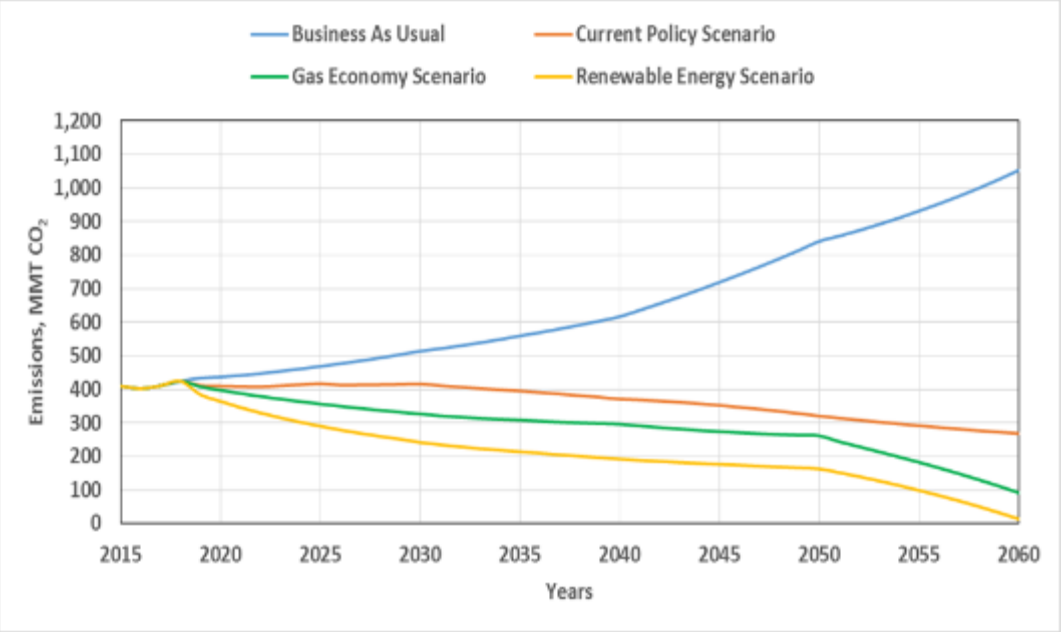


Figure 3. 6: Emission profile for all the scenarios

Figure 3.7 shows the evolution of emissions for the scenarios. The results indicate that the CPS, GES, and RES, respectively, could reduce the base year emissions by 24.5%, 38.3% and 61.5% in 2050, whereas the reduction would be by

36.7%, 78.3% and 96.8% in 2060. It is worth noting that only the RES passed the vision of Nigeria's LTV-2050 of cutting emissions by 50% by 2050. The CPS has not performed close to net-zero by 2060 because the ETP's total emission amount does not account for over 60% of emissions from AFOLU. The implication is that the GES and RES have better potential than ETP and CPS to support the LT-LEDS of Nigeria by 2060; however, only the RES points in the direction of net zero.

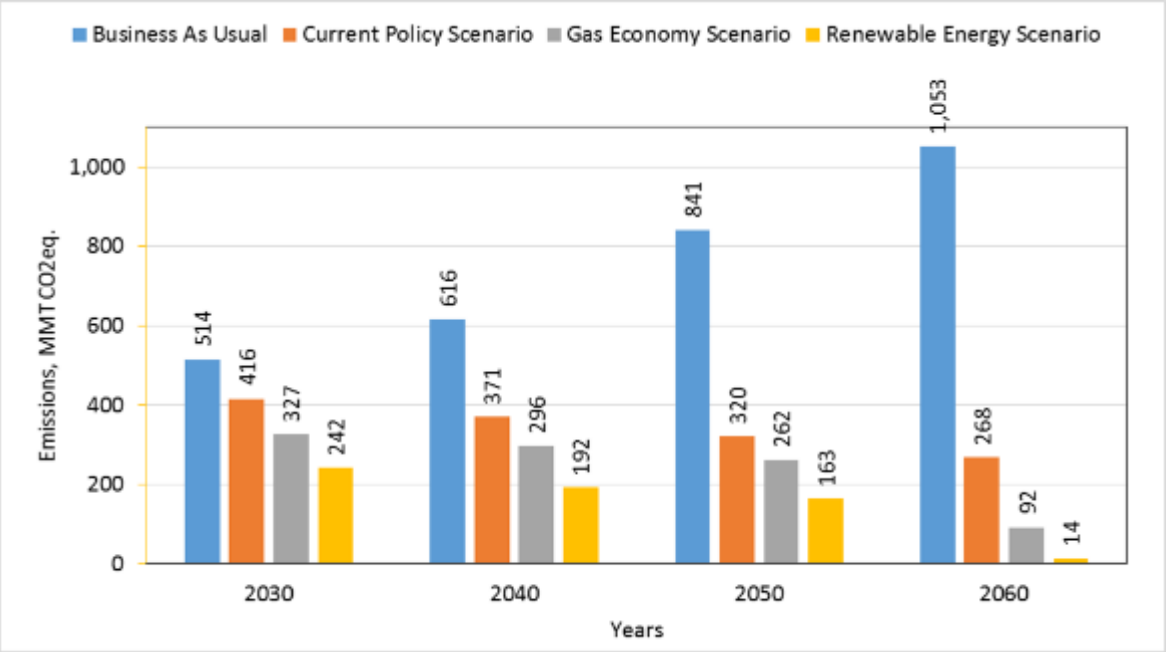


Figure 3.7: Evolution of emissions by scenarios

Figure 3.8 shows the emission contribution by sectors (energy, AFOLU, IPPU, waste and others) to each scenario; where emissions from oil and gas extraction, building and residential, transport and power aggregate to the energy sector's emissions. In 2030, under the BAU case, the shares of the energy, AFOLU, IPPU, waste and others, are respectively, 50.4%, 32.8%, 4.3%, 11.6% and 0.9%; under the CPS case, the share of energy, AFOLU, IPPU, waste and others, respectively, are 52.3%, 34.4%, 3.6%, 8.6% and 1.0%; under the GES case, the share of energy, AFOLU, IPPU, waste and others, respectively, are 73.4%, 10.9%, 3.4%, 11.0% and 1.3%; and under the RES case, the shares of energy, AFOLU, IPPU, waste and others, respectively, are 66.3%, 18.8%, 4.1%, 9.7%, and 1.1%. However, in 2050 and 2060, AFOLU will serve as a carbon sink for GES and RES, which is attributed to aggressive afforestation, forest management and forest waste-to-energy.

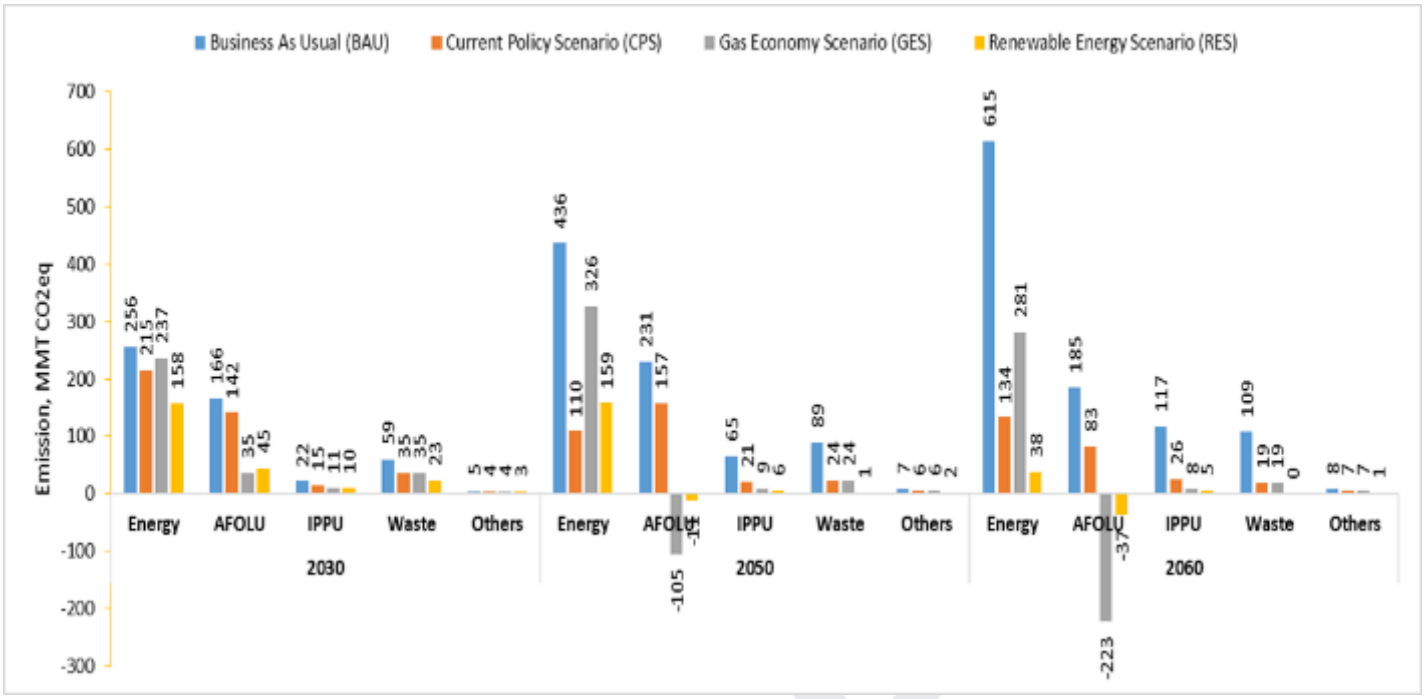
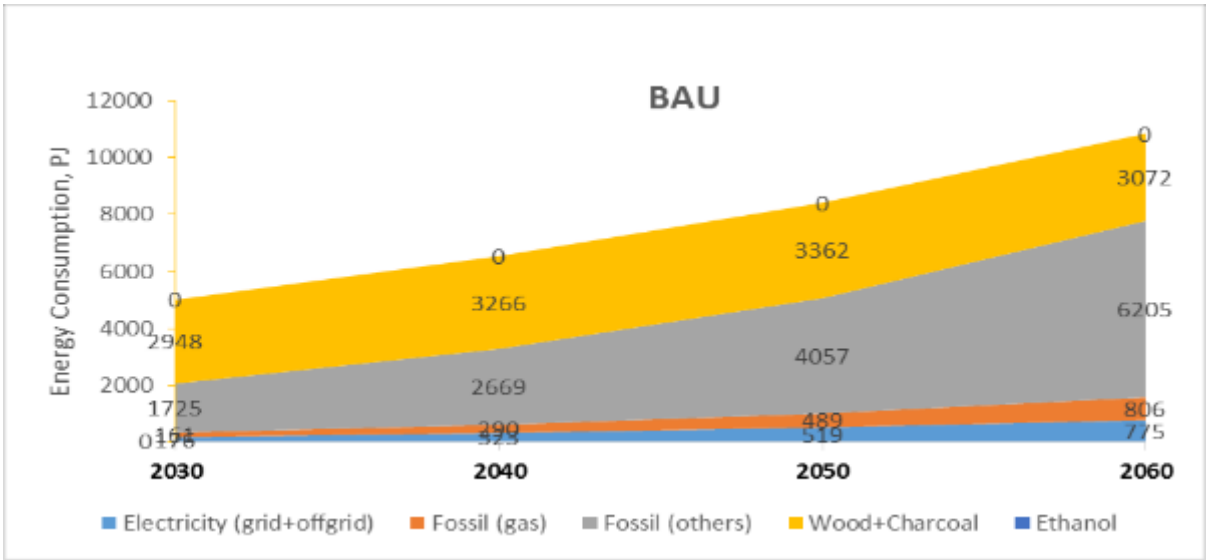


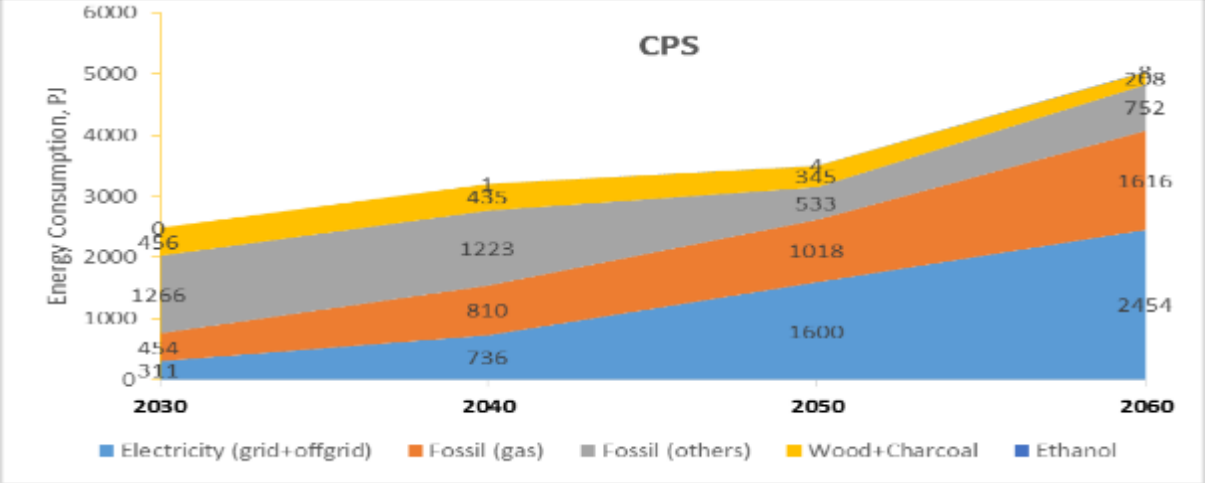
Figure 3. 8: Sectoral emissions contribution to the scenarios

Figure 3.9 presents the energy mix across all four scenarios – the energy is classified into electricity (grid and off-grid), fossil (gas), fossil (others – kerosene, gasoline, diesel, and coal), wood and charcoal and ethanol. For the BAU (**Figure 3.9a**), firewood and charcoal (at 2948 PJ) will dominate the energy space in 2030, whereas fossil fuel (others), with insignificant contribution from coal at 0.82 PJ, will dominate the energy space beyond 2030.

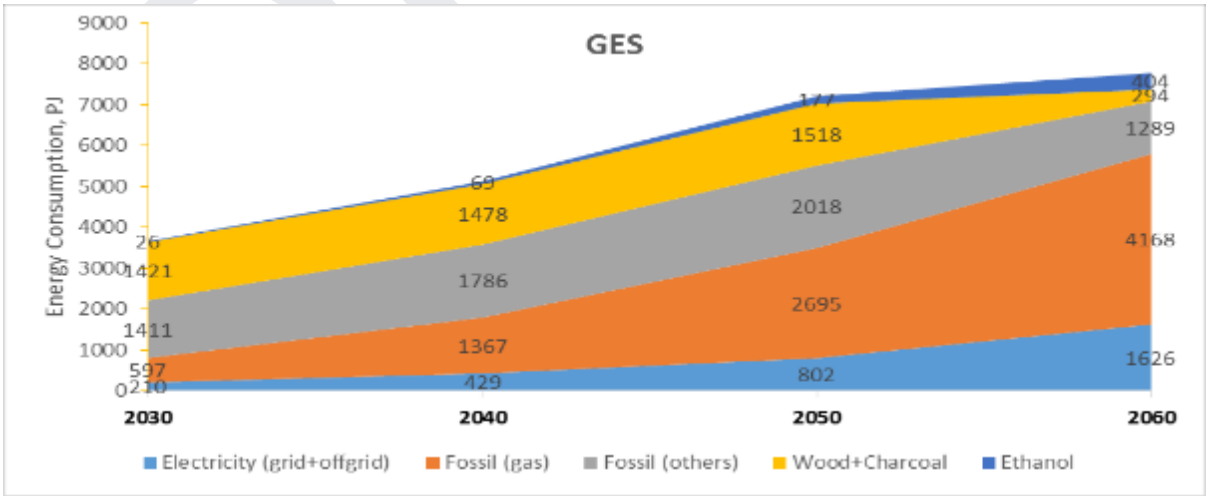
Figure 3.9b, the CPS, indicates that fossil (others) will dominate energy space between 2030 (1266 PJ PJ) and 2040 (1223 PJ), with electricity controlling the energy space beyond 2040. Furthermore, for the GES, fossil (others) at 1421 PJ will dictate the energy space in 2030, while fossil (gas) will dominate the energy space beyond 2040 (**Figure 3.9c**). For the RES, firewood, and charcoal (at 1528 PJ) will dominate the energy space in 2030, while electricity will dominate beyond 2050 (see **Figure 3.9d**). The GES energy scenario shows higher total energy consumption than the CPS and the RES. This is attributed to lower efficiency of energy conversion of the GES.



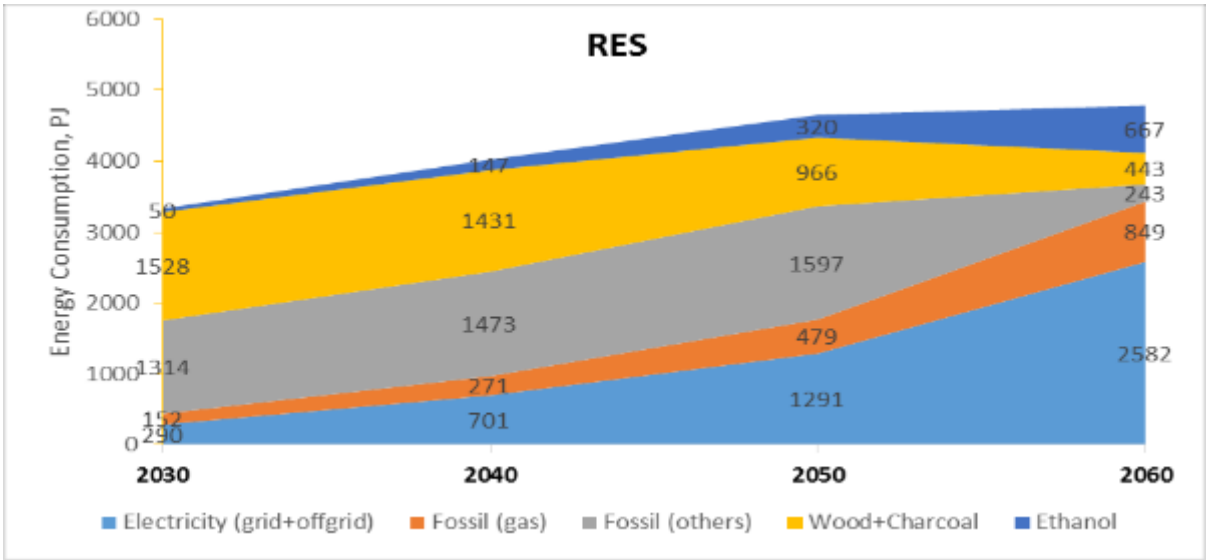
a. Business As Usual (BAU)



b. **Current Policy Scenario**



c. **Gas Economy Scenario (GES)**



d. **Renewable Energy Scenario (RES)**

Figure 3. 9: Energy share across the scenarios (a-d)

Sectoral Emissions and Strategic Policy Measures Under Mitigation

4.1 Agriculture, forestry, and other land use (AFOLU) sector

4.1.1. Emissions from the AFOLU Sector

The agricultural sector's contributions to the GDP and sectoral employment quota to the entire labour force in the country in 2016 were 21.2 % and 39.5 %, respectively (World Bank, 2018). More than 80% of farmers in Nigeria are smallholders, i.e., holding less than 1 Ha, (Mgbenka and Mbah, 2016). Over 38 million Nigerians (about 20% of the population) are directly engaged in agriculture, making it the highest employer of labour.

However, it is usually reported that about 70% of the labour force is engaged in one form of agricultural activity or the other. The agriculture, forestry, and other land use (AFOLU) sector is Nigeria's second highest producer of greenhouse gas emissions, after the energy sector and the decarbonization of the AFOLU sector is very challenging due to "difficulties in emission estimation, the disperse nature of AFOLU emissions, and the complex links between AFOLU activities and poverty reduction."*(Anyanwu, C. N., Ojike, O., Emodi, N. V., Ekwe, E. B., Okereke, C., Diemuodeke, E. O., ... & Nnamani, U. A. (2023)*

In the BAU, the AFOLU will contribute 32.8% of the emissions in 2030, while in the CPS, GES and RES, the contribution of the AFOLU is 34.4%, 10.9% and 18.8%, respectively.

The result shows that AFOLU emissions contribution in RES is higher than the GES because of the better consideration of afforestation and reforestation measures in GES. The emission share continues to increase for the BAU until 2060, when there is a marginal decrease in the emissions, as shown in **Figure 4.1**, which could be attributed to the deforestation rate.

According to the FAO, between 2010, Nigeria lost of 409,650 ha or year of forested Nigeria lost 47.5% cover over these (about 8,193,000 nothing is done, would have lost of its 2020 forest 2060. Hence, the that at least 2.3% rate per annum required to deforestation. Furthermore, national forest to increase forest cover from 6% to 25% (the in 2000) by *Forest Policy, 2020).* reforestation will have to outpace deforestation to achieve this in the near to medium term. Therefore, it is impossible to imagine a transition to net-zero carbon economy in Nigeria without the deep decarbonisation of the AFOLU sector. Going forward, the Gas Economy Scenario (GES) adopted a reforestation rate of 5% to accommodate the reversal of the forest loss and natural carbon sink for the expected emissions from the diverse uses of gas in the economy – power generation, transport, cooking, and industry. The AFOLU emissions in the CPS show a remarkable decrease compared to the BAU. On average, the AFOLU emissions in the CPS indicate about a 46% reduction between 2050 and 2060 compared to the AFOLU emissions from the BAU in the same time horizon. However, the AFOLU sector serves as a carbon sink in the GES and RES between 2040 and 2060 and 2050 and 2060, respectively, as shown in **Figure 4.1**.

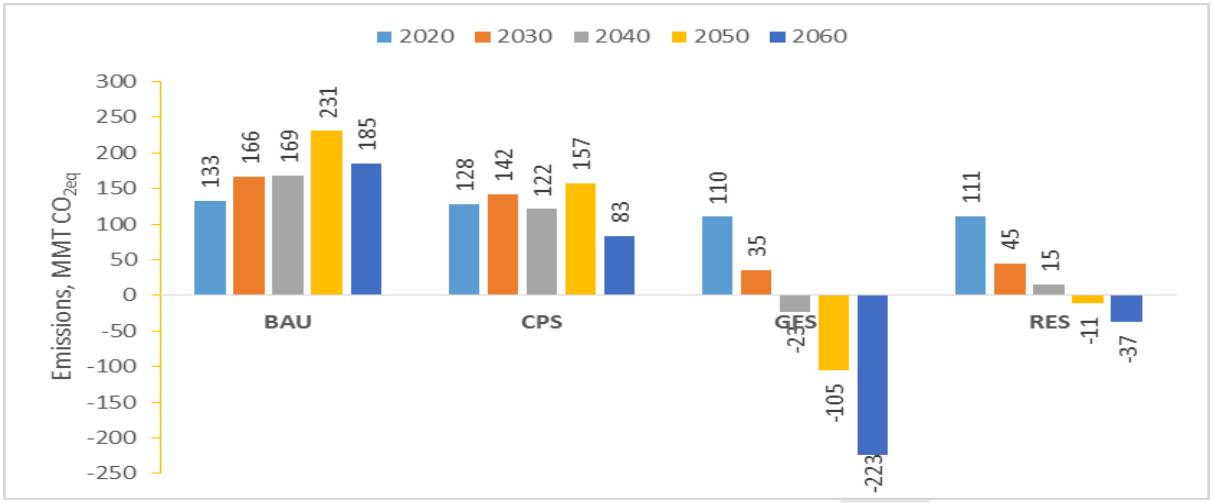


Figure 4.1: Emissions from AFOLU under the scenarios

Some of the specific agricultural activities that lead to GHG emissions are enteric fermentation in domestic livestock rearing, land use land-use change and forestry (LULUCF), livestock manure management, rice cultivation, agricultural soil management, and field burning of agricultural residues, liming, urea fertilization and on-farm energy use. However, enteric fermentation and LULUCF account for over 65% of AFOLU BAU's emissions between 2020 and 2050, as demonstrated in **Figure 4.2**.

These observations call for the combination of strategies (e.g., ranching of animals to reduce enteric fermentation, reforestation as a mitigation strategy alongside climate-smart agriculture practices) to reduce emissions from the AFOLU sector. Increasing resilience to climate change and effectively reducing GHG emissions in the AFOLU sector will be feasible within LTV-2050's vision for AFOLU, which is elaborated in the adaptation section.

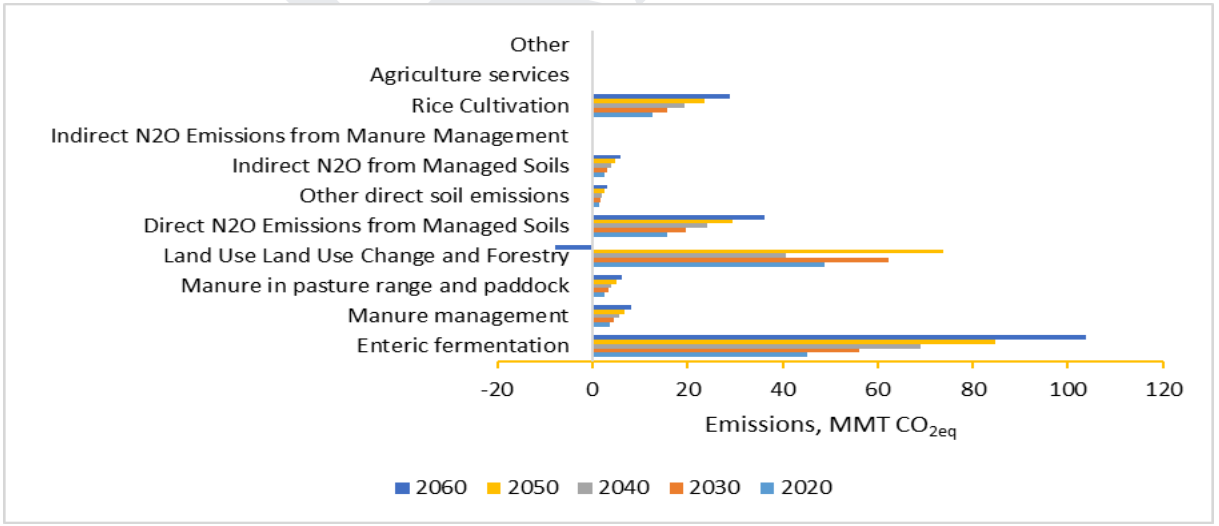


Figure 4.2: AFOLU activities contributing to emissions in BAU

4.1.2 Mitigation Measures for the AFOLU Sector

The AFOLU sector includes crop production, animal production, fisheries, and forestry subsectors. The mitigation strategies by 2060 will focus on the following five key thematic areas of

1. Adoption and implementation of climate-smart agricultural practices. Emphasis will be:

- Educating a minimum of 5 million farmers on climate-smart agricultural practices, including but not limited to efficient irrigation systems, agricultural biotechnology on ethanol production, use of improved seedlings, improved use of manure and responsible use of fertilizer, improved methods of crop cultivation, etc.
- Developing/implementing national guidelines on different aspects of agricultural practice such as Climate smart irrigation schemes, etc.
- Adopting efficient food storage and processing methods to reduce food loss in the supply chain.

2. Promotion of nationwide animal ranching practice for improved enteric fermentation management by:

- Ensuring effective implementation of the National Diary Policy, National Livestock Transformation Plan, etc
- Undertaking massive education of herders and other livestock keepers.
- Providing adequate land for ranching activities
- Adopting sustainable livestock management
- Putting regulations in place to discourage open grazing.
- Mainstreaming climate adaptation into dry land management plans and strategy.

3. Promotion of afforestation and reforestation activities to increase Nigeria's forest cover to 25 % by 2060 will involve:

- Discouraging deforestation.
- Establishing forest reserves
- Promoting community forestry.
- Planting at least 25 million trees annually using indigenous and fast-growing tree species.

4. Adoption of nature-based solutions for sustainable ecosystem management. This will be emphasised by:

- Conserving mangrove forest
- Effecting land management practices
- Planting of covered crops in plantation.
- Restoring degraded lands.

5. Reduced forest and carbon losses from Agriculture will involve:

- Developing guidelines for sustainable agricultural practices
- Undertaking capacity building to educate farmers on sustainable agricultural practices.
- Enforcing laws and regulations to stop bush burning, charcoal production and unsustainable mineral exploitation.
- Supporting the reduction of food, fibre, and forest products with high GHG emissions in the production chain. This includes (i) switching from consuming products with higher GHG emissions in the process chain to products with lower GHG emissions and (ii) making

land available for other GHG reduction activities. (iii) Ensuring behavioural change for adapting to new technologies and practices that are climate smart in AFOLU, e.g., the use of energy-efficient cooking stoves in rural and semi-urban Nigeria. Changes in human diets toward fewer animal products and increased carbon stocks in long-lived wood products will contribute to the demand-side mitigation options in the AFOLU sector for low-carbon societies in Nigeria.

It is noted that increasing resilience to climate change and effectively reducing GHG emissions in the AFOLU sector will be feasible within LTV-2050's vision for AFOLU, which is elaborated in the adaptation section.

4.2 Power Sector

4.2.1 Emissions from Power Sector

The power sector is very critical to the socioeconomic development of Nigeria. Presently, the installed power capacity in Nigeria is about 14GW, with the maximum available capacity fluctuating around 5 GW[13]. The electricity generation of 36 TWh[14] can only meet up to one-third of the country's electricity needs. Also, the record shows that only 55% of Nigerian households are connected to the national grid *(World bank, Energy Progress Report*), but Nigeria's NDC has the vision to electrify all homes in Nigeria by 2030. Nigeria's electricity installed capacity is mainly from fossil fuel (over 80% of total capacity), and the power sector is directly responsible for 17 $mtCO_{2e}$ emissions in the country*. (IRENA, 2022).* This means that to meet the "energy for all" target and to electrify other aspects of the economy, the Nigerian power sector must be substantially and rapidly decarbonized. Interestingly, the issue of power decarbonization does not imply the provision of clean energy only, but it may also suggest an increase in electricity (when net-zero is in view) needs since electrification of other sectors is seen as a veritable instrument to deeply decarbonise the entire economy. Thus, there will only be meaningful sector-wide decarbonization in Nigeria if the power sector is given significant attention. Since Nigeria has abundant gas and renewable energy reserves, decarbonisation is possible from the power sector through a mix of policies and strategies ranging from a gas-focused economy with carbon capture to a fully renewable economy. The choice of pathways will depend on a combination of social, economic, and political calculations ideally with a balance between demand and supply measures*. (Diemuodeke, O., & Okereke, C. (2020)*

Figure 4.3 shows the GHG emissions of power generation for the four scenarios. The GHG emissions of the BAU scenario will grow steadily from 15 to 118 mtCO2e by 2060. The emissions of the CPS scenario will peak at 18 $mtCO_{2e}$ in 2040 and drop to 0.4 $mtCO_{2e}$ by 2060. A similar trend is observable in the GES, peaking at 14 $mtCO_{2e}$ in 2050 and dropping to 0.1 $mtCO_{2e}$ in 2060. The low emissions in these scenarios are associated with the penetration of renewable energy and the deployment of carbon capture technologies, respectively. The emissions of the renewable energy scenario will peak at 23 $mtCO_{2e}$ in 2050 and drop to about 7 $mtCO_{2e}$ by 2060. Although the RES deploys renewable energy technology, the emissions from biomass are the reason for 7 $mtCO_{2e}$ in 2060.

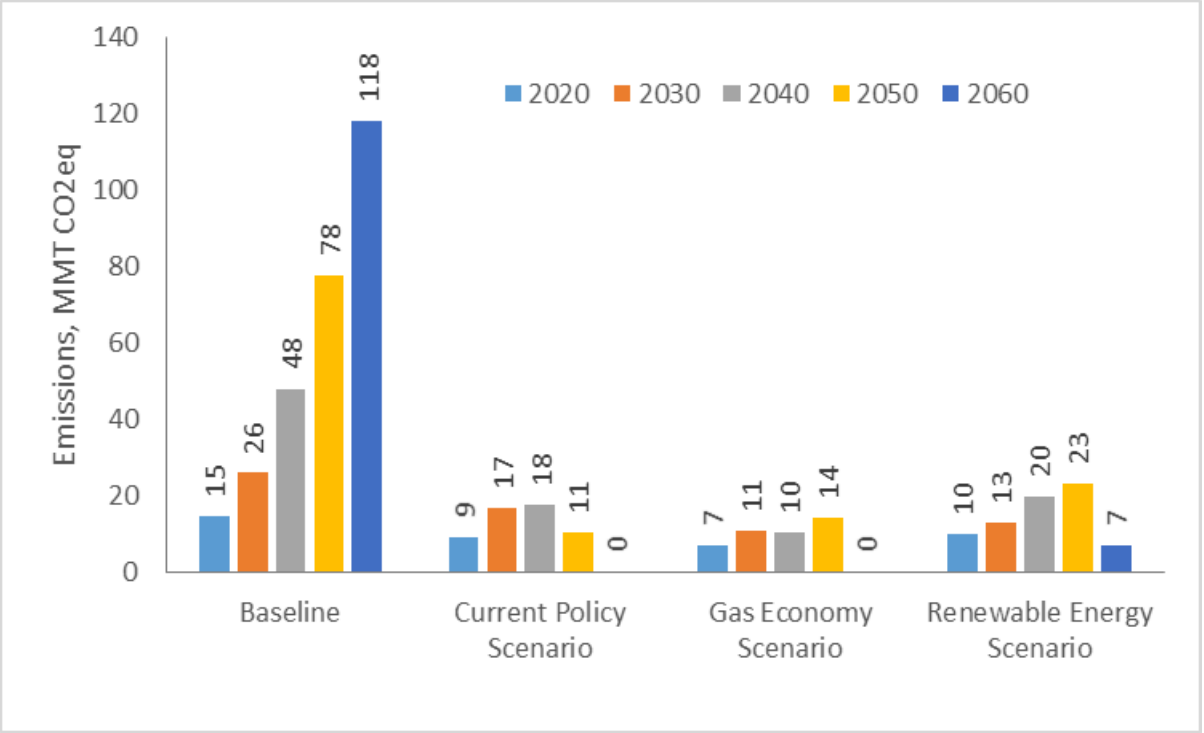


Figure 4.3: GHG emissions of power generation

Figure 4.4 shows the emission factor of the baseline and LT-LEDS scenarios. The BAU shows an increase in the power sector emission factor from 429 gCO_{2e} per kWh of electricity generation in 2020 to 461 gCO_{2e} per kWh in 2060. However, the figure shows reductions in emission factors of the mitigation scenarios. The emission factor of the CPS will peak at 176 gCO_{2e} per kWh in 2030 and decrease to 1 gCO_{2e} per kWh in 2060. The emission factor of the RES will gradually decrease from 210 gCO_{2e} per kWh in 2020 to 10 gCO_{2e} per kWh in 2060. For the GES, the emission factor decreases from 191 gCO_{2e} per kWh in 2020 to 0.3 gCO_{2e} per kWh in 2060. By 2060, the emission factors of the mitigation scenarios will fall to 1, 0.3 and 10 gCO_{2e} per kWh, respectively, for GES, CPS and RES, as compared with 461 gCO_{2e} per kWh of the BAU. It is observed that the emission factor from RES will be the highest among the three decarbonization scenarios by 2060, even though it is renewable energy dominated. However, the RES emission factor will be the lowest on an aggregated national emission accounting due to the absorption of biomass emission by regenerating biomass to drive the afforestation and reforestation considered in the AFOLU sector. The observation is attributed to emissions from the use of biomass in electricity generation plants. The huge reduction seen in the emissions of these scenarios, when compared to the baseline scenario emissions, is due to carbon capture technologies and the deployment of renewable energy and nuclear power technologies.

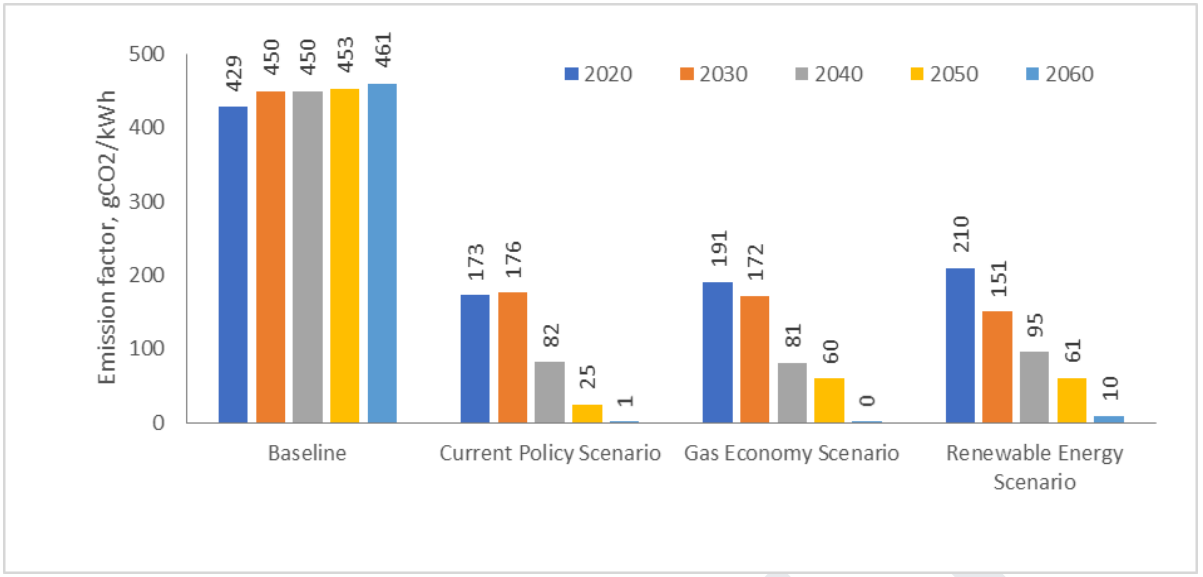


Figure 4.4: Emission factor of power generation

Figure 4.5 shows the electricity generation for all the scenarios for 2030, 2040, 2050, 2060. In the BAU, electricity generation will increase 9 folds from 28 TWh in 2018 to 257 TWh (grid: 213 TWh; off grid: 44 TWh) in 2060. For CPS scenario, electricity generation will increase by 23 folds from 28 TWh in 2018 to 637 TWh (grid: 622 TWh; off grid: 15 TWh) by 2060. For GES, electricity will increase by 17 folds from 28 TWh in 2018 to 484 TWh (grid: 468 TWh; off grid: 16 TWh) by 2060. For RES, electricity generation will increase by 27 folds from 28 TWh in 2018 to 761 TWh (grid: 647 TWh; off grid: 114 TWh) by 2060. The electricity generation is highest in the RES because more electricity will be demanded to meet the energy needs of the different sectors of the economy in the RES than in other scenarios. The energy demand in the RES will be dominated by electricity because the transport, residential (e.g., cooking), industry sectors will be driven by electrification. This is possible because renewable energy is better converted to electricity than being used as primary fuels in other sectors of the economy.

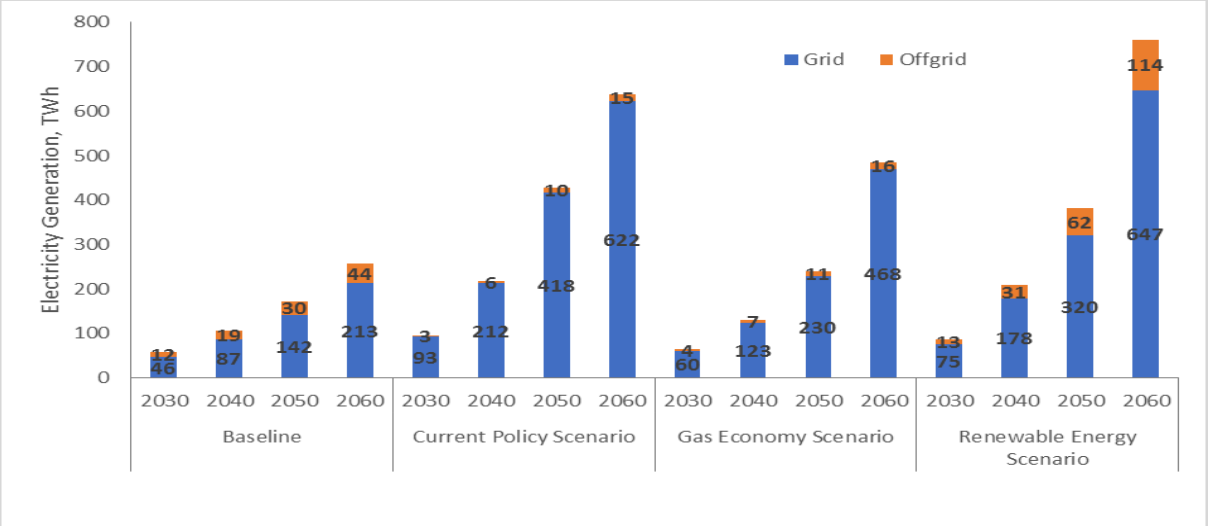
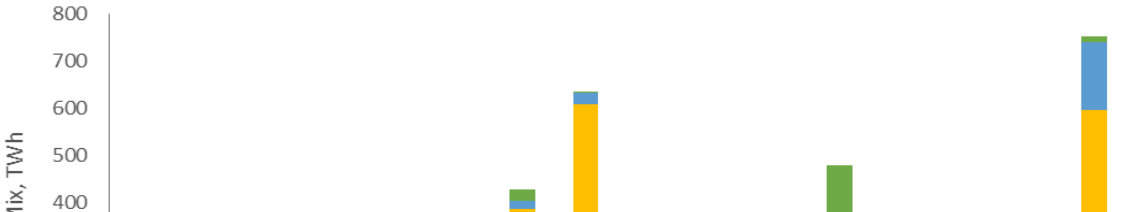


Figure 4.5: Electricity generation (Grid and off-grid)

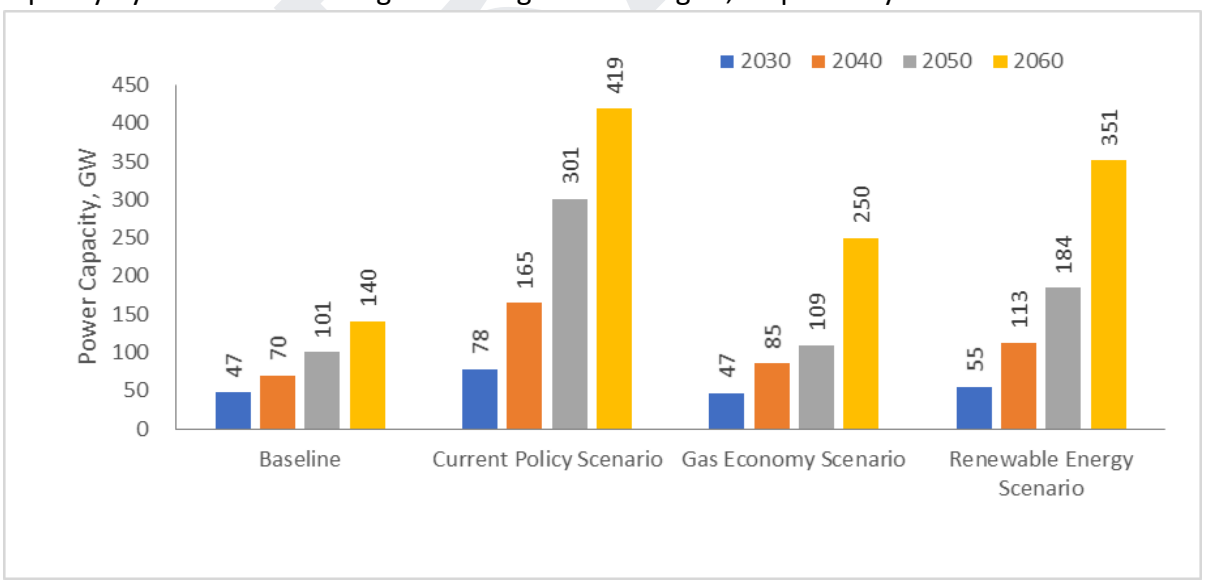
Figure 4.6 shows the electricity generation mix. The BAU shows that most of the electricity generation is from fossil sources (gas power plants and diesel generators), contributing 84 % of the generation by 2060. For the CPS scenario, most of the electricity generation by 2060 will be from solar and hydro (large and small hydro) at 47 % and 39 %, respectively. For GES, most of the electricity generation will be from fossil fuel (gas power plant with carbon capture), solar, nuclear, and hydro at 29 %, 27 %, 23%, and 15%, respectively. For RES, electricity generation is mainly from solar, hydro, biomass and nuclear at 37%, 27%, 19% and 9%, respectively. The 9% of power generation from nuclear power is well aligned with the Nigerian Nuclear Power Programme. It is expected that the implementation of the programme will evolve along safety and risk measures and capacity development.



	Baseline				Current Policy Scenario				Gas Economy Scenario				Renewable Energy Scenario			
	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Fossil fuel	50	89	144	217	23	33	23	1	49	55	96	140	16	21	23	12
Biomass	0	0	0	0	4	10	17	24	1	10	18	27	8	49	92	144
Solar	2	4	8	10	43	105	215	299	1	40	77	129	22	54	117	280
Nuclear	0	0	0	0	9	21	33	33	0	0	0	110	10	9	16	68
Hydro	6	12	20	29	12	32	111	250	13	23	46	71	29	59	103	208
Wind	0	0	0	0	6	16	27	28	0	1	1	2	2	17	28	41

Figure 4.6: Electricity generation mix

Figure 4.7 shows the power generation capacities of the four scenarios. For the BAU scenario, the power generation capacity will increase 4-fold from the 2018 value to 140GW by 2060, while CPS, GES and RES will increase by 18, 8 and 11 folds by 2060. Although the RES requires more electricity generation than the CPS, the power generation capacity of the RES is lower than that of the CPS because of the high energy density and conversion efficiency that will be deployed in the RES mix. **Figures 4.7a** and 4.**7b** show the power capacity by a mix of technologies in the grid and off-grid, respectively.



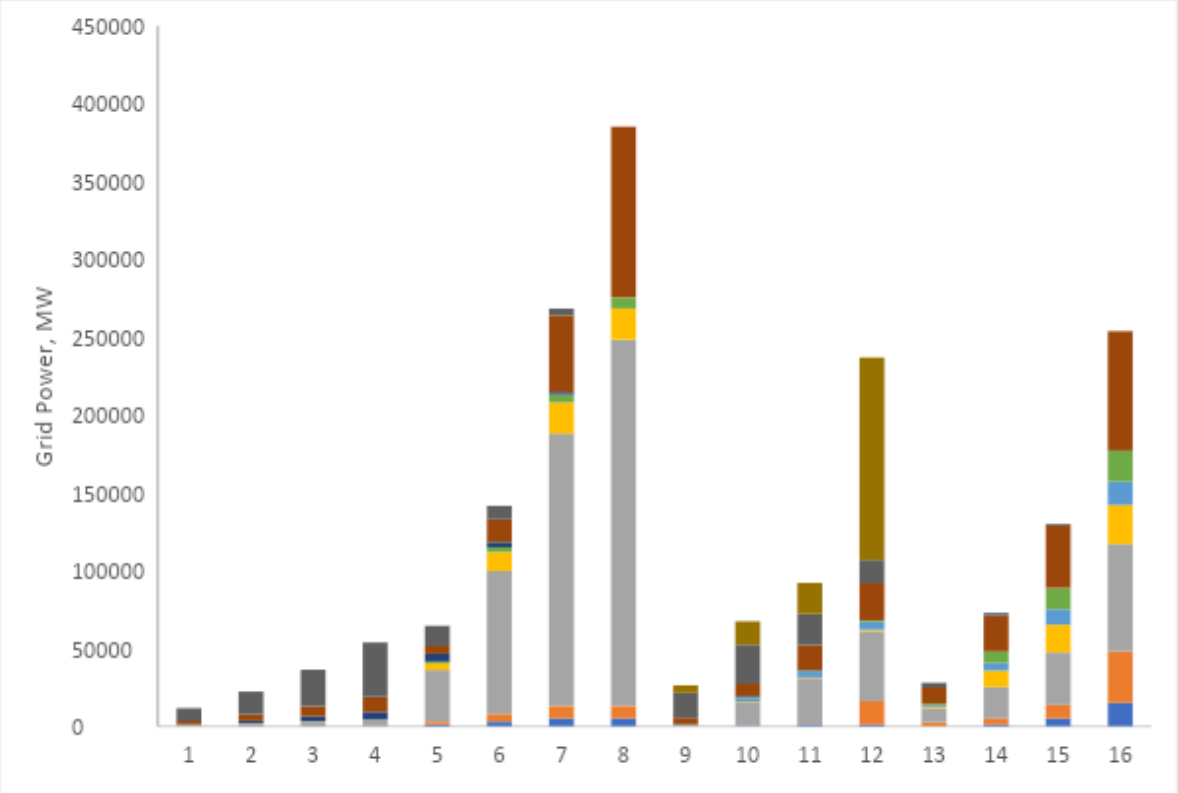


Figure 4.7a: Grid power generation capacity by technology

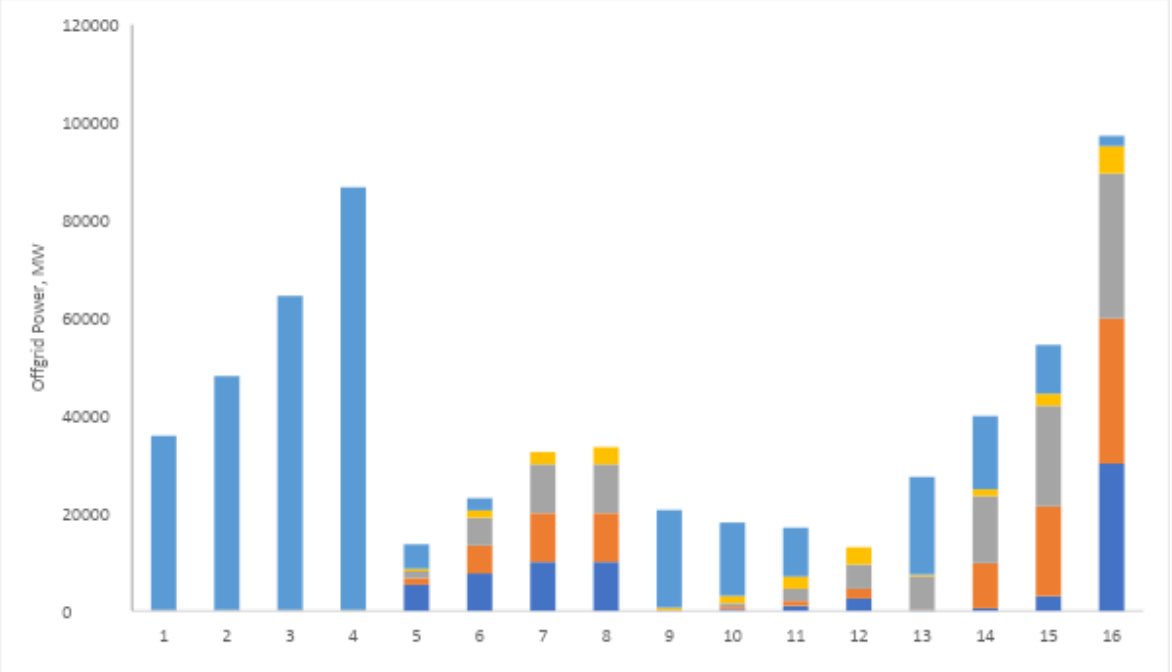


Figure 4.7b: Off-grid power generation capacity by technology

Figure 4.7: Power generation capacity

Figure 4.8 shows the amount of power to be installed yearly for the various technologies/fuels from 2023 to meet the power requirements of the four scenarios. The BAU shows that 1608MW of backup generators will be needed yearly. High solar installation is required for the CPS and the RES at 6700MW and 4300MW, respectively. While the GES requires 3625MW of gas power plants annually. Other power capacities are also shown in the figure.

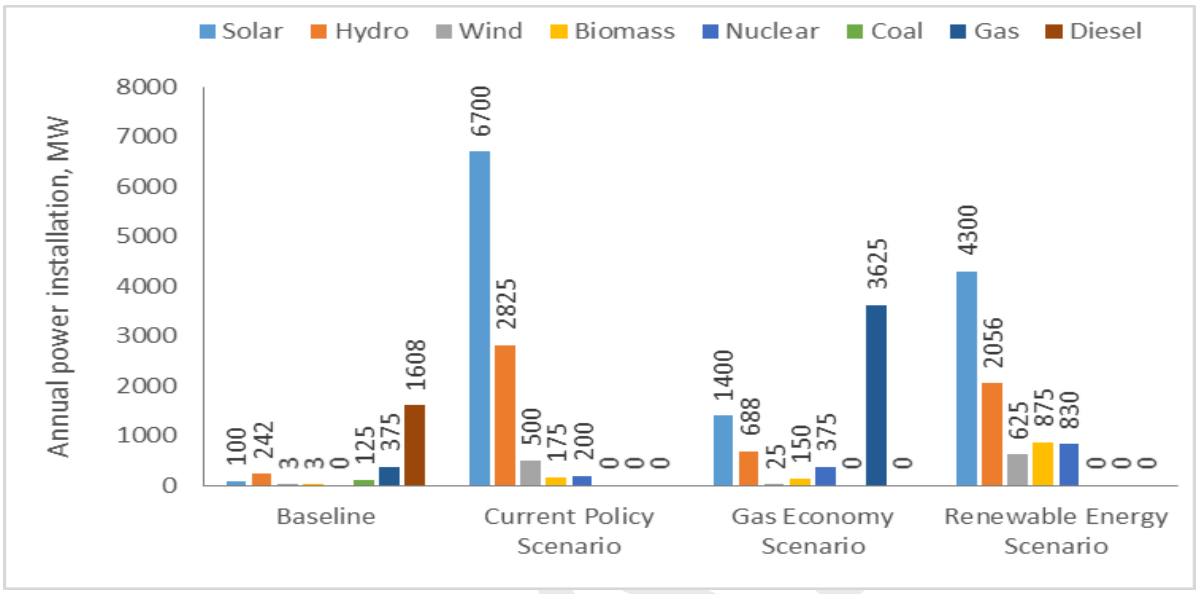
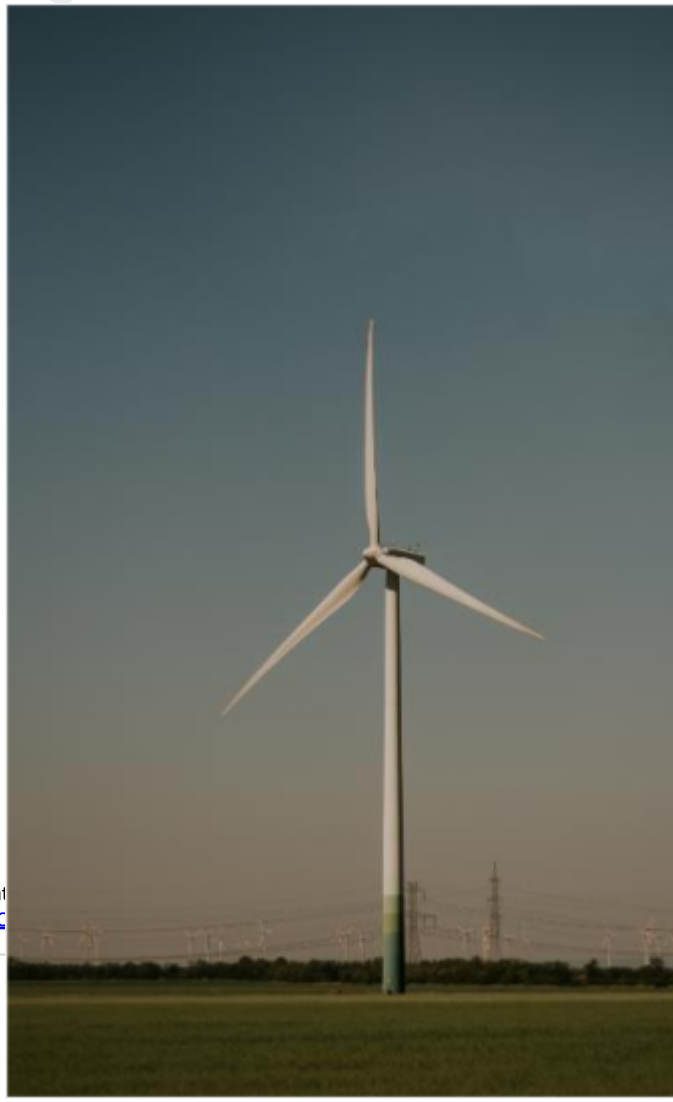


Figure 4.8: Annual power installation by scenarios

From the analysis of the power sector, the decarbonization scenarios show that (i) the "energy for all" target can be achieved by 2030, (ii) the CPS and GES have more ambitions to reduce emissions in the power sector than other scenarios by 2060; however, on aggregated national emissions accounting the RES has the highest decarbonisation potential due to the use of the emission for biomass regeneration through the afforestation and reforestation measures in the AFOLU sector and(iii) the GES will require significant investment in the grid electricity generation because of the large scale installation of gas power plants with carbon capture and sequestration (CCS) since gas power plants with CCS technology are expensive (2635 USD/kW as the capital expenditure, excluding operational expenditure)[15] as against gas power plants



[15] The cost data for CCGT with carbon capture were derived from AEO (2020) cost dat
https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capital_cost_AEC

without CCS (1500 USD/kW capital expenditure)[16].

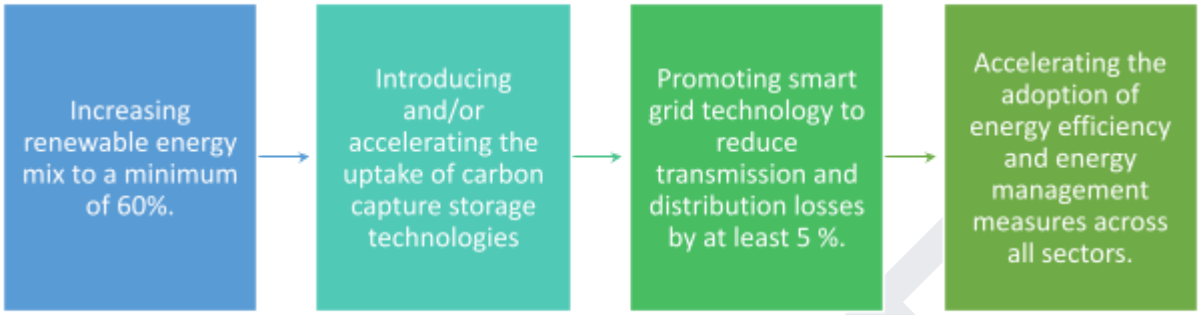
4.2.3 Mitigation Measures for Power Sector

Nigeria's Net-Zero plan for the energy sector will be driven by a shift towards further reliance on Hydro, Biomass, Wind, Solar PV and Nuclear as the country starts to exploit its large renewable energy potential for a successful energy transformation. The current electricity access rate is approximately 55 % of the population, of which 86 % are based in urban areas and 34 % are in rural areas. The modeling indicates that about 60 % and 80 % of Nigeria's electricity demand in 2050 can be met with renewable energy sources under the gas economy and renewable energy scenarios, respectively, which will progress to 92 % in 2060 under the renewable energy scenario.

[16] The cost data were sourced from a report that reflects true cost of electricity generation in Nigeria - https://ng.boell.org/sites/default/files/true_cost_of_power_technical_report_final.pdf

The mitigation strategies by 2060 will focus on the following three key thematic areas:

[17].



[17] Although the RES indicate that Nigeria should target 97 % in its renewable energy mix, the stakeholders are of the view that no more than 60 % can be achieved, of which about 60 % from Solar, 5 % from wind, 10 % from biomass, 20 % from hydropower and 5 % from nuclear.

1. Increased renewable energy mix to a minimum of 60%. This will include sourcing electricity from the following means:

- Generating up to 15,000MW from Concentrated Solar Power (CSP) and up to 45,000 MW from Solar PV utility by 2060.
- Generating a minimum of 20,000 MW from biomass sources by 2060.
- Generating energy from waste of up to 15,000MW by 2060.
- Expanding the country's hydropower potential to generate up to 24,000MW from large and small hydropower systems by 2060.
- Generating up to 25,000 MW from wind by 2060.
- Generating up to 20,000 MW from Nuclear sources by 2060.
- Encouraging massive private sector investment in the local production of solar equipment and other equipment for power generation from biomass, wind, and nuclear technology.

2. Introducing and/or accelerating the uptake of carbon capture storage technologies with emphasis on the following:

- Deploying significantly improved gas-fired combined cycle thermal power plants with carbon capture technology to at least 58 % of the thermal power generation technologies by 2060.
- Accelerating the standardization of CCS to improve its cost, scheduling, and safety, enabling its widespread implementation using best global practices.

3. Promotion of smart grid technology to reduce transmission and distribution losses by at least 5 % by 2060: This will entail:

- Adopting a decentralised approach for all the renewable energy mix generation and distribution in the rural areas.
- Supporting micro-financing of solar equipment to SMEs and households
- Promoting research and development in renewable energy use and production changing single cycles to multi or combine cycle power plants in Power generation

4. Accelerate adoption of energy efficiency and energy management measures across all sectors: Emphasis will be to:

- Developing a national programme to implement the adopted Energy Management System (EnMS) for all sectors.
- Enforcing energy efficiency standards, building codes, appliance efficiency standards and labelling.
- Providing an incentive for manufacturers to develop a standardised energy-efficient product. Providing wavers/incentives by Government for importation of renewable energy components

The Government will support necessary capacity-building initiatives that will enhance national capacity to accelerate the development of solar home systems locally, encourage the establishment of local factories for briquette production to substitute charcoal and firewood across the states and support rapid production of locally manufactured improved biomass and gasifier cookstoves. Existing energy policies to support the rapid development of medium to high manpower to drive the entire value chains of the renewable energy conversion technology space and household solar panels will be reinforced.

In implementation, the Government will also align the measures mentioned above with relevant national policies, plans and extant laws such as:

i. Renewable Energy Roadmap Nigeria-2023
ii. National Energy Masterplan 2022
iii. National Energy Policy 2022
iv. National Renewable Energy Action Plan 2015-2030.
v. 2015 National Renewable Energy and Energy Efficiency Policy (NREEEP).
vi. 2017 National Energy Efficiency Action Plan (NEEAP).
vii. 2021 Nigerian Climate Change Law.
viii. 2022 Energy Transition Plan (ETP).

In addition, the country will fully implement the National Generator Emission Control Programme (NGECP).

4.3 Buildings and Residential

4.3.1 Emissions from Building and Residential Sector

Nigeria's buildings and residential sector is a substantial consumer of the total delivered primary and final energy of the economy, with an energy consumption of 2423 PJ in 2020, according to the LT-LEDS BAU analysis (**Figure 4.9**). The energy consumption in the BAU will grow steadily with the population growth exacerbated by (i) cooking involving inefficient use of biomass in the traditional cookstove and the use of fossil-based cookstoves (LPG and kerosene) and (ii) use of inefficient appliances *(Omene Tietie, D.E, Diemuodeke, E.O., Owebo, K., Okereke, C. et al., 2021)*. In addition, it has been established that energy consumption in the buildings and residential sector is adversely affected by poor architectural design and inefficient appliances. *(Ochedi et al. (2022),* though the emissions from these sources of energy consumption are accounted for at the point of generation, power sector, for example.

The CPS has the lowest energy consumption across the horizon (**Figure 4.9**), which is attributed to the massive electrification of building and residential services, cooking, for example. In 2060, the RES will record the highest emission (at 801 PJ) among the three decarbonization scenarios because of a mix of electricity and improved biomass cookstoves. However, considering the use of emission to support the regeneration of biomass (the afforestation and reforestation measures) in the AFOLU sector, the RES emissions become comparable with the CPS emissions. A conscientious effort to see a shift from traditional biomass use for cooking, deployment of more energy-efficient electrical appliances and a higher focus on electricity and exploitation of other efficient cooking, lighting and space cooling systems will contribute to the realistic decrease in energy intensity in the residential sector as energy demand sources get increasingly decarbonized in all the scenarios.

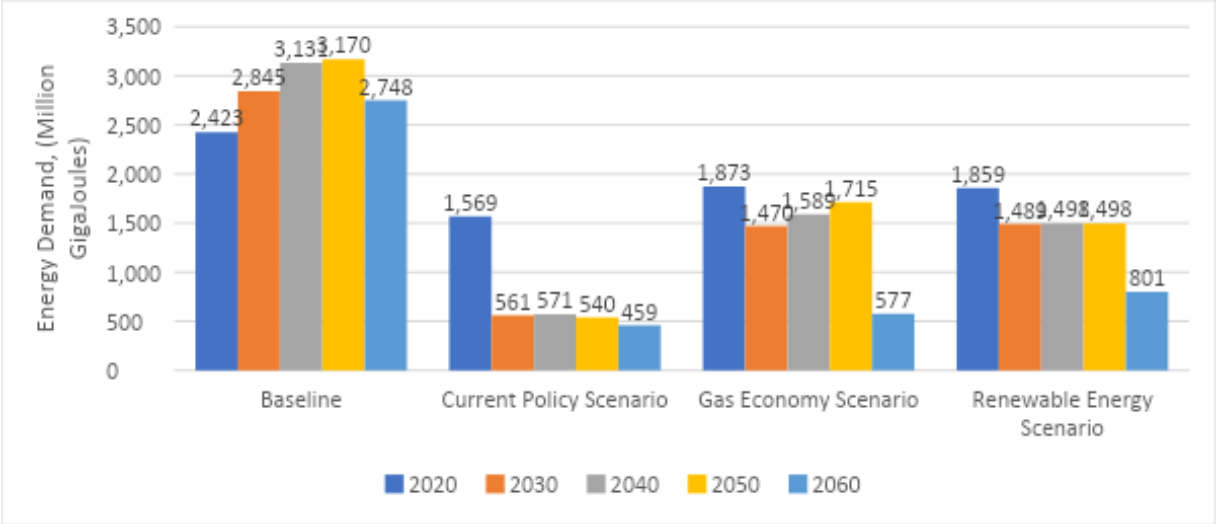


Figure 4. 5: Building and residential sector energy demand under various scenarios

The emission from the building and residential sector is presented in **Figure 4.10** which indicates that the emissions from the BAU grows moderately across the years at 26.0, 30.8, 33.8, 34.4 and 30.4 $mtCO_{2e}$ in 2020, 2030, 2040, 2050 and 2060, respectively. However, emissions from CPS, GES and RES will reduce by 84%, 71% and 79%, respectively, in 2060 compared with the base year (2018) emissions. The high emission reduction in CPS is attributed to a high level of electrification (71%), and moderate use of gas (8%) in the building and residential sector compared to 46% and 11% and 44% and 1% electricity and gas utilization for GES and CPS, respectively. The emissions were assessed with respect to building operations, referred to as ***operational emissions***; whilst other forms of emission obtainable from this sector which are produced during the mining, processing, manufacturing, transporting, and installation of building materials are referred to ***as embodied emissions*** are accounted for in the industrial sector. The major drivers of energy demand and emissions in the residential sector are population growth, household income and urbanization recognizable in (i.) an increase in population causing demand for new residential floor spaces; (ii.) more construction of a new building to bridge the current housing deficit in the country; (iii.) high cost of living pushing low-income earners to use ineffective appliances and fuels; (iv) more demand for residential floor spaces by high-income earners; (v) demolition and upgrade of old buildings to modern buildings in the urban areas; (vi) changes in construction practices (vii) increase in end-use demand and energy intensity; amongst others. Activities in the residential sector from which GHGs result are cooking lighting, refrigeration air-conditioning and the construction process, these demands vary between the urban and the rural sectors.

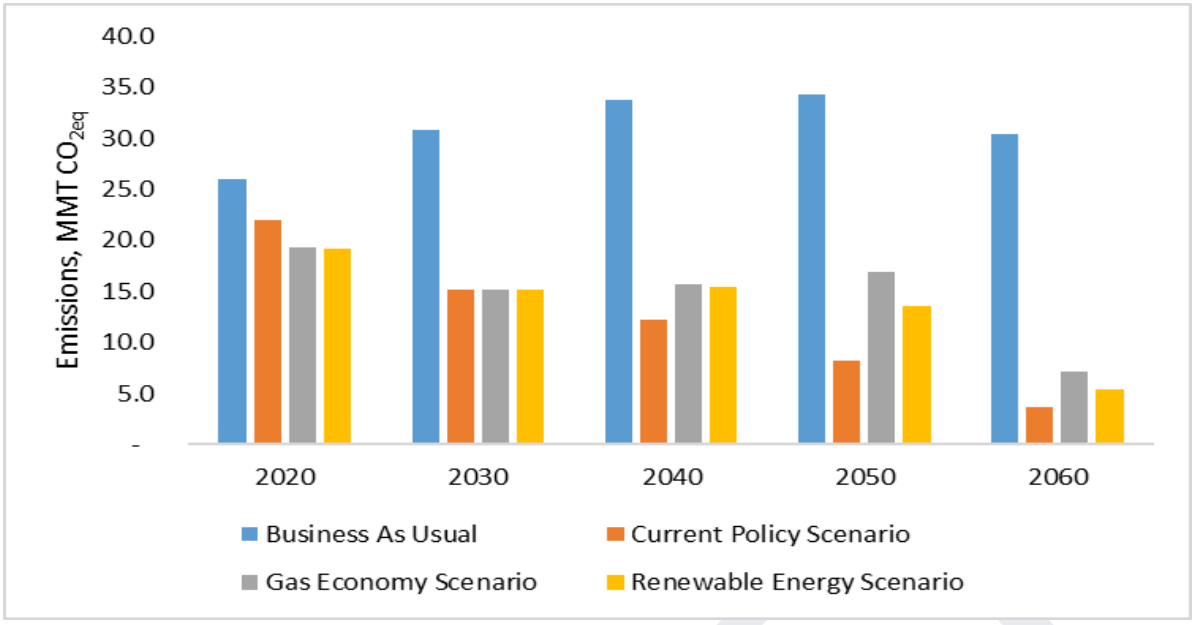


Figure 4.10: Building and residential sector emissions from scenarios

The energy resource assessed in the residential sector includes electricity (off-grid and on-grid), natural gas, liquefied Petroleum gas (LPG), kerosene, wood, charcoal, dung, and other biomass waste, solar and candle, with percentage contribution shown in **Figure 4.11**. The relatively high volume of wood and charcoal use in GES and RES by 2060 is attributed to the significant adoption of improved cookstoves matched with the reforestation programme at the rate of 5% and 2.3%, respectively.

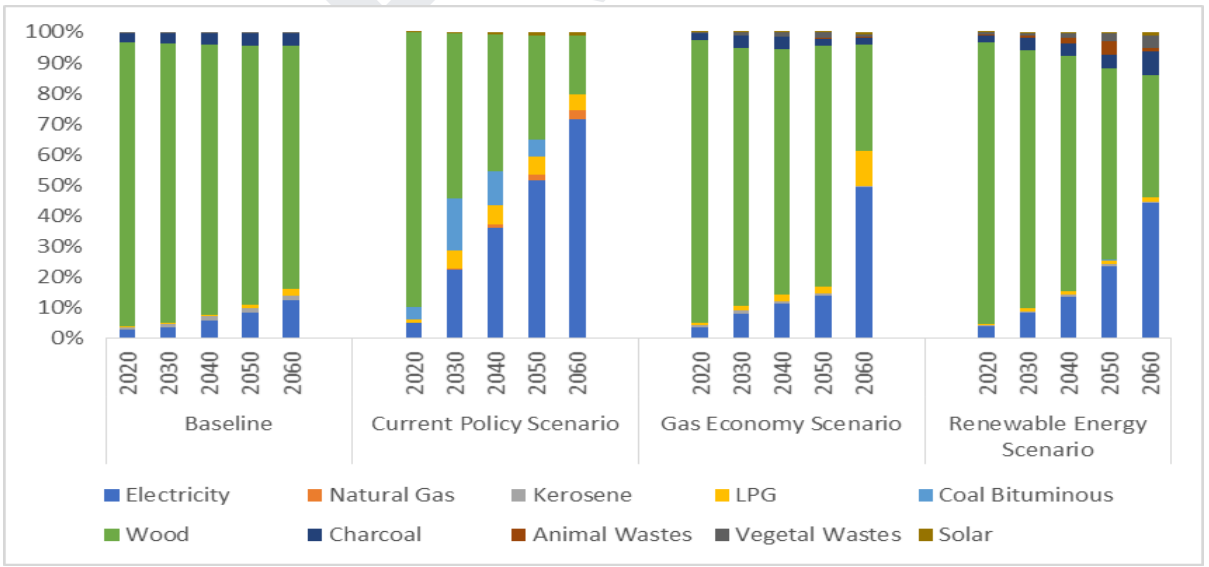
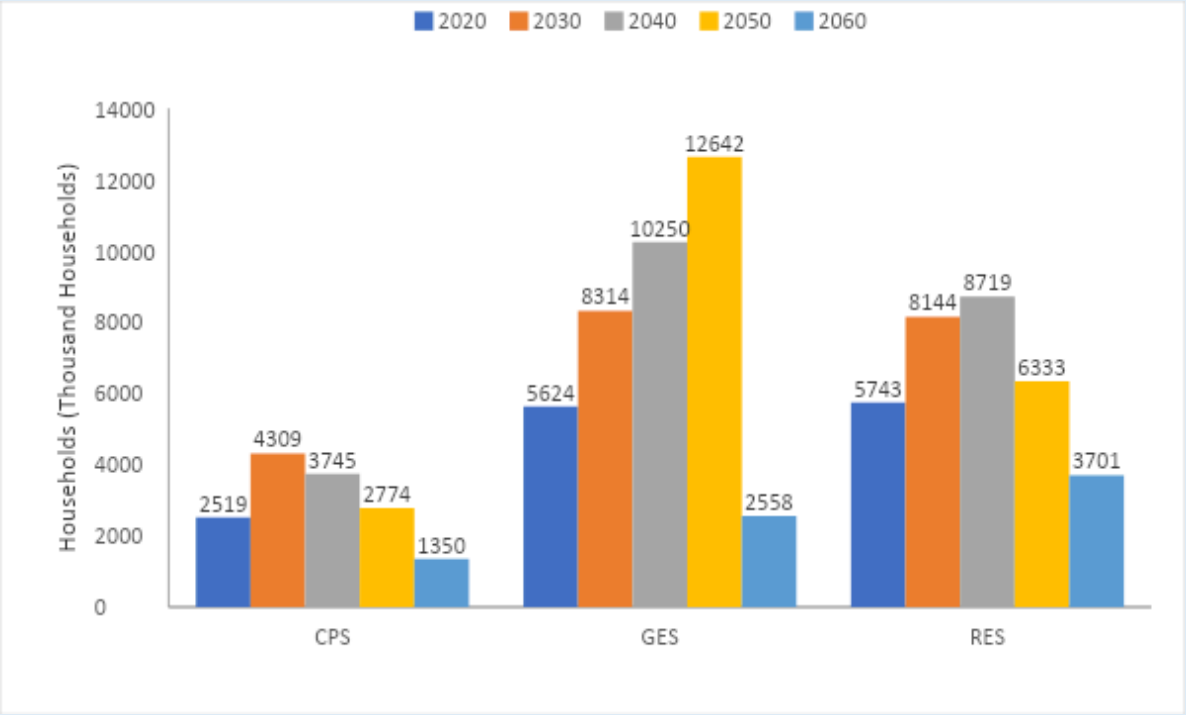


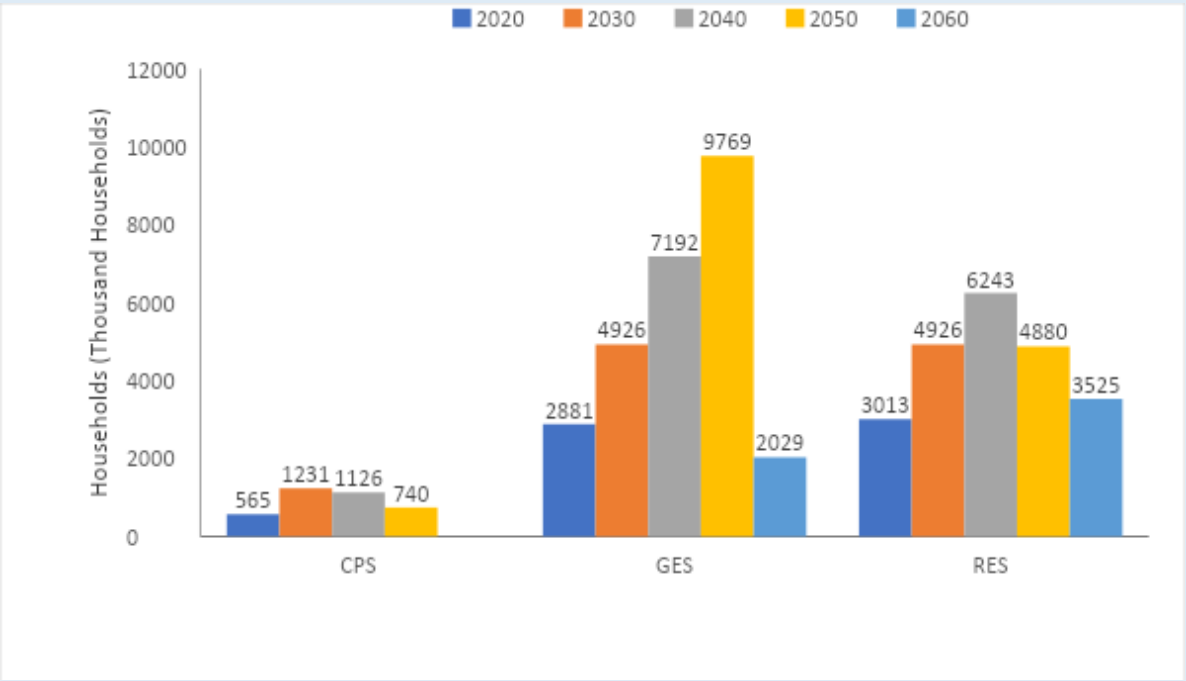
Figure 4.11: Percentage share of fuel used in building and residential sector

Figure 4.12a shows the number of households that will use the improved cookstoves, across the horizon for the three decarbonization scenarios. As expected, the RES has the highest number of households that will use the improved cookstoves by 2060 because the improved cookstoves can be classified as renewable energy with the adequate match of reforestation and forest management programmes. However, the number of households using improved cookstoves (4.31 million households) in the current policy scenario (CPS) is less than the number (7.3 million households) presented in the NDC by 2030, which reflects the ETP electrification of cooking services since CPS is anchored on NDC and ETP.

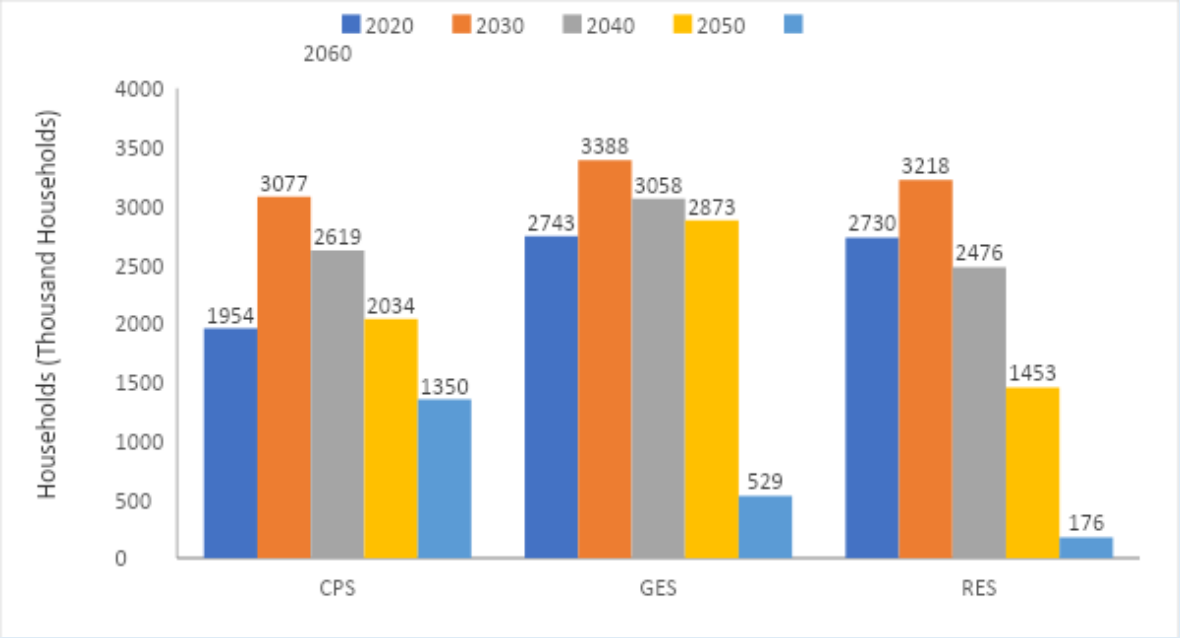
Figures 4.12b and **4.12c** show the share of urban and rural of the number of households with improved cookstoves, with the urban population having a higher share because of the growth in urban population; urban households grew from 56% in 2020 to 81% by 2060. The adoption of improved biomass cookstoves (especially in the GES) was envisaged to be driven by the freezing of petroleum products subsidies which will drive prices of kerosene and LPG higher with the resulting shift to biomass use, especially in rural communities. However, health concerns about the use of improved biomass cookstoves are still a subject of debate and research as some existing improved biomass (briquette and pelletized biomass) cookstoves show reduced health risks. *(Thakur et al. (2018).*



(a) Total number of households using improved cookstoves



(b) Rural split of households using improved cookstoves



(c) Urban split of households using improved cookstoves

Figure 4.12: Number of households using improved cook stoves under various scenarios

4.3.2 Mitigation Measures for the Building and Residential Sector

The vital strategic measures to reduce GHG emissions in the building sector and make buildings considerably more energy efficient and transit to net-zero emissions by 2060 will focus on the following five key thematic areas:

1. Improving access to clean and affordable energy in residential buildings, which includes 90% of households in the urban areas and 80% of households in the rural areas using electricity from clean sources by 2060.
2. Ensuring massive penetration of renewable energy technologies for household use such as adoption of improved cookstoves includes replacing inefficient technologies by 100% with efficient ones by 2060.
3. Sensitising private sector participation in supporting households in acquiring the appropriate renewable energy technology that includes a share of clean cooking to 50% in 2030 and 95% in 2060.

4. Providing subsidised renewable energy materials and equipment and ensuring a pricing structure and feed-in-tariff (FiT) for the household renewable energy equipment.
5. Encouraging the construction of green buildings through the development/implementation of relevant policies.

The mitigation strategies presented will help reduce emissions from the residential and building sectors by at least 79% compared to the 2018 emissions of about 25 mtCO2e from the building and residential sectors of the country. However, for effectiveness, these measures are to be implemented with a Nationally Appropriate Mitigation Actions (NAMAs) policy framework that will prioritise the building and residential sector in the country's national climate change strategies as key to meeting national GHG emission reduction targets in the building sector. The Government will also use appropriate policy instruments such as regulatory, fiscal, economic, informational and capacity-building measures to (i) increase the energy efficiency of buildings; (ii) increase the energy efficiency of appliances that use energy; (iii) encourage energy generation and distribution companies to support emission reductions in the sector; (iv) change attitudes and behaviour towards energy consumption; and (v) promote the substitution of fossil fuels with renewable sources of energy. *(UNEP (2009).*

4.4 Oil & Gas Sector

4.4.1 Emissions from Oil and Gas Sector

The oil and gas sector is one of the main drivers of the Nigerian economy. Oil has contributed significantly to the total export revenue since the 1990s, for example, over 86% of the total export revenues in 2021*(OPEC, 2021).* According to a study conducted by the Central Bank of Nigeria (CBN) and the Nigerian Institute of International Affairs (NIIA), foreign direct investment in the oil and gas sector significantly impacts Nigeria's economic growth. But even if the oil and gas sector remain reasonably strong over the next three decades, the imperative to decarbonize the sector remains strong, given its contribution to climate change. In addition, it is necessary for Nigeria to seize the opportunities in the global shift from oil and gas utilization to the decarbonization space to position its economy on the path of shared socio-economic prosperity in the long term. For example, the current analysis

shows that more than 50% of the emissions from the energy sector were from the oil and gas subsector in 2018, which are related to commercial production and transformation of oil and gas.

Figure 4.13 shows the emissions from the scenarios with respect to the time horizon under the oil and gas sector. As expected, the figure indicates that the BAU has the highest emissions across the years under consideration. However, there will be remarkable reductions in emissions in the next four decades, for example, about 79 % emission reduction in 2060 compared with the base year (2018) emissions. The GES and RES have a huge reduction in emissions in 2060 compared with 2018 emissions at 97.4 % and 98.5%, respectively. The drastic reduction can be attributed to the use of carbon capture technology, the application of advanced technology for methane leak containment, the elimination of gas flaring and the elimination of other fugitive emissions.

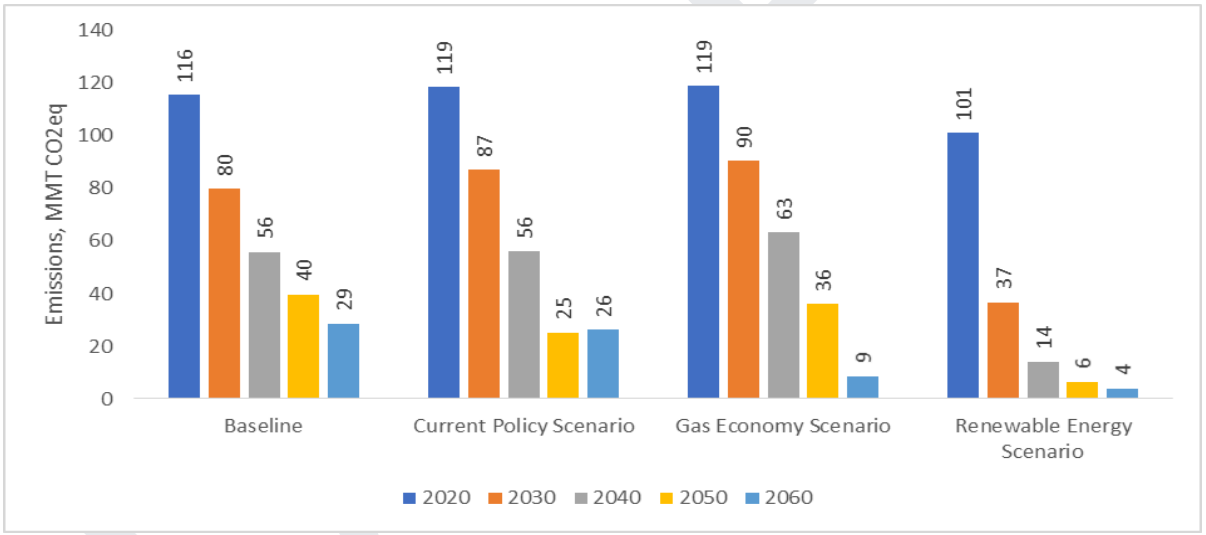


Figure 4.13: Emissions from the oil and gas sector under various scenarios

Figure 4.14 presents the contributions of emissions from the oil and gas sector to the total emissions under various scenarios and time horizons. It is shown that between 2020 and 2030, the oil and gas sector will contribute significantly to the total emissions across the scenarios, which is followed by average marginal reduction beyond 2030 except for the RES scenario. The relatively high percentage in emissions contribution between 2050 and 2060 by the oil and gas sector (at low emissions of 4 $mtCO_{2e}$ in 2060, for example) under the RES scenario is attributed to massive natural-based carbon sink due to reforestation (at the rate of 2.3% per annum) and excellent forest management. The natural carbon sink (negative emissions) from the AFOLU sector will intuitively amplify the little emissions (4 $mtCO_{2e}$) from the oil and gas sector in the total emission (14 $mtCO_{2e}$ in 2060, for example). In addition, the oil and gas sector emissions contribution to the aggregated energy sector in 2030 and 2060 will be 30% (BAU), 39% (CPS), 37%

(GES) and 22% (RES), and 4.5% (BAU), 17.7% (CPS), 1.2% (GES) and 5.4%(RES), respectively,

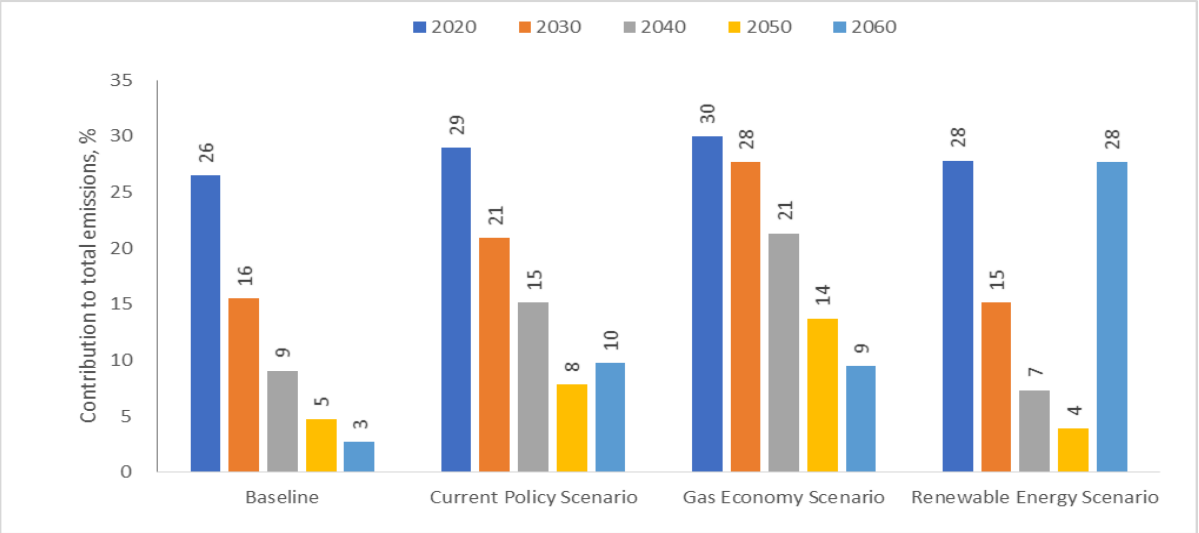


Figure 4.14: Oil and Gas Sector Emissions Contribution to Total Emissions

4.4.2 Mitigation Measures for the Oil and Gas Sector

From the scenarios analysis, the strategic measures recommended for reducing emissions from the oil and gas sector by over 96% to achieve net zero in 2060 include the following:

1. Introducing and/or accelerating the uptake of carbon capture storage technologies at a 10% annual growth rate with emphasis on the following:
    - Deploying significant CCS on production platforms.
    - Significantly Deploying CCS throughout the value chains of oil and gas
    - Accelerating the standardization of CCS to improve its cost, scheduling, and safety, enabling its widespread implementation using best global practices.
    - Aggressive financing of CCS technology, deployment, and capacity building to target local professionals.
    - Building capacities in Measurement, Reporting and Verification (MRV) to quantify emissions granularly.
2. Improving emission management in the oil and gas sector to attain a 97.5 % reduction in process gas losses, mainly methane leak containment through early carbon capture technologies.
3. Enabling policy that mandates all oil and gas companies to present annually verifiable Measurement, Reporting, and Verification (MRV) showing the greenhouse emissions from their organisation.
4. Eliminating gas flaring by 2030 entails adopting industry standards to reduce GHG emissions while minimising natural resource loss from the gas flare to achieve 0 % gas flaring by 2030.

5. Deploying advanced fugitive emission curtailment technologies to achieve at least 85 % methane leakage by 2050 and progressively to 98 % by 2060 that include effective regulatory measures.
6. Incorporating renewable energy technology into the sector to meet at least 50 % of operations' energy demand by 2050.
7. Using gas in the form of LPG as a transition fuel in the short term to facilitate the establishment of low-carbon energy development to address the nation's clean cooking deficit. This measure will be emphasised by:
    - Providing infrastructure to support nationwide gas collection, transmission, and distribution.
    - Sensitisation on clean cooking initiative
    - Incentivize industrial and domestic consumers to shift to gas usage.
    - Support standardisation and rapid adoption of technologies across the sectors.

The Government will continue to build on the momentum of the Energy Transition Plan (ETP) in integrating the country's energy mix to align with the net-zero target. Regulations currently in the process of implementation and those still under development represent a radical shift towards lowering and ultimately removing emissions across the upstream, midstream, and downstream sectors of the oil and gas. The mitigating measures take cognisance of the energy trilemma/dilemma and aim to strike the necessary balance to achieve the energy transition plan of the country.

In line with the National Gas Policy, the scenarios analysis clearly shows gas as the transition path for the country as it moves Nigeria from a crude oil export-based to a gas-based industrial economy by 2030. Nigeria has about 209.5 trillion cubic feet *(2020 PWC Report).* It is an enormous resource that would drive cleaner, affordable, sustainable, and secured energy balance for the country. The Petroleum Industry Act (PIA) 2021 aligns very well with implementing measures vis-a-vis collaborations with several industry regulators across upstream, midstream, and downstream sectors to achieve the net-zero target.

4.5 Industrial Sector

4.5.1 Emissions from Industrial Sector

Several forms of pollution including the release of greenhouse gases (GHG), come from the industrial sector. Nevertheless, the industrial sector remains one active domain for both developed and developing nations due to its huge positive economic benefits while contributing to significant GHG emissions. In Nigeria, although the percentage of emissions contribution from industry is relatively low according to the current analysis (4.56 % in 2020), the sector still plays a huge role in the country's GDP contributing about 14.16 and 33.34 % between 1988 and 2018 of the nation's total *(National Bureau of Statistics, (2020)*.. Furthermore, with the country's population expected to reach nearly 401 million in 2050, making it the world's third most populous country, there is huge potential for industrial expansion in manufacturing, cement, and related subsectors that will substantially increase emissions.

The emissions from the industry sector are presented in **Figure 4.15**. From the

BAU, emission will reach 133.39 mtCO_{2e} in 2060, which is about 7 times the 2018 emissions. The cement industry contributed 42.9% (8.3 MMTCO_{2e}) of the industry emissions (19.34 mtCO_{2e} in 2018, whereas it will contribute about 43.9% (58.5 mtCO_{2e}) of the 2060 emissions under the BAU scenario (2.3% increase). However, the emission presented does not account for the emissions associated with power generation to avoid double accounting of the power sector emissions.

The emissions from GES and RES are steadily decreasing because of the massive utilisation of carbon capture and sequestration technology and electrified efficient systems in the cement industry. To obtain the industrial emissions reduction in 2060, the CPS scenario will require about 42 % of CCS in energy requirements from natural gas utilizations. Similarly, the GES and RES will require about 58 and 22 %, respectively of CCS.

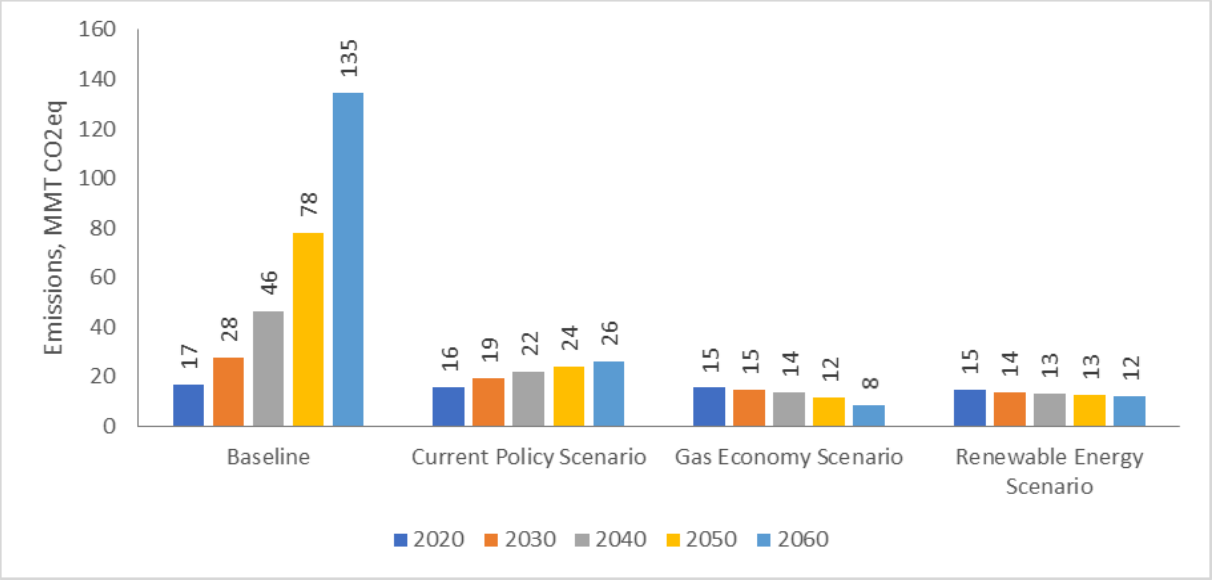


Figure 4.15: Industry Emissions from Various Scenarios

4.5.2 Mitigation Measures for the Industrial Sector

The following are four measures to take low carbon pathways such as energy efficiency, renewable energy, and resource waste reduction, among others, for the industry sector:

1. Developing and adopting Carbon Capturing, Utilization and Storage (CCUS) technologies, including pre- and post-combustion capturing processes. For example:

    - Capturing carbon from industrial process stream.
    - Adopting CCUS technologies in the cement industry by at least 58 % by 2060
    - Adopting of CCUS technology in other industries such as Rice Mills (parboiling of rice), fertiliser blending (Chemical Mixers), Aluminum Smelting and Iron and steel (Blast Furnaces), among others.
    - Reducing clinker-to-cement ratio by blending with mineral substitutes and using lower-carbon alternative fuels to fire the kiln.

2. Creating micro-distribution systems by creating clusters within areas for more accessible and straightforward energy utilisation. This requires:
    - Undertaking feasibility surveys and mapping industrial clusters
    - Determining the energy requirement for various clusters.
    - Connecting the clusters to various nearby non-grid power generation system
3. Immediate shifting to the use of bioenergy sources and adoption of cleaner energy sources in production processes
4. Incorporating the renewable energy mix in the industry, at least by the energy mix in the power sector
5. Using gas as a transition fuel in the short term to facilitate the establishment of low-carbon energy development to address industrial needs.

Enabling innovations for the implementation of these strategies in the industry sector will include:

i. Effective stakeholder engagement.
ii. Ensuring synergy among policies and institutions.
iii. Enhanced research on catalysis technology that can facilitate and improve the production process at a lower energy consumption.
iv. Syndicate financing and special intervention funds for the industry sector in implementing the LT-LEDS.
v. Promoting the implementation of policies (e.g., National Renewable Energy and Energy Efficiency Policy (NREEEP) (2015), the National Energy Efficiency Action Plan (NEEAP) (2016), and the Sustainable Energy for All (SE4ALL) Action Agenda (2016)) and regulations on industry-related to energy efficiency, renewable energy, and emissions regulation.
vi. Investing in innovative technology to locally produce more energy-efficient machines and equipment for use in the country at affordable prices.

4.6 Transport Sector

4.6.1 Emissions from Transport Sector

In Nigeria, transportation is a significant contributor to energy-related carbon emissions accounting for 16% of the national inventory (67.3 $mtCO_{2e}$ in 2018). The road transport segment is the most energy and emission intensive as it accommodates to a large extent the transport requirements of the population *(Emodi, N.V, Okereke, C., Abam, F.I., Diemuodeke E.O. et al (2022) Transport).* The road transport fleet increased from 8.5 million vehicles in 2000 to 12.4 million in 2018, mainly determined by private transport demand. Despite the rapid growth of the fleet, ageing vehicles lacking emission control technologies still characterize the fleet. Regarding urban passenger transportation, public systems and non-motorized modes are the predominant alternatives for travelling. Conventional transit bus systems are common in all cities in Nigeria, while the bus rapid transit (BRT) systems are in place in the largest cities, as can be seen in Lagos and Abuja. Regarding freight transportation, more than 90% of goods in the country are transported by trucks. In terms of energy demand, road cargo is the segment that uses the most energy and made up about 32% of all the energy demanded by road transportation in 2018. Most light-duty vehicles are gasoline powered, whereas heavy-duty vehicles, including buses and trucks, run on diesel. The share of other energy carriers, such as natural gas and electricity, contribute to less than 1% of the final energy consumption in 2018.

Energy consumption in the transport sector is expected to increase significantly with economic growth and population increase from 2018 to 2060. The transport sector model is divided into domestic aviation, road, rail, and domestic shipping. In domestic aviation, passenger air travels increased from 9.1 billion p-km to 131.1 billion p-km from 2018 to 2060. On the other hand, air freight increased from 19.8 million tonne-km to 286 million tonne-km between 2018-2060. Road transport is subdivided into passenger and freight. Passenger and freight vehicle activities within road transport rose from 9.6 and 2.7 million vehicles in 2018 to 51.2 and 14.4 million in 2060, respectively. Road passenger vehicles are composed of cars and taxis (62.8%), motorcycles and three-wheelers (12.8%), and buses (24.4%), while freight is composed of light-duty vehicles (59.1%) and heavy-duty vehicles (40.9%) in the base year, 2018. Similarly, rail transport is subdivided into passenger and freight, with rail passenger mobility increasing from 1.7 billion p-km in 2018 to 5.1 billion p-km in 2060, while rail freight movement increases from 168.4 million tonne-km to 1.34 million tonne-km between 2018 and 2060. Domestic shipping activities are projected to increase from US$649.1 billion to above US$6 trillion in 2060.

The transport model adopts the transport configuration of the National Gas Expansion Program (NGEP) and the 2021 updated Nationally Determined Contribution (NDC). The distribution of the transport sector and sub-sector emissions for the three scenarios under the period of 2020-2060 is shown in Figure 4.16. Across the alternative scenarios, emissions peaks in 2040 in the CPS (95.59 $mtCO_{2e}$) and 2050 in both GES (236.34 $mtCO_{2e}$) and RES (111.99 $mtCO_{2e}$) scenarios. The rate of decline, which visibly lowers the projected increase in GHG under the BAU scenario, is attributed to the policy assumptions outlined in Appendix 5.

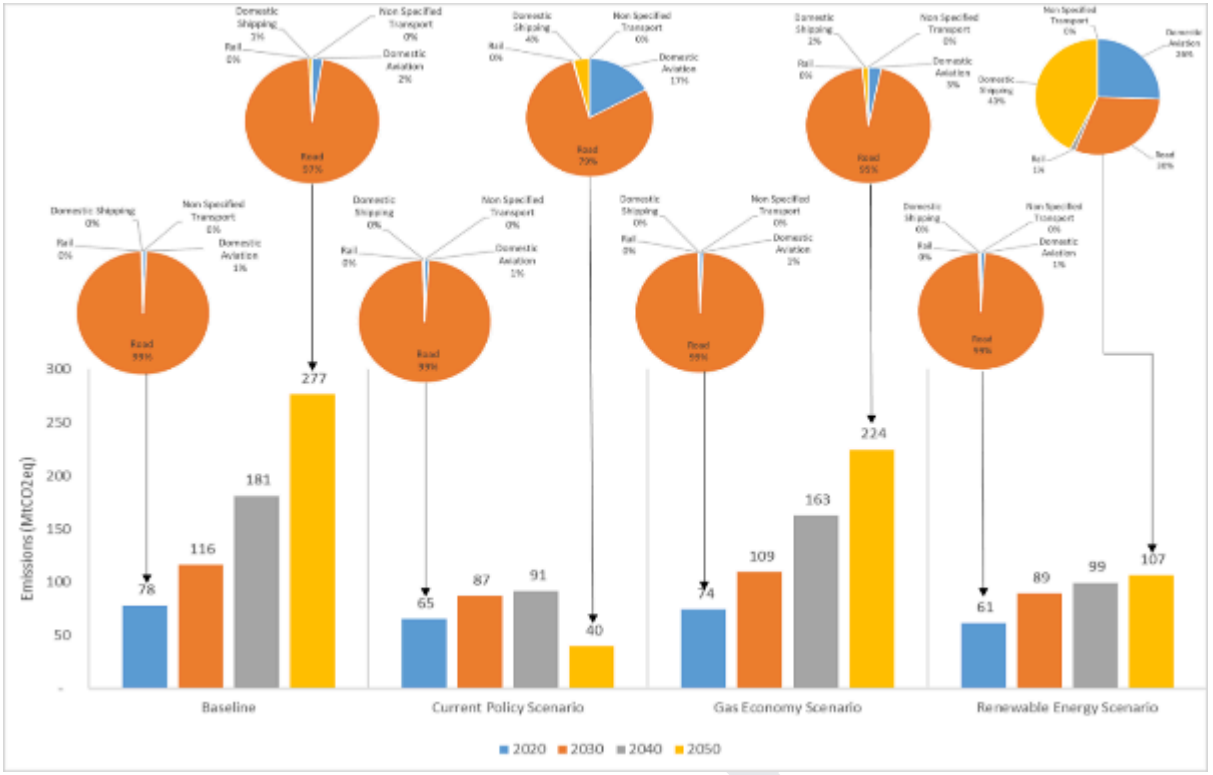


Figure 4.16: Transport sector GHG profile 2020-2060

Transport emissions under the GES are higher than the CPS and RES scenarios due to the high integration of CNG vehicles in the transport sector, which is expected to replace 45% of Nigeria's current passenger and freight mobility stock. Although non-mobility measures such as car sharing, cycling, and walking are implemented to decrease passenger movements within the model, emissions in the GES will only decrease to 212.45 $mtCO_{2e}$ by 2060. In the CPS scenario, the lower emission trend compared to the GES is attributed to the shift in transport mode as 43% of car users are expected to move to BRT buses following the updated NDC program. Also, the dependency on diesel for freight transport (LDV and HDV) decreases as the use of LPG and electricity increases by 15% and 85%, respectively. The decrease in emissions under the GES reshapes the percentage contribution of transport modes as road mobility emissions reduce to 79% in 2060 from 98% in 2020. In the more ambitious RES, Nigeria's transport sector is decarbonized with a target of shifting 50% of road passenger car transport to BRT buses and 40% of the buses are fully electric. About 80% of the remaining road passenger vehicles are expected to be electrified, while 40% of buses will be powered by ethanol before 2060. Other non-mobility measures are implemented in addition to the introduction of EURO IV efficiency standards for all road vehicles. A combination of the transportation sector policies in the RES will displace 205.62 $mtCO_{2e}$ and 51.34 $mtCO_{2e}$ recorded in the GES and CPS scenarios by 2060, respectively.

4.6.2 Mitigation Measures for the Transport Sector

The following are four proposed categorised strategies for low emission development in the transport sector of Nigeria based on the need to

(A) Wide adoption of electric vehicles (EVs) and ethanol vehicles through:

- Encouraging and promoting the use of electric and ethanol vehicles by at least 55 % and 45 %, respectively, of light-duty vehicles by 2060.
- The promotion of at least 40 % of the buses fully electric, about 80 % of the remaining road passenger vehicles electrified, and 40 % of buses powered by ethanol before 2060.
- The use of electric and ethanol-powered motorcycles and three-wheelers to substitute gasoline motorcycles and three-wheelers 100 % by 2060.
- The implementation of the national plan on electric vehicles (EVs), the National Vehicular Emission Control Programme (NVECP)
- The implementation of the Nigerian biofuel policy to support the adoption of ethanol vehicles.
- Providing charging infrastructure along major roads and designated public places.
- Providing incentives for private investment in EVs.

(B) Encouraging massive deployment of CNG and LPG vehicles up to 2060. Emphasis will be to:

- Accelerating the implementation of the Presidential CNG initiatives on national adoption of CNG-fuelled vehicles.
- Strengthening the adoption of Circular Economy principles, such as sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible.

(C) Adopting measures to reduce or avoid travel. This will entail:

- Making city centres 'Car-less' by encouraging the use of Mass transit options such as waterways, rail, and air.
- Focusing on Non-Motorised Transport (NMT) in the planning, design, managing and budgeting stages of transport projects, which includes the use of animal-cart in rural areas, cycling, etc

- Encouraging the use of bicycles as a green and environmentally friendly means of transportation by mapping out dedicated cycling routes in urban centres.
- Adopting up-to-date Transport Information Technology for efficient management of transport infrastructures.

(D) Shift to low carbon mode. This involves:

- Shifting 50 % of road passenger car transport to BRT buses.
- Improving vehicle standards, inspection, and enforcement of relevant regulations for behavioural change.
- Developing and implementing eco-friendly transportation policy and system.
- Embarking on public Sensitisation on safe driving and proper road use.
- Introducing EURO IV efficiency standards for all road vehicles
- Working with the private sector to transition to soot-free transport. (Box 2)

Box 2: Example of Private Sector-Led Transition to Soot Free Mass Transit.

To attain a climate friendly and sustainable city road transport system in Lagos State through the Lagos Metropolitan Transport Authority in 2022, signed with Oando Clean Energy Limited (OCEL) a Memorandum of Understanding. This enables the successful deployment of an Electric Vehicle Infrastructure Ecosystem (electric buses, charging stations, and other supporting infrastructure).

Over the next seven years, and through the rollout of over 12,000 buses, this initiative will transition the current combustion mass transit buses to electric, starting in Lagos State and eventually across the country. In the medium to long term, the efforts within sustainable transport will lead to improved air quality, enhance public health, enable the employment of at least 3,000 new drivers and an additional 2,000 workers to support bus maintenance, depot management, etc., as well as estimated economic cost savings of $2.6bn (3.6 per cent of Lagos's GDP)

The EV rollout plan is aligned with the Nigeria Energy Transition Plan, specifically supporting the Government's roadmap for EV implementation across Nigeria and its ambition to boost local capacity in the medium term through the construction of EV assembly plants.

Source: https://punchng.com/oando-receives-electric-mass-transit-buses-for-lagos/

4.7 Waste Sector

4.7.1 Emissions from Waste Sector

Wastes (solid and liquid) constitute a significant threat to health and the environment due to uncontrollable and illegally dumped wastes in open spaces without proper waste management *(Diemuodeke E.O. et al (2022).* Waste management aims to reduce the amount of "unusable substances" and prevent potential environmental and health hazards. In general, waste mismanagement is an epidemic in Nigeria, and it is responsible for air, soil, and water contaminations with severe health challenges. The waste, trash, or garbage, is derived from

the mix of everyday items from local residences, businesses, industries, and public institutions, including hospitals and schools. The wastes contain biomass-derived materials (for example, paper, food scraps, cardboard etc.) and non-biomass-derived materials (for example, plastics, glass, metals, appliances, and batteries). Biodegradable wastes are responsible for the emission of GHGs like methane, nitrogen oxide and carbon dioxide. In recent years, Nigeria experienced an increased volume of electronic waste (e-waste). Nigeria is the leading importer of electronic and electrical appliances in the African continent, with half a million-tonne of waste generation capacity annually *(UNEP, 2023).* E-waste is attributed to some health challenges like respiratory and dermatological diseases, eye infections and a decrease in life expectancy. However, the Nigerian Government has recently made move towards the curbing of the e-waste challenges in the country by amending the national environmental regulations for sustainable e-waste management *(NESREA, 2022).*

The emissions in the waste sector are presented in **Figure 4.17** The emissions in waste fall from 43.37 $mtCO_{2e}$in 2020 to 19.33 $mtCO_{2e}$ in 2060 and 40.73 $mtCO_{2e}$ in 2020 to 0.15 $mtCO_{2e}$ in 2060, for the GES and RES, respectively. The fall in waste emissions is due to improved waste management practices and waste-to-energy generation, assuming a circular economy, especially in RES. On the other hand, most of the waste in the RES is used for power generation, where the emissions have been well accounted for in the power generation processes using the waste.

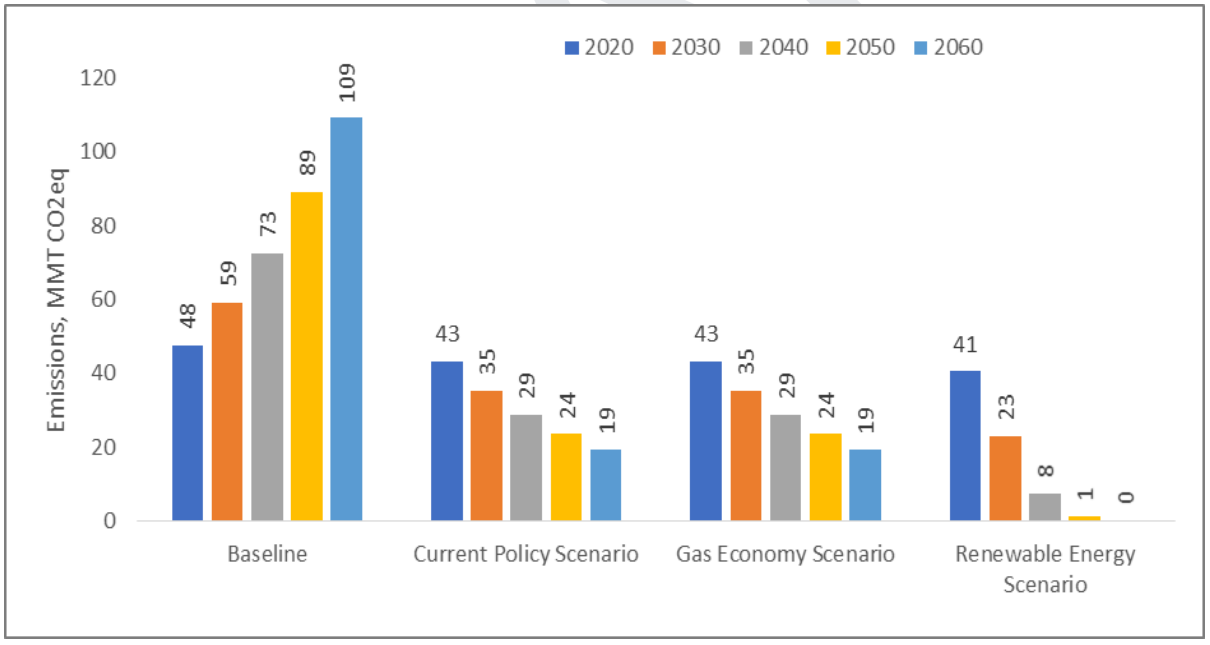


Figure 4.17: Greenhouse Gas Emissions in Waste

4.7.2 Mitigation Measures for the Waste Sector

The key strategic measure for the Waste Sector includes:

Adopting the circular and bio-economy approach is essential towards achieving long-term low emissions in Nigeria.

The mitigation strategies in the waste sector by 2060 will focus on the following two key thematic areas:

i. Adoption of the circular and bio-economy approach in waste management and
ii. Improving the waste management process.

Adoption of the circular and bio-economy approach in waste management. This will entail:

- Developing and implementing National and sub-national circular and bio-economy policies and action plans.
- Promoting and developing grassroots awareness campaigns to inform and influence more sustainable consumption patterns and product designs that efficiently utilise materials to reduce emissions.
- Promoting collaboration with the private sector to upscale and finance circular and bio-economy.
- Encouraging the conversion of organic /agricultural waste to animal feeds.
- Encouraging and promoting waste-to-energy technologies to support the power sector.

Improve waste management process. This involves:

- Adequately implementing and enforcing policy on waste management
- Setting up paper, plastic, glass and metal separation systems in all state capitals and municipalities.
- Adopting renewable energy in cooling storage systems to reduce waste and loss of food items.
- Promoting waste reduction through efficient material designs.

Overall, the Government of Nigeria will increase awareness and understanding of the circular and bio-economy coupled with all stakeholders taking responsibility and investing in solutions, especially adopting, and imbibing the circular economy paradigm in their everyday living. This will also remove the barriers of poor waste management systems and cultural barriers regarding lack of consumer interest and awareness and a hesitant use and recycling culture. Increasingly, there are demonstrable projects in this CE sector to ensure zero Carbon emission, for instance, through biomass waste (Box 3).

Box 3: Zero Carbon Emission through biomass waste-: Dangote Cement Plant Alternative Project

Dangote Cement Plc., Ibese Plant, recently announced is taking possession of some 100 trucks. The trucks are customized for easy transportation of biomass waste from all over the country for

the Alternative Fuel project. The Alternative Fuel Project presents a win-win opportunity for the Plant and Nigeria such that the waste that would have contributed to environmental degradation is being evacuated from the communities at a cost and employed as fuels in the Plant, thereby reducing the Plant's carbon footprint and energy cost and simultaneously providing direct and indirect job opportunities. The Plant is committed to collecting biomass waste from anywhere available to feed its alternative fuel machines during cement production in line with its zero-carbon emission blueprint and in conformity with the United Nation's Sustainable Development Goal No 13.

The dedicated and customized fleet would increase the availability of biomass waste for the Plant's consumption by 50%, thereby boosting the Plant's posture on partial substitution of fossil fuels.

The recourse to alternative fuel is strategic given that the cement manufacturing industry is considered a contributor to CO2 emissions globally. Cement production requires massive amounts of energy, while carbon dioxide is emitted during the conversion of limestone, a key natural ingredient, to clinker, an intermediate component of finished cement. Emissions also arise from the combustion of fossil fuels in the kiln and the production of electricity to power the Plant".

In summary, while the goal is to divert waste from landfills, it serves to reduce its carbon footprint, conscious of the impact of global warming and carbon emissions. Simultaneously it is aimed at providing sustainable income opportunities for numerous households that are part of the agro-waste value chain.

Source :
https://theeagleonline.com.ng/zero-carbon-emission-dangote-cement-ibese-commissions-trucks-for-biomass-waste-management/

4.8 Macro-Economics Implication of the Long-Term Low Emission Strategy

Policymakers expect to understand the long-term impacts of the long-term strategy beyond its techno-economic feasibility, energy supply and emissions impacts within the energy sector *(Emenekwe et al. (2022).* Given the vast importance of energy in several dimensions of human activities and the economy of Nigeria, it is expected that shocks in the energy sector (i.e., changes in key energy variables) would extend to other sectors and affect macroeconomic outcomes. The impacts could be measured in terms of real gross domestic product (including per capita) impacts, households' available income, employment, etc. Therefore, the macroeconomic modelling presented below is a first exploration of the macro- and socio-economic consequences of decarbonisation pathways for the Nigerian economy in the medium run, based on a coherent, hybrid modelling framework.

4.8.1 Macroeconomic Scenario Description

The KLEM-NGA model was produced by coupling with the LEAP-NGA and used to explore five scenarios:

- A Baseline scenario that projects the Nigerian economy in the absence of any major change of its energy system, but under the assumption of structural transformations allowing it to converge to a stabilised growth path in year 2035 (**Baseline**).

- Deriving from the Baseline, three distinct evolutions of the Nigerian energy system (described in section 3.2) (**CPS**, **GES**, **RES**).
- One last scenario considering the RES evolution of the Nigerian energy system but relying on international aid to fund the incremental energy supply investment required to shift from the CPS to the RES energy trajectory (**RES+**).

Each of the five scenarios builds on sets of both shared and specific macroeconomic and energy assumptions.

4.8.2 Macroeconomic Scenario Assumptions

Four macroeconomic assumptions are used to calibrate the model with three of them common to all scenarios. The first two macroeconomic assumptions common to all explored scenarios are the potential economic growth and the underlying investment effort. The third assumption is a trade balance trajectory constraint, and is common to Baseline, CPS, GES, and RES scenarios, but not for the case of RES+ scenario. The fourth macroeconomic assumption, which is a positive trade shock is also common to all scenarios.

The first macroeconomic element common to all the scenarios is potential growth, resulting from the combination of exogenous assumptions of active population growth (interpreted by KLEM as the labour supply) and labour productivity (**Figure 4.18**). These assumptions are deduced from the statistical series of real GDP and employed population reported by the World Bank for Nigeria from 2018 to 2021. The dynamic calibration allows, therefore, to include the effects of the Covid-19 pandemic. Subsequently, they are inspired by the second scenario of the Shared Socioeconomic Pathways (SSP2) developed by the Intergovernmental Panel on Climate Change (IPCC). The potential average annual growth rate of real GDP resulting from these assumptions over the period 2021-2060 is 5.87%. This growth rate fares better than Nigeria's historical trends of 3.68% over 1961-2021, 3.07% over 1980-2021 or 5.23% over 2000-2021(World Bank's World Development Indicators Database).

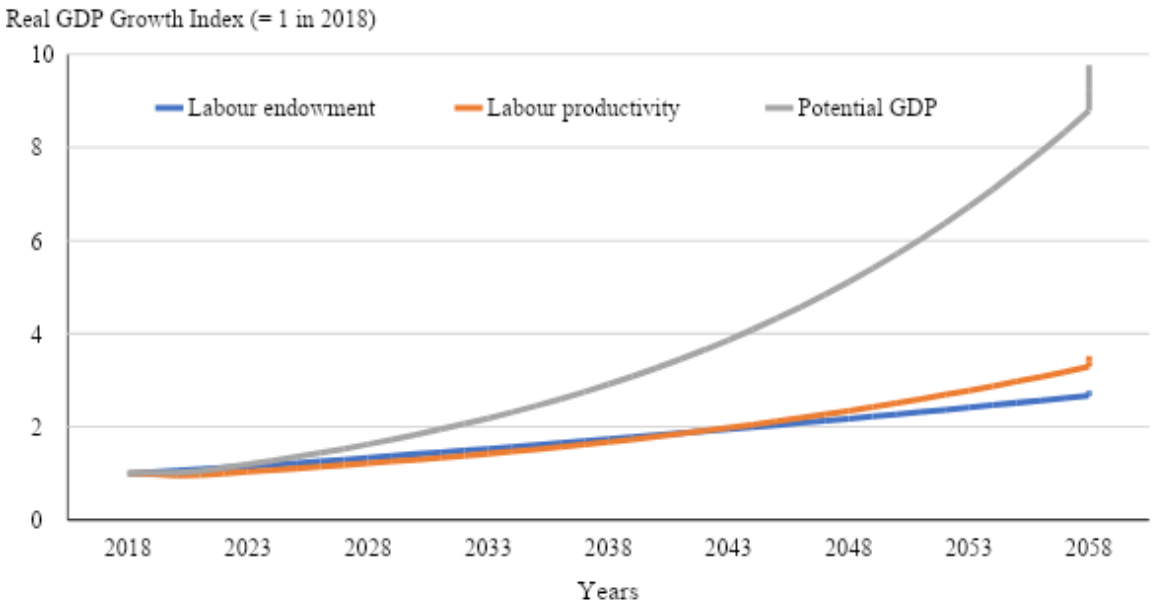


Figure 4.18: Exogenous Labour Productivity and Active Population (Labour Force) Trajectories, which Define Potential Growth in KLEM-NGA *(World Bank data (2018-2021),*)

The second macroeconomic element common to all scenarios is the assumption regarding the investment effort[18]. Calibration of the investment rate trajectory on the potential growth trajectory results in investment efforts declining slightly over the projection horizon, starting at 33.1% in 2021 and declining to reaching 28.7% of GDP in 2060. The third macroeconomic assumptions encompass a gradual (linear) reduction in the trade deficit in goods and services, including energy, from its estimated level of -3.5% in 2021 to -1% in 2035 and beyond.[19] This is common to all scenarios except RES+. In the RES+ scenario, however, the trade balance objective is relaxed by an amount equivalent to the difference between the investment in energy supply required in the CPS and RES scenarios. The underlying policy assumption is that, in the RES+ scenario, Nigeria benefits from foreign transfers (without repayment required) corresponding to the level of necessary incremental investment in the energy sector to shift from the CPS to the RES energy trajectory. This constraint on the trade balance aims to reflect the Nigerian economy's expectations and development objectives in the medium term.

Without additional assumption, under the baseline scenario, constraining trade deficit to -1% induces a downward adjustment of the real effective exchange rate (REER[20]) of the Nigerian economy in KLEM-NGA, thus implying an increase in the cost of Nigerian imports relative to domestic consumption and a gain in competitiveness for the country's exports on world markets, to reach the targeted trade deficit. This downward adjustment in the exchange rate inevitably leads to a decrease in the purchasing power of Nigerian wages, as imported consumption becomes more expensive. As the desired trade balance is achieved through a relative price adjustment, we can expect that the constraint of a gradual control of the trade deficit accumulation, and thus the country's external debt, results in macroeconomic and social performances that are below the average annual potential growth deduced by labour endowment and labour productivity (see **Figure 4.19**). As a matter of fact, the unemployment rate nearly triples—reaching 26%—in 2060 in the Baseline scenario, compared to an already high 8.46% level in 2018, while the annual average GDP growth rate reaches 4.45%, thus below the growth potential of 5.57% for the 2018-2060 period, due to a decrease in consumption by households of both imported and domestic goods and services. Moreover, based on the GDP index, this would translate into a GDP 33% below its potential in 2060.

[18] There is no assumption regarding capital productivity. Transformations, notably linked to structural changes in the economic activity, will be more legitimately analysed within the multisectoral framework of IMACLIM-NGA, of which KLEM-NGA is the precursor.

[19] The option of an exogenous investment effort and trade balance corresponds to the so-called Johansen macroeconomic closure: public policies control the level of savings in the national economy to guarantee a certain investment effort, given the contribution of imported savings (the opposite of the goods and services balance).

[20] The REER is defined as the relative price level of the Nigerian household consumption basket and the import basket of the economy. Like most macroeconomic models used in the energy/economy forecast, KLEM does not represent any currency, which it therefore implicitly considers as neutral. The REER fluctuations calculated by the model can however be interpreted as nominal exchange rate adjustments of the same magnitude, which would have a similar effect on the competitiveness of the economy.

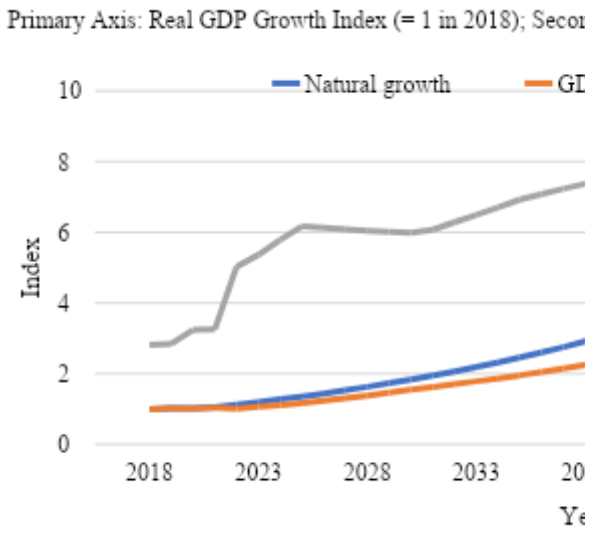


Figure 4.19: GDP Index and Unemployment Rate Development Assuming Only Trade Deficit[21]

Accordingly, *due to the unacceptable socioeconomic performances of the Baseline scenario, it was decided to create an additional macroeconomic variant, encompassing a structural transformation of the Nigerian economy.* This variant simulates a positive non-price competitiveness shock that reduces the trade deficit and increases non-energy exports while negatively impacting non-energy imports and unemployment rates. Rather than assuming some level of shock and measuring its macroeconomic consequences, the flexibility of KLEM allows to reverse causalities and reveal what shock is necessary to converge the Nigerian economy towards some stabilised growth path. We define that path by extending the macroeconomic constraints of the model to the socioeconomic objective of the unemployment rate declining from 8.46 % in 2018 to 5.0% in 2035 and beyond This resulting shock level—estimated under the baseline conditions—was uniformly applied across all scenarios. The magnitude of this shock, corresponding to the implementation of public policies aimed at generating a positive, non-price competitiveness and development of exports capacities of non-energy goods and services, must grow rapidly to reach 74% in 2030, before culminating at approximately 100% in 2035, then slowly decreasing down to 78% in 2060. The actual magnitude of the shock is better interpreted by considering that non-energy imports and exports mobilise respectively 13.2% and 2.4% of Nigerian GDP at our 2018 calibration year. The development of domestic alternatives to imports is thus the major political objective to be pursued to concretise our Baseline scenario.

Figure 4.20: Trade Shock (Index 1 in 2018), Baseline Scenario[22]

[21] Computation released by the author using the KLEM-NGA model)

[22] Computation released by the author using the KLEM-NGA model)

4.8.3 Macro-Economic Scenario Results

The first set of key results (see Figure 4.21) show the implication of the scenarios on economic activities. At first glance, it appears as though energy system options do not to significantly impact Nigerian activity growth over the explored horizon (Figure 4.21, left panel). By design, the positive trade shock introduced to shape the Baseline scenario into a 'stabilised' benchmark trajectory, i.e. one of controlled trade deficit and reduced unemployment, induces growth roughly in line with its potential of combined labour supply and productivity gains (see Section .4.8.2).[23] The sustained pace at which this potential increases dwarfs any activity differential across scenarios.

However, the year-by-year gap between the GDPs attained by each scenario (Figure 4.21, right panel) makes for better reading of results. In broad terms, the CPS and GES Scenarios lead to economic activity levels that are slightly higher than Baseline activity, while the RES activity increasingly lags behind all three. However, the RES+ marks the benefits of the surmised international support that differentiates it from RES: it dominates all other scenarios up to 2054, when it roughly falls in line with the more active of them (first with CPS then with GES).

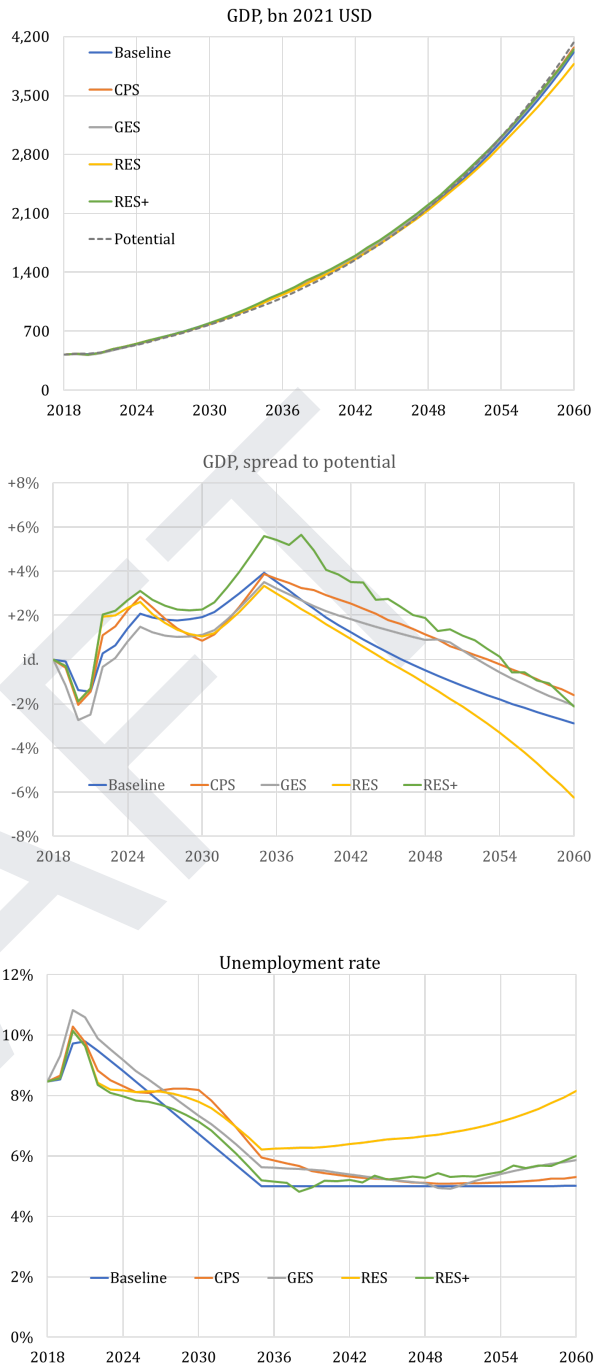


Figure 4.21: Economic Activity of the Scenarios[24]

Before 2035, the growth of all scenarios increasingly overshoots its potential thanks to the gradual reduction of the unemployment rate (**n**Figure 4.21, lower panel).[25] The positive trade shock benefits

[23] It is important to underline again that this economic performance is conditional to the successful implementation of public policies aimed at generating the positive, non-price competitiveness shock, at no macroeconomically significant cost.

[24] Computation released by the author using the KLEM-NGA model)

[25] Potential growth only considers labour supply (active population) and labour productivity variations, under the implicit assumption of a constant unemployment rate.

activity by mobilising more of the available workforce to address the rising foreign demand for Nigerian exports and, more importantly, the substitution of national production to imports. The 2035 peaking of the favourable trade shock (see .Figure 4.20) induces a sharp turning point for the comparison of all scenarios to potential growth as well as, expectedly for their unemployment results.[26] Detailed modelling results highlight two major causes to that scenario differentiation: the impact of scenario assumptions on the cost share of energy in non-energy production, and that on energy trade.

Non-energy production constitutes the larger share of Nigerian economic activity. It generates 86% of Nigerian GDP at our 2018 calibration year, and the proportion increases through time in all scenarios as the limited availability of oil and gas resources significantly constrains the development of energy supply activities. KLEM is designed in such a way that any increase of the cost share of energy in non-energy production drags growth of that production below its potential through losses of competitiveness on domestic and international markets, in favour of the international variety of non-energy goods and services. The evolution of that cost share hangs in turn on the combined evolutions of the energy intensity of non-energy production and of the price of energy to the non-energy producer.

In all scenarios, the energy intensity of non-energy production decreases through time (Figure 4.22, left panel). This implies energy efficiency gains. In the Baseline scenario, the gains happen at the average pace of 1.30% a year. CPS brings that pace to 2.01% a year, while RES and RES+ push it further to 2.33% and 2.31% a year. GES, which only records gains of 0.81% per year, stands out as more inefficient than Baseline. The RES, RES+ and CPS scenarios clearly achieve better efficiency gain due to the effort to improve energy efficiency as per scenario design.

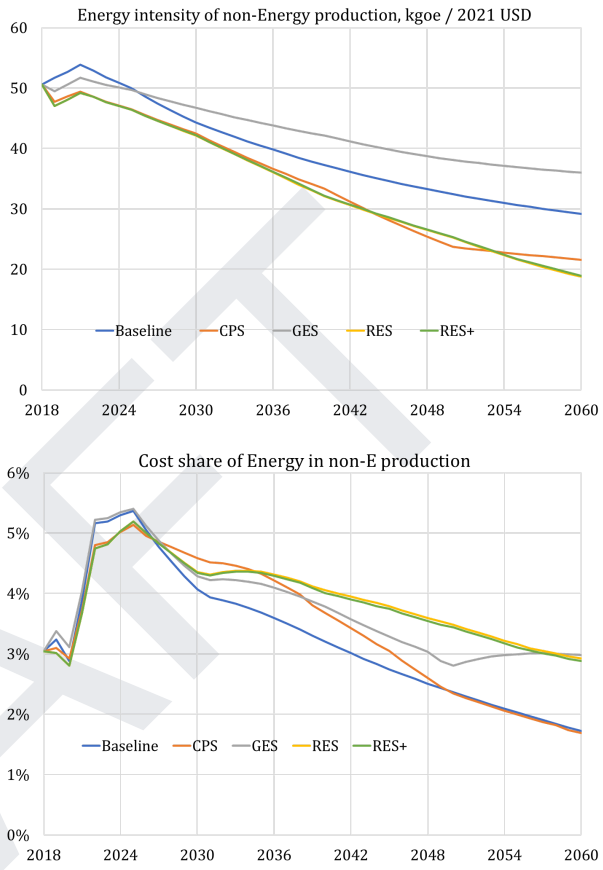


Figure 4.22: Energy intensity and cost share of non-energy production across scenarios.[27]

Energy cost for non-energy production rises the highest in baseline and GES up to 2025, and falls (for baseline) afterwards below every other scenario (Figure 4.22, right panel). The above ordering of cost share evolutions is the reason for the lower activity of RES compared to CPS or Baseline, as well as that for the relative closeness of the latter two scenarios. Higher cost shares affect competitiveness on domestic and international markets. However, the trade balance is pre-determined in all scenarios including

[26] The sharpness of the turning point must not be over interpreted. It results from the choice of a linear convergence of the unemployment rate to 5% in 2035 as target to the trade shock calibration process Smoother convergence assumptions would deliver smoother GDP and unemployment profiles.

[27] Computation released by the author using the KLEM-NGA model)

RES+ (although laxer). The loss of competitiveness thus induces downward adjustments of the real effective exchange rate (REER, the ratio of domestic to international prices) to warrant that trade balance objectives are met. These adjustments are the ultimate cause of the loss of activity through the increase of import costs for the producers and consumers alike. As could be expected from the modelling choice of controlling trade deficits i.e., the foreign debt accumulation, trade effects are central to the macroeconomic consequences of the energy system costs differentiation.

There are, however, more direct consequences of the five scenarios on trade (i.e., their impacts on the import and export of energy commodities). The impact of scenarios on energy trade and its propagation to non-energy trade via the trade balance constraint is the other major driver of scenario assessment. In Baseline, the unchecked rise of domestic energy consumptions disturbs the export capacity to the point that Nigeria becomes net energy importer (in money value) in 2042, ending up necessitating 0.89% of its 2060 GDP to cover the incurred net costs. GES also experiences a more rapid decline of its export capacity than other scenarios because of unchecked domestic energy demand increases. However, it allows Nigeria to remain a net energy exporter through the development of natural gas extraction, as well as the substitution of the domestically extracted gas to imports of refined oil products. Lastly, CPS, RES, and RES+ benefit from transitions of domestic energy demand away from fossil fuels that allow Nigeria, despite lower production levels, to remain a net energy exporter. In those three scenarios net export revenues, although rapidly declining in early years, remain above 2% of GDP.

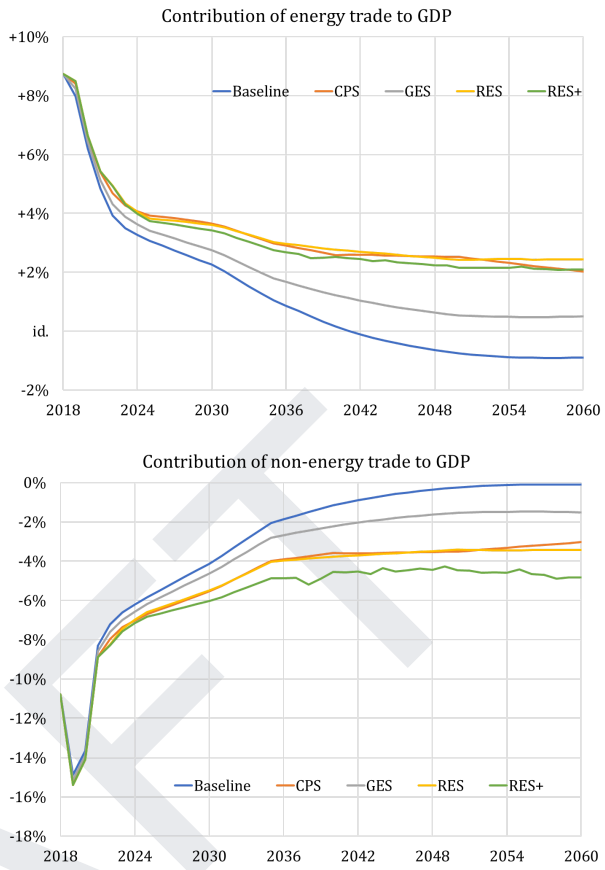


Figure 4.23: Trade implication of the scenarios.[28]

The 1% trade deficit objective of Baseline, CPS, GES, and RES warrants that the dynamics of the contributions of non-energy trade to GDP mirror those of energy trade (Figure 4.23, right panel). However, the RES+ non-energy trade contribution to GDP stands out as marking the slack on trade deficit being allowed by the international aid that differentiate it from RES. We thus identify this slack as the main cause of the performance of RES+ compared to RES, considering how close the two scenarios are on the energy cost share and energy trade indicators. In more detail, the RES+ scenario assumes international financial transfers amounting to an average 1% of Nigerian GDP from 2022 to 2060, with fluctuations corresponding to the chronogram of incremental energy supply investment required to shift from CPS to RES. Over

[28] Computation released by the author using the KLEM-NGA model)

the modelled period the cumulative international financial aid required amounts to 859 billion 2021 USD.

4.8.4 Key Messages from the Macroeconomic Analysis

The critical requirement for Nigeria's economic (and by extension LT-LEDS) future, is a structural transformation that induces local production and consumption of otherwise imported non-energy goods, and positive trade shock that doubles her export potential by 2035 compared to current levels.[29]

In this context of successful economic diversification, the five explored scenarios have limited impacts on either potential growth or the employment level. At the 2060 end year of the explored horizon, the GDP gap from the highest (CPS) to the lowest (RES) performing scenario is of 4.7%. It corresponds to the loss of 0.12 points of average annual growth, from 5.53% (CPS) to 5.41% (RES) (see **Table 4.1**).

Table 4.1: Macroeconomic Indicators by Scenario (2018-2060)

Scenario	Real GDP Growth Rates (annual growth rate 2018-2060)	Unemployment rate (2060)	Emissions (2060, MMT CO_2-eq)
Baseline	5.50%	5.00%	1,053
CPS	5.53%	5.30%	268
GES	5.52%	5.85%	92
RES	5.41%	8.16%	14
RES+	5.52%	6.00%	14

Overall, the RES+ holds the most promise as it achieves a low emission rate that is the same with the RES scenario in 2060, compared with BAU, and real GDP growth and unemployment rates of 5.52% and 6.00%, respectively (significantly lower than RES of 5.41% and 8.16%, respectively). International financial support to the RES+ extra investment effort compared to the Current Policy Scenario (CPS), at 1.7% of RES+ GDP in 2060, is the major cause for this performance gap.

However, over the 38-year period, the cumulated international financial aid to achieve the RES+ amounts to 859 billion 2021 USD. This is a rough half of the overall cost of Nigeria's Energy Transition Plan (ETP), estimated at 1.9 trillion USD. Although that level of support may be in line with the annual global USD 100 billion support pledge of developed countries in the framework of the UNFCCC—all the more so as up to 39% of the close-to 1 trillion aid would be required by Nigeria after 2055 only—, strong uncertainty remains about its concretization, as ongoing debates around the 100 billion pledge testify.

In case RES+ failed for lack of international support, CPS and RES can be interpreted as delineating the development versus carbon mitigation trade-off faced by Nigeria in coming decades. At 36.7% emission decrease by 2060 from current (2018) levels, the environmental performance of CPS does not pass the Nigeria's LTV-2050 of cutting emissions by 50% by 2050 (including 2060). Moreover, the RES increases that performance significantly, compared to CPS, by bringing emissions to 96.8% below current levels. However, this environmental gain comes at the economic cost of a 4.7% decrease of 2060 GDP, and at the social cost of a 2.9-point increase of unemployment. There is no doubt that a continuum of scenarios covers the environmental and economic ground in-between the CPS and RES, from which the Nigerian government could be inclined to choose. There is also the manifest possibility that options unexplored in the

[29] While halving her imports considerably.

proposed scenarios could improve on the terms of the revealed trade-off. Further implementation of the coupled KLEM-LEAP framework will strive to identify such options.

Strategic Priorities and Policy Measures Under Adaptation

Mitigating climate change alone will not be enough in the long-term strategies. As rightly expressed in Article 7 of the Paris Agreement, Nigeria like other countries, will need to continue to adapt to the unavoidable impacts of climate change, to build its resilience, reduce its vulnerability, and turn the problems of climate crisis into sustainable development solutions. Thus, in addition to mitigation, Nigeria will adapt to the unavoidable impacts by building resilience. This reduces the vulnerability to negative climate effects and can turn the problems of climate crisis into effective and sustainable development solutions for the sustainable growth of Nigeria as a country and its economy. Moreover, climate adaptation has many co-benefits, such as cleaner air, green job creation, and biodiversity improvement through the expansion of green space. Increased efforts in adaptation rather than mitigation over time may be necessary to meet the national target for climate-resilient sustainable development to be reached in 2060.

5.1 Climate Change Impacts in Nigeria and the Imperative for Adaptation

Nigeria has experienced temperature increases of 0.03°C per decade between 1901–2016, with stronger increases occurring over the last 30 years of 0.19°C per decade. The trends of the country's rainfall show a high degree of variability and the last six decades have witnessed an incremental decrease in seasonal rainfall across the country. Rising temperatures and large annual variation of rainfall, particularly in the northern parts of the country, has resulted in climatic shocks and hazards, such as floods and droughts (World Bank Group, 2021). This variability in weather extremes, coupled with the expected global warming-induced sea level rise, are expected to have even more significant impacts on the country's economy as already have been identified. Some of these expected climate change impacts are summarised in Table 5.1 for the relevant sectors in Nigeria.

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Table 5. 1: Some expected climate impacts and associated vulnerabilities

Sector	Expected climate change impacts

Agriculture	• Reduced yields from increased temperatures, particularly for rice with expected nutrient decline of up to 17% • Reduced livestock productivity, particularly in arid and semi-arid regions, due to stressed grazing lands and direct impacts of heat on livestock health. • Crop failure or reduced growing season due to unpredictable rain patterns, intense storms, and floods. • Increased damage to crops and livestock from pests and diseases. • Agricultural productivity in general could decline between 10 to 25 per cent by 2080
Water Resources	• Possible reduced river flows (especially east and central Niger Basin), impacting water supply. • Increased flooding and associated impacts on water quality and water infrastructure • Substantially altered water flow in the Chad Basin • Possible significant changes in surface runoffs and groundwater flows in shallow aquifers • Increased demand on water resources to irrigate crops (addressing higher temperatures and variable rainfall) • Salinization of existing surface and groundwater resources in coastal areas
Coastal Marine Environment	• High risk of coastal inundation along parts of the country's long coastline of over 800km • A 0.2-meter rise in sea level would inundate 3,400 km of Nigerian coastland and a 1.0 m rise in sea level would cover 18,400 km and submerge the Niger Delta's entire oil and gas infrastructure, loss of human lives and property, the destruction of socio-physical infrastructures, the loss of species and ecosystems, soil impoverishment. • Vulnerability to strong storm surge activity due to sea-level rise
Forest Ecosystem and Grassland	• The forest ecology and the ecosystems that are already under significant human pressure would be additionally adversely affected by climate change. • Persistent flooding and waterlogging due to accelerated sea level rise or extreme weather events could render forest regeneration more difficult. • The savanna biome would be very vulnerable to any climate-change-related dramatic reduction in rainfall in the region to result in widespread degradation of habitats.
Human Health	• Increase in heat stress and heat stroke, particularly in elderly and other vulnerable populations. • Increased outbreaks of waterborne diseases like cholera • Loss of life, disruption to food production, and contamination of water supplies due to storm surges and flooding. • Reduced air quality; exacerbation of respiratory infections

Energy	• Increased energy demand • Reduced supply of biomass used for fuel. • Evaporation and drying of water resources used for hydropower. • Damage to infrastructure and disruption to energy production from flooding and storm surges
Extreme Weather Events	• Increase in frequency, spatial extent, and severity of droughts, while increase in the frequency of heavy rain occurrences is projected over most of the arid and semi-arid parts of the country, resulting in more frequent floods. • Increasing vulnerability of the Benue and Niger river systems to persistent flooding
Environment and Security	• The climate change-induced shrinking of Lake Chad has resulted in severe economic impacts on the fisheries, flood recessional agriculture, livestock rearing and other wetland industries in the northeastern part of Nigeria. • Chronic food insecurity in the region and a proliferation of diseases have induced significant migration from the region, and this has increased the pressure on natural resources in adjoining areas to the south; inciting social tensions, that is ball rolling into severe national insecurity of the region.

The government of Nigeria recognizes the importance of adequately exploring and strengthening adaptation-mitigation intrinsic linkages for low-carbon climate-resilient development and will take appropriate adaptation measures to complement its national mitigation measures elaborated in Section 3. The national focus will be on using nature-based solutions (NbS) that can contribute to the country's climate change mitigation and adaptation objectives by helping to strengthen climate resilience, while also contributing to climate change mitigation through functions such as carbon sequestration. For example, the restoration of a wetland will reduce flood risk and at the same time provide a carbon sink, thereby removing carbon from the atmosphere[30]. The Nature-based solutions catalogue (Bank, 2021) developed by the World Bank Group could be used as guidance for relating appropriate solutions to the problems at hand. For this, an overview of vulnerable locations to climate hazards is necessary.

[30] ibid

5.2 Modelling Nigeria's Vulnerability and Adaptation

Nigeria's development is particularly vulnerable to climate-related stressors and the risks of climate change are increasing. According to the Global Climate Change Vulnerability Index, Nigeria is among the top ten countries and Lagos is among the top ten vulnerable cities in the world. In fact, the 2021 Notre Dame Global Adaptation Index (ND-GAIN)[31] ranks Nigeria as the 53rd most-vulnerable country and the 6th least-ready country in the world to adapt to climate change. The 2021 Global Climate Risk Index, which indicates the level of exposure and vulnerability to extreme events and is published by the German watch Organization, further classifies Nigeria as a region of moderate risk, but its weak adaptive capacity makes the country very vulnerable to the impact of climate change.

The recent National Policy on Climate Change *(Federal Ministry of Environment (2021)* clearly states that all aspects of Nigeria's development are vulnerable to climate-related stressors. Its natural capital (including land, forests, landscapes, water, and fisheries) and physical capital (including cities, infrastructure, and other kinds of produced capital), as well as its human capital, which makes the economy highly susceptible to the impact of climate change. Extreme weather events, such as floods, storm surges, and heat waves can strain cities, roads, drainage systems, power plants, ports, and other types of infrastructure. For example, rising temperatures and more frequent floods are likely to make people more vulnerable to water- and vector-borne diseases. Floods may also prevent children from reaching schools for their education. In general, the combination of frequent natural disasters, large population, poor infrastructure, limited preparedness, and low resilience to economic shocks, makes Nigeria especially vulnerable to climatic risks. Furthermore, the high incidence of poverty and heavy reliance of poor people on agriculture and natural resources increases their vulnerability to climate change.

Studies have shown that the degrees of vulnerability vary from one region of the country to another *(Federal Government of Nigeria (2014).* These studies indicate that the northeast and northwest geopolitical zones, that constitute the arid and semi-arid areas of northern Nigeria and where most of the country's livestock are raised, are the most vulnerable to climate change in Nigeria. This is attributed to the regions' averagely low adaptive capacity, low sensitivity, high relative exposure, and vulnerability. Recent detailed climate vulnerability mapping of the arid and semi-arid northern Nigeria indicates that Adamawa, Bauchi, Borno, Jigawa, Kano and Yobe States have high vulnerability to climate change, while other States like Kebbi, Katsina, Sokoto and Zamfara have medium vulnerability. Kaduna and Taraba States are areas of low vulnerability to climate change, relative to other parts of the arid and semi-arid northern Nigeria. In this, the impact of drought as a climate risk is most significant. The climate risks of pluvial and coastal flooding are more significant in the Southern part of Nigeria. Heat stress-related issues mostly revolve around urban settlements, whereas the

[31] The ND-GAIN Country Index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help governments, businesses and communities better prioritize investments for a more efficient response to the immediate global challenges ahead.

drought issue as stated above mainly affects the natural capital of Nigeria's citizens. Thus, climate change adaptation is a development challenge that impacts the livelihoods of Nigerians.

To this end, an improved understanding of both the spatial variabilities and short-term preparedness for its impact will be crucial to analyzing the long-term climate change impact. Also, it will require putting in place adaptation strategies that consist of short-term actions that ensure preparedness for immediate threats, and long-term actions that make for climate-resilient development in the country. To generate an overview of priorities within the adaptation strategy, a distinction is necessary between the short-term adaptation measures that deal with the already exposed climate vulnerabilities, and a long-term strategy to monitor on, and gain insights into, the long-term vulnerabilities of Nigeria and apply best practices to coping with these uncertain threats in complex systems. Modelling adaptation strategies are especially important in long-term strategies to gain an understanding of the uncertainties in future developments. And these are essential to cope with these uncertainties. For example, the modelling outcomes give directions about the timelines and the consequences of adaptation (or mitigation) failures.

Furthermore, it is important to continuously monitor and update the modelling and the strategies based on the latest insights. The uncertainties require an adaptive policy approach. A possible valuable approach put forward in this LT-LEDS which is explorative has been the implementation of the Dynamic Adaptive Policy Pathways (DAPP) (**Figure 5.1**) (*Haasnoot et al. 2019*). This approach is a continuously recurring process where the effectiveness of taken measures are monitored and proportioned to set goals for the short term. This requires important information about the expected costs for climate adaptation and the uncertainties of these costs. It helps to quantify the benefits of climate mitigations investments. Thus, determining the cost implications as well as reduction in losses is a crucial aspect to the implementation of adaptive measures necessary to tackle the climate crisis. The results of this quick adaptation scenario assessment indicate several adaptation options that can be aligned with national development needs and adaptation projects and initiatives in various sectors that provide multiple benefits to the country's pathway to net-zero, low-carbon climate-resilient development.

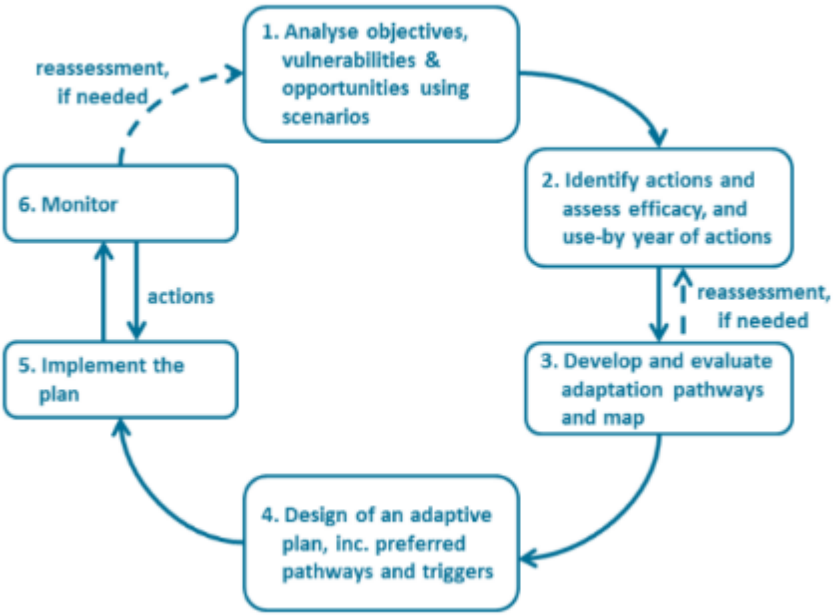

Figure 5.1: Dynamic Adaptive Policy Pathways (DAPP)

By applying the DAPP, Nigeria can take effective climate action to meet short-term goals. These short-term goals must be related to the appropriate climate tipping points for different regions in Nigeria. By setting short-term objectives for the different sectors, boundary conditions can be set to ensure these objectives are met. The climate hazards that affect the successful protection of these boundary conditions should then be dealt with. This approach also helps to involve significant actors in different sectors or across multiple to get involved.

For example, the urban coastal areas must focus on urban flooding rather than focusing on improving all suburbs to expected rainfall extremes for 2060, with high uncertainty.

The DAPP approach, including the adaptation tipping point approach, shows what climate extremes Nigeria can cope with (See figures 5.2).

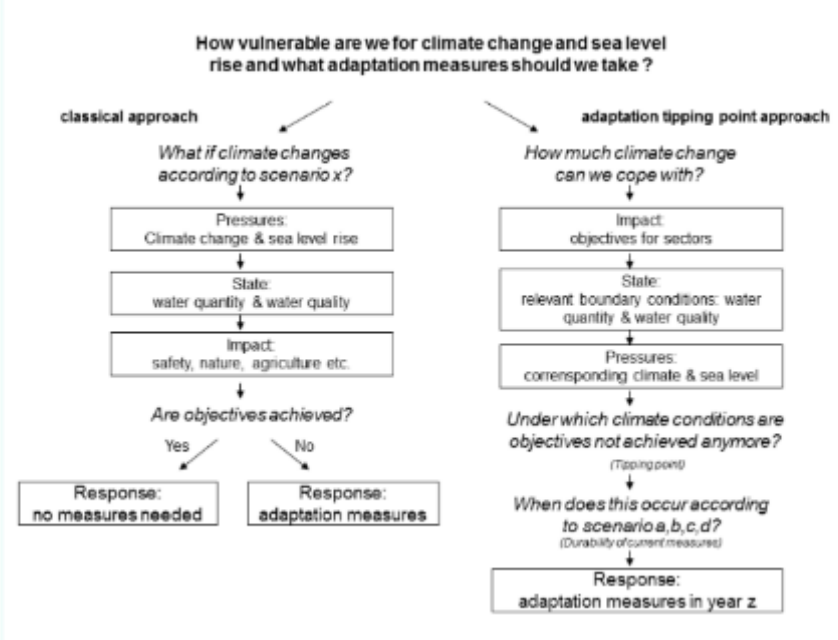

Figure 5. 2: DAPP Approach in Comparison to the Classical Approach

Figure 5.3 provides an idea of how long to wait with the decision about the implementation of an adaptation measure in the light of uncertainties around extreme weather event. In Figure 5.4, a perspective is provided on adaptation pathways that could be adapted.

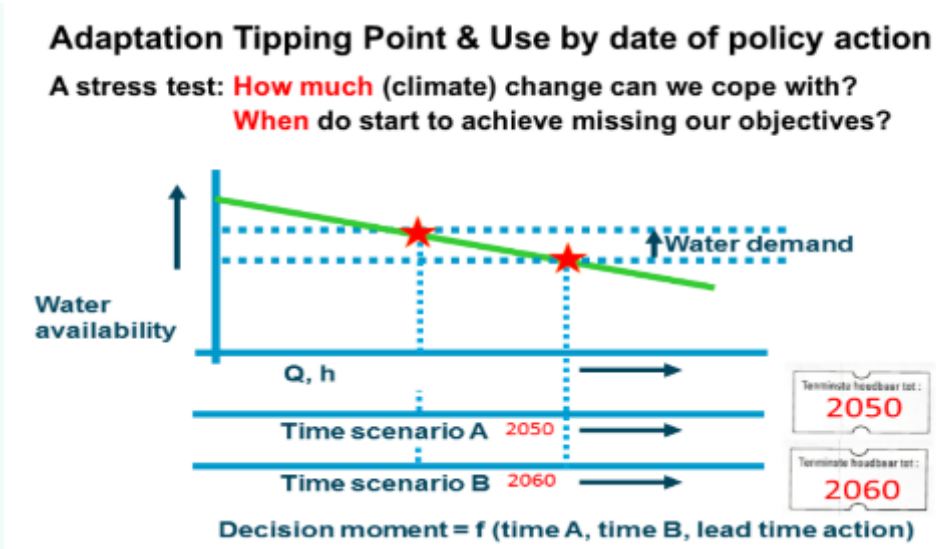

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Figure 5.3: Understanding Tipping Points

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Figure 5.4: Mapping Adaptation Pathways

5.3 Macroeconomic Impacts of Adaptation Measures

This section focuses on the expected role of adaptation measures in the macroeconomy of Nigeria, and the results presented and discussed here represent the outcome of an independent Computable General Equilibrium (CGE) -based study that is still ongoing (Box 4). As already indicated in earlier chapters of this document, the agriculture sector is susceptible to climate change, and the AFOLU sectors, by extension, have the highest contribution to GHG emissions in Nigeria. Therefore, the modelling emphasis in this section is on the macroeconomic impacts of key adaptation measures in the agriculture sector using a Computable General Equilibrium (CGE) modelling framework. The CGE model is particularly suited for this type of analysis because apart from providing explicit modelling of the agriculture sector, it also accounts for the effects of climate shocks on agriculture and captures the consequences of these shocks on the overall economy through the different linkages among prices, income, supply and demand for goods and services in the economy.

Box 4: Methodology- using a Computable General Equilibrium (CGE) modeling framework

The ex-ante analysis of climate change and adaptation pathways uses primarily a CGE model customized to the Nigerian economy using a 2018 Social Accounting Matrix (SAM). The adaptation measures included are those with dual benefits of reducing emissions and increasing agricultural productivity simultaneously. Considering the long-term outlook of the climate change shocks, a **comparative static CGE model** with long-term macro-economic closure rules is built for Nigeria. This standard CGE model is adapted to the climate change issue by adopting a long-term closure rule to consider the time dimension. Hence, labour, agricultural land, and other capital are fully mobile between economic activities, representing a long-term situation where the economy has time to adjust. Current public expenditure and fiscal balance are fixed relative to GDP. Despite the many attractions of the **comparative static CGE model,** a core limitation of this modeling approach is its inability to generate time paths of the effects of successive climate change-related agricultural crop productivity shocks on key macroeconomic variables.

Nigeria is a small country in terms of its trading links with the rest of the world, i.e., the government does not influence international prices of both imported and exported products, which remain fixed in the model. The foreign trade current account balance is kept fixed relative to GDP, thereby effectively linking external financing to the economy's performance. The volume of investment is also kept fixed relative to GDP through household savings. Thus, the model is investment-driven in that total investment determines total saving, i.e., the sum of private, government, and foreign savings. This closure rule allows to capture the full effect of the climate shock; in other words, inter-generation welfare transfers are not allowed.

Many studies use a deterministic approach to assess the effects of climate change on agriculture. However, deterministic shocks ignore the uncertainty associated with climate change and its implications on yield. In this analysis, we use a **stochastic approach** to consider the uncertainties in the evolution of the climate and its effects on agricultural yields.

The climate change shock is translated into variation in the productivity of agricultural

activities and, consequently, is propagated in the economy through the upstream and downstream linkages of the agricultural sector with the rest of the economy.

A stepwise implementation of the methodology is as follows:

- First, the simulation scenarios are built through an exhaustive review of existing literature to collect evidence on the impact of climate change and adaptation options on agricultural productivity.
- Second, evidence on the productivity effects of climate shocks is fed into the macro-model to assess economic growth, employment, and income changes by type of production factors and category of household.

On the macroeconomic effects of climate change adaptation strategies, four adaptation measures, which have been found in much peer-reviewed literature to reduce soil carbon emissions and increase agricultural productivity, are tested. These include:

1. Soil and water conservation (reduced tillage, terracing, ridging, bunds, and mulching),
2. Use of improved varieties,
3. Irrigation, and
4. Responsible use of fertilizer.

Empirical evidence on the impacts of these adaptation strategies on crop yields was obtained from existing research results (peer-reviewed), and the empirical results were then fit into the model for simulation purposes.

The simulation results indicate that overall, the country's GDP is expected to be lower in the climate change scenario by 4.92% when compared with the business-as-usual scenario (Figure 5.5) over the long-term period [for example, by 2050] due to damage to the economy by climate change. It should be noted however that this result would most likely be different if all climate impacts were to be captured in this analysis. The agriculture sector is expected to endure the most severe shock and the resulting output damage in the sector will contribute the largest share to the expected GDP decline accounting for 64% of the total decline from the business-as-usual scenario.

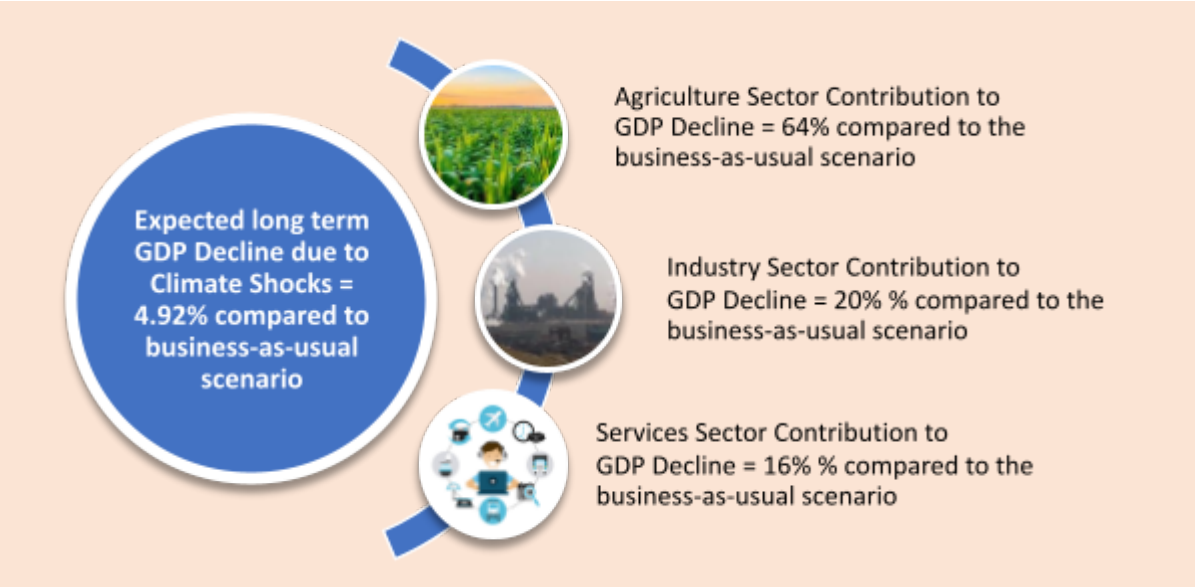


Figure 5. 5: Sectoral Contribution to Climate Change-Induced GDP Decline in Nigeria

The industry sector, which has a stronger backward linkage with the agriculture sector when compared to the services sector, is expected to contribute 20% to the simulated GDP decline over the long-term period. This is followed closely by the services sector which is expected to contribute 16% to the simulated GDP decline.

The adaptation measures will help answer the question of how much adjustment in behavior or investment in real terms will be required by the country to recover from, or compensate for the expected GDP decline due to climate shocks? The results of the four adaptation measures are presented in Figure 5.6.

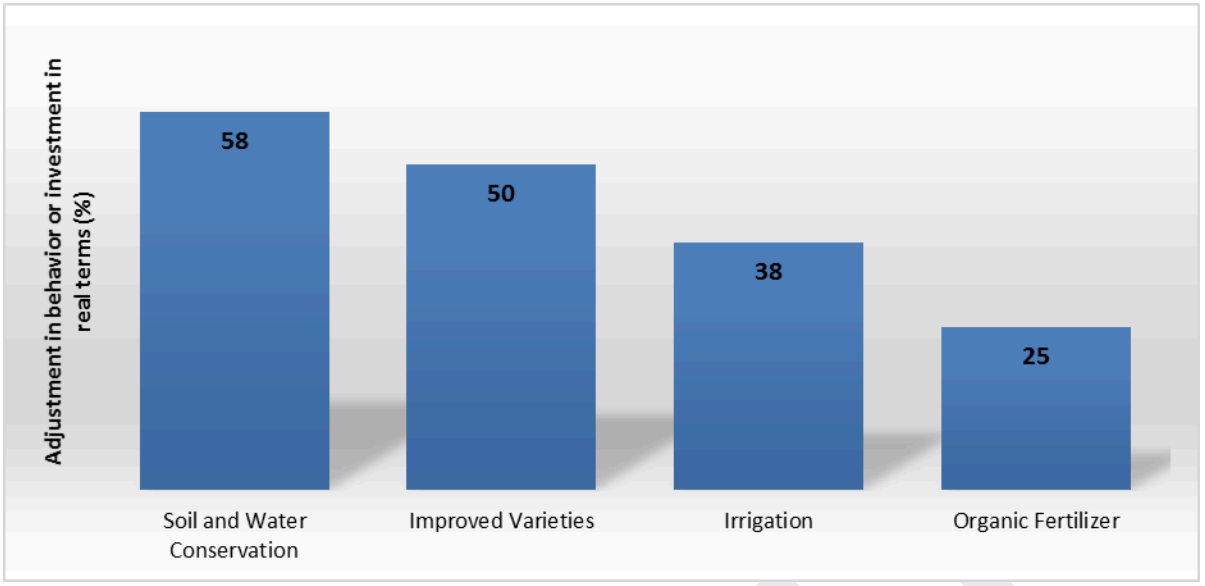
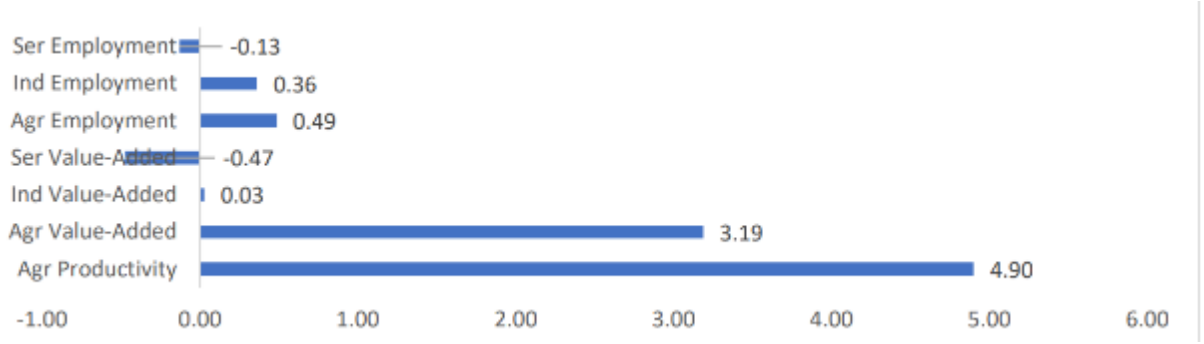


Figure 5. 6: Adaptation Measures to Compensate for CC-Induced GDP Decline in Nigeria % of Cultivated Area)

The country is expected to expand the use of Climate Smart Agricultural practices of reduced tillage, terracing, ridging, bunds, and mulching to cover an additional 58% of the cultivated area to recover from the damage to GDP due to climate shocks. These methods of farming are known to be very effective in soil and water conservation, increasing farm productivity, and reducing soil carbon emissions. A complementary adaptation measure is to increase the cultivation of improved varieties including drought-tolerant and early-maturing crop varieties. The simulation results indicate that the country needs to cultivate these improved varieties on an additional 50% of the cultivated area to reverse the expected GDP loss due to climate change. Similarly, irrigated land should be expanded to cover an additional 38% of cultivated area in the country to recover from the damage to GDP due to climate change. Finally, the use of organic fertilizer should be expanded to cover an additional 25% of the cultivated area so as to recover from the expected decline in GDP due to climate change.

5.3.1 Breakdown of Expected Macroeconomic Impacts of Adaptation Measures

It will be instructive to also present results of the macroeconomic impacts of the adaptation measures on productivity in the agriculture sector as well as on value-added and employment in the agriculture, industry, and services sectors of the Nigerian economy. These results are presented in Figure 5.7 (All variations indicated are changes from the business-as-usual scenario).

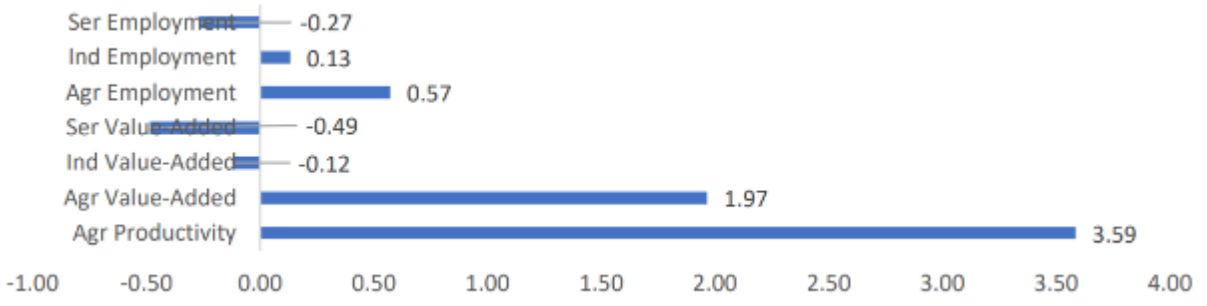


Percentage growth compared to BAU

Figure 5.7: Breakdown of Expected Impacts of Adaptation Measure - Soil and Water Conservation

A decomposition of the macroeconomic impacts of adaptation measures to improve Soil and Water Conservation using Climate Smart Agricultural practices of reduced tillage, terracing, ridging, bunds, and mulching indicate that when compared to the business-as-usual scenario, agricultural productivity will be enhanced by 4.9% over the long-term simulation period. Value-added in the agriculture sector will also increase by 3.19% and employment in agriculture will increase marginally by 0.49%. Industry sector employment will also grow by 0.36% and the related value-added will see an increase of 0.03% over the period. In all, the services sector will not benefit much from these adaptation measures on Soil and Water Conservation. Services employment is expected to decline by 0.13% and value-added services will also decrease by 0.47%. The expected poor performance of the services sector in response to adaptation measures on Soil and Water Conservation may be indicative of the very weak linkages between the agriculture and services sectors in Nigeria. Simulation results of adaptation measures to expand the use of improved varieties in the country are also expected to be like those of soil and water conservation.

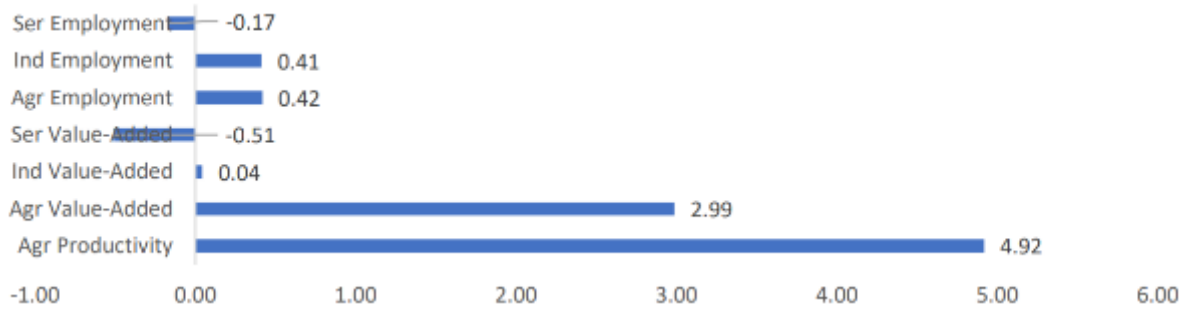
As shown in Figure 5.8, when compared to the business-as-usual scenario, agriculture productivity will be enhanced by 3.59% and agricultural employment will also increase by 0.57% if the use of improved varieties is expanded to cover an additional 50% of cultivated areas. This will be driven by an increase in agricultural value-added of 1.97%. A decline of 0.27% and 0.49% is expected in the services sector employment and value-added respectively following an expansion in the use of improved varieties, suggesting that some labor factor services will be migrating to the agriculture sector where productivity is increasing.



Percentage growth compared to BAU

Figure 5.8: Breakdown of Expected Impacts of Adaptation Measure - Improved Varieties

The breakdown of the simulation results on the macroeconomic impacts of adaptation measures on the expansion of irrigated land indicates that when compared to the business-as-usual scenario, agricultural productivity is expected to grow by 4.92% in the country over the long-term period as shown in Figure 5.9. At the same time, agricultural value-added will grow by 2.99%. Industry sector employment and agriculture sector employment will also increase by 0.41% and 0.42% respectively. However, services sector employment is expected to decline by 0.17% due to an expansion of irrigation coverage of the cultivated land area in the country.



Percentage growth compared to BAU

Figure 5.9: Breakdown of Expected Impacts of Adaptation Measure – Irrigation

When compared to the business-as-usual scenario, the use of organic fertilizer, which is climate-friendly, will also enhance agricultural productivity in the country by 2.77% and agricultural value-added by 1.28% as reported in Figure 5.10. This adaptation measure will also increase agriculture sector employment by 0.42% and industry sector employment will in the same vein increase by 0.41%.

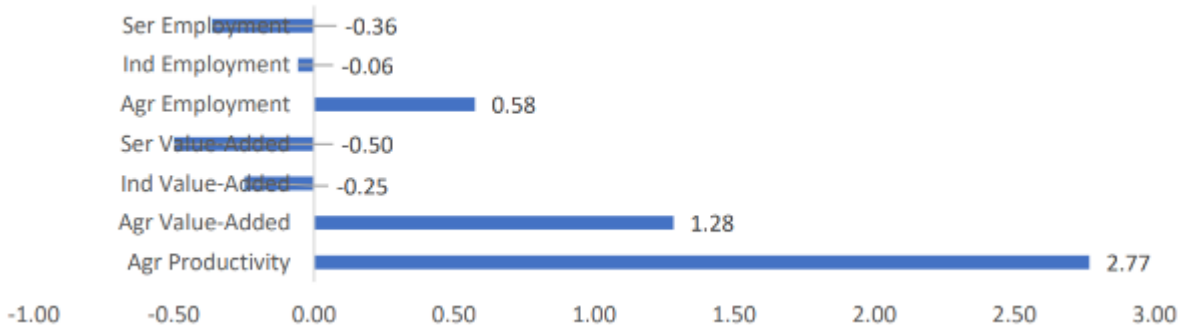


Figure 5.10: Breakdown of Expected Impacts of Adaptation Measure - Organic Fertilizer

In all, the simulation results clearly suggest that the selected adaption measures for this report are consistent with the goal of recovering the Nigerian economy from a climate-induced GDP loss over the long-term period. The agriculture sector will no doubt play a central role in climate adaptation efforts. The roles of the agriculture and industry sectors will be mutually reinforced in this respect, and this is as a result of the strong linkages between these two sectors of the economy.

5.4 Adaptation Finance

Responding effectively to the development challenge of climate change in Nigeria regarding mitigation and adaptation measures will require a robust financial management plan. In this regard, climate finance remains central to achieving climate-compatible development. The updated 2021 NDC is estimated at USD177 billion for a 47 per cent emissions reduction by 2030 *(Federal Government of Nigeria (2021)* will be required to implement its aligned projects across the highest emitting sectors in terms of the magnitude of mitigation and adaptation measures, as well as the upfront capital cost for implementation across all sectors, including waste and water. This may even be higher when comprehensive investment plans for all sectors of the country's development are developed. For the struggling Nigerian economy, this poses a severe challenge to the vision of net-zero emission and climate-resilient economy by 2060. Thus, the Federal Government is looking at various options to finance her climate response activities at all levels of governance in the country. To this end, some of the strategic measures will include:

§ Strengthen the capacity of the Secretariat of the National Council on Climate Change to develop bankable projects that can enable Nigeria to access UNFCCC Financial Mechanisms and other development partners' climate funds.

§ Make the National Climate Change Fund established under the Nigeria Climate Change Act 2021 operational and ensure its effective implementation. Incentivise and actively engage the private sector to invest in climate actions.

5.5 Loss and Damage

The actual costs of economic losses and damages caused by the impacts of extreme climate events on the Nigerian economy remain a challenge as it is very difficult to isolate the climate component of total losses due to extreme weather events. Nevertheless, the losses and damages are enormous. To gain more insights into the potential effects of climate hazards as stand-alone risks, model representations of Nigeria can help gain understanding, which

improves the substantiation of the decision to be made. Based on actual extreme occurrences, it has been reported in what is considered Nigeria's worst extreme weather event-induced floods in decades, over 600 persons lost their lives in 2022 and up to 33 states in the country were affected. In addition, the devastation affected up to 2.5 million persons and led to the destruction of over 300,000 hectares of farmlands and transport infrastructure. Overall, Nigeria lost an estimated $6.681 billion as direct damages recorded between June and November 2022 *(World Bank Global Rapid Post Disaster Assessment Damage Estimation (GRADE) Report, 2022)*. In implementing the LT-LEDS, Nigeria will strategise to benefit maximally from the new global loss and damage funding for vulnerable countries that, hopefully, would be finalised at the UNFCCC 28th Conference of Parties (COP 28) in UAE. This means Nigeria will also establish policy guidelines that include climate-adaptive reconstruction to ensure the exact locations will not be affected by the same climate hazards.

5.6 Adaptation Strategies

5.6.1 Adaptation Initiatives and Priority Measures

In addition to formulating some adaptation-specific plans such as the National Strategy and Plan of Action for Climate Change in Nigeria (NASPA-CCN, 2011), Nigeria's National Adaptation Framework (2020), the updated NDC (2021), as well as the National Climate Change Policy (2020) and the National Climate Change Programme (2020), Nigeria is undertaking a variety of adaptation actions across sectors and scales at national and subnational levels.

A brief account of Nigeria's current adaptation actions and goals is presented in the country's updated NDC and its National Communication to the UNFCCC. Some of the existing vital initiatives and projects in the last decade include the following:.

1. The Building Nigeria's Response to Climate Change (BNRCC) project, which was a five-year project (2007-2-12), was funded by the Canadian International Development Agency (CIDA) and implemented by the Federal Ministry of Environment. BNRCC researched climate vulnerability, promoted gender-responsive climate response, raised awareness and implemented community-based adaptation pilot projects. A significant output of BNRCC implementation is the development of the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN), which remains the only National Adaptation Plan (NAP) for Nigeria until the ongoing implementation of the BAP Process that should come up with a more elaborate national adaptation programme for the country.
2. Community-based Adaptation pilot projects of the BNRCC project were implemented to understand the impacts of climate change in all ecozones and to test adaptation strategies to address these challenges. The pilot projects were executed In different ecological zones of Nigeria. They ranged from alternative livelihood options to increasing water supply, trials of improved varieties of crops, testing fuel-efficient wood stoves, providing tools for weather forecasting and planting trees for

dune stabilisation. The implementation of the pilot projects led to the development and adoption of improved seed varieties to improve food security, provision of fuel-efficient wood stoves, improved access to water sources, rehabilitation of ecosystems by planting trees and establishment of alternative sustainable livelihoods for poverty reduction and weaning communities off forest products, improving.

3. The World Bank assisted Nigeria Erosion and Watershed Management Project (NEWMAP), which the Federal Ministry of Environment implemented to tackle the menace of gully erosion in south-east Nigeria and other forms of land degradation in northern Nigeria through an integrated watershed management and climate-resilient approach.
4. The Great Green Wall s, which the National Agency currently implements for the Great Green Wall (NAGGW) of the Federal Ministry of Environment to combat climate change, fight desertification and address food insecurity, migration, and conflict in the arid areas of northern Nigeria, is to increase the amount of arable land and promote climate-resilient development in the Sahel.
5. The Africa Development Bank's (AfDB) newly launched USD25 billion (EUR25 billion) Africa Adaptation Acceleration Program (AAAP) in collaboration with the Global Centre on Adaptation (GCA). The AAAP is expected to unlock financing from African governments, investors, foundations, resilience bonds and debt for climate adaptation swaps.
6. Adapting to Climate Change in the Lake Chad Basin is a Project (2013 – 2018) funded by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). It is focused on providing adaptation solutions and best practices to 1,100 villages in the region and in bordering countries for improved food security in the area.
7. The UK Foreign, Commonwealth and Development Office (FCDO) and the United States Agency for International Development (USAID) have also supported the development of knowledge products, country reports, climate risk resources and research across Nigeria.
8. Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL), which the World Bank supports and currently implemented by the Federal Ministry of Environment to replicate and upscale NEWMAP's approach and successes to the 19 States in northern Nigeria, is targeted at addressing the challenges of large-scale watershed degradation, improving community climate resilience, strengthening institutional capacity and enabling institutional and policy foundation for multisectoral integrated landscape management and climate resilience, among others.
9. The Lagos State Climate Change Action is a subnational initiative whose goals align with the Paris Agreement on Climate Change, particularly the ambition to keep the average global temperature rise to 1.5°C. It will not only help to mitigate climate change by reducing emissions, but also improve Lagos's population, economy, and infrastructure's resilience to its effects. It further seeks to maximise the co-benefits

of climate actions in support of the State's vision to create a cleaner, greener, healthier, stable, and more prosperous Lagos in the face of a changing climate.

Alongside these initiatives are many nationally accepted adaptation measures for various sectors of national development that have been variously identified in the updated NDC, Third National Communication, NASPA-CCN and other federal policies and plans. A sample list of key adaptation measures for Nigeria for various sectors is presented in Table 5.2

Nigeria's updated NDC emphasised the potential role of nature-based solutions (NbS) as effective adaptation measures for the country. Nature-based solutions "are actions that protect biodiversity, sustainably manage and/or restore ecosystems, while simultaneously contributing to the achievement of multiple sustainable development goals, including national goals for climate, food security, water security, disaster risk reduction and livelihoods" (NDC Updated 2021 p.14). Thus, they can help strengthen climate resilience while contributing to climate change mitigation through functions such as sequestering carbon. As they are usually affordable and provide additional co-benefits, such as supporting biodiversity and fostering mitigation-adaptation linkages, as well as reducing exposure and vulnerability to the impacts of climate change, the importance of designing and implementing nature-based solutions in building resilience and adaptation in priority sectors will be emphasised in the implementation of this LT-LEDS.

Table 5. 2: Key adaptation measures in Nigeria

Sector	Adaptation Measures
Agriculture	• Provision of accurate and timely weather forecasting • Adoption of drought-tolerant and early-maturing crop varieties • Diversifying livelihoods to improve income. • Increasing and upgrading crop storage facilities • Control of pests, insects, and birds • Growing more cover crops like potatoes and melon to protect soil from erosion. • Intensive livestock keeping • Enhancing agricultural extension services • Irrigation • Flood control • Drainage • Weather insurance • Improving transportation between rural areas and urban centres

Water Resources	• Integrated water resource management at the watershed level • Improved groundwater exploitation • Extend and improve water supply and water management infrastructure. • Water efficiency and improved water demand management • Gender–responsive, socially inclusive. and resilient water and sanitation infrastructure. • Small–scale earth dams for multi-purpose use • Inter- and intra-basin water transfer • Strengthened river basin governance and scaled-up regional cooperation. • Increased the network density of hydrometric network for early warning forecasting. Strengthened capacity for smart water management
Coastal Marine Environment	• Hard protection, or "gray infrastructure" including dikes and static seawalls, groins and artificial headlands, detached breakwaters, and artificial reefs. • Creation of artificial land above the sea, such as Eko Atlantic in Lagos State, to create new buildable areas. • Soft protection, including dune rehabilitation and sand/beach nourishment, including beach nourishment that projected accommodation, which takes projected SLR into account. • Ecosystem-based Adaptation (EbA), which includes the restoration of salt marshes, mangroves, *oyster* beds, or coral reefs and other coastal ecosystems to mitigate marine flooding and coastal erosion. • Managed retreat, which involves rethinking living on the coast by accepting that certain coastal infrastructure, neighborhoods, or even cities will need to relocate entirely.

Forest Ecosystem and Grassland	• Strengthened forest management and increase in tree cover through gender-responsive socially and environmentally responsible reforestation and restoration initiatives. • Community-based Forest resources management • Functional forest inventory system • Afforesting with suitable indigenous and exotic species • Strengthened partnerships among CSOs, communities, and the private sector to restore community and private natural forests, plantations, and nurseries. • Improved management of forest reserves and enforcement of low-impact logging practices • Alternative livelihoods to reduce unsustainable resource use and loss of biodiversity. • Forests resources accounting • Climate change adaptation is mainstreamed into forest management. • Reduce ecosystem vulnerability and ecosystems' exposure to extreme events. • Enhanced financing for the implementation of the REDD+ Strategy and the Great Green Wall Initiative
Human Health	• Improved understanding of the health impacts of climate change in Nigeria • Strengthened disease prevention and treatment systems. • Wastewater and solid waste management facilities • Wide adoption of practices and technologies that reduce exposure and health impacts from extreme heat. • Early warning and health surveillance programs. • Strengthened surveillance programs for monitoring human health under a changing climate. • Climate-resilient health infrastructure. • Community hygiene and general cleanliness in all sectors • Improved primary healthcare delivery system to effectively response to climate-induced diseases and pandemics

Energy	• Strengthened infrastructure against storm events or wind. • Protection of infrastructure against flooding with dykes or berms or construction of new infrastructure in areas vulnerable to flooding, salinity, or storm events • Improved sustainability of charcoal production through enforcement of regulations against illegal charcoal production activities and improved charcoal production technologies • Diversification of household and community energy generation sources to reduce reliance on biomass as an energy source and thus reduce pressure on natural systems (e. g. solar energy or small-scale hydropower generation) • Increase in the level of rural electrification in line with the Government's objective of 75% electrification rate by 2020 and full electrification by 2040 to reduce reliance on biomass as an energy source and increase reliance on use of sustainable, climate-proofed large scale generation sources where possible. • Climate proofing of existing and future hydropower infrastructure through the implementation of structural and/or non-structural measures that may include (a) construction or augmentation of reservoirs, (b) modifications to spillway capacities, (c) installation of controllable gates on spillways, (d) modifications to the number and type of turbines, (e) modification of canals or tunnels, (f) development of hydrological forecasting techniques and adaptative management operating rules, and (g) development of basin wide management strategies that take into account the full range of downstream environmental and human water uses under changing climate Promote decentralized energy systems to increase resilience, with an emphasis on mini-grids and stand-alone systems
Transport	• Strengthening existing transportation and communications infrastructure for climate-resilience • Provision of diverse transportation options, such as pedestrian, bicycle, and transit routes • Mainstream adaptation into transport planning, decision-making and implementation • Improved public and private-sector investment in climate-proofed and climate-resilient transport infrastructure • Diversification of transport modes with appropriate adaptive capacities

Industry	• Promoting a value-chain-based approach for climate-resilient industry. • Harnessing the potential of clean technologies for climate-resilient industrial development. • Fostering innovation and strengthening entrepreneurship to develop new capacity for wealth creation whilst safeguarding the environment and promoting sustainable climate-resilient industrial development. • Fostering the diffusion of financial tools aiming to reward resilient enterprises or enterprises belonging to resilient industrial clusters. • Promoting adaptation actions in the industry sector, based on an ecosystem approach. • Developing green infrastructure and payments for ecosystem services (PES) • Strengthening synergies among adaptation measures and other environmental issues, such as floods and droughts, water scarcity, biodiversity conservation, air quality and resource efficiency • Increasing the awareness of industrial and financial operators about the effects (threats and opportunities) of climate change on industrial production • Defining opportunities for new green products and new green jobs related to the adoption of climate adaptation measures
Transport	• Include increased protective margins in the construction and placement of transportation infrastructure (i.e., higher standards and specifications for greener technology) • Undertake risk assessment and risk reduction measures to increase the resilience of the transportation and communication sectors. • Strengthening existing transportation and communications infrastructure for climate-resilience • Provision of diverse transportation options, such as pedestrian, bicycle, and transit routes • Mainstreaming adaptation into transport planning, decision-making and implementation • Improved public and private-sector investment in climate-proofed and climate-resilient transport infrastructure • Diversification of transport modes with appropriate adaptive capacities
Human Settlements	• Assess the impacts of climate change and raise awareness among citizens. • Expropriation and greening of abandoned lots in major cities • Create green and blue infrastructure to reduce urban heat islands. • Green and cultural urban corridors • Create infrastructure and pilot projects to reduce the risk of flooding. • Implement a program to strengthen and extend the support network for vulnerable communities.

	• City center development projects • Social housing program • Crisis preparedness and management plans
Vulnerable Groups	• Create awareness among national and sub-national disaster and emergency management institutions about climate change impacts and how these impacts affect vulnerable groups. • Strengthen capacity of relevant disaster and emergency management agencies on the use of gender awareness tools to enhance implementation capacities. • Adapt government programs and plans at national and sub-national levels to better address the impacts of climate change on vulnerable groups. • Adapt public service facilities, including school buildings, to withstand storms and excess heat. • Intensify the immunization of children and youth to provide protection against diseases that are expected to become more prevalent with climate change. • Retrain health workers to appreciate emerging climate change challenges within the context of immunization delivery and other comprehensive healthcare delivery. • Encourage faith-based and civil society organizations, as well as the private sector to provide social welfare programs and other support to address the climate-change- induced needs of vulnerable groups
Extreme Weather Events	• Greater collaboration with policymakers towards an open-source database of standardized, publicly available data to raise awareness of the need for climate adaptation. • Develop better climate risk models which can help form a more accurate picture of future weather patterns as well as the risks they might pose to communities. • More accurate risk data and modelling to help inform policymakers on hazards, exposures, and vulnerabilities. • Weather insurance indexing and innovation, particularly digitalization, to increase the impact of risk finance and insurance on resilience

Environment and Security	• Strengthen capacity to anticipate disasters and impacts on internal migration and security. • Strengthen capacity to respond through information and awareness, training, equipment, plans and scenarios and communication. • Strengthen individual and community-based emergency preparedness and response capacity in climate change high-risk areas. • Strengthening rural infrastructure and the availability of jobs to discourage out- migration. • Integrate climate change into the national and regional security strategies. • Strengthening the capacities of security agencies and institutions to mainstream gender-based perspectives and climate risk considerations in security planning and operations. • Strengthen capacity at national and sub-national levels to anticipate and respond to disasters and impacts on internal migration and security. • Develop robust projections in terms of climate change impacts for the formulation of appropriate policies towards reducing vulnerability. • Promote open and constructive dialogue for coordinated multilateral mechanisms to address climate risks and the development of effective policy responses and strategies on climate change-related security issues. • Institutionalize inclusive, participatory decision-making process to reflect the voices of women, girls, and youth as ecosystem managers under increasing insecurity. • Develop and implement strategies that allow for the better management of climate variability and lessen its impact on livelihoods and agricultural production to enhance security. • Strengthen rural infrastructure and promote sustainable rural livelihoods. • Minimize the existence of ungoverned spaces. • Integrate migration and human displacement issues in national climate change planning

5.7 Mitigation and Adaptation Measures Synergy

Both mitigation and adaptation strategies are crucial in managing Nigeria's climate crisis in a holistic and coordinated manner. The recognition by Nigeria of the potential interlinkages between the climate change impacts, mitigation and adaptation activities, and the developmental outcomes, will help in identifying climate-resilient development pathways.

Synergies in climate action, as defined in the fourth IPCC Assessment Report (Klein et al., 2007), means "interaction of adaptation and mitigation such that their combined effect is greater than the sum of their effects if implemented separately" (Nordic Working Group for Global Climate Negotiations, 2017). Although the Nigerian LT-LEDS programme considers mostly the mitigation measures needed for net-zero sustainable economic growth, some of the results obtained indicate that both mitigation and adaptation measures can be adopted pari passu to greater effect.

This LT-LEDS emphasizes that the synergies between adaptation and mitigation actions, in sectors related to terrestrial and wetland ecosystems, food security and production, and energy, with their adaptation and resilience efforts must be undertaken jointly with mitigation efforts. This section considers the mitigation and adaptation synergies in the three most significant sectors with the highest contributions towards national emissions, namely; energy, AFOLU, and transport.

Energy:

The single most undesirable source of emission in the energy sector in Nigeria is gas flaring, emanating from oil and gas operations, which accounts for about 30% of the energy sector emissions in the BAU scenario. Mitigation measures here would realistically be implemented in phases such as utilizing gas to produce LPG, as well as raw materials for the petrochemical industries. This could be pursued to materialization by 2030. Combining both measures could prove highly beneficial towards achieving net zero emissions in the energy sector. A major vulnerability would be higher ambient temperatures for thermal power plants, which constitute the bulk of power plants in Nigeria. Since warmer ambient temperatures reduce the efficiency of thermal conversion, it is recommended that process water from flue gases can be re-used as an adaptation measure, and this can cover 25–37% of cooling needs, according to International Atomic Energy Agency (2019). Other adaptation measures in the energy sector will involve increased renewable energy mix in the long term.

AFOLU:

The AFOLU sector accounts for the second highest contribution towards overall emissions in Nigeria both in the NDC and the LT-LEDS projections. A major highlight under the AFOLU sector is deforestation, which has increased tremendously from 1990 till date. In total, Nigeria has lost 35.7% of its forest cover or about 6,145,000 hectares, between 1990 and 2005. Under the LT-LEDS, reforestation has been projected as a preferred mitigation option rather than enhanced forest management, as recommended by the NDC. Experience from other countries shows clearly that sustained action over many years is required to implement a successful reforestation or forest management programme with Managed natural regeneration which is likely to be the most cost-effective way to restore tree cover in many areas, especially arid and semi-arid. Although reforestation while serving as a mitigation strategy alongside climate-smart agriculture practices to reduce emissions also increases resilience and adaptation to climate change. Thus, the technique of planting plants such as *Jatropha curcas and Azadirachta indica*, and other resistant trees and crops represents a possible adaptation response to climate change.

Transport:

With 68.83% of the total emissions, the transport sector is the third largest contributor to emissions under the BAU scenario. However, because of the number of mitigation strategies, especially the introduction of electric vehicles etc, the sectoral emissions were reduced significantly under the other scenarios. Well-proven adaptation measures in the transport sector could be better aerodynamics, cutting vehicle weight, and building engines with high standards, which can reduce energy consumption by up to 50%. Low-carbon transport systems such as rapid bus systems (BRT as already practised in Lagos and planned for Kaduna) can reduce pollution in urban areas if adopted by more states. Also, building resilient roads, and strong resilient transport infrastructure are major adaptations in the transport sector.

5.8 Cross-Cutting Sectors' Measures and Instruments

These include measures for Communication and Information Communication and Technology (ICT), carbon tax, removing inefficient subsidies, gas transformation, carbon budget, carbon market, blue economy, health, youth and people with disabilities, gender etc.

The LT-LEDS will play a critical role in aligning climate goals and targets with national and sub-national sustainable development objectives and the international objectives of addressing the global challenge of climate change. Its implementation will also be considered within the imperative of balancing between emission reduction and economic development, as well as other sustainable development indicators and supporting issues such as just transition, fairness and equity, healthy living, climate resilience, gender responsiveness, inclusivity, intergeneration, and vulnerable groups, etc.

5.8.1 Communication and Information Communication and Technology (ICT)

The two important strategic measures with which ICT can be used to mitigate climate change and will be adopted by the Government of Nigeria are:

- Building Information Modeling, software can be used to design "smart buildings" that reduce material and energy consumption during construction. Various sensor technologies can control environmental and energy variables during the life of the buildings and therefore reduce GHG emissions associated with energy production.

- Developing smart grids to allow greater use of renewable energy generating technologies and using onsite renewable power generation equipment such as fuel cells, solar stations, wind generators and micro hydro installations, and

high-efficiency energy storage solutions is now in development. This will create more control over energy generation and transmission and reduce energy losses (ESCAP/APCICT 2014).

5.8.2 Carbon Credit and Trading

The Carbon Credit and Trading are based on a market-based mechanism to control greenhouse gas emissions which is becoming increasingly popular. Different countries are looking at how to engage in carbon markets to meet their net-zero strategically. Article 6 of the Paris Agreement provides information on establishing international carbon markets where countries can trade carbon credits. Beyond international climate markets under Article 6, to help achieve the global goal of carbon-neutral growth as part of the aviation sector's contribution, International Civil Aviation Organization (ICAO) established the carbon offsetting and reduction scheme for international aviation (CORSIA).

The carbon market is either voluntary or compliance (mandatory).[32] The two types of carbon credits, which are market-based mechanisms, include voluntary emissions reduction (VER) - when a carbon offset is exchanged voluntarily for credits- and certified emissions reduction (CER). VER - when a third party helps in regulating it. Nigeria will explore the best alternatives for the carbon market in its quest to attain Net-Zero emissions by 2060.

In its National Climate Change Act of 2021, Nigeria recognises the need to set a national carbon budget that will make the country contribute significantly to the global goal of keeping average increases in temperature within 2°C and pursue efforts to limit the temperature increase to l .5°C above pre-industrial levels and in line with its NDCs, In this regards, appropriate incentives will be given to companies to offset their carbon emissions with credits from other companies that have reduced their emissions. This helps businesses to reduce their carbon footprint and makes them more environmentally friendly. Companies can sell these credits to other companies who want to offset their carbon footprint, or they can buy credits from other companies who have already done so.

Under Paris Agreement, Nigeria will make use of the carbon credit and carbon trading opportunities to boost the implementation of sectoral targets in her NDC and the National Climate Change Action Plan that will be developed by the National Council on Climate Change to focus on formulating and implementing long-term, low-emission sectoral measures and strategies to achieve sustainable, long-term, low-carbon economic growth.

Strategic measures will include:

i. Ensuring the identification and analysis of priority sectors, and eligibility criteria, setting a price on carbon.
ii. Understanding existing carbon offset projects to achieve the long-term net zero emissions goal.
iii. Developing and implementing programmes to provide a vast supply base to meet the demand for a compliance carbon market.
iv. Effectively using of cooperative approaches under Article 6, paragraph 2.

[32] See definition in the Acronyms and definition section.

v. Using of the mechanism under Article 6, paragraph 4; and use of non-market approaches under Article 6, paragraph 8.
vi. Imploring qualitative limits on the use of voluntary cooperation, including environmental integrity, transparency, and avoidance of double counting of emission reductions.

5.8.3 Blue Economy

There is global recognition and the imperative of integrating the ocean economy (blue economy) into Nigeria's response to climate change. Blue economy plays a vital role in the country's overall economy considering that all sectors of the economy solidly depend on import and export through maritime transportation. Expectedly, the African Union (AU) adopted the blue economy in its Africa Agenda 2063 as a mechanism to accelerate economic growth on the continent. Also, Nigeria has created a full fledge ministry of marine and blue economy, Hence the LT-LEDS notes the needs for this sector to be empowered or capitalised to join the decarbonisation race in reducing emissions while driving growth and profitability of the national economy. Strategies on cutting down emissions across the various sub-sectors (fishery and aquaculture, coastal tourism, renewable energy, ship, and boat building, etc) would include investing in solutions and services that would go beyond best efforts.

This action includes ensuring the country's adoption of mitigation techniques and evolving technologies to support the optimal realization of jurisdictional maritime zone entitlements. This could be through maximum use of offshore renewable energy, decarbonized maritime transport, port infrastructure, sequestration of carbon by the coastal and marine ecosystem, sustainable fishing and market-based measures to achieve increased opportunities for technological solutions, creating upward momentum across the blue economy value chain. These are likely to ensure better and improved GDP and employment opportunities, meeting the food needs of the growing population and sustainable and regenerative tourism. These actions that would include activities in the various sub-sectors of the blue economy are anticipated to include verifiable commitments backed by continuous progress monitoring toward the net zero goal envisioned in the LT-LEDS.

5.8.4 Culture

Culture is an important component of Nigeria's society and is preserved and transmitted to future generations through mostly traditional rights, oral folklore, and music despite the recent influence of external cultures.

By incorporating cultural ideas and indigenous technology into the LT-LEDS, communities can be quickly drawn into the climate change control process. Encouraging the protection of heritage sites and intangible heritage practices also protects the environment and conserves biodiversity. The attendant impact is overall benefits for the environment and climate. Local culture is a fundamental part of the lives of the population and incorporating part of the people's culture will give them a sense of belonging thereby committing themselves to the climate change mitigation and adaptation measures. This also helps to bring into perspective the fact that the indigenous peoples and marginalized populations are particularly exposed

and vulnerable to climate change impacts due to their resource-based livelihoods and the location of their homelands in marginal environments. In Nigeria, the application of the Climate Vulnerability Index for Sukur demonstrated the value of the process for cultural properties in identifying key points of vulnerability to climate change as well as opportunities to manage impacts to both the landscape and the associated community *(Jon Day*, Scott Heron, Ishanlosen Odiaua, Jane Downes, Eugene Itua, Aliyu Lass Abdu, Brenda Ekwurzel, Anthony Sham, William Megarry (2020).*

The implementation of the LT-LEDS will ensure that local and indigenous communities participate effectively in climate change decision-making so that adaptation strategies contribute to the well-being of the communities, including marginalized groups, and avoid strengthening existing inequalities. The knowledge possessed by indigenous peoples can contribute to climate change assessment and adaptation by offering observations and interpretations at a much finer spatial scale with considerable temporal depth and by highlighting elements that may not be considered by climate scientists. Culture-induced knowledge, attitude, and perception as well as education have been shown to be a major factor in determining the rate at which Nigerian households adopt the use of modern cooking technologies such as improved stoves and *LPGs (Okereke, C., Onyeneke, R. U., Ijeoma, S., Fadero, T., Ahanotu, K., & Anieze, E. E. (2023)*.

5.8.5 Health

Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food, and secure shelter. The World Health Organization (WHO) has indicated that between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year, from malnutrition, malaria, diarrhoea, and heat stress. This could result in about USD 2- 4 billion in direct damage costs to health *(Climate Change and Health, 2023).*

Evidence abounds that climate change impacts in Nigeria arise from well-known and articulated climate change-related causes such as increases in temperature, rainfall, sea level rise, extreme weather events and, especially, increased health risks. They generate health risks such as cerebra-spinal meningitis, a cardiovascular respiratory disorder of the elderly, skin cancer, malaria, high blood pressure and morbidity were identified as the direct consequences of climate change *(Monday, I. F. (2019).* Thus, reducing emissions of greenhouse gases through better transport, food and energy-use choices can result in improved health, particularly through reduced air pollution *(Climate Change and Health, 2023).*

Strategic measures that governments will undertake in the implementation of the LT-LEDS to not only reduce emissions in health-related activities but also build the resilience of the health sector in the process of pursuing net-zero emission by 2060 in line with the aspiration of LT-LEDS, include:

i. Harness the health benefits of climate action by prioritizing those climate interventions with the largest health-, social- and economic, as well as energy gains,

ii. Develop environmentally sustainable healthcare facilities across sectors to reduce morbidity rate.

4.8.6 Women, Youth and People Living with Disability

Considering the significant roles of climate-sensitive populations such as youth, and persons with disability in mitigating and adapting to climate change, their effective inclusion is central to the successful development and delivery of Nigeria's LT-LEDS.

This entails full and equal participation of young people and other marginalized segments.

Key mitigating strategies that Nigeria will adopt for the inclusion and mainstreaming of these vulnerable groups into low carbon development path in the implementation of the LT-LEDS include:

i. Changing the current labour market situation which leaves behind people with disabilities by offering better training and deliberately integrating them into various roles along the low-emission value chain.
ii. Aligning Low carbon offsetting and mitigation strategies with Nigerian Disability Laws at National and State levels.
iii. Ensuring deliberate inclusion and prioritization of these vulnerable groups while funding low emission initiatives from the programme design, monitoring, and reporting, where possible providing incentives.

5.8.7 Gender

While gender inequalities exacerbate the effect of climate change, it also makes existing inequalities worse and generally slows progress toward gender equality. Nigeria's agricultural sector is vital due to its contribution to the national economy and the employment opportunities it generates. Women constitute a substantial part of the agricultural labour force (75%) in a sector characterised mainly by smallholder farmers who mostly cultivate rain-fed farms. Agricultural growth relies on environmental resources such as land, forest and water. Climate change is also expected to result in long-term water and other resource shortages, land degradation, drought and desertification, and disease and pest outbreaks. These will lead to changes in land use and the transition of forests to grasslands, leading to biodiversity loss.

The energy challenge in Nigeria overlaps with issues such as gender, which includes, for instance, the need to use firewood or charcoal for cooking in the absence of better and more healthy alternatives. Women are primarily responsible for most domestic tasks and are worst affected by the health impacts of smoke inhalation with firewood or charcoal for cooking. Nigeria generates over 32 million tonnes of solid waste annually. Solid waste is one of Nigeria's largest sectors causing pollution, but also a significant contributor to climate change. Both women and men are involved in generating the production of agricultural and domestic waste and, as a result, contributes directly to greenhouse emission through the

generation of methane from anaerobic decay of waste and the emission of nitrous oxide from solid waste combustion facilities.

According to reports from UN-Water and the Interagency Network on Women and Gender Equality (2015), women in the majority of households in Nigeria are tasked with sourcing water and maintaining hygiene in the house and its environs. Furthermore, the report also indicated the gender divide in decisions bordering on water management and sanitation projects in rural areas. Men are more likely to access relevant training to maintain and repair water systems than women. Climate change is further exacerbating the water and sanitation challenges experienced in Nigeria, and this is placing more of a burden on women as they go farther distances to access.

Mainstreaming gender sensitivity into energy and climate-related policies and projects requires a paradigm shift that recognises women's contributions to 44 climate change responses and promotes the development of new opportunities for women in the energy sector. To accomplish this goal, women generally need to gain greater confidence and expertise in business management to build their capacity to undertake new economic activities *(National Action Plan on Gender and Climate Change for Nigeria, 2020).*

The government of Nigeria recognizes the need for a gender-responsive approach in addressing the imperative of low carbon development and specifically toward a net-zero emission by 2060 and also dealing with the challenges vulnerability. In this regard, it will pursue the following broad gender strategic measures or interventions:

i. Ensure gender-responsive and inclusive participation in its development activities–Ensure gender balanced representation in climate mitigation decision-making and integrate women's and men's needs and contributions across the planning and execution cycles of climate mitigation policies and projects.

ii. Undertake gender analysis and sex-disaggregated data to direct policies and actions –Gather quantitative and qualitative sex-disaggregated data to produce in-depth and evidenced-based analysis that interrogate sources of gender-based vulnerability, and women's historical and current disadvantages in mitigation actions. Set measurable gender-related targets and accountability frameworks for impacts and results.

iii. Promote linking climate mitigation and technology to women's economic empowerment. Invest in female entrepreneurship, capacity building in green skills, and access climate finance support to ensure women are not left behind in the transition to low-carbon economic development. Adopt gender-specific policies that support equality and parity in all spheres of societal life in addition to affirmative action in favor of women-led businesses for uptake of economic opportunities in climate mitigation and technology.

5.8.8 Just Transition

The idea of a just transition came about because of the realization that shifting from extractive to regenerative energy and economics requires consideration of social justice and

poverty in addition to the environment. "It seeks to ensure that the substantial benefits of a green economy transition are shared widely and provides support for those who stand to lose economically."[33] It outlines the transition from our existing social and economic systems to ones in which all jobs are environmentally and socially responsible, eliminates poverty, and local communities can prosper. Employers, governments, and workers must all participate in the transformation process for this to be successful. Based on each community's particular requirements, the framework for a Just Transition should appear different in each one.

Just Transition in Nigeria's LTS will entail making sure that social dialogue and stakeholder engagement take place among workers, employers, governments, communities, and civil societies, affected workers and communities receive the support, social protection, and investments they need to work and thrive in a zero-carbon future, revenue streams that governments currently receive from fossil fuel production are replaced in equitable ways by 2060, companies create decent jobs and contribute to economic growth while taking positive action on climate change**.** (WRI) through:

- Strengthening climate governance and implementation of sustainable development goals at all levels.
- Enhancement of green investments and alignment between investment and climate policies and programmes.
- Strengthening of programmes for upskilling climate responsive actions.
- Undertaking consistent public dialogues to promote improved employment, social protection, and well-being of workers.
- National engagement in the global discourse on Just Transition

5.8.9 Water Sector

With an annual growth rate of 3.2%, the population of Nigeria has been variously projected to reach about 263 million individuals by 2030[34]. Water use will be expected to at least triple the current situation. The WRMP report (FMWR, 2014) estimated the annual total water demand in Nigeria to be about 5.93 billion m^3. It is expected to increase to 16.58 billion m^3 in 2030.

The mitigation strategies by 2060 will focus on the following four key thematic areas of (i) Improving Energy Efficiency and Energy Production in the extraction, distribution, and treatment of water. (ii) Implementation of nature-based solutions in aquatic ecosystem management in improving the national carbon sink (iii) Adoption of nature-based solutions in water pollution control and management and (iv) Establishment of an effective and sustainable Public Private Partnership for the provision of climate -smart water supply and sanitation facilities and infrastructure across all sectors.

[33] What is a just transition? (ebrd.com)
[34] Available at https://www.populationpyramid.net/nigeria/2030

1. **Improving Energy Efficiency and Energy Production in the extraction, distribution, and treatment of water.** Emphasis will be to:
    - Install energy efficient pumping system.
    - Metering of water consumption
    - Water distribution, system monitoring and regulation
    - Reduction in leakage, metering errors and water theft
    - Adopt sustainable technologies and engineering for energy conservation in water production and usage.
    - increase Share of Nigerians with Access to water supply services from 68% to 90%.
2. **Implementation of nature-based solutions in aquatic ecosystem management in improving the national carbon sink.** This will involve:
    - Adopt sustainable water management practices.
    - Restore natural floodplains and riparian habitats to absorb carbon and create suitable environments for aquatic life.
    - Restore degraded wetlands and coastal habitats.
3. **Adoption of nature-based solutions in water pollution control and management.** This will entail:
    a. Encourage the use of bioremediation in aquatic pollution control and management to reduce the emission of carbon and other GHGs into the environment.
4. **Establishment of an effective and sustainable Public Private Partnership for the provision of climate -smart water supply and sanitation facilities and infrastructure** by:
    - Introducing reforms in establishment, management, operation and maintenance of water supply and sanitation schemes and services
    - Deploy sustainable energy for water and sanitation facilities and infrastructure.
    - Continuation of the Partnership Expansion for Water Sanitation and Hygiene (PEWASH)

The government will support the adoption of water-saving technologies especially in the agricultural and industrial sectors, Energy generation from biogas from anaerobic wastewater treatment plants, Heat recovery from wastewater and secondary wastewater products; and Source water protection, including ecological restoration activities - may also be an important mitigation opportunity and potential activities with automation to minimise water loss. This will require encouraging cultural change amongst consumers to improve efficiency and water infrastructure development in both supply and use, as captured in the water sector of the National Climate Change Programme.

5.8.10 Natural Capital with Biodiversity

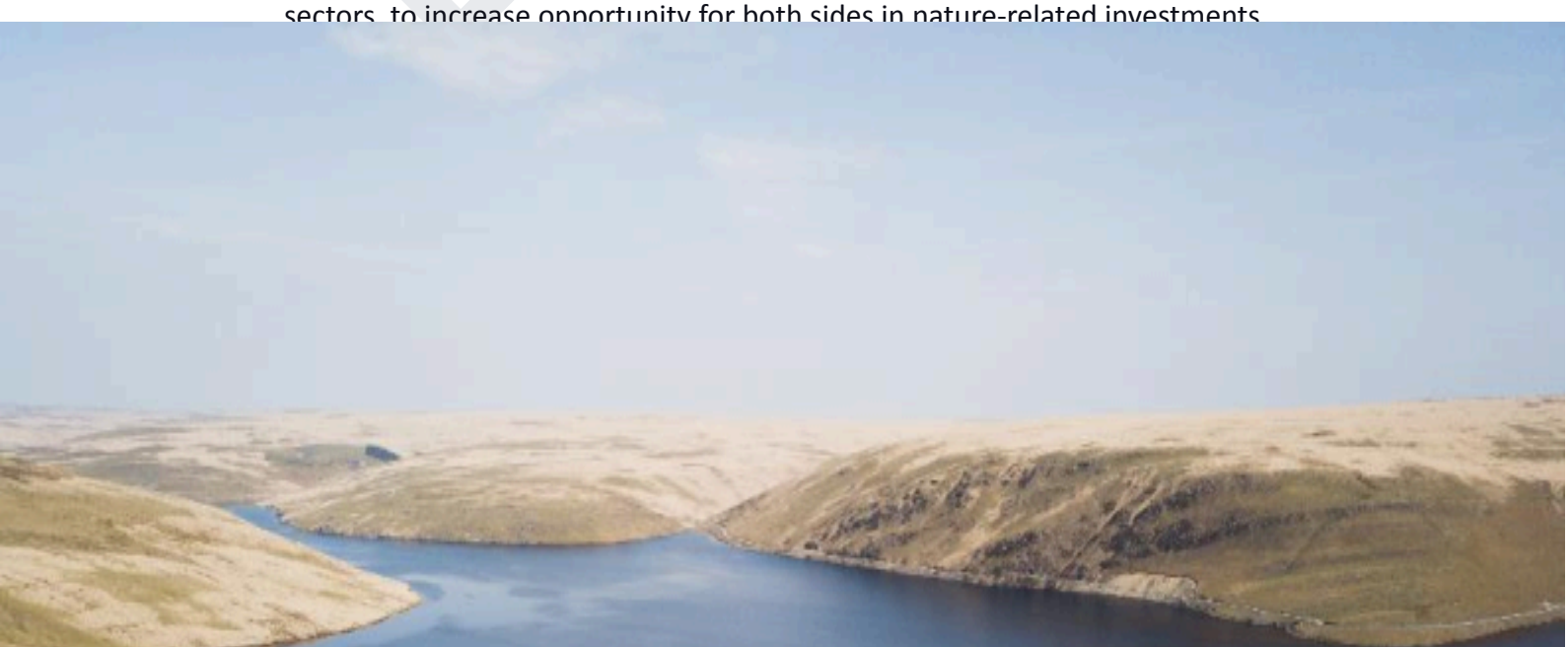
Climate change is a major driver of biodiversity erosion, and loss of biodiversity also accelerates climate change processes. Natural capital is the global stock of natural assets, such as geology, soil, air, water and all living things. Biodiversity adds to the world's natural capital, by making it richer, and more varied and robust: it effectively acts as a multiplier of the value of natural capital.[35] Nigeria has enormous and untapped natural capital with biodiversity that are crucial to addressing these challenges, whether in terms of climate change mitigation, resilience, and adaptation.

[35] https://www.lloydsbank.com/business/resource-centre/insight/biodiversity-natural-capital.html

There exist clear paths today that demonstrate climate mitigation and adaptation are possible by investing in nature. Climate action requires both the reduction of emissions and the removal of carbon dioxide already in the atmosphere. Nature offers a way to address increased resilience as the climate changes. Through conservation, restoration, and land-management measures, natural capital as natural climate solutions increase carbon storage and avoid greenhouse gas emissions.

The mitigation measures suggested for harnessing the power of nature for Nigeria are outlined below:

- Investing in data collection for better valuation and measurement of natural capital, including implementing and integrating natural capital and ecosystem services into the standard system of national accounts such as UNSEEA;
- Creating a coherent framework for organising and standardising data biodiversity and natural capital data coming from different sources.
- Implementing appropriate fiscal and market instruments for optimal utilisation of both renewable and non-renewable natural resources that take climate change and green growth into account;
- Engaging leading sectors that depend upon natural capital and ecosystem systems, such as forestry, agriculture, fishing, and tourism, to find sustainable solutions. Examples include Payment for Ecosystem Service schemes or seeking funding through impact investment.
- Investing in the capacity, technology, approaches and tools needed to benefit from best practices in exploration and licensing initiatives and international agreements and
- reforming institutions to improve transparency and implement best practices for the government of natural resources.
- Ensuring integrated landscape planning in the water catchments through a role for natural capital accounting (NCA) to also support climate change mitigation and adaptation
- Catalysing transformational change in conservation and sustainable management of critical transboundary landscapes and integrating NCA in the regional landscape planning and management
- Encouraging businesses through enabling policies to understand nature-related risks, impacts, and dependencies is essential for growing businesses.
- Improving the flow of data in both directions, between the private and public sectors, to increase opportunity for both sides in nature-related investments



Key Enablers for Implementing Nigeria's LT-LEDS

This LT-LEDS is about Nigeria reconciling its response to the climate crisis and challenge in terms of its mitigation and adaptation initiatives to foster low-carbon climate-resilient development that will promote economic growth, reduce poverty, improve inclusiveness and gender-responsive development. On one hand, mitigation measures will be in place to contribute to the global effort to prevent the degree of climate change from becoming unmanageable. On the other hand, adaptation measures to reduce the harm from climate change that proves unavoidable will be implemented to enable Nigerians to adjust to a warmer world, to protect people, nature, our prosperity, and our way of life. Effective balancing of mitigation and adaptation initiatives in its national development agenda will help Nigeria to overcome its major challenges and turn current problems into effective solutions, as well as make the country's development climate compatible and resilient. This will be in addition to helping Nigeria to contribute its international climate commitment.

The main challenge for Nigeria is how to rapidly transform its current heavy fossil fuel-based economy to a low-carbon economic development that will not only improve the well-being of its citizenry but will also enable her to fulfil her commitment to the global climate change agreement as elaborated in its NDC. In particular, the pursuit of long-term development targets by achieving net-zero emissions must be substantial implemented through the national transformation of the development agenda. Meeting this challenge needs fresh ideas and a radical new innovative way of thinking and doing things. This includes strategic planning and how we maintain, improve, and use our natural resources (renewable and non-renewable) to generate and sustain long-term pro-poor economic growth, thereby reducing poverty and supporting the achievement of the goals of the PA and the SDGs. It also requires that new strategic approaches are in place to attract significant investment in the country's development to make it climate

resilient as climate change affects the ability of natural capital to deliver its wide range of products and services. To do this effectively, Nigeria will put in place critical enabling innovations for the implementation of the LT-LEDS. These Innovations will be related to policies, economic and social development, finance, technology, and research and development.

6.1 Policy Innovation

Nigeria will design and implement enabling policies that will create a conducive environment for the LT-LEDS implementation. Policymakers will be empowered to appropriately consider social equity, environmental justice, and gender equality in designing policies to ensure that the benefits of LT-LEDS are equitably shared across society. The enabling policy approach to incentivise low-carbon development will include setting appropriate regulatory frameworks, designing effective carbon pricing mechanisms, providing incentives for renewable energy development, and investing in sustainable infrastructure.

- *Regulatory Frameworks*:

These will be used to set targets for greenhouse gas emissions reduction and enforcement of those targets. Clear rules and regulations for renewable energy development, energy efficiency, and sustainable transport, among others will be established.

- *Carbon Pricing Mechanisms*:

Carbon pricing, as a policy instrument that puts a price on greenhouse gas emissions to create a financial incentive for polluters to reduce their emissions, will be established. The opportunity for carbon pricing mechanisms in the form of carbon taxes, cap-and-trade systems, or carbon fees to fund LT-LEDS, will be explored.

- *Incentives for Low-Emission and Renewable Energy Technologies*:

In the implementation of the LT-LEDS, policies that incentivize the deployment of low-emission and renewable energy technologies, such as solar and wind power will be implemented. They will take the form of tax credits, subsidies, or feed-in tariffs that provide a guaranteed price for renewable energy generation. The implementation of these policies will help to reduce the cost of renewable energy, making it more competitive with fossil fuels and enhancing wider adoption by the populace to accelerate the national path to net-zero emission development in Nigeria.

- *Investment in Sustainable Infrastructure*:

Investment in sustainable infrastructure, such as public transportation, green buildings, and sustainable urban planning, that is critical to enabling the implementation of LT-LEDS will be promoted through public-private partnerships. The government of Nigeria will prioritize public investment in sustainable infrastructure, which can reduce greenhouse gas emissions, improve air quality, and create jobs. For example, investing in public transportation can reduce emissions from private cars while improving access to employment and services.

A major innovation will be to knit relevant policies from the plethora of national sectoral policies in the country together into a robust, coherent, and inclusive policy framework to support systemic transformations for the implementation of the LT-LEDS. A concerted national effort will be made to implement well-established robust policies to ensure timely shifting of investments at a scale that will have a significant drive for the attainment of net-zero emission, low-carbon, and climate-resilient development in the National Agenda 2050.

6.2 Economic Innovation

Implementing the LT-LEDS will require significant economic transformations and innovations. These may include transitioning to low-carbon economies, investing in sustainable infrastructure, and promoting green jobs. In particular, green finance mechanisms will be employed to accelerate the deployment of low-carbon and climate-resilient investments, as well as provide needed capital for low-emission infrastructure development. They may include measures and instruments like green bonds, which are debt securities issued to finance environmentally friendly projects, and for which Nigeria had already issued twice through the Federal Ministry of Environment and the Stock Exchange Commission (SEC) and used for programmes and projects within individual MDAs sector strategies. In addition to the use of green bonds, Nigeria will explore other innovative financing mechanisms, such as green banks and public-private partnerships to finance needed economic transformations to low-carbon sustainable development. Enterprises will be encouraged and supported to adopt green and low-carbon technological innovation is an important measure to cope with climate change and achieve low-carbon economic development. Pollution tax, low-carbon technology innovation subsidy, and environmental protection publicity and guidance that can effectively stimulate enterprises' green and low-carbon technology innovation will be used as economic incentives.

6.3 Social Innovation

Successful implementation of Nigeria's LT-LEDS will require significant changes in social behaviour and norms. In this regard, Nigeria will ensure inclusiveness and community-based approaches that prioritize local knowledge, culture, and values in implementing LT-LEDS. This will include promoting public participation in decision-making processes and ensuring that vulnerable communities are not left behind. Key measures to this effect will include:

- *Public participation:*

Governments at all levels will involve citizens in the decision-making process, particularly those who are most impacted by climate change, in the process of LT-LEDS implementation, through public consultations, citizen assemblies, and participatory budgeting, to ensure transparency, accountability and responsiveness to local needs.

- *Equity:*

This will include addressing the needs of vulnerable communities, such as

low-income households, indigenous peoples, and marginalized groups to ensure that the benefits and costs of LT-LEDS are equitably shared across society.

- *Community engagement:*

As different stakeholders have been involved in the development of the LT-LEDS, communities will also be involved in its implementation to increase awareness, build support, and create ownership of low-emission strategies. Public consultations, stakeholder engagement, and citizen science initiatives, among others, will be used as means of engagement.

- *Behaviour change*:

The government recognises that changing individual and collective behaviour will be critical for the successful implementation of the LT-LEDS. A major innovation will be to use social norms, education, and nudges to promote low-carbon lifestyles, such as active transportation, reduced meat consumption and energy conservation to motivate behaviour change.

- *Social entrepreneurship*:

Social entrepreneurship, involving the use of entrepreneurial skills and methods to create social entrepreneurs, will be developed to scale up LT-LEDS solutions by creating new products, services, and business models that address social and environmental challenges. Social entrepreneurship will also create promoted to create green jobs and foster economic growth in communities for the sustainability of various LT-LEDS initiatives.

- *Collaborative governance*:

Collaborative governance that brings together different stakeholders, including government at all the three tiers of governance of Nigeria, civil society, and the private sector, will be promoted and sustained in the implementation of Nigeria's LT-LEDS to collectively address the necessary complex social and environmental transformations for the attainment of net-zero, low-carbon, and climate-resilient development. This will help to build trust, increase transparency, and foster innovation in the implementation of the LT-LEDS.

6.4 Technological Innovation

Just as the causes of climate change are complex, climate change impacts are also disruptive and largely unpredictable, diverse and context dependent. Thus, climate change mitigation and adaptation activities and initiatives are so many and varied. They range from simple techniques and practices to highly sophisticated technologies. Advancements in technology will, therefore, be critical to enabling the implementation of the LT-LEDS. The development and deployment of innovative technologies will help to reduce greenhouse gas emissions, increase energy efficiency, and promote sustainable development. The following are some ways in which technological innovations will be deployed to support the implementation of the LT-LEDS, particularly in areas of renewable energy, energy storage, and carbon capture and storage:

- *Renewable energy technologies:*

The government will accelerate the deployment of renewable energy technologies in the implementation of the

LT-LEDS in an innovative and globally competitive manner to capture latest technologies that will help the required rapid transition to low-carbon energy system.

- *Energy storage technologies:*

Up-to-date energy storage technologies, such as batteries, flywheels, and pumped hydro storage, that will help address the intermittent nature of some renewable energy sources and improve the reliability and resilience of the electricity grid will be deployed to reduce the need for fossil fuel-based peaking power plants and support the integration of variable renewable energy sources in the process of the LT-LEDS implementation.

- *Energy efficiency technologies:*

Energy efficiency technologies, such as smart thermostats, efficient lighting, and building insulation, that can help reduce energy consumption and greenhouse gas emissions in buildings, industry, and transportation will be promoted for wide adoption. They will also be deployed to reduce energy costs, improve comfort and health, and create jobs in the implementation of Nigeria's LT-LEDS.

- *Carbon capture and storage technologies*:

Carbon capture and storage (CCS) technologies that will help capture and store carbon dioxide emissions from existing fossil fuel-based power plants and industrial facilities will appropriately be deployed for the development of low-carbon industrial processes, such as carbon-neutral steel making, in the implementation of the LT-LEDS.

- *Digital technologies*:

Digital technologies, such as artificial intelligence, big data, and the Internet that can help optimize the operation of energy systems, improve energy efficiency, and enable the integration of renewable energy sources will be deployed to help monitor and manage the implementation of the LT-LEDS.

In general, Nigeria will invest in research and development of low carbon technologies, promote technology transfer from developed countries, support the development of domestic clean technology industries and. prioritize the adoption of smart technologies to accelerate the pace of transition to net-zero emission, low-carbon, and climate resilient development.

6.5 Financial Innovation

In view of the expected high cost of transiting to net-zero, low-carbon and climate-resilient development financial innovations will be necessary to mobilize the necessary resources to implement the LT-LEDS. Nigeria will explore innovative financing mechanisms such as carbon pricing, green bonds, and climate risk insurance and prioritize public investment in LT-LEDS and encourage private investment in sustainable development. It will create financial incentives for the adoption of sustainable practices such as energy efficiency and renewable energy. In addition to the use of green bonds that was mentioned as part of the economic

incentive, the following are some ways in which financial innovations will be adopted to support the implementation of the LT-LEDS:

i. ***Climate risk insurance***:

Climate risk insurance is a financial product that helps protect vulnerable populations and businesses from the impacts of climate change. It will be deployed to help reduce the financial risks associated with LT-LEDS initiatives, such as extreme weather

events, natural disasters, and policy changes. By providing a safety net for investments in low-emission strategies, climate risk insurance can help increase the attractiveness of LT-LEDS investments.

ii. *Impact investing*:

Impact investing involves investing in companies, organizations, and funds that generate measurable social and environmental impact, as well as financial returns. Impact investing will be encouraged through appropriate policies to help support the development and scaling up of the LT-LEDS solutions by providing capital, expertise, and networks to social and environmental entrepreneurs. By aligning financial returns with positive social and environmental outcomes, impact investing will help unlock new sources of capital for Nigeria's LT-LEDS.

iii. *Payment for ecosystem services*:

Payment for ecosystem services (PES) will be deployed to provide financial incentives to landowners and communities for conserving or restoring ecosystems that provide valuable services, such as carbon sequestration, water purification, and biodiversity conservation. This will effectively help support the implementation of the LT-LEDS by incentivizing the adoption of sustainable land management practices, such as agroforestry, sustainable agriculture, and reforestation and by providing a source of income to rural communities, PES will also help reduce poverty and improve people's well-being and livelihood that are so critical to the sustainable development of Nigeria.

iv. *National Climate Fund:*

The Climate Change Act 2021 established Climate Change Fund, which will warehouse amounts paid by way of carbon taxes and emission trading; appropriations from the National Assembly, funding from international organisations; fines and charges issued to private and public entities; subventions, grants, donations, and fees etc. It is expected that its modality and operationalization will be a major priority for the National Council on Climate Change for its effective deployment to promote net-zero emission, low-carbon, and climate-resilient development by 2060 in the country.

v. *Emission trading system (ETS):*

The Government of Nigeria is also in the process of establishing an ETS as one of the mechanisms to mobilise effectively for financing its climate response. ETS or cap-and-trade system, sets a limit ("cap") on total direct GHG emissions from specific sectors and sets up a market where the rights to emit (in the form of carbon permits or allowances) are traded.

This approach allows polluters to meet emissions reduction targets flexibly and at the lowest cost. It provides certainty about emissions reductions, but not the price for emissions, which fluctuates with the market. ETS will be fully deployed in the implementation of the LT-LEDS.

These financial innovations would be designed and implemented in a way that maximizes social and environmental benefits and minimizes negative impacts, such as social exclusion, environmental degradation, and financial instability.

6.6 Research and Development

Demand-driven research partnerships with research users across the public and private sectors that can lead to innovation in mitigation and adaptation research and scaling will be promoted. Its outputs will be used to inform decision-making by governments, the private sector, and development organizations at all levels of governance in Nigeria. This will invariably support the implementation of high-impact mitigation and adaptation actions for meaningful progress toward the country's LT-LEDS targets. Nigeria will implement monitoring and evaluation processes, and engage scientific institutions, to strengthen learning from and improvement of LT-LEDS policy processes and inform and implement a ratcheting-up strategy as provided by the PA.

Overall, enabling policy, economic, social, financial, and technological innovations, with adequate demand-driven research is critical for the successful implementation of LT-LEDS. By developing a comprehensive and collaborative approach that addresses these key areas, Nigeria will create a sustainable and climate-resilient low-carbon future. It will design and implement enabling policy, economic, social, financial, and technological innovations. The Government will prioritize public investment in LT-LEDS and encourage private investment in sustainable development. Furthermore, the Government prioritize social equity, environmental justice, and gender equality in designing policies and implementing LT-LEDS to ensure that the benefits are equally shared across society.

Way Forward- Implementation Framework for the LT-LEDS

7.1 Action Plan for Implementing the LT-LEDS

To realise net-zero emissions by 2060 and ensure a climate resilience society, the strategic mitigation and adaptation measures are summarised in the action plan outlined in the immediate, short-term, and long-term (Appendix 5 and 6). Also outlined in the action are the responsibilities and performance indicators. The action plan will guide the full and effective implementation of the LT-LEDS and take into cognizance the multi-sectoral nature of the LT-LEDS

A brief on the finance strategy, governance structure and roles and responsibilities with action for climate empowerment (ACE) and capacity building are presented in this Section. Also described are the aspects of technology development and transfer and the

monitoring, reporting, and verification.

7.2 Governance Structure, and Roles and Responsibilities

The institutional arrangements draw from the governance structure used in elaborating this LT-LEDS through all stakeholders' formal agreement and commitment. The arrangements include planning, coordinating, and implementing climate change policy and action and integrating climate change aspects into broader development planning. Such formal institutional arrangements ensure the integration of climate and development priorities. It thus provides a high-level endorsement to the LT-LEDS to place climate change at the heart of government decision-making, which already has an overarching vision for enhancing institutional capacities at all levels, preventing, and minimizing possible challenges and trade-offs through coordination, ensuring effective coordination, and providing strategic orientation in achieving the long-term goal.

The UNFCCC Focal Point has the ownership and responsibility, to work with the other stakeholders to ensure the implementation of this LT-LEDS.

7.3 Finance Strategy

Consistent financial flows with a pathway towards low-emission and climate-resilient development are vital to implementing this LT-LEDS. The financial needs for implementing the LT-LEDS include as much as possible finance needs described general statements on needs and costed needs, which have identified funding sources (domestic finance, international support, and private finance). It also involves efforts taken so far by the government to increase finance flows through economic policy measures, financing mechanisms or financial instruments, such as taxes, levies, fiscal incentives, and carbon pricing mechanisms.

Climate finance needs to involve mitigation measures developed for the following sectors: energy, forestry, industry, land use, and transportation sectors. Agriculture, coastal protection, disaster risk management, disaster risk reduction, and ecosystem and biodiversity are critical for adaptation measures.

The funding sources for implementing this LT-LEDS will be domestic finance and international support with the support of private finance. As outlined in this strategy, using relevant channels and instruments that include establishing bilateral and regional cooperation, promoting green investment through strategic sector cooperation, allocating grants and loans for capacity-building, and sponsoring research and development of innovative technologies for mitigation and adaptation. The government anticipates increasing finance flows through economic policy measures, financing mechanisms or financial instruments as it implements the existing fiscal policies such as taxes, levies, fiscal incentives, and carbon pricing to spur low-carbon investments. Other economic or regulatory policies and measures would include green tariff systems and emission pricing based on the 'polluter pays' principle, dedicated programmes and incentives for green investments, and national action plans to regulate emissions (as per the 2021 Climate Change Act).

In addition, for broader efforts to transition to low-emission and climate-resilient development, other relevant financial instruments shall include loans, guarantees, grants and strengthening the green bond market that issues green sovereign bonds. Also, efforts would redirect financial flows consistent with the pathway that aligns with this LT-LEDS for low-emission and climate-resilient development by developing national financial strategies such as attracting foreign direct investment and establishing green taxonomies to facilitate redirecting financial flows and developing climate finance strategies and road maps.

Thus, substantial investments are required to ensure a transition to a long-term low-emissions pathway that aligns with economic and environmental necessity. The finance strategy of the LT-LEDS, which aims to provide a data-driven blueprint, needs to be developed. This will align with and complement the existing climate finance policies and strategies to finance the transition to a low-emission pathway and reach NET-Zero emissions by mid-century. An outline of the finance strategy for Nigeria's LT-LEDS is provided in Appendix 7

7.4 Action for Climate Empowerment (ACE) and Capacity Building

ACE is relevant to ensure the effective implementation of LT-LEDS mitigation and adaptation measures. ACE elements include, for example, climate education and public awareness, training, public participation, and public access to information. These elements provide bases for domestic and international cooperation on the ACE elements as they are indispensable tools for mobilizing all sectors of society towards achieving the measures outlined to achieve long-term goals. This is even more so as the transition to a low-emission and resilient economy and culture could be achieved only with a collective long-term vision, strategy, and efforts. Such efforts include all community members, including children and youth, educated, and empowered to make climate-conscious decisions, fully equipping the current and future workforce with the skills necessary to address the climate crisis.

Capacity-building is crucial to the implementation of the LT-LEDS as an operational strategy. Capacity-building measures are a cross-cutting issue with an overarching enabler for adaptation and mitigation commitments and actions. For instance, capacity-building facilitates technology development, access to climate finance, public engagement, and transparent information communication.

The LT-LEDS recognizes that adaptive capacity for managing the transition to a decarbonized and climate-resilient future in the long term through enhanced social and ecological capacity is needed. This supports the system to absorb stresses and maintain functions in the face of climate change and to reorganize social activities and human behaviour in preparation for the future impacts of climate change.

The capacity-building, including education and training, to all stakeholders raised awareness for a climate-conscious society and equipped the population with the skills and knowledge needed for climate action.

An integrated approach to capacity development at all levels would ensure an inclusive transition towards the pathway to net zero emissions and a climate-resilient economy. This LT-LEDS requires international cooperation to fulfil the identified capacity needs and gaps, including technical, infrastructural, financial, human, and institutional needs and gaps.

Fundamentally, the LT-LEDs will support ensuring capacity-building partnerships through regional and international institutions are essential for aligning national and regional plans and actions.

7.5 Technology Development and Transfer with International Partnership

Technologies and innovation are fundamental to addressing climate change and the economic growth of Nigeria. These assist in creating jobs, increasing competitiveness, supporting sustainable development, and enhancing living standards. A well-designed mix of policies is relevant as these serve to reduce costs, including public research and development, demonstration and pilot projects, and demand-pull policies, which create incentives and market opportunities.

Raising public awareness of available and affordable climate technologies was considered an effective tool for implementing climate technologies on both the supply and demand sides. However, the current lack of energy security will hamper decarbonization efforts in some LT-LEDS. The joint development by Nigeria and its international partners would lead to sustainable energy consumption technologies, including energy-saving and energy-efficiency technologies, delivering low-cost emission reduction measures cost and significant synergistic benefits in the medium and long term.

7.6 Monitoring, Reporting, and Verification

To optimise monitoring and support policymaking, support the design, cost-benefit analyses and prioritisation of adaptation measures, it is required to set up a dedicated climate data center. The work packages for the realisation:

1. Set up a national (or regional) physical data center. Develop and install a platform that consists of a data warehouse, decision support toolkit and several (example) decision support tools. The Centre will serve as a hub for region-wide information, including water, land use, environmental and climate change information, education, and outreach, and provide support to specialized studies and research projects that inform decisions and investments in the region.

2. Capacity building. Provide an extensive training program for operations, data engineers, scientists, and decision support tool developers. Create a digital experience centre to train policymakers, decision makers and end users in how to use the DSS tools to their advantage. Set up an educational program to connect to future stakeholders. Profit from the innovation created within the world of science.

3. Set up a data governance, business model and sharing policy to ensure data availability and enable commercial and noncommercial stakeholders to profit from the centre.

The results would be a locally maintained data centre and platform with a vibrant ecosystem of decision support tools providing valuable information to end-users enhancing the capacity to manage and adapt to climate change. Trained stakeholders and sustainable data governance and related business models would also result.

Indicators and reporting elements shall include quantified data such as GHG emissions, sink capacity, economic and energy statistics for the current situation and intermediate and long-term targets, and qualitative descriptions by sector, including but not limited to

agriculture, buildings, energy, industry, LULUCF, transport and waste, to inform on the achievement of domestic policies and measures.

7.7 Possible Challenges/Risks in the Implementation of the LT_LEDS

In the implementation of the LT-LEDs, some challenges have been identified, which include, notably:

a. The challenge to economic resilience posed by the global transition requires less reliance on fossil fuel revenues as the world moves towards a low-carbon world. This needs the development of additional fiscal revenues to meet development objectives and push mitigation and adaptation measures simultaneously. This is a challenge to Nigeria.

   The role of oil and gas (exports) in the Nigerian economy, today and tomorrow, looks strong reading the body language and pronouncements of the government. The critical question of what happens by 2040-60 if prices of oil and gas drop as a result of a global reduction in the use of oil and gas remains the elephant in the room. Would continual investments in fossil fuel-intensive systems delay or obstruct the transition to low-carbon alternatives – which would put the country's climate efforts in danger and potentially cause higher costs for the transition to a low-carbon economy? *Would continual fossil fuel-intensive investments be* neutral for Nigeria's ability to meet its future development aspiration for a rapidly growing population with lower global demand? What alternative measures does Nigeria count on to pick up the corresponding loss of government revenues? These questions remain critical and need further analysis as we advance to adequately situate this in Nigeria's climate efforts and avert the danger that could potentially cause higher costs for the transition to a low-carbon economy.

b. Generally, decarbonisation technologies and practical use are still in their infancy. Effective international cooperation will require steadfast commitment backed by genuine and resource support to the nation.

c. Another possible risk is what is termed a transboundary and cascading climate risks. Risks that are occasioned by events elsewhere, but which impacts are greatly felt where they are least expected. These impacts are capable of eroding any adaptation measure s/gains being undertaken where they manifest. The need for some anticipatory measures is imperative.

7.8 LT-LEDS Update

As much as possible, this LT-LEDS reflects the most recent data and information, analysis, and scenario for potential future contributions to the global climate actions in achieving the Paris Agreement's goal and supporting the development agenda in Nigeria. As one of the countries contributing to less than 4% of global GHG emissions and one with the least

adaptive capacity, the country will likely experience dynamic changes that will impact the current situation upon which the report is based.

Necessarily, the LT_LEDS will be monitored, reviewed and updated. The result will be used to update the report and inform relevant decisions, considering national circumstances, capacity and capability, and the provision under the Paris Agreement.

Thus, given many significant changes can occur over a long-term period, including factors beyond the control of the country, Nigeria shall keep this LT-LEDS as a live document to reflect changes in technology, socio-economic and political context, scientific knowledge, and national capacity as they occur.

The timeline to review and update this LT-LEDS would align with the timeline to update NDCs so that the LT-LEDS will guide subsequent NDC revisions and updates.

7.9 Conclusion

The Nigeria LT-LEDS has been developed as an easy-to-implement strategy that considers the country's economic growth and social development objectives based on science and robust stakeholders undertaken. Also, while meeting climate objectives, it is designed to protect and improve the management and use of natural resources and ecosystems through institutional capacity building, governance, and investment/financing requirements.

The LT-LEDS, which properly align key national development policies, strategies, and plans for coherence, provide a pathway for a long-term whole-of-society transformation. It will guide medium to long-term planning and investment decisions for an effective transition to a low greenhouse gas emission and resilient future while promoting shared socio-economic prosperity.

In conclusion, Nigeria's ability to achieve the LT-LEDS lofty goals will be contingent, among others, on the maturity of the available decarbonisation technologies and practical and effective international cooperation, even concerning building a climate-resilient society.

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APPENDICES