United Nations Industrial Development Organization

Climate Technology Centre & Network

Federal Ministry of Environment - Department of Climate Change

Federal Ministry of Science, Technology and Innovation – Department of Environmental Sciences and Technology

Technology Needs Assessment and associated action plan for climate change mitigation and adaptation in Nigeria's most vulnerable economic sectors

Report on advanced energy models, capability and data inventory analysis to quantify costs of effective measures by sector and sub-sector

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Contents

1. Introduction and objectives

Nigeria has requested the support of Climate Technology Centre and Network (CTCN) and United Nations Industrial Development Organization (UNIDO) for the development of a TNA and associated action plan for climate change mitigation and adaptation. These documents will be used by Nigeria to implement its climate action plans, and to propose financing requests toward climate finance sources such as the Green Climate Fund (GCF). In this context, the three priority sectors for TNA in Nigeria are agriculture and land use, energy, and industry and commerce. These sectors were validated in the inception workshop conducted in September 2018, which was led by the Federal Ministry of Science and Technology (FMST), in collaboration with Federal Ministry of Environment's Department of Climate Change (FMEnv – DCC). The three priority sectors are not only key in addressing Nigeria's development challenges, but are also climate-sensitive and vulnerable to the impacts of climate change. Consequently, the prioritized technologies for Nigeria's Technology Action Plan (TAP) were selected from these three sectors and associated sub-sectors through a series of desktop review, stakeholder evaluation, and workshops.

This report will focus on the technologies prioritized under the energy sector, providing discussions on technology description, readiness of Nigeria and expected impacts, as well as estimated costs. The prioritized technologies in the energy sector will play a significant role in reducing greenhouse gas (GHG) emissions, introducing renewable energy to the country's energy mix, and fostering Nigeria's future economic growth. The objective of this report is to give useful information that will help stakeholders to develop effective projects in Nigeria that will contribute to the country's development and help achieve Nigeria's commitments in climate change. Furthermore, this report can be leveraged to establishing concept notes for specific international partners that enhance Nigeria's access to climate finance.

2. Overview of the Nigerian energy sector

According to the 2016 GHG inventory, the energy sector is the second largest source of emissions after the Agriculture, Forestry and Other Land Use (AFOLU) sector with approximately 34%.[1] In Nigeria's energy sector, fugitive emissions from leaks or other unintended releases of gases, are a substantial source of GHG emissions, accounting for 34.4 percent of total emissions of the energy sector.[2] Despite the fact that the energy sector is responsible for significant amount of GHG emissions in Nigeria, the demand for energy is expected to increase significantly as the population grows and per capita energy consumption increases driven by industrialization and other long-term development programmes. It is projected that approximately 35,000 MW of electricity is needed by 2020 to achieve Vision 20:2020, supported by on- and off-grid electricity generation. The projected growth rate required to achieve the vision will demand even greater electricity generation by 2030. Provision of reliable and stable electricity supply is also needed to support growth of the industry sector. The energy sector has objectives to increase access to electricity to 75 percent and 90 percent (rural and urban) by 2020 and 2030, respectively, and at least 10 percent of renewable energy mix by 2025. Furthermore, Nigeria aims to achieve universal coverage of 100 percent electrification by 2040. Therefore, the energy sector is an important sector in terms of addressing climate change and achieving economic development and growth.

The Nigerian energy sector, however, faces several challenges. Given the fact that Nigeria has a significant land area while having an urgent need to provide access to electricity to its population, it is necessary to work on different themes such as energy supply and efficiency

[1] Federal Republic of Nigeria. 2020. Third National Communication (TNC) of the Federal Republic of Nigeria under the United Nations Framework Convention on Climate Change (UNFCCC).

[2] Ibid.

improvement, reflecting the actual situation of each region. In addition, oil and gas are naturally endowed in Nigeria, which can be an obstacle when promoting low carbonization or energy efficiency improvements from an economic perspective. Although energy efficiency improvement is essential for the country to meet its climate change targets, increasing electricity supply to meet the country's growing electricity demand is also equally important, creating a challenge to promote energy efficiency. In addition, there is limited promotion of energy efficiency behavior while high consumption behavioral patterns and customs remain prevalent, especially among households in rural areas. There is also an issue of the increase in the use of fuelwood driven by the country's growing population, which is not only leading to deforestation but also raising health concerns among households. There issues are also highlighted in Nigeria key sectoral policies, including National Energy Policy and Energy Transition Plan.

To address these issues, technology action plans for the prioritized technologies were developed, which is as follows:

Action Plan 1: Raising awareness

Action Plan 2: Capacity building

Action Plan 3: Development of enabling environment for private sector engagement

Action Plan 4: Dissemination of technologies

The first action plan aims at raising the awareness of the relevant stakeholders such as government institutions, energy-sector stakeholders, technology developers, end-users, potential investors, and financial institutions. The objective of the second action plan is mainly to strengthen the technical and institutional capacity of relevant government institutions to allow them to make informed decision to design the required gender-responsive policies such as regulations, standards, fiscal instruments and incentives, among others, to support the implementation and dissemination of the technologies. The third action plan intends to develop the enabling environment for private sector stakeholders, to encourage them to take-up and scale-up the technologies and measures under each technology. Finally, as opposed to the previous three action plans which focuses on transversal measures applicable for all the technologies, the fourth action plan details the concrete activities needed to disseminate technologies by sub-sector. The successful implementation of the action plans and the diffusion of prioritized technologies is critical for Nigeria to deploy and disseminate the prioritized technologies, to not only help Nigeria's efforts in achieving its climate change targets and priorities, but also contribute to the country's development.

3. Technologies prioritized in the electricity supply sub-sector

For the electricity supply sub-sector, the following technologies were prioritized during the validation workshop that took place on August 1st, 2022: solar PV/concentrated solar power (solar thermal), waste-to-energy (biomass generation), and carbon capture and storage. These technologies generally aim at reducing GHG emissions and increase electricity supply.

3.1. Solar PV/Concentrated Solar Power (Solar Thermal)

3.1.1. Description

Solar Photovoltaic (Solar PV) refers to the technology of using solar cells to convert solar radiation directly into electricity. Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ in 2018. Of which, electricity generation (on-grid and off-grid) contributes 24% of the sector's GHG emissions. Nigeria's energy mix is dominated by fossil-fuel fired thermal power plants. Solar power generation can greatly contribute to reducing GHG emissions from the existing energy mix. Solar PV has been explicitly identified in the NDC as a key climate change mitigation measure. Specific targets for Solar PV include a 6.5GW capacity for on-grid electricity, and 13GW off-grid renewable energy (i.e., mini-grids, solar home systems and streetlights, and self-generation) which are more likely to be achieved through Solar PV.

Concentrated Solar Power (CSP: Solar Thermal) systems, on the other hand, generate electricity by concentrating solar energy using mirrors or lenses into a receiver. Electricity is generated when the concentrated energy from the sun allows heat transfer fluid to produce superheated steam, which is then used to turn turbines to generate electricity. CSP could make the power system more resilient to extreme climate events compared with conventional power systems, although not as resilient compared with Solar PV applications. Solar thermal technology was not specifically identified as a mitigation measure in the NDC. However, the TNC includes CSP as one of the low carbon development options. Similarly, CSP is identified as part of solar technologies considered in the NREEEP. Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.

3.1.2. Readiness of Nigeria and expected impacts

Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 MtCO2e in 2018. Of which, electricity generation (on-grid and off-grid) contributes 24% of the sector's GHG emissions. Nigeria's energy mix is dominated by fossil-fuel fired thermal power plants. Solar power generation and CSP can greatly contribute to reducing GHG emissions from the existing energy mix.

Solar PV applications in Nigeria remains low, especially for utility scale. For CSP systems, studies have been conducted, however, there is no evidence of CSP systems being deployed in Nigeria. Solar PV has been explicitly identified in the NDC as a climate change mitigation measure with specific targets for Solar PV including a 6.5GW capacity for on-grid electricity, and 13GW off-grid RE (i.e., mini-grids, solar home systems and streetlights, and self-generation). These technologies are also identified in National Renewable Energy and Energy Efficiency Policy (NREEEP). Given the fact that solar PV applications are commercially available globally, the technology may be available in short to medium term (until 2030).

3.1.3. Estimated Costs

Globally, there has been a decrease in the cost of solar PV systems in recent years. For instance, solar roof top PVs cost ranges from USD 1,000,000 to 1,500,000 per MW and utility-scale solar PV can cost approximately USD 1,321,000 for MW. For large CSP systems, the installation cost can range from USD 5,000,000 to 9,000,000 per MW. Concessional financing or grants will be required initially for infrastructural development and to cover the risks for private sector developers.

3.2. Waste-to-energy (biomass power generation)

3.2.1. Description

Waste-to-energy technologies refer to the combustion of solid waste as an alternative source to produce heat or electricity. In the context of electricity supply, this includes the use of agricultural biomass waste or municipal solid waste as fuel for the generation of electricity. Biomass energy could make the power system more resilient to extreme climate events, especially for decentralized (off-grid/mini-grid) applications wherein the area affected by power outage is limited. Biomass power generation technologies are generally mature and considered to be competitive wherever low-cost agricultural or forestry waste is available. Additionally, new technologies that show significant potential of further cost reductions are emerging. Yet, technologies to make pollutant emissions reduced to acceptable levels are required in the case of using municipal solid waste, which could result in higher total costs.

3.2.2. Readiness of Nigeria and expected impacts

Efficient utilization of biomass is part of the climate priorities of Nigeria. However, this focuses on its efficient use rather than as fuel for power generation. The NREEEP identifies strategies to promote biomass power generation in the country. Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy. A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation. In addition, utilization of biomass, especially solid waste, avoids improper disposal that pollutes the environment. The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood in Nigeria. It also increases access to electricity, especially for off-grid applications, potentially reducing poverty.

Given the favorable policy environment as well as the significant amount of biomass resources in Nigeria, and the enabling environment is favorable. Therefore, the technology can be implemented in the short (2022 - 2025) to medium term (2026 - 2030).

3.2.3. Estimated Costs

Biomass power generation technologies are generally mature and considered to be competitive wherever low-cost agricultural or forestry waste is available. Additionally, new technologies that show significant potential of further cost reductions are emerging. This includes incineration plants based on circulating fluid bed (CFB) (approx. USD 5,000,000 per boiler) and hydrothermal carbonization (approx. USD 40,000,000 per plant). Yet, technologies to make pollutant emissions reduced to acceptable levels are required in the case of using municipal solid waste, which could result in higher total costs.[3]

3.3. Carbon capture and storage

3.3.1. Description

Carbon Capture and Storage (CCS) is the process of capturing CO2 from emission sources such as power plants, transporting, and storing it in underground geological formations. CCS prevents CO2 release into the atmosphere. It contributes to GHG emissions reduction even in hard-to-abate sectors such as cement industry. There are 26 large-scale CCS facilities are operating commercially in the world. Yet, it is hard to say that CCS technologies are mature and widely deployed. Several applications of CCS, including chemical absorption of CO2 from ammonia production and natural gas processing, are already widely deployed today. Many of other applications are still at the early adoption stage, such as chemical absorption from coal-fired power generation and hydrogen production from natural gas, compression of CO2 from bioethanol production and coal-to-chemicals plants, and CO2 storage in saline aquifers. Several other applications, including DAC (direct air capture) and CO2 capture from cement and iron and steel making, are still at the pilot stage.

3.3.2. Readiness of Nigeria and expected impacts

CCS have the potential to reduce emissions from hard-to-abate sectors of Nigeria. CCS also have the potential to improving environmental quality by reducing air pollution from the treatment process. However, CCS has not been introduced in Nigeria yet and most of the technologies associated with CCS are not available commercially. Therefore, the technology may only be available in the mid to long term (2030 - 2050). There is, however, an ongoing Industrial CCUS programme that is being implemented by the World Bank Group in collaboration with the Office of the Vice President, which may accelerate the dissemination of the technology in Nigeria.

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[3] IRENA "Bioenergy for Power" Available at https://www.irena.org/costs/Power-Generation-Costs/Bioenergy-for-Power

3.3.3. Estimated Costs

Significant investment is required to implement the technology. The cost of CCS depends on types of power and industrial processes in which the CCS is installed. For instance, for refinery, the cost of CCS can range from USD 50 to 100 per ton CO2 while the cost of CCS can range from USD 75 to 150 per ton CO2 for iron and steel industries.4 The total capital requirement for retrofitting a power plant can reach USD 1888/KW. This means that total cost can reach up to USD 2 billion if CCS is installed in 1000MW plant in Nigeria.

4. Tools available for data assessment and modeling (electricity supply)

This section identifies tools that can utilized for data assessment and modeling, specifically to prioritized technologies in the electricity supply sub-sector.

Tools	Description
Long-Range Energy Alternatives Planning System (LEAP) [5]	This is a software for analyzing energy policy/planning and assess climate change mitigation. This tool has been utilized by government organizations, consulting firms, academia, energy utilities, and among others in over 190 countries. It is a scenario-based modelling software that would allow to track energy consumption and production, as well as resource extraction in different sectors of the economy. It can also be used analyze emissions patterns and regional air pollutants and calculate country-level climate benefits. Furthermore, it can be used to compare emission reduction scenarios and strategies.
National Solar Radiation Database (NSRDB)[6]	This tool may be used specifically for evaluating Solar PV/CSP projects. The NSRDB collects hourly and half-hourly values of the three most common measurements of solar radiation (global horizontal, direct normal, and diffuse horizontal irradiance) and meteorological data. Utilizing this data, project developers can estimate the amount of solar energy expected, which is necessary in developing effective projects for Solar PV and CSP projects.
Renewable Energy Potential (reV) Model[7]	This is a modelling assessment tool with the objective of helping utility planners, regional and national agencies, project and land developers, and researchers to evaluate renewable energy potential. This enables users to calculate renewable energy capacity, generation, and cost based on geospatial intersection with grid infrastructure and land-use characteristics.
Biomass Environmental Assessment Tool (BEAT2)[8]	By allowing users to input information on different categories of bioenergy conversion plant and feedstock, BEAT2 provides data for assessing the potential benefits, as well as associated environmental impacts, of bioenergy technologies. Even though it is a United

[4] Global CCS Institute “Technology Readiness and Cost of CCS”

[5] NDC Partnership “Long-Range Energy Alternatives Planning System (LEAP)”

[6] National Renewable Energy Laboratory “National Solar Radiation Database (NSRDB)”

[7] National Renewable Energy Laboratory “Renewable Energy Potential (reV) Model”

[8] Forest Research “Biomass Environmental Assessment Tool (BEAT2)”

	Kingdom-based tool, the data developed through this tool may provide baseline data to assess waste-to-biomass projects.
Carbon Capture Simulation for Industry Impact (CCSI2)[9]	An open source tool set was developed as part of the CCSI2 initiative, to allow stakeholders to utilize for modeling, optimization, and uncertainty quantification of carbon capture applications. There are several computer models and tools that can be used as part of calculating the risks and benefits of installing carbon capture technology.

5. Technologies prioritized in the energy demand sub-sector

For the energy demand sub-sector, the following technologies were prioritized during the validation workshop that took place on August 1st, 2022: improved cookstoves, demand-side management, and smart grid. These technologies generally aim at managing the rising demand and reducing reliance on fuelwood.

5.1. Improved cookstoves

5.1.1. Description

Improved cook stove technologies pertain to cooking stoves with improvement in efficiency (available in different forms and sizes). In Nigeria, about 50% of the population depends on traditional biomass for their energy needs, with only 45% of the population having access to electricity (2016). Since those without electricity use fuelwood as their primary fuel source, improving the energy efficiency of cook stoves by introducing alternative fuels such as sustainable biomass or liquefied petroleum gas is expected to result in significant emissions reduction in rural areas. Promoting the use of improved cook stoves leads to less use of fuelwood. This prevents deforestation, which in turn makes the land resilient against flooding. The technology also has social impacts with respect to health, empowering women, and saves lives by avoiding respiratory diseases particularly in rural population.

5.1.2. Readiness of Nigeria and expected impacts

Improved cook stoves have been implemented in Nigeria, including those under the clean development mechanism (CDM). In addition, the Federal Government of Nigeria intends to implement a program to meet the country's clean cooking targets. As such, the technology may be available in the short to medium term (until 2030) in Nigeria.

Efficient and sustainable use of biomass resources is a priority for Nigeria considering that demand for biomass leads to deforestation. The NDC and TNC identifies efficient cookstoves to reduce biomass fuel demand, along with alternative heating sources such as Liquified Petroleum Gas (LPG). Specific targets include, 48% of population (26.8 million households) using LPG and 13% (7.3 million) using improved cookstoves by 2030. Moreover, since those without electricity use firewood as their primary fuel source, improving the energy efficiency of cook stoves by introducing alternative fuels such as sustainable biomass or liquefied petroleum gas is expected to result in significant emission reduction in rural areas.

5.1.3. Estimated Costs

The technology generally does not require significant investments. Improved cook stoves are available at USD 45 per unit on average.[10]

[9] Carbon Capture Simulation for Industry Impact (CCSI2)
[10] Project drawdown "Clean cooking"

5.2. Demand-side management

5.2.1. Description

Demand-side management consists of the planning, implementing, and monitoring activities of electric utilities to encourage consumers to modify their level and pattern of electricity usage. It allows distribution utilities to satisfy power needs of more customers with little to no increase in power supply generation. Demand-side management consists of demand response, energy efficiency, and strategic load growth components.

5.2.2. Readiness of Nigeria and expected impact

While demand-side management could contribute to GHG emissions reduction, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.

Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NREEEP specifically encourages energy efficient measures. This technology can contribute to meeting these targets. In addition to the tangible energy efficiency targets, applying demand side management appliances contribute to improving environmental quality by reducing emitted air pollutants from power generation at site. Demand side management technology is mature and has been successfully implemented in developing countries. Yet, demand-side management has not been widely applied in Nigeria.

5.2.3. Estimated Costs

Depending on the methodology, demand side management may require significant costs. For instance, advanced metering infrastructure can cost up to USD 2,500,000 per unit.

5.3. Smart grid

5.3.1. Description

Technology for the electrical system that can sensibly execute the operations to all interconnected elements from generator to consumers. Although smart grid is a relatively new concept, its deployment is increasingly progressing, with China, India and Brazil leading smart grid development among developing countries. Some smart-grid applications include distribution automation system, wide area monitoring system, and flexible alternate current transmission system, which are smart-grid applications utilized in monitoring and control. There are also smart-grid components that are related to renewable energy, such as weather forecasting systems, energy storage system, simulation systems, and distributed generator monitoring and control.

5.3.2. Readiness of Nigeria and expected impact

While smart grid system could contribute to GHG emissions reduction, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity. Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NDC also includes improving the electricity grid as one of its key measures. The NREEEP encourages energy efficient measures. This technology can contribute to meeting these targets. Furthermore, using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation as well as provide positive macroeconomic impacts, boosting economic activity. The technology overall is still an emerging technology globally. Therefore, the technology may be available in the mid to long term in Nigeria (2030 - 2050).

5.3.3. Cost analysis of the technology

The technology has various components, which can make the overall cost high. The annual investment needed in deploying smart grid ranges from USD 17 billion to 24 billion, with expenses allocated for transmission and substations are between 19 and 24% of total costs, while expenses allocated for distribution are between 69 and 71 %, and costs for consumer services are between 7 and 10%.[11]

6. Tools available for data assessment and modelling (energy demand)

This section identifies tools that can utilized for data assessment and modeling, specifically to prioritized technologies in the energy demand sub-sector.

Tools	Description
Model for Analysis of Energy Demand (MAED-2)[12]	This model considers different types of energy forms (including traditional fuels) in all economic and consuming sectors/subsectors at end-use level, allowing to provide a systematic framework for mapping trends and anticipating change in energy needs, particularly as countries correspond to alternative scenarios for socioeconomic and technological development. Energy demand is divided into a large number of end-use categories corresponding to different goods and services. This model has been utilized by over 60 countries.
Global Energy and Climate (GEC) Model[13]	The GEC is a modelling framework, which covers 26 regions, that can used to understand analytical capacities in energy markets, technology trends, policy strategies and investments across the energy sector that would be critical to achieve climate goals. It can be utilized identify indicators such as final energy demand, energy transformation, and energy supply. This framework also considers policies and regulations.
WASHplus Consumer Cookstove Toolkit[14]	This toolkit allows users to determine essential indicators that are essential when developing cookstove projects, such as cookstove designs that are appealing to consumers, cookstove performance, and marketing and financing approaches to disseminate cookstoves. It also has a capacity building component that educates users on how to use and maintain cookstoves in a sustainable manner.
Demand Analysis and Planning (DAP)[15]	DAP is a software tool that provides forecasts of electricity demand and the peak load, which would in turn allows users to prepare demand-side management actions. It has a library of determining factors that would allow the user to forecast electricity demand and peak load more accurately. This tool can also provide cost

[11] European Commission "Assessing smart grid benefits and impacts"
[12] International Energy Agency "Model for Analysis of Energy Demand (MAED-2)"
[13] International Energy Agency "Global Energy and Climate (GEC) Model"
[14] USAID "WASHplus Consumer Cookstove Toolkit"
[15] Innovation Energy Development (IED) "DAP - Demand Analysis and Planning"

	analysis.
RAPSim (Renewable Alternative Power systems Simulation)[16]	RAPSim is an open source software that provides basic modelling for simulation of various renewable energy sources and load demand within a microgrid/smart gird. It can simulate performances and conduct power growth analysis, as well as analyze the impact of renewable energy sources to the system.

7. Technologies prioritized in the energy efficiency sub-sector

For the energy efficiency sub-sector, the following technologies were prioritized during the validation workshop that took place on August 1st, 2022: energy management systems, energy efficiency buildings, and energy efficient standards and labels. These technologies generally aim at achieving energy efficiency and reducing energy-related GHG emissions.

7.1. Energy management systems

7.1.1. Description

Energy management system involves the introduction of energy management tools aimed at improving energy use in mining, manufacturing including food and beverage, and chemical industries through introduction of innovative technologies such as high energy efficiency and variable motors, on-site electricity generation, energy system optimization and energy management standards. Some notable energy management systems are as follows: advanced metering structure, building energy management systems and factory management systems.

7.1.2. Readiness of Nigeria and expected impact

Similar to smart grid technology, while energy management systems could contribute to GHG emission reduction, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity. Energy management systems have not been explicitly indicated in any of the policies. However, the Nigerian government is promoting energy efficiency measures through the NREEEP.

Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity. Energy management system is a mature technology and widely deployed at factories, buildings, households around the globe. While information on energy management systems in Nigeria is limited, it is assumed that Nigeria has the potential to implement given the government's strategy to promote energy efficiency. In addition, there exist energy management companies providing such service in the country. As a result, the technology may be available in short to medium term (until 2030).

7.1.3. Cost analysis of the technology

The technology has various components, which can make the overall cost high. Minimum initial investment cost can reach up to USD 250,000 per system with operational cost ranging from USD 30,000 to 60,000 per year.[17]

7.2. Energy efficient buildings

7.2.1. Description

Buildings that incorporate measures to alter energy-consuming behavior and as a result, reduce

[16] Institute of Networked and Embedded Systems "RAPSIM"
[17] Institute for Industrial Productivity "Annual cost of energy management systems for enterprises"

overall energy consumption. Technologies associated with energy efficient building, including solar power, energy storage system, and energy management system, are mature technologies and widely deployed around the globe.

7.2.2. Readiness of Nigeria and expected impact

Energy efficient buildings could contribute to GHG emissions reduction. However, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity. Energy efficient building designs incorporate more resilient materials for structure, as well as incorporate the use of on-site electricity generation (i.e., Solar PV). This results in increased climate resilience.

Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NREEEP encourages energy efficient measures. This technology can contribute to meeting these targets. Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation. Improving building's energy consumption have positive macroeconomic impacts, reinforcing supply chain and material supply value chain boosting economic activity. It is assumed that Nigeria has the potential to implement given the government's strategy to promote energy efficiency. In addition, there exist energy management companies providing such service in the country. As a result, the technology may be available in short to medium term (until 2030).

7.2.3. Cost analysis of the technology

Depending on the application, the technology may require significant costs. The range for constructing energy efficient buildings can be from USD 1,000 to 1500 per sq.[18]

7.3. Energy efficiency standards and labels

7.3.1. Description

Energy efficient standards and labels are sets of procedures and regulations that, respectively, prescribe the minimum energy performance of manufactured products and the informative labels on these indicating products' energy performance. Energy efficiency standards and labelling do not require any sophisticated technologies, while it is required to establish an evaluation and monitoring system, which includes human and financial resources.

7.3.2. Readiness of Nigeria and expected impact

Energy efficiency standards and labels could contribute to GHG emission reduction. However, similar to other technologies identified in this sub-sector, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.

Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NREEEP encourages energy efficient measures. This technology can contribute to meeting these targets. Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation. Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity. While information on energy efficiency standards and labelling in Nigeria is limited, it is assumed that Nigeria has the potential to implement given the government's strategy to promote energy efficiency. Given that this

[18] Managanelli "Affordability assessment of energy efficient building Construction in Italy"

technology does not require sophisticated technologies, it may be available in short to medium term (until 2030).

7.3.3. Cost analysis of the technology

No significant costs associated with implementing the technology.

8. Tools available for data assessment and modelling (energy efficiency)

This section identifies tools that can utilized for data assessment and modeling, specifically to prioritized technologies in the energy efficiency sub-sector.

Tools	Description
RetScreen Expert[19]	Developed by the Canadian government, RetScreen Expert is a software that allows to identify, optimize and assess the technical and financial feasibility of potential renewable energy, energy efficiency and cogeneration projects. It can also be used to measure actual performances of energy efficient facilities and identify energy saving opportunities. The software is available in 37 languages.
MEASUR[20]	MEASUR is an open platform that aims to help project developers and technology providers improve industrial system efficiency and identify potential savings opportunities. It can provide measurement on how much energy is used in a facility and the estimated annual cost if an energy efficiency equipment is introduced. Some assessments that are included in the platform are pumping system assessments, fan system assessments, and steam system assessments.
Wattics Energy Analytics Software[21]	The energy analytics software provided by Wattics allows energy professionals and technology developers to discover energy saving and cost saving opportunities and thereby improve sustainability in their operations. It gives a single dashboard that allows users to manage, monitor, and analyze energy, commodities, and related data, which includes energy usage in appliances, equipment, or entire buildings.

[19] Government of Canada "RETScreen"

[20] US Department of Energy "MEASUR"

[21] Wattics "Energy Data Analytics Software Platform For Energy Professionals"