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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

## Technology Fact Sheets – Energy

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## 1. Introduction

The objective of this assignment is to develop a comprehensive Technology Needs Assessment (TNA) and associated action plan for Nigeria’s climate change mitigation and adaptation. To achieve this objective, it is necessary to identify the relevant technologies that can contribute to Nigeria’s climate objectives, especially in the three priority sectors, namely, agriculture and land use, energy, and industry and commerce. From the three priority sectors, sub-sectors were pre-selected and identified for each sector by performing a thorough assessment and desktop review of key national strategies and sectoral policies in Nigeria. After the long-list of mitigation and adaptation technologies that can be applicable to each subsector was prepared, a total of 26 technologies were then prioritized and validated through regional and validation workshops.

This report, therefore, will present technology fact sheets on the prioritized technologies in the energy sector. The technology fact sheets summarize mainly the potential of the technology to contribute to climate change mitigation/adaptation, the technology’s impact on development priorities, barriers and opportunities in implementing the technology, as well as the current status of the technology in Nigeria. Furthermore, it will provide an evaluation on the timeframe of implementing the technology, looking at short term (2022 - 2025), medium term (2026 - 2030), and long term (2030 - 2050) outlook. These technology fact sheets will serve as basis in developing the Technology Action Plans, which will provide detailed project ideas on the identified and prioritized technologies.

## 2. Technology fact sheets – energy

### 2.1 Electricity supply

#### 2.1.1 Solar PV/Concentrated solar power (solar thermal)

Technology characteristics	Description	Solar Photovoltaic refers to the technology of using solar cells to convert solar radiation directly into electricity. <sup>1</sup> On the other hand, CSP systems generate electricity by concentrating solar energy using mirrors or lenses into a receiver. Electricity is generated when the concentrated energy from the sun heat fluid to superheated steam which is used to turn turbines to generate electricity.
	Climate change mitigation/adaptation benefits	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 MtCO <sub>2</sub> e in 2018. Of which, electricity generation (on-

<sup>1</sup> CTCN, “Solar PV” Available at: [Solar PV | Climate Technology Centre & Network](#)

		<p>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.</p> <p>Utility-scale Solar PVs are not severely impacted by extreme weather events such as rise in sea level, droughts, or flooding, compared with fossil-fuel based power plants and other renewable energy technologies. In addition, distributed Solar PV application could make the power system more resilient to extreme climate events compared to the conventional centralized systems. It would allow for more spatial diversification of energy supplies, which reduces the vulnerability of the energy supply from a single event or a single critical location, which increases overall energy system resilience. In addition, 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.</p>
Potential co-benefits	Environmental	A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation.
	Social	The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood. It also increases access to electricity, potentially reducing poverty.
	Economic	Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.
Applicability and potential in Nigeria		Solar PV has been explicitly identified in

	<p>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 RE (i.e., mini-grids, solar home systems and streetlights, and self-generation) which are more likely to be achieved through Solar PV. In this context, 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 National Renewable Energy and Energy Efficiency Policy (NREEEP). Nigeria has identified solar technologies as the most promising among renewable energy sources. Nigeria’s annual solar radiation ranges between 12.6 to 25.2 MJ/m<sup>2</sup>/day, with an average sunshine of 6.5 hours per day. The available solar energy is about 27 times the country’s total fossil fuel resources and over 115,000 times the electrical power generated.</p>
<p>Status of the technology in Nigeria</p>	<p>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.</p>
<p>Enabling environment for the technology</p>	<p>As mentioned above, 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 NREEEP.</p>
<p>Opportunities and barriers</p>	<p>The lifecycle cost of solar power generation has been decreasing rapidly, which is now more or less cost competitive against that of thermal power</p>

	generation.
Costs and financial requirements	As mentioned earlier, 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 for infrastructural development and to cover the risks for private sector developers.
Time frame	Given the favorable enabling environment and the fact that solar PV applications are commercially available globally, the technology may be available in short to medium term (until 2030).

### 2.1.2 Waste-to-energy (biomass power generation)

Technology characteristics	Description	Waste-to-energy technologies refer to the combustion of solid waste as an alternative source to produce heat or electricity. <sup>2</sup> 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.
	Climate change mitigation/adaptation benefits	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 MtCO <sub>2</sub> e 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. Power generation from renewable biomass sources can greatly contribute to reducing GHG emissions from the existing energy mix.

<sup>2</sup> CTCN, "Energy supply from waster" Available at: [Energy supply from waste | Climate Technology Centre & Network](#)

		Biomass energy could also 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.
Potential co-benefits	Environmental	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.
	Social	The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood. It also increases access to electricity, especially for off-grid applications, potentially reducing poverty.
	Economic	Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.
Applicability and potential in Nigeria		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. Nigeria has abundant biomass resources in the form of wood waste, agricultural residues, and municipal solid waste. Therefore, biomass power generation technologies can be utilized effectively in Nigeria.
Status of the technology in Nigeria		Biomass power generation has not been implemented yet in the country.
Enabling environment for the technology		The NREEEP identified strategies to promote biomass power generation, which in turn can be the basis in implementing this technology in Nigeria.
Opportunities and barriers		There is abundant supply of biomass

	resources, however the cost can be a barrier in implementing the technology.
Costs and financial requirements	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. <sup>3</sup>
Time frame	There are enough 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).

### 2.1.3 Carbon capture and storage

Technology characteristics	Description	Carbon Capture and Storage (CCS) is the process of capturing CO <sub>2</sub> from emission sources such as power plants, transporting, and storing it in underground geological formations.
	Climate change mitigation/adaptation benefits	CCS prevents CO <sub>2</sub> release into the atmosphere. It contributes to GHG emission reduction even in hard-to-abate sectors such as cement industry. However, it has no significant impact on climate resilience.
Potential co-benefits	Environmental	CCS contributes to improving environmental quality by reducing air pollution from the treatment process.
	Social	No significant social co-benefit

<sup>3</sup> IRENA "Bioenergy for Power" Available at <https://www.irena.org/costs/Power-Generation-Costs/Bioenergy-for-Power>

	Economic	No significant economic co-benefit
Applicability and potential in Nigeria		CCS have the potential to reduce emissions from hard-to-abate sectors of Nigeria.
Status of the technology in Nigeria		CCS have not been implemented yet in Nigeria.
Enabling environment for the technology		CCS is not mentioned in any of key policies or priorities in Nigeria.
Opportunities and barriers		There are 26 large-scale CCS facilities are operating commercially in the world. <sup>4</sup> Yet, it is hard to say that CCS technologies are mature and widely deployed. Several applications of CCS, including chemical absorption of CO <sub>2</sub> 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 CO <sub>2</sub> from bioethanol production and coal-to-chemicals plants, and CO <sub>2</sub> storage in saline aquifers. Several other applications, including DAC (direct air capture) and CO <sub>2</sub> capture from cement and iron and steel making, are still at the pilot stage. <sup>5</sup>
Costs and financial requirements		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 CO <sub>2</sub> while the cost of CCS can range from USD 75 to 150 per ton CO <sub>2</sub> for iron and steel industries. <sup>6</sup> The total capital requirement for retrofitting a

<sup>4</sup> Statista “Number of large-scale carbon capture and storage (CCS) facilities worldwide as of 2020, by status” Available at <https://www.statista.com/statistics/726624/large-scale-carbon-capture-and-storage-projects-worldwide-by-status/>

<sup>5</sup> IEA “CCUS technology innovation” Available at <https://www.iea.org/reports/ccus-in-clean-energy-transitions/ccus-technology-innovation>

<sup>6</sup> Global CCS Institute “Technology Readiness and Cost of CCS”

	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.
Time frame	Due to the limited availability of the technology commercially, the technology may only be available in the mid to long term (2030 - 2050).

## 2.2 Energy demand

### 2.2.1 Improved cookstoves

Technology characteristics	Description	Improved cook stove technologies pertain to cooking stoves with improvement in efficiency (available in different forms and sizes). <sup>7</sup>
	Climate change mitigation/adaptation benefits	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 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.  Promoting the use of improved cook stoves leads to less use of firewood. This prevents deforestation, which in turn makes the land resilient against flooding.
Potential co-benefits	Environmental	Improves environmental quality by reducing air pollution. Contributes to forest conservation.
	Social	Improves health, empowers women, and saves lives, especially in rural population.
	Economic	Efficient cooking saves time, in turn, leading to more time for other activities contributing to economic growth.
Applicability and potential in Nigeria		Efficient and sustainable use of biomass

<sup>7</sup> CTCN, "Improved Cook Stoves" Available at: [Improved Cook Stoves | Climate Technology Centre & Network](#)

	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 LPG. Specific targets include, 48% of population (26.8 million households) using LPG and 13% (7.3 million) using improved cookstoves by 2030.
Status of the technology in Nigeria	Improved cook stoves have been implemented in Nigeria, including those under the clean development mechanism (CDM).
Enabling environment for the technology	Several climate change policies, such as NDC and TNC, emphasize the importance of deploying efficient cookstoves. Therefore, it is likely that the Nigerian government will be supportive of disseminating this technology.
Opportunities and barriers	Improved cook stove technologies are mature and widely deployed around the globe, especially in developing countries.
Costs and financial requirements	The technology generally does not require significant investments. Improved cook stoves are available at USD 45 per unit on average. <sup>8</sup>
Time frame	Since there is evidence of the technology already being implemented in the country, the technology may be available in the short to medium term (until 2030) in Nigeria.

## 2.2.2 Demand-side management

Technology characteristics	Description
	Demand-side management consist of the planning, implementing, and monitoring activities of electric utilities which are designed to encourage consumers to modify their level and pattern of electricity usage. <sup>9</sup> It allows distribution utilities to

<sup>8</sup> Project drawdown “Clean cooking”

<sup>9</sup> U.S. Energy Information Administration, “Electricity Utility Demand Side Management” Available at: [Electric Utility Demand-Side Management \(eia.gov\)](http://www.eia.gov/energyexplained/demand-side-management/)

		satisfy power needs of more customers with little to no increase in power supply generation.
	Climate change mitigation/adaptation benefits	While demand-side management could contribute to GHG emission reduction, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity. However, there is no significant impact on climate resilience
Potential co-benefits	Environmental	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.
	Social	No significant social co-benefits
	Economic	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.
Applicability and potential in Nigeria		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. This technology can contribute to meeting these targets. It is assumed that Nigeria has the potential to implement the technology given the government's strategy to promote energy efficiency.
Status of the technology in Nigeria		Information on demand-side management in Nigeria is limited.
Enabling environment for the technology		Demand side management have not been explicitly indicated in any of the policies. However, the Nigerian government is promoting energy efficiency measures through the NREEEP.
Opportunities and barriers		Demand side management technology is mature and has been successfully implemented in developing countries.
Costs and financial requirements		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.
Time frame	The technology may be available in the short to medium term (until 2030) as the government is promoting energy efficiency measures.

### 2.2.3 Smart grid

Technology characteristics	Description	Technology for the electrical system that can sensibly execute the operations to all interconnected elements from generator to consumers. <sup>10</sup>
	Climate change mitigation/adaptation benefits	While smart grid system could contribute to GHG emission reduction, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity. Moreover, the technology has no significant impact on climate resilience.
Potential co-benefits	Environmental	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.
	Social	No significant social co-benefits
	Economic	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.
Applicability and potential in Nigeria		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 energy efficiency targets of Nigeria.

<sup>10</sup> CTCN, "Smart grid", Available at: [Smart grid | Climate Technology Centre & Network](https://www.ctcn.org/)

Status of the technology in Nigeria	Smart grid technology has not been deployed in Nigeria.
Enabling environment for the technology	Smart grid technology has not been indicated in any of Nigeria's key policies.
Opportunities and barriers	Although smart grid is a relatively new concept, its deployment is increasingly progressing among developing countries.
Costs and financial requirements	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%. <sup>11</sup>
Time frame	The technology is still an emerging technology globally. Therefore, the technology may be available in the mid to long term in Nigeria (2030 - 2050).

## 2.3 Energy efficiency

### 2.3.1 Energy management systems

Technology characteristics	Description	This 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. <sup>12</sup>
	Climate change mitigation/adaptation benefits	While energy management systems could contribute to GHG emission reduction, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household,

<sup>11</sup> European Commission "Assessing smart grid benefits and impacts"

<sup>12</sup> Republic of Zambia, "Technology Needs Assessment: Mitigation"

		commercial and institutional use of electricity. The technology has no significant impact on climate resilience.
Potential co-benefits	Environmental	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.
	Social	This technology can create an energy management industry, potentially resulting in job creation.
	Economic	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.
Applicability and potential in Nigeria		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.
Status of the technology in Nigeria		Information regarding this technology is limited.
Enabling environment for the technology		Similar to demand side management, 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.
Opportunities and barriers		Energy management system is mature technology and widely deployed at factories, buildings, households around the globe.
Costs and financial requirements		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. <sup>13</sup>
Time frame		It is assumed that Nigeria has the potential to implement given the

<sup>13</sup> Institute for Industrial Productivity “Annual cost of energy management systems for enterprises”

	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).
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### 2.3.2 Energy efficient buildings

Technology characteristics	Description	Buildings that incorporate measures to alter energy-consuming behavior and as a result, reduce overall energy consumption.
	Climate change mitigation/adaptation benefits	<p>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.</p> <p>Energy efficient buildings could also contribute to GHG emission reduction. However, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.</p>
Potential co-benefits	Environmental	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.
	Social	No significant social co-benefits
	Economic	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity
Applicability and potential in Nigeria		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.

Status of the technology in Nigeria	Information regarding this technology is limited.
Enabling environment for the technology	There are no policies that explicitly identifies this technology as a mitigation/adaptation measure.
Opportunities and barriers	Technologies associated with energy efficient building, including solar power, energy storage system, and energy management system, are mature technology and widely deployed around the globe.
Costs and financial requirements	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. <sup>14</sup>
Time frame	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).

### 2.3.3 Energy efficiency standards and labels

Technology characteristics	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. <sup>15</sup>
	Climate change mitigation/adaptation benefits	Energy efficiency standards and labels could contribute to GHG emission reduction. However, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional

<sup>14</sup> Managanelli "Affordability assessment of energy efficient building Construction in Italy"

<sup>15</sup> Energy Charter Secretariat (2009) "Policies that work: Introducing Energy Efficiency Standards and Labels for Appliances and Equipment"

		use of electricity. In addition, the technology has no significant impact on climate resilience.
Potential co-benefits	Environmental	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.
	Social	No significant social co-benefits
	Economic	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.
Applicability and potential in Nigeria		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.
Status of the technology in Nigeria		Information on energy efficiency standards and labelling in Nigeria is limited
Enabling environment for the technology		This technology has not been mentioned in any of Nigeria's key policies.
Opportunities and barriers		Energy efficiency standards and labelling do not require any sophisticated technologies, while it is required to establish the evaluation and monitoring system, including human and financial resources.
Costs and financial requirements		No significant costs associated with implementing the technology
Time frame		Given that this technology do not required sophisticated technologies, it may be available in short to medium term (until 2030).

### 3. Next Steps

These technology fact sheets will be used as reference in developing the Technology Action Plans, which presents the implementation plans for the prioritized technologies. Once the technology action plans for the prioritized technologies are prepared by the consulting team in coordination with the local experts, the technology action plans will be validated by the stakeholders through the subsequent



validation workshop.