



United Nations Industrial Development Organization  
Climate Technology Centre & Network  
Federal Ministry of Environment - Department of Climate Change  
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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 – Industry and commerce

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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 industry and commerce 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 – industry and commerce

### 2.1 Agribusiness and agro-allied sectors

#### 2.1.1 Modular palm oil mills

Technology characteristics	Description (illustration of the technology is provided in the appendix)	A modular palm oil mill is an automated mill like industrial (large-scale) mill but with lower capacity (typically from 1-10 tons/hr.). It can operate 24 hours a day like scale-scale plants. Important facilities include reception unit, sterilizer, thresher, digester, press, clarifier, and storage tank. The oil palm fresh fruit bunches from the reception unit are taken into the high pressure steam sterilizer for cooking and inactivation of lipase enzymes and easy detachment of
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		<p>fruits from the spikelet of the bunch. The thresher/stripper detaches the fruits from bunches while the digester breaks the oil-bearing cells of the mesocarp, which enables the press to extract the oil. Clarifier is used to separate impurities from crude palm oil. The crude palm oil is stored in the storage tank. Other parts of the system are palm nut/fiber separator, which separates the palm nut from the mesocarp fibre and palm nutcracker/separator. The nutcracker breaks the hard endocarp releasing the oil-bearing palm kernel and palm kernel shell.</p> <p>The produced oil palm wastes are used to generate steam and electricity for the operation of the mill making it self-sustaining. Another design can include the generation of biogas from the produced palm oil mill effluent. The biogas is used to generate electricity for the mill.</p>
	Climate change mitigation/adaptation benefits	<p>The large-scale mills emit 468 kg CO<sub>2</sub>-eq per t FFB to the atmosphere, while small-scale mills emit about 162kg CO<sub>2</sub>-eq per t FFB. Installation of the cluster automated mills (5-10 tons per hr mills) with composting facilities for empty fruit bunches and palm oil mill effluent will reduce emissions as reported in large scale mills using same technology by over 200% while increasing the quality of palm oil to industrial standard as well as yield per ton of processed fresh fruit bunch. The technology will reduce emissions due to importation of palm oil products and low productivity by small-scale processors. On the other hand, the technology has no significant impact on climate resilience.</p>
Potential co-benefits	Environmental	<p>The technology can contribute to reducing air, soil and water pollution</p>

		from fossil fuel combustion, open burning, and disposal of biomass. It also reduces soil and water pollution from disposal of oil palm mill effluent.
	Social	The technology will enhance job security and increase opportunity for women in the industry with the elimination of labor-intensive job.
	Economic	The technology will increase Nigeria palm oil capacity, reduce importation of the product, and increase economic activity in the rural oil palm belt.
Applicability and potential in Nigeria		The technology is not identified in any of Nigeria's climate change policies and priorities. However, inadequate palm oil processing technology, shortage of high-grade palm oil is mentioned in the Nigeria Industrial Revolution Plan and it could contribute to overall goal of CO2 emissions reduction. Food security is key area in National climate change Policy for Nigeria
Status of the technology in Nigeria		Large-scale and different levels of mechanized systems are operational in Nigeria. Furthermore, several levels of small-scale fresh fruit bunch processing systems have been deployed in Nigeria
Enabling environment for the technology		As mentioned above, there are no policies in Nigeria that indicates this technology.
Opportunities and barriers		There are several companies around the world with track records in manufacturing of palm oil mills including customized designs.
Costs and financial requirements		Depending on the design, significant investments may be necessary. For instance, the cost of a small palm oil mill (5ton/h) equipment can range from USD 5,500 to 7,000 while a palm oil mill with capacity of 10ton/h will require approximately USD 60,000. The cost of the 6ton/h automated modular system ranges from USD 100 000 dollars to

	<p>USD 3.500.000 depending on capacity and production location. The upper range is inclusive of transport from abroad, installation, supervision, steam boiler, and steam turbine for a 6T/hr mill. Most of the parts can be produced in Nigeria while others with no local capability can be sourced from Europe. Steam turbine is optional.</p>
Time frame	<p>Given that there are already some applications of this technology in Nigeria, the technology may be available in the short to medium term (until 2030).</p>

### 2.1.2 Anaerobic digesters

Technology characteristics	Description (illustration of the technology is provided in the appendix)	<p>Wastewater from industrial and agricultural activities emits methane. In anaerobic digesters, the methane (in form of biogas) is collected for use as fuel. The generated carbon dioxide during combustion of methane has lower global warming potential. Biogas (over 60% methane) can be generated from most organic materials in the absence of oxygen. Anaerobic digesters are particularly necessary where fermentation will occur from industrial or agricultural wastes. In anaerobic digestion, microorganisms feed on the organic material at appropriate operating parameters producing biogas and digestate, which can be converted to organic fertilizer. Anaerobic digestion is also part of some industrial processes including waste-water treatment.</p>
	Climate change mitigation/adaptation benefits	<p>Generated biogas from anaerobic digesters can replace fossil fuel. In palm oil mill, biogas from palm oil mill effluent anaerobic digesters can be used to generate electricity or replace petrol in boiler start-up and can reduce emission by up to 44%.</p>

		In addition, the technology will increase access to cooking gas for people in the rural area enabling them to be more resilience to impact of climate change on agricultural and availability of firewood
Potential co-benefits	Environmental	The technology prevents the uncontrolled release of pollutant from both aerobic and anaerobic digestion of wastewater. Availability of less expensive cooking gas will prevent pollution associated with burning firewood. It reduces odor emissions from direct organic material application in the farm.
	Social	The technology could create employment.
	Economic	The technology could reduce the cost of cooking gas and the number of people burning wood as fuel. Deployment of anaerobic digester will increase farmers' access to fertilizer and reduce cost of food production.
Applicability and potential in Nigeria		Anaerobic digestion is mentioned as a mitigation measure in the second Biennial Update Report (BUR2). Therefore, the enabling environment is favorable in implementing the technology.
Status of the technology in Nigeria		Anaerobic digester is fast gaining popularity in Nigeria for the generation of cooking gas.
Enabling environment for the technology		Since this technology is mentioned in Nigeria's BUR2 as a mitigation measure, the Nigerian government may be willing to support the dissemination of the technology.
Opportunities and barriers		Different types of technology including conventional, sludge retention and fixed film digesters are widely used around the world. The most common type in Nigeria uses conventional technology with a fixed dome anaerobic digester

	plant. <sup>1</sup> The application varies from crude systems to automated anaerobic digesters.
Costs and financial requirements	Depending on the type of technology and application, the overall cost can be high. The most common type of aerobic digestion, the wet and dry aerobic digestion plants can cost up to USD 9,200,000 for installment. <sup>2</sup> For operation, it can cost approximately 3,000,000 per year which includes the maintenance of the digester, indirect cost, and working capital. Locally constructed anaerobic digester for palm oil mill effluent can cost as low as USD 80000 with capacity of 175m <sup>3</sup> /day biogas.
Time frame	Considering the favorable enabling environment, the technology may be available in the short to medium term (until 2030).

## 2.2 Solid minerals and metals

### 2.2.1 Use of alternative fuels

Technology characteristics	Description	Applies specifically to the cement industry. The technology involves the use of waste materials as alternative fuels for clinker production in the cement industry. Waste materials used as alternative fuels include waste tires, sewage sludge, animal residue, waste oil, paper residue, plastic, textile, and other lumpy materials. <sup>3</sup> In general, alternative fuels can be categorized into five categories: hazardous waste, non-hazardous industrial and commercial waste, municipal waste, biomass, and other unclassified alternative fuels.
	Climate change mitigation/adaptation	The cement industry is the highest GHG emitting industry in the IPPU sector

<sup>1</sup> Orhorhoro and Erameh "A comprehensive review of anaerobic digester plant"

<sup>2</sup> Ibid.

<sup>3</sup> Ali Naqi and Jeong Gook Jang (2019), "Recent Progress in Green Cement Technology Utilizing Low-Carbon Emission Fuels and Raw Materials"

	benefits	accounting for 53.4% of emissions in the sector. This technology is an option to contribute to reduced emissions in the sector. It is also worth considering that emissions from industrial processes and other product use (IPPU) sector is the least emitting sector for Nigeria contributing only 5.3% of total GHG emissions. However, it has no significant impact on climate resilience.
Potential co-benefits	Environmental	Improves environmental quality by reducing air pollution from reduced fossil fuel use in cement production. Use of waste materials as fuels also decreases the improper disposal of such materials.
	Social	No significant social co-benefit
	Economic	No significant economic co-benefit
Applicability and potential in Nigeria		Use of alternative fuels is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO <sub>2</sub> emission reduction.
Status of the technology in Nigeria		Information on use of alternative fuels for cement in Nigeria is limited, with no indication of implementation in the country.
Enabling environment for the technology		As mentioned above, this technology is not identified in any of Nigeria's key policies and strategies.
Opportunities and barriers		The technology of using alternative fuel is mature and widely implemented. The main alternative fuels used in cement industry globally are residue oil and solvents, contaminated wood and process waste from wood. There are also several alternative fuel use in cement projects implemented under the CDM. In CDM, biomass residue was used to replace fossil fuels used in two cement kilns in Nigeria.
Costs and financial requirements		Significant investment is required initially. Initial investment in implementing alternative fuel in cement plant can cost up to USD 60,000,000.

	However, this cost does not include cost associated with waste management and waste collection activities, which will be necessary for Nigeria. The total cost for establishing the necessary environment and implementing the technology, therefore, can range from USD 70,000,000 to 90,000,000.
Time frame	The technology may be available in the medium to long term (2030 – 2050) as there is no application of this technology yet in Nigeria

### 2.2.2 Advanced grinding technologies

Technology characteristics	Description	In cement production, the grinding process accounts for more than 60% of the electrical power demand during cement production while also being of the greatest importance for the final product quality. <sup>4</sup> In this context, advanced grinding technologies refer to grinding technologies that are more energy efficient, which includes contact-free grinding systems, ultrasonic-comminution, high voltage power pulse fragmentation, low temperature comminution.
	Climate change mitigation/adaptation benefits	This technology has the potential of reducing emissions from Nigeria's cement industry, which is responsible for 53.4% of the aggregated emissions from the IPPU sector. However, no significant impact on climate resilience.
Potential co-benefits	Environmental	The technology can contribute to improving environmental quality by reducing air pollution from the cement making process.
	Social	No significant social co-benefit
	Economic	No significant economic co-benefit
Applicability and potential in Nigeria		The technology is not identified in any of Nigeria's climate change policies and

<sup>4</sup> European Cement Research Academy "Future Grinding Technologies"

	priorities. However, it could contribute to overall goal for CO2 emission reduction.
Status of the technology in Nigeria	There is no known case of this technology in Nigeria.
Enabling environment for the technology	There are no policies or regulations that identify this technology as a climate change mitigation measure. .
Opportunities and barriers	Advanced grinding technologies are still under development and have not been implemented commercially.
Costs and financial requirements	Depending on the technology, significant investment may be required. For instance, the cost of a small scale advanced grinding technology can range from USD 1,600 to 2,450 per unit.
Time frame	The technology may be available in the medium to long term (2030 - 2050) as the commercial use of the technology is still limited globally

### 2.2.3 Unhydrated cement recycling

Technology characteristics	Description	Unhydrated cement recycling allows unhydrated cement (which some estimates show that 50% of cement can remain unhydrated) to be recovered and reused as new cement. <sup>5</sup>
	Climate change mitigation/adaptation benefits	A study suggests that unhydrated cement recycling can reduce carbon dioxide emissions by 2.5 Gt CO2 annually. <sup>6</sup> This can therefore contribute in reducing emission from Nigeria's cement industry, which is responsible for 53.4% of the aggregated emissions from the IPPU sector. However, no significant impact on climate resilience.
Potential co-benefits	Environmental	The technology can contribute to improving environmental quality by reducing air pollution from the cement

<sup>5</sup> IEA "ETP Clean Energy Technology Guide: Unhydrated cement recycling"

<sup>6</sup> Bellona Europa "How can recycling in the cement and concrete sector contribute to climate change mitigation?"

		making process.
	Social	No significant social co-benefit
	Economic	No significant economic co-benefit
Applicability and potential in Nigeria		The technology is not identified in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO2 emission reduction.
Status of the technology in Nigeria		There is no known case of this technology in Nigeria.
Enabling environment for the technology		As mentioned above, the technology is not identified in any of Nigeria's climate change policies and priorities.
Opportunities and barriers		Unhydrated cement recycling is an emerging technology that is still under development.
Costs and financial requirements		Significant initial investment is required in implementing the technology as the technology is still limited in the market. The overall project in implementing this project can be approximately USD 600 million.
Time frame		The technology may be available in the medium to long term (2030 - 2050) as the commercial use of the technology is still limited globally

## 2.3 Construction and manufacturing

### 2.3.1 Shifting to renewable sources for electricity

Technology characteristics	Description	Moving away from reliance to fossil fuels and shifting to renewable energy like hydro power, solar power etc. for electricity.
	Climate change mitigation/adaptation benefits	This technology is an option to contribute to reduced emissions in the sector, as well as contribute to the renewable energy targets. It is also worth considering that emissions from industrial processes and other product use (IPPU) sector is the least emitting sector for Nigeria contributing only 5.3% of total GHG emissions.

		Distributed renewable energy applications could also make the power system more resilient to extreme climate events and not fully dependent on grid status.
Potential co-benefits	Environmental	A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation.
	Social	Use of renewable energy is still a greenfield area in Nigeria and has the potential for job creation through skilled & unskilled labor requirements.
	Economic	Resilience of the electricity system through self-generation ensures economic growth and development, especially during extreme weather events.
Applicability and potential in Nigeria		Renewable energy is a key climate and development priority for Nigeria, with specific targets of 13GW off-grid RE, of which, 5GW are from self-generation. Therefore, this technology can contribute to meeting the renewable targets of Nigeria.
Status of the technology in Nigeria		Several small-scale solar for commercial and industrial applications have been deployed in Nigeria.
Enabling environment for the technology		This technology has been identified in many of Nigeria's climate change policies and as a result, the Nigerian government will be supportive of disseminating this technology.
Opportunities and barriers		Renewable energy technologies for self-generation such as solar PVs and mini hydro are widely used.
Costs and financial requirements		Depending on the technology, significant investment may be necessary initially. For instance, the cost of small hydropower projects can range from 1,300,000/MW to 8,000,000/MW while

	utility-scale solar PV can cost approximately USD 1,321,000 for MW. <sup>7</sup>
Time frame	Due to the favorable enabling environment, the technology may be available in the short to medium term (until 2030).

### 2.3.2 Disaster-resilient buildings

Technology characteristics	Description	Disaster-resilient buildings refer to buildings that are developed to primarily reduce or avoid the impacts of coastal flooding. <sup>8</sup>
	Climate change mitigation/adaptation benefits	Even though the technology does not significantly contribute to reducing GHG emissions, the technology enhances the climate resilience of communities.
Potential co-benefits	Environmental	No significant environmental co-benefits
	Social	Increased resilience leads to better livelihood and reduced poverty.
	Economic	Increased resilience boosts economic activity.
Applicability and potential in Nigeria		The construction of climate resilient buildings was identified in the TNC as an adaptation strategy and is in line with Nigeria's National Adaptation Plan Framework.
Status of the technology in Nigeria		Information on disaster-resilient buildings in Nigeria is limited
Enabling environment for the technology		The technology is being mentioned in Nigeria's National Adaptation Plan Framework as an adaptation strategy. Therefore, it is likely that the Nigerian government will be supportive of disseminating this technology.
Opportunities and barriers		CTCN assessed technology maturity of flood proofing as level of 4-5, with 5 indicating that the technology is fully mature and widely used.
Costs and financial requirements		Significant investment may be required

<sup>7</sup> IRENA "Renewable energy cost analysis – hydropower"

<sup>8</sup> CTCN, "Disaster-resilient buildings" Available at: [Disaster-resilient buildings | Climate Technology Centre & Network](#)

	initially. The cost of wet flood proofing structures can range from USD 30 to 100 per square foot whereas cost of dry flood proofing structures can range from USD 40 to 1300 per square foot. The total cost will depend on the number of items that are installed, such as waterproof membrane (USD 19 per linear meter), plumbing check valve (USD 1060 each), and metal flood shield (USD 1230 per linear meter).
Time frame	Since there is a favorable enabling environment for the technology, the technology may be available in the short to medium term (until 2030)

### 2.3.3 Zero energy buildings

Technology characteristics	Description	Zero Energy Building refers to “an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy”. <sup>9</sup> In other words, it “combines energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specified time period”. <sup>10</sup>
	Climate change mitigation/adaptation benefits	Zero energy buildings/houses are more resilient to climate change. Being able to generate electricity on site while using it efficiently, the zero energy building/house are less dependent on electricity supplied from the grid which might be damaged in the case of extreme weather events.  Furthermore, zero energy buildings could contribute to GHG emission reduction. However, its impact could be

<sup>9</sup>US Department of Energy (2015) “A Common Definition for Zero Energy Buildings”

<sup>10</sup>US Department of Energy “Zero Energy Buildings” Available at <https://www.energy.gov/eere/buildings/zero-energy-buildings> (Accessed: 29 July 2021)

		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.
Potential co-benefits	Environmental	Introducing renewables and using electricity efficiently contribute to improving environmental quality by reducing emitted air pollutants
	Social	No significant social co-benefits
	Economic	The technology has the potential to improve productivity
Applicability and potential in Nigeria		Although not specifically indicated in any of the climate change policies and priorities, it can be considered as part of “adapting buildings to reduce the impacts of climate change”, which is mentioned in Nigeria’s TNC.
Status of the technology in Nigeria		Even though there are some studies on zero energy buildings in Nigeria, it is still limited.
Enabling environment for the technology		As mentioned above, since this technology can be considered as part of adapting buildings to reduce climate change impacts, the Nigerian government may be willing to support in disseminating this technology.
Opportunities and barriers		Most technologies associated with zero energy buildings are mature and available in many countries.
Costs and financial requirements		Significant investment may be required initially. An average-sized zero energy home can cost USD 263,000. <sup>11</sup> Initially investment for large scale zero energy building utilizing integrated PV system can cost up to USD 1,500,000. <sup>12</sup>
Time frame		Since there is a favorable enabling environment for the technology, the technology may be available in the short to medium term (until 2030)

<sup>11</sup> Mysiteplan “Cost to build a net-zero energy home”

<sup>12</sup> Wang et al. “Prediction of the Energy Self-Sufficiency Rate of Major New Renewable Energy Types Based on Zero-Energy Building Certification Cases in South Korea”

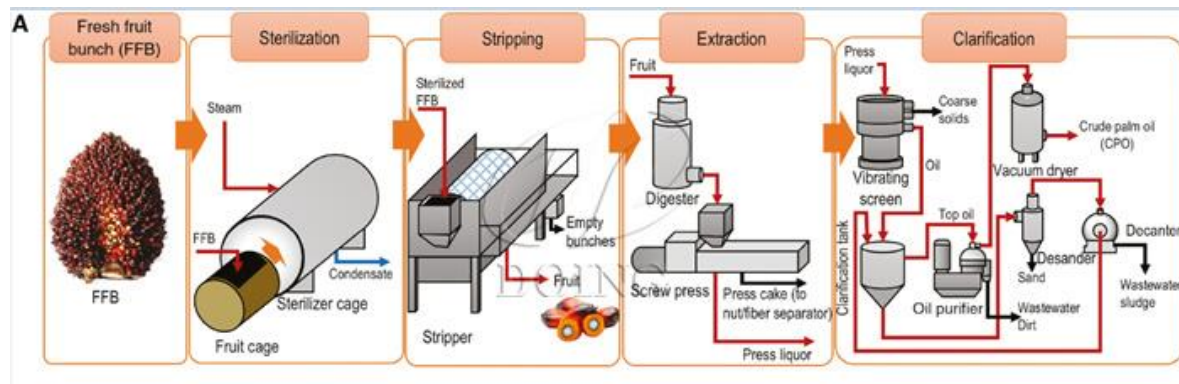


### 3. Next Steps

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.

## 4. Appendix

### 4.1 Illustration of palm oil mill



Source:  
[https://www.palmoilprocessingmachine.com/FAQ/process\\_flow\\_diagram\\_for\\_palm\\_oil\\_production\\_39.html](https://www.palmoilprocessingmachine.com/FAQ/process_flow_diagram_for_palm_oil_production_39.html)

### 4.2 Illustration of anaerobic digester

