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Technology

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

Mitigation technologies in industry and commerce sector

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1. Introduction/Overview

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. In this context, the next step is to identify and confirm the mitigation and adaptation technologies that can be applicable to each subsector, which will be the basis for Nigeria's TNA and action plan.

This report, therefore, will first discuss the sector and subsector prioritization process, including the process taken for sector and subsector selection and the results of the prioritization process. Then, the report will provide a general overview of gender considerations that are relevant to the sectors and subsectors that have been prioritized. It will then shift the focus on the industry and commerce sector and its subsectors, and provide a list of technologies applicable to the subsectors. This section will include an assessment of how the technologies contribute to climate change mitigation/adaptation and identify the barriers and gaps of implementing the technology. Finally, the report will present a summary of mitigation technologies that were considered during the process.

2. Institutional arrangement and stakeholder involvement

As part of conducting the TNA, the TNA Project Committee was established representing the key stakeholders from each prioritized sector. The main objective of the TNA Project Committee is to oversee the progress of the TNA and to ensure the engagement of key stakeholders throughout the TNA process. In this regard, to determine the appropriate composition of the TNA Committee, the consulting team conducted a stakeholder mapping for the purpose of identifying key stakeholders in the public sector, private sector, civil society, academia, and NGOs to ensure proper sectoral, transversal and climate-relevant representation of stakeholders. The stakeholder analysis was later refined by stakeholder consultations, which was generally conducted bilaterally. In coordination with the National Project Coordinator and the Deputy TNA Project Coordinator of the TNA Project Committee, these stakeholder consultations and analysis supported the finalization of the TNA Committee in Nigeria and assured the full representations of key stakeholders in the TNA process. In this context, there was an emphasis on ensuring equal representation of women and men as well as participation of gender focal points and associations that promote gender equality and the empowerment of women (GEEW) and other vulnerable groups. Throughout the TNA process, the consulting team also made sure that there was an engagement and consultation with representations from the private sector.

3. Sector and subsector prioritization process

For Nigeria's TNA, the three priority sectors were selected in the inception workshop led by the Federal Ministry of Science and Technology (FMST), in collaboration with Federal Ministry of Environment's Department of Climate Change (FMEv – DCC) in September 2018. As mentioned earlier, the three priority sectors for Nigeria's TNA are: agriculture and land use, energy, and industry and commerce. The three key sectors are not only significant for Nigeria's



long-term development, but also climate sensitive and vulnerable to the impacts of climate change. The subsectors, therefore, were identified and pre-selected from the three priority sectors.

To pre-select the subsectors, all key national strategies and sectoral policies were reviewed and analyzed to identify development priorities as well as climate change priorities. In this process, a total of 17 documents were reviewed and assessed, which led to the identification of the subsectors. For the agricultural and land sector, four sub-sectors were identified, namely, crop production, livestock production, forestry, and fish production. As for the energy sector, electricity supply, energy demand and energy efficiency were identified as the sub-sectors for this sector. Finally, for the industry and commerce sector, the subsectors are agribusiness and agro-allied sectors, solid minerals and metals, oil and gas-related industries, and construction and manufacturing.

Consequently, these subsectors were then pre-scored by the consulting team by using a set of criteria, which included (1) relevance to development priorities; (2) potential for climate change mitigation; (3) potential for climate change adaptation; and (4) overall enabling environment, including regulatory, institutional, and financial information. The purpose of the initial scoring was to assist the stakeholders in the actual selection and prioritization process that took place in the validation workshop on June 9th, 2021.

The stakeholders' validation workshop was conducted as hybrid meeting in Abuja, Nigeria and on the virtual platform, in which a total of 47 stakeholders participated in the workshop, 26 physical participants and 21 virtual participants. The stakeholders' validation workshop provided an opportunity for the stakeholders to have an overview of the subsector prioritization process, to discuss on issues regarding each subsector, and to revisit the scoring of the subsectors. In this regard, the stakeholders provided valuable inputs or feedbacks including, but not limited to, whether to incorporate the latest political negotiations as well as gender implications in the prioritization process, to add another subsector reflecting the results of agricultural activities, and to change the subsector from "construction, light manufacturing and services" to "construction and manufacturing". In addition, as part of the interactive session of the validation workshop, the initial scoring of each subsector was assessed by the stakeholders, mainly taking into account all discussions raised across the criteria, including the potential for climate change mitigation and adaptation, as well as the role of enabling environment.

The scoring was confirmed as shown in the table below:

Sector	Sub-sector	Potential for climate change mitigation (GHG emissions)	Potential for climate change adaptation (vulnerability)	Relevance to development priorities	Overall enabling environment	Total score
Agriculture and land	Crop production	3	3	3	2	11

Sector	Sub-sector	Potential for climate change mitigation (GHG emissions)	Potential for climate change adaptation (vulnerability)	Relevance to development priorities	Overall enabling environment	Total score
use	Livestock production	3	3	3	2	11
	Fish production	1	3	3	2	9
	Forestry	3	3	3	2	11
Energy	Electricity supply	3	3	3	3	12
	Energy demand	3	3	3	2	11
	Energy efficiency	3	3	3	1	10
Industry and commerce	Agribusiness and agro-allied sectors	2	2	3	1	8
	Solid minerals and metals	3	1	3	1	8
	Oil and gas-related industries	3	2	3	1	9
	Construction and manufacturing	3	1	3	1	8

As a result, the prioritized subsectors were confirmed with consensus from the TNA Committee: crop production, livestock production, forestry, electricity supply, energy demand, energy efficiency, agribusiness and agro-allied sectors, solid minerals and metals, construction and manufacturing. Therefore, the preliminary long-list of technologies was prepared by the



consulting team based on the prioritized subsector and the discussions from the validation workshop. In this context, the subsequent sections will identify and assess the technologies for each subsector that can contribute to climate change mitigation in Nigeria.

4. Methodology

After the prioritized sectors and subsectors were confirmed with consensus from the TNA Committee, the consulting team developed the preliminary long-list of technologies. These technologies were then evaluated against the following criteria:

- (a) **Potential impact on climate change mitigation/greenhouse gas emissions reduction** in the context of Nigeria’s climate change targets. Indicators may include GHG emission share of sub-sector in which the technology could be applied, and theoretical or practical effects of the technology itself in the reduction of GHG emissions.

3: High	The sub-sector is a major source of GHG emissions, and the technology could bring about a large emission reduction effect.
2: Moderate	The sub-sectoral emission share is moderate, but the technology could bring about a large emission reduction effect. Or, while the sub-sector accounts for a large portion of GHG emissions, the expected emission reduction effect of the technology is not particularly large.
1: Low	The emission reduction effect is negligible.
0: Null	Not applicable.

- (b) **Potential impact on climate change adaptation**, if any, in the context of Nigeria’s climate change targets. Indicators may include the size of population and economy (e.g., sub-sectoral GDP) which could be affected by the climate change related events that the technology tackles with, and theoretical or practical effects of the technology itself on adaptation to climate change.

3: High	The sub-sector is a major industry and the potential for the technology to enhance climate resilience is expected to be large.
2: Moderate	While the sub-sector is a major industry, the expected impact of the technology on climate resilience is not particularly large. Or, the size of population and/or economy of the sub-sector is moderate, but the technology could bring about a large positive impact on climate resilience.
1: Low	The effect on adaptation to climate change is negligible.
0: Null	Not applicable.

- (c) **Alignment with climate change policies and priorities:** Evaluates to what extent the technology aligns with key national strategies and sectoral policies, and climate change priorities. Strategies and priorities to be reviewed are those analyzed for the sub-sector selection. Indicators may include whether the technology is mentioned in the policies or



priorities and whether the technology could be expected to address the major challenges identified in the policies or priorities.

3: High	The technology is mentioned in several (more than one) key policies or priorities.
2: Moderate	The technology is mentioned in one of the key policies or priorities. Or, the technology is related to several focus areas of investment in the key policies or priorities.
1: Low	The technology itself is not mentioned in any policy or priority, but it could be related to one of the focus areas of investment in the key policies or priorities.
0: Null	Implementation of the technology is not necessarily prioritized in the key policies or priorities.

(d) **Consideration of co-benefits** (environmental, social, and economic):

- i. Environmental: the potential impact on Nigeria’s environment
- ii. Social: the potential impact on Nigeria’s employment/poverty reduction
- iii. Economic: the potential impact on Nigeria’s economy

3: High	Implementation of the technology could bring about co-benefits in three categories.
2: Moderate	Implementation of the technology could bring about co-benefits in two categories.
1: Low	Implementation of the technology could bring about co-benefits in one of the three categories.
0: Null	Implementation of the technology is not expected to bring about any co-benefit.

(e) **Technological constraints:** Evaluates how practical or realistic the implementation of the technology is in general. Indicators may include the maturity level of the technology, the number of use cases around the globe or in developing countries, and the magnitude of barriers to implementing the technology.

3: High	The technology has already been widely used commercially, and no or only minor barriers are expected in implementing the technology.
2: Moderate	There are some use cases but not yet widely used commercially.
1: Low	The technology is still at the pilot test stage.
0: Null	The technology is still at the research/study stage and is not expected to be used in practice as of now.



(f) **Readiness of Nigeria for the technology:** It evaluates to what extent Nigeria has the appropriate and sufficient environment to implement the technology. The indicators may include the number of use cases in the country, policy environment which could facilitate the implementing of the technology, and acceptability of stakeholders.

3: High	There are several use cases in Nigeria, and no or only minor barriers are expected in implementing the technology.
2: Moderate	There is/are (a) use case(s) in Nigeria. Despite the existence of some challenges in implementing the technology, these could be addressed in the short-term.
1: Low	There is no use case in Nigeria, but there is the environment which could support the implementation of the technology.
0: Null	There is no use case or policy which could promote the use of the technology in Nigeria, and there are many challenges to overcome to implement the technology as of now.

The result from this exercise will provide a total score for each technology, which will be used as a reference to guide the actual section and prioritization of technologies by the stakeholders in the next step.

5. Gender considerations

The UNFCCC and Federal Government of Nigeria recognize the importance of developing national-level climate change policies that are gender-responsive. This section provides an overview of gender priorities, issues and concerns for the prioritized TNA sectors and subsectors. According to the World Economic Forum’s 2021 World Gender Gap Report, Nigeria ranks 139 of 156 countries on gender equality.¹ As of 2019, women held 5.6 percent of seats in the lower house of parliament and 6.4 percent of seats in the upper house.² A woman has never held the position of governor of any of Nigeria’s 36 states. According to the World Bank data for 2019, men’s participation in the workforce in Nigeria was 60.89 percent, and women’s participation was 48.52 percent.³

The majority ethnic groups in Nigeria - the Hausa-Fulani, Igbo and Yoruba – make up around 60 percent of the country’s population.⁴ Minority groups face political, economic and cultural marginalization.⁵

The population of persons with disabilities in Nigeria was at 3.3 million - 2.32 percent of the population - at the 2006 Nigerian census.⁶ Persons with disabilities face environmental,

¹ World Gender Gap Report: http://www3.weforum.org/docs/WEF_GGGR_202117.pdf

² Inter-Parliamentary Union, Women in national parliaments: <http://archive.ipu.org/wmn-e/classif.htm>

³ <https://data.worldbank.org/indicator/SL.TLF.CACT.FE.ZS?locations=NG>

⁴ The World Factbook: Explore All Countries – Nigeria: <https://www.cia.gov/the-world-factbook/countries/nigeria/>

⁵ An International Journal of Arts and Humanities. Ethnic Minorities and The Nigerian State. Page 90

⁶ Nigeria-Population Census 2006 : <http://nigeria.opendataforafrica.org/xspplpb/nigeria-census>



institutional, and social challenges,⁷ limiting their opportunities to actively participate in society in general, and in the workforce in specific.⁸

Almost half of Nigeria's population is under the age of 15.⁹ Older adults (65 years and above) make up 3.1 percent of the total population.¹⁰ Seventy-five percent of children live in poverty,¹¹ while 40.1 percent of Nigeria's total population lives below the poverty line.¹²

5.1. Commerce and industry sector

There is a lack of women's representation across industry, commerce, and business in Nigeria. Studies have shown that a lack of women's representation in any sector – particularly in leadership roles – leads to an inadvertent male bias in decision and policy-making.¹³

5.1.1. Agribusiness and agro-allied sectors

Women's participation in business in Nigeria faces a number of constraints. Some agribusiness subsector policies, such as Presidential Initiative on Cassava, are gender-blind. Disparity in land ownership, and the lack of collateral and credit history limits women's access to financial services. Less than one-third of loans are given to women and some financial institutions will only grant a woman a loan with the consent of her husband.¹⁴ Education and training play a role; in 2018 the literacy rate for rural women was 35 percent, compared with 60 percent for rural men.¹⁵ Women also spend up to four hours a day less than men on wage-earning activities due to their domestic responsibilities.¹⁶ According to the World Bank, "women could increase the yields on their farms by an estimated 20–30 percent if they had the same access to productive resources as men."¹⁷

5.1.2. Solid minerals and metals

According to Nigeria's 2004 Labor Act, women cannot be employed for night work in a public or private industrial undertaking and cannot work underground in any mine. No such stipulations

⁷ Nigerian Country Report on Disability:

http://www.disabilityrightsfund.org/wp-content/uploads/Country-Report_Nigeria_2018.pdf

⁸ Models of Equal Employment Opportunity: https://doi.org/10.1300/J156v02n03_06

⁹ UNICEF, Situation of women and children in Nigeria: <https://www.unicef.org/nigeria/situation-women-and-children-nigeria>

¹⁰ Tanyi, Perpetua, Pelsler, Andre, Mbah, Peter 2018/12/03 Care of the elderly in Nigeria: Implications for policy, VL - 4 10.1080/23311886.2018.1555201 Cogent Social Sciences

¹¹ UNICEF, Situation of women and children in Nigeria: <https://www.unicef.org/nigeria/situation-women-and-children-nigeria>

¹² World Bank data: <https://data.worldbank.org/indicator/SI.POV.NAHC?locations=NG>

¹³ Ibid. Pages 9-12

¹⁴ African Development Bank. Economic Empowerment of African Women through Equitable Participation in Agricultural Value Chains. Page 24

¹⁵ Statista: <https://www.statista.com/statistics/1124741/literacy-rate-in-nigeria-by-area-and-gender/>

¹⁶ African Development Bank. Economic Empowerment of African Women through Equitable Participation in Agricultural Value Chains. Page 25

¹⁷ World Bank. Leveling the field, closing gender gap in Agriculture in Africa. Page 6



are made for men.¹⁸ This may be one reason for the low representation of women in the solid minerals sector which stood at 6.8 percent for 2019.¹⁹

5.1.3. Construction and manufacturing

The World Bank has identified construction and manufacturing among the sectors that have the highest employment potential for youth in Nigeria.²⁰ It is difficult to find current data on the rates of women's participation in either sector; however, gender stereotypes as well as cultural and social norms appear to keep women's participation at a minimum.²¹

5.2. Gender-Responsive Approach to the Implementation of Mitigation Technologies

The aim of implementing gender-responsive technology programming is twofold:

- To prevent existing **gender inequalities** from being exacerbated by climate change and
- To prevent the exacerbation of **climate change impact** due to existing gender inequalities.

Key tools to address gender in climate change mitigation programs are gender analyses to identify gaps; gender-responsive budgets; gender targets and indicators; and sex-and age-disaggregated data.

When women and men, regardless of age, disability status, ethnicity, or geographical location, participate in decision-making and have equal access to assets, resources, knowledge, and skills they jointly assist in building the resilience of communities.

6. Assessment of technologies in the Industry and Commerce sector

6.1. Agribusiness and agro-allied sectors

1. Modular Palm Oil Mills

➤ Introduction

Small-scale processors contribute about 80% palm oil production in Nigeria. The produced palm oil by this sector contains very high free fatty acids, which is an important quality indicator of palm oil. This is mainly because of the time lag between harvest and processing of fresh fruit bunches occasioned by poor processing techniques. Palm oil produced by these processors has

¹⁸ World Resources Institute. Gender and Extractive Governance: Lessons from Existing Legal and Policy Frameworks. Page 30

¹⁹ Premium Times. Women make only 6.8% of Nigeria's extractive sector workforce. 3 August 2021. <https://www.premiumtimesng.com/news/headlines/477265-women-make-only-6-8-of-nigerias-extractive-sector-workforce.html>

²⁰ World Bank/IBRD/IFC (November 2018) Nigeria Systematic Country Diagnostic (SCD) Transitioning to a Middle-Class Society <https://openknowledge.worldbank.org/handle/10986/23099>

²¹ Kasam, Shirka & Amin, Nor. (2020). Gender Discrimination in Building Construction Industry in Nigeria: Threat to Achieving Goal-5 of Vision 2030. World Journal of Engineering and Technology. 08. 33-41. 10.4236/wjet.2020.81004.



lower storability. The sector depends more on fossil fuel to operate their machines while capacity and efficiency are very low. There are existing technologies for large, medium, and small-scale technologies. The semi-mechanized and smallholder technologies in Nigeria make up the small-scale sector as described above. 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 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.

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The large-scale mills emit 468 kg CO ₂ -eq per t FFB to the atmosphere, while small-scale mills emit about 162kg CO ₂ -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.	3
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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 CO ₂ emissions reduction. Food security is key area in National climate change Policy for Nigeria	2
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	3
	The technology can contribute to reducing air, soil and water pollution from fossil fuel combustion, open burning, and disposal of biomass. It also reduces soil and water pollution from disposal of oil palm mill effluent	
	<i>Social</i>	
	The technology will enhance job security and increase opportunity for women in the industry with	



	the elimination of labor-intensive job.	
	<i>Economic</i>	
	The technology will increase Nigeria palm oil capacity, reduce importation of the product, and increase economic activity in the rural oil palm belt.	
Technological constraints	Large-scale and different levels of mechanized systems are operational in Nigeria. There are several companies around the world with track records in manufacturing of palm oil mills including customized designs. There are experienced local manufacturers	3
Readiness of Nigeria for the technology	Several levels of small-scale fresh fruit bunch processing systems have been deployed in Nigeria. Oil palm processing is traditional to the oil palm producing areas in Nigeria.	3

2. Anaerobic digesters

➤ Introduction

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.

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	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%.	3
Potential impact on climate change adaptation	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.	1
Alignment with climate change policies and priorities	Anaerobic digestion is mentioned as a mitigation measure in the second Biennial Update Report (BUR2).	3
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	3
	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.	
	<i>Social</i> The technology could create employment.	
	<i>Economic</i> 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.	
Technological constraints	Different types of technology including conventional, sludge retention and fixed film digesters are widely used around the world. The application varies from crude systems to automated anaerobic digesters.	3
Readiness of Nigeria for the technology	Anaerobic digester is fast gaining popularity in Nigeria for the generation of cooking gas.	3

6.2. Solid minerals and metals

1. Clinker Replacement

➤ Introduction

Applies specifically to the cement industry. This technology involves blending cement with increased proportion of alternative feedstocks (non-clinker) to reduce overall energy consumption in the cement making process.²²

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The cement industry is the highest GHG emitting industry in the IPPU sector accounting for 53.4% of emissions in the sector. This technology is an option to contribute to efficient energy use and 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.	2
Potential impact on	No significant impact on climate resilience	0

²² CTCN, "Clinker replacement", Available at: [Clinker replacement | Climate Technology Centre & Network](#)

climate change adaptation		
Alignment with climate change policies and priorities	Clinker replacement is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO ₂ emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	1
	Improves environmental quality by reducing air pollution from reduced clinker use in cement production.	
	<i>Social</i>	
	No significant social co-benefit	
	<i>Economic</i>	
	No significant economic co-benefit	
Technological constraints	The technology for replacing clinker with alternative non-clinker feedstocks is mature and widely used such as in Europe, US, China and India. There are also several clinker replacement projects implemented under the CDM.	3
Readiness of Nigeria for the technology	Information on clinker replacement in Nigeria is limited, with no indication of implementation in the country.	0

2. Use of Alternative Fuels

➤ Introduction

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.²³

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The cement industry is the highest GHG emitting industry in the IPPU sector 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.	2

²³ Ali Naqi and Jeong Gook Jang (2019), "Recent Progress in Green Cement Technology Utilizing Low-Carbon Emission Fuels and Raw Materials"

Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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 ₂ emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	1
	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.	
	<i>Social</i>	
	No significant social co-benefit	
	<i>Economic</i>	
	No significant economic co-benefit	
Technological constraints	The technology of using alternative fuel is mature and widely implemented. There are also several alternative fuel use in cement projects implemented under the CDM.	3
Readiness of Nigeria for the technology	Information on use of alternative fuels for cement in Nigeria is limited, with no indication of implementation in the country.	0

3. Direct casting

➤ Introduction

This is a main technology utilized in the iron and steel industry where iron and steel products are made based on moulds to shape the molten metal.²⁴

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The iron and steel industry is the second highest GHG emitting industry in the IPPU sector accounting for 46.4% 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.	2

²⁴ CTCN, "Direct casting for iron and steel sector", Available at: [Direct casting for iron and steel sector | Climate Technology Centre & Network](#)



Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	Direct casting is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO ₂ emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	1
	Improves environmental quality by reducing air pollution from energy savings and less materials used.	
	<i>Social</i>	
	No significant social co-benefit	
	<i>Economic</i>	
	No significant economic co-benefit	
Technological constraints	The technology of direct casting in iron and steel is mature, with major producers such as China, Japan and US using the technology.	3
Readiness of Nigeria for the technology	Information on direct casting in Nigeria is limited, with no indication of implementation in the country.	0

4. Molten oxide electrolysis

➤ Introduction

Molten oxide electrolysis (MOE) is the process of developing liquid metal from oxide feedstocks, which eliminates the need for coking ovens and blast furnaces as well as reduce carbon intensive processes.²⁵

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The technology can contribute in reducing carbon dioxide emissions from the iron and steel sector, which is the second highest GHG emitting industry in the IPPU sector accounting for 46.4% of emissions.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	The technology is not mentioned in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO ₂ emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	0
	No significant environmental co-benefit	
	<i>Social</i>	

²⁵ IEA "ETP Clean Energy Technology Guide: Molten oxide electrolysis"

	No significant social co-benefit	
	<i>Economic</i>	
	No significant economic co-benefit	
Technological constraints	Molten oxide electrolysis is still an emerging technology that is still at the research or development phase.	1
Readiness of Nigeria for the technology	Information on this technology in Nigeria is limited, with no indication of implementation in the country.	0

5. Unhydrated cement recycling

➤ Introduction

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.²⁶

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	A study suggests that unhydrated cement recycling can reduce carbon dioxide emissions by 2.5 Gt CO ₂ annually. ²⁷ 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.	3
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	The technology is not identified in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO ₂ emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	1
	The technology can contribute to improving environmental quality by reducing air pollution from the cement making process.	
	<i>Social</i>	
	No significant social co-benefit	
	<i>Economic</i>	
	No significant economic co-benefit	
Technological constraints	Unhydrated cement recycling is an emerging technology that is still under development.	1

²⁶ IEA "ETP Clean Energy Technology Guide: Unhydrated cement recycling"

²⁷ Bellona Europa "How can recycling in the cement and concrete sector contribute to climate change mitigation?"



Readiness of Nigeria for the technology	There is no known case of this technology in Nigeria.	0
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6. Advanced grinding technologies

➤ Introduction

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.²⁸ 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.

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	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.	3
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	The technology is not identified in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO ₂ emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i> The technology can contribute to improving environmental quality by reducing air pollution from the cement making process.	1
	<i>Social</i> No significant social co-benefit	
	<i>Economic</i> No significant economic co-benefit	
Technological constraints	Advanced grinding technologies are still under development and have not been implemented commercially.	1
Readiness of Nigeria for the technology	There is no known case of this technology in Nigeria.	0

7. Metal Roofing Sheets Substitute

➤ Introduction

²⁸ European Cement Research Academy "Future Grinding Technologies"



Clay roof tiles are widely used as exterior building components in different parts of the world. The production process includes clay mining, grinding and mixing with water, extrusion or molding, drying and firing in a kiln. The firing temperature can reach 1200oC with a thermal cycle of 24-48 h from cold to cold. The heating can be provided by biomass, LPG, or electricity. Biomass ash can be added to the clay to improve the properties of the tile including 4oC reduction in indoor temperature with 20% ash addition. Some advantages include better appearance, thermal absorption, while one disadvantage is difficulty in handling. The handling challenges increase the flight cost and makes local production and consumption cost effective.

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	A life cycle assessment of a metal sheets house demonstrates greenhouse gas emissions of 456 tons CO ₂ eq. in comparison to 453 tons CO ₂ eq. for terracotta roof tiles. The difference will be much greater with production of clay roof tiles in Nigeria replacing importation of aluminum, stone coated, and zinc roofing sheets.	2
Potential impact on climate change adaptation	Clay is a poor conductor of heat and will regulate the internal temperature of the buildings.	1
Alignment with climate change policies and priorities	The technology is not identified in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO ₂ emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	2
	No significant environment co-benefit. Though, mining and manufacturing of clay roof tiles may lead to local water, air and soil pollution, regulatory measures will reduce the environmental impacts.	
	<i>Social</i>	
	A plant of 8,250,000 pieces annual capacity will employ about 48 people. The technology will create jobs and reduce poverty in the rural areas where the clay is mined.	
	<i>Economic</i>	
	The technology will reduce capital flight, spur local economic activities with the potential for export to other African countries.	
Technological constraints	The technology is used in Europe and Asia (particularly China) for many years. Nigeria has abundant clay.	3
Readiness of Nigeria for the technology	There is evidence online of clay roof tiles marketing in Nigeria but no evidence of it manufacturing within	1



	the country. With abundant clay in Nigeria, the potential for the production of clay roof tile is evident.	
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6.3. Construction and manufacturing

1. Shifting to renewable sources for electricity (cross-cutting)

➤ Introduction

Moving away from reliance to fossil fuels and shifting to renewable energy like hydro power, solar power etc. for electricity.

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	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.	2
Potential impact on climate change adaptation	Distributed renewable energy applications could make the power system more resilient to extreme climate events and not fully dependent on grid status.	1
Alignment with climate change policies and priorities	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.	3
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i> A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation.	3
	<i>Social</i> Use of renewable energy is still a greenfield area in Nigeria and has the potential for job creation through skilled & unskilled labour requirements.	
	<i>Economic</i> Resilience of the electricity system through self-generation ensures economic growth and development, especially during extreme weather events.	
Technological constraints	Renewable energy technologies for self-generation	3

	such as solar PVs and mini-hydro are widely used.	
Readiness of Nigeria for the technology	Several small-scale solar for commercial and industrial applications have been deployed in Nigeria.	3

2. Waste Heat Recovery (WHR) system

➤ Introduction

Waste heat recovery system captures and reuses the lost or “waste heat” that is intrinsic to all industrial manufacturing, whereby increasing overall energy efficiency.²⁹

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	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.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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.	2
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	2
	Improves environmental quality by reducing air pollution emitted from reduced fossil fuel use or use of grid electricity.	
	<i>Social</i>	
	No significant social co-benefit	
	<i>Economic</i>	
	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.	
Technological constraints	WHR is a mature technology and has been successfully implemented in industries within developing countries.	3
Readiness of Nigeria for the technology	There are no waste heat recovery power generation systems installed in Nigeria and no evidence of	0

²⁹ Republic of Philippines, “Technology Needs Assessment Report: Mitigation”



	active marketing by the major players. ³⁰	
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3. Zero Energy Buildings (cross-cutting)

➤ Introduction

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”.³¹ 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”.³²

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Zero energy buildings 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 use of electricity.	2
Potential impact on climate change adaptation	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.	2
Alignment with climate change policies and priorities	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.	1
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	2
	Introducing renewables and using electricity efficiently contribute to improving environmental quality by reducing emitted air pollutants	
	<i>Social</i>	
	No significant social co-benefits	
	<i>Economic</i>	
	The technology has the potential to improve productivity	
Technological constraints	Most technologies associated with zero energy	3

³⁰ IFC (2014), “Waste Heat Recovery for the Cement Sector: Market and Supplier Analysis”

³¹ US Department of Energy (2015) “A Common Definition for Zero Energy Buildings”

³² US Department of Energy “Zero Energy Buildings” Available at <https://www.energy.gov/eere/buildings/zero-energy-buildings> (Accessed: 29 July 2021)



	buildings are mature and available in many countries.	
Readiness of Nigeria for the technology	Even though there are some studies on zero energy buildings in Nigeria, it is still limited.	1

4. Absorption chillers (cross-cutting)

➤ Introduction

Absorption chillers rely on the relationship between boiling point of a liquid and pressure. Industrial waste heat is used to providing cooling effect instead of the conventional air conditioning systems. It means cooling effect can be achieved with lower energy consumption

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology reduces greenhouse gas emissions associated with operating air conditioners especially if through fossil fuel. It can rely entirely on waste heat and renewable solar energy.	3
Potential impact on climate change adaptation	The technology provides climate resilience due to global warming	3
Alignment with climate change policies and priorities	Vulnerability of increased temperature is mentioned in Nigeria's climate change policies and priorities. The technology is key to climate resilience.	3
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i> The technology could reduce pollution from consumption of fossil fuels in powering conventional air conditioning systems. It uses environmentally friendly chillers including water and lithium bromide as "refrigerants".	2
	<i>Social</i> There is no significant social impact	
	<i>Economic</i> The technology could reduce the cost of industrial cooling.	
Technological constraints	The technology is adopted in different countries	3
Readiness of Nigeria for the technology	The technology is not widespread in Nigeria. Investment in this area will be needed	0

5. Shifting to wooden buildings (cross-cutting)

➤ Introduction

Wood as a building material predates cement in blocks and concrete. In different parts of the world including Germany, the use of wood in modern buildings has been demonstrated with huge success. Carbon sequestration is the process of capturing and storing atmospheric CO₂. An important means of sequestering carbon is through trees. When plant in the form of wood is used



in construction, the carbon dioxide absorbed by it during growth period is stored in the wood as long as the building stands. The construction of buildings with more wood and less cement and metal utilizations contribute significantly to carbon sequestration. Wood can replace concrete beams, reinforced concrete slabs, walls, and floors in addition to roofing. Walls can be made of glasses instead cementitious block walls. Wooden building emits about 30% less GHG than concrete building

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The technology sequesters carbon and stores it for decades. When the wood is sourced locally, emissions associated with transportation of building materials are reduced. GHG emissions can be reduced on a displacement factor of 1 ton CO ₂ eq. per ton of wood.	2
Potential impact on climate change adaptation	Wooden houses are less responsive to increased temperature and provide resilience to climate induced heat and makes artificial air conditioning less attractive	2
Alignment with climate change policies and priorities	Promoting climate-proofing of construction and infrastructural development is a key policy statement in the National climate change policy for Nigeria. Carbon sequestration is a key technology to support Nigeria's climate targets.	3
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i>	3
	The technology reduces pollution associated with sand mining, and stone, steel and cements production. This will increase reforestation and the associated environmental benefits.	
	<i>Social</i>	
	The technology will create more jobs in the rural areas especially in sustaining the supply chain.	
	<i>Economic</i>	
	The technology will support the forestry sector and increase economic activity. Rural communities in forested areas benefit a lot from timber sourcing.	
Technological constraints	The world tallest wooden skyscraper of 85 meters is in Norway while in Germany a proposal for 98-meter skyscraper featuring 29 floors has been approved. The technology is also popular in Austria, France, and Poland. The share of residential wooden multi-story construction is about 5–6% of all residential multi-story buildings.	3
Readiness of Nigeria for the technology	Wood is an integral part of building in Nigeria. There is limited report on largescale modern wooden house.	2



6. Promotion of green roof/wall (cross-cutting)

➤ Introduction

Green roof and wall are roof top and wall gardens, or different kinds of vegetables employed on modern buildings. A green roof/wall typically consists of several components, including vegetation, growing medium, filter membrane, drainage layer, root barrier and water proofing membranes. Interest in green roofs is growing especially in developed countries including Germany, Switzerland, Denmark, Canada, USA, Singapore, Scandinavia, and Japan. Green facades are based on the application of climbing or hanging plants along the wall while living wall system are based on the application of lightweight and permeable screens in which plants are inserted individually.

➤ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Energy savings of 63% have been reported in tropical climate. Reduction in CO2 concentration of 0.63% near green walls compared to bar wall has been reported.	3
Potential impact on climate change adaptation	The technology can reduce urban heat wave island effect, provide thermal comfort, and improve microclimatic conditions	2
Alignment with climate change policies and priorities	Carbon sequestration is a key technology to support Nigeria's climate targets.	2
Consideration of co-benefits (environmental, social, and economic)	<i>Environmental</i> Reduces urban heat island, stormwater, enhance air and water quality, urban biodiversity, and pollution associated with the replaced roofing material, improve aesthetic value in urban environment. Experiments show green roof can retain runoff by up to 77.2%, noise can be reduced by about 20 dB while a 1000 m2 green roof can capture dust approximately 160–220 kg per year. Roof leakage is an important challenge of green roof.	3
	<i>Social</i> The technology would require a new set of skills in the urban areas and is gender freely	
	<i>Economic</i> The technology could increase value of real estate; year sales figure of green roof application in Germany is worth 254,000,000.	
Technological constraints	The technology is popular in developed countries including Austria, Germany, Hungary, Switzerland, United Kingdom, and the Scandinavia with over 90 million square meters green roof. In Japan, public buildings larger than 250 m2 and private buildings larger than 1000 m2 ae required to green 20% of the	3



	rooftop or pay 2000USD annually.	
Readiness of Nigeria for the technology	The awareness of the technology is increasing among stakeholders. There are no reported applications of green roof and green wall technology in Nigeria. However, most of the materials are available locally and being used for other construction works	1



7. Summary of list of mitigation technologies

Technology	(a) Potential impact on climate change mitigation/ greenhouse gas emissions reduction	(b) Potential impact on climate change adaptation	(c) Alignment with climate change policies and priorities	(d) Consideration of co-benefits	(e) Technological constraints	(f) Readiness of Nigeria for the technology	Total
<i>Industry and Commerce: Agribusiness and agro-allied sector</i>							
Modular palm oil mills	3	0	2	3	3	3	14
Anaerobic digesters	3	1	3	3	3	3	16
<i>Industry and Commerce: Solid minerals and metals</i>							
Clinker replacement	2	0	1	1	3	0	7
Use of alternative fuels	2	0	1	1	3	0	7
Direct casting	2	0	1	1	3	0	7
Molten oxide electrolysis	2	0	1	0	1	0	4
Unhydrated cement recycling	3	0	1	1	1	0	6
Advanced grinding technologies	3	0	1	1	1	0	6
Metal roofing sheets substitute	2	1	1	2	3	1	11
<i>Industry and Commerce: Construction and manufacturing</i>							
Waste Heat	2	0	2	2	3	0	9



Recovery (WHR) system							
Zero energy buildings	2	2	1	2	3	1	11
Absorption chillers	2	1	2	2	3	0	10
Shifting to wooden buildings	2	2	3	3	3	2	15
Promotion of green roof/wall	3	2	2	3	3	1	14