Nigeria Cement Industry Decarbonization

Knowledge Dissemination

March 2024

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Context and Objectives of the Deep Dive Study

Context

- At COP26 in Glasgow at the end of 2021, Nigeria **committed to achieving Net Zero** by 2060
- Within the Energy Transition Plan, the **industry sector was calculated to represent about 16% of total in-scope emissions** in Nigeria as of 2020, **half of which were attributed to cement production**
- Leading companies in the Nigerian cement sector have commenced waste-to-energy initiatives to reduce their carbon footprint and there still **exists significant opportunities for scaling**
- Through assessment of a list of decarbonization levers adopted by cement manufacturers globally and based on our assessment, **waste-to-energy (alternative fuels) stands out as the most feasible lever** to implement in the immediate term in Nigeria

Objectives

- Enlighten stakeholders on the **decarbonization levers applicable to the Nigerian cement industry** and show potential opportunities to decarbonize in the immediate term
- Present findings on **waste-to-energy projects and opportunities, impact and key success factors for these,** including commercial value proposition to **stimulate the required actions and investments** into decarbonization projects

Overview of Global and Nigeria's Cement Industry

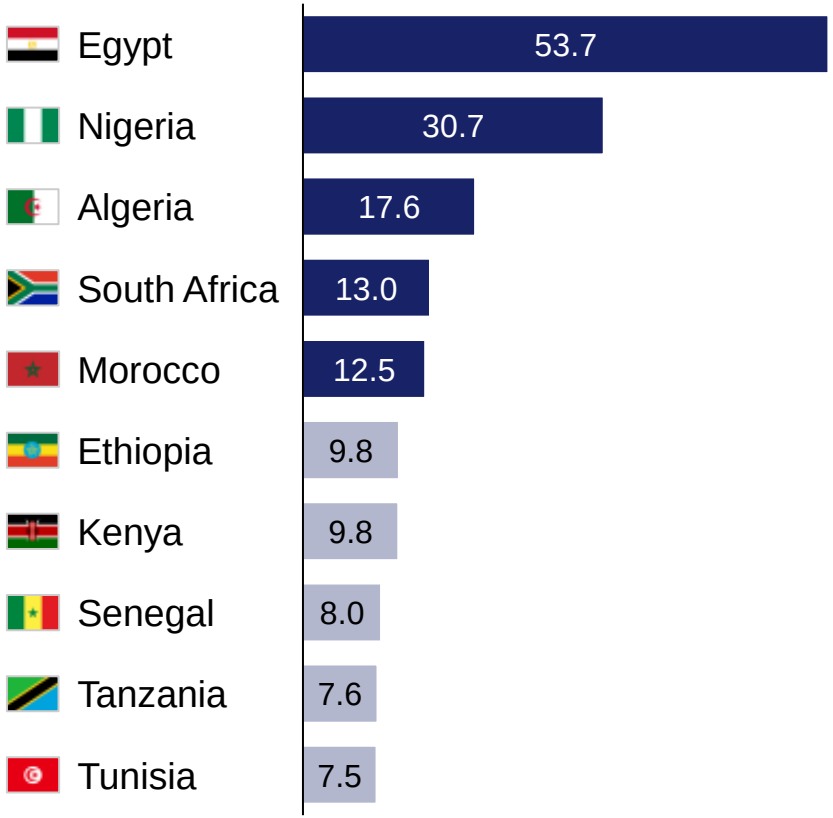
Evaluation of Decarbonization Levers

Waste-to-Energy Opportunities & Potential Projects

High Level Decarbonization Action Plan

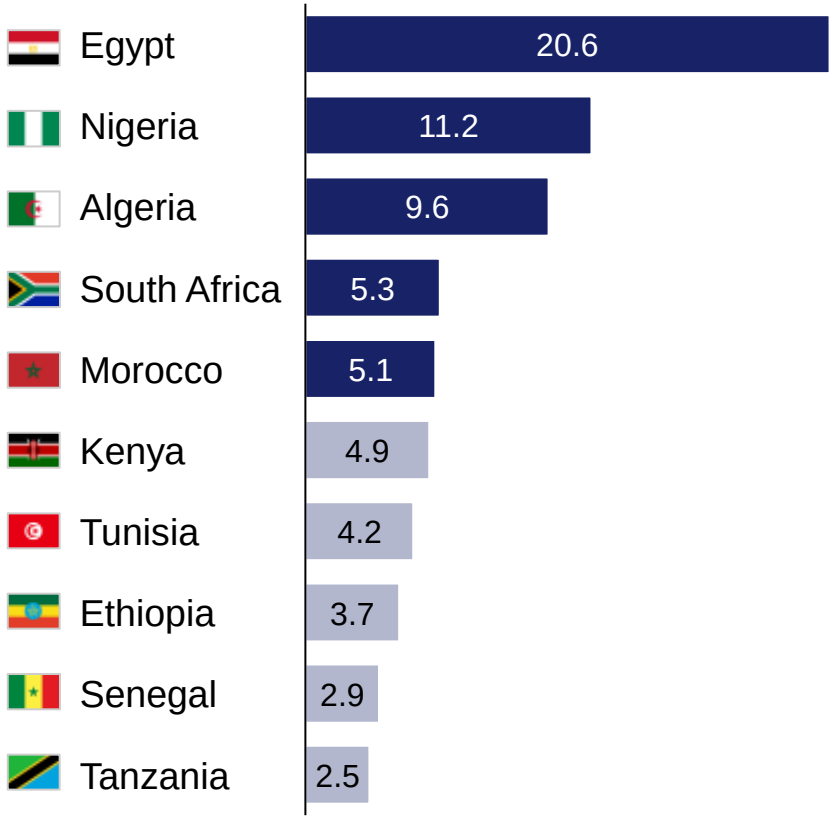
Nigeria is the 2nd highest cement producer and emitter in Africa

Top 10 cement producing countries in Africa, 2022, Million Mt



Top 5 countries in Africa account **for 54% of production**

Top 10 countries by CO_2 emissions from cement industry in Africa, 2022, Million Mt



Key Insights

There is a **direct correlation between the amount of cement produced and CO_2 attributed to the cement industry** of African countries

This could imply a level of **similarity in maturity of decarbonization efforts** within the cement production process **across African countries**

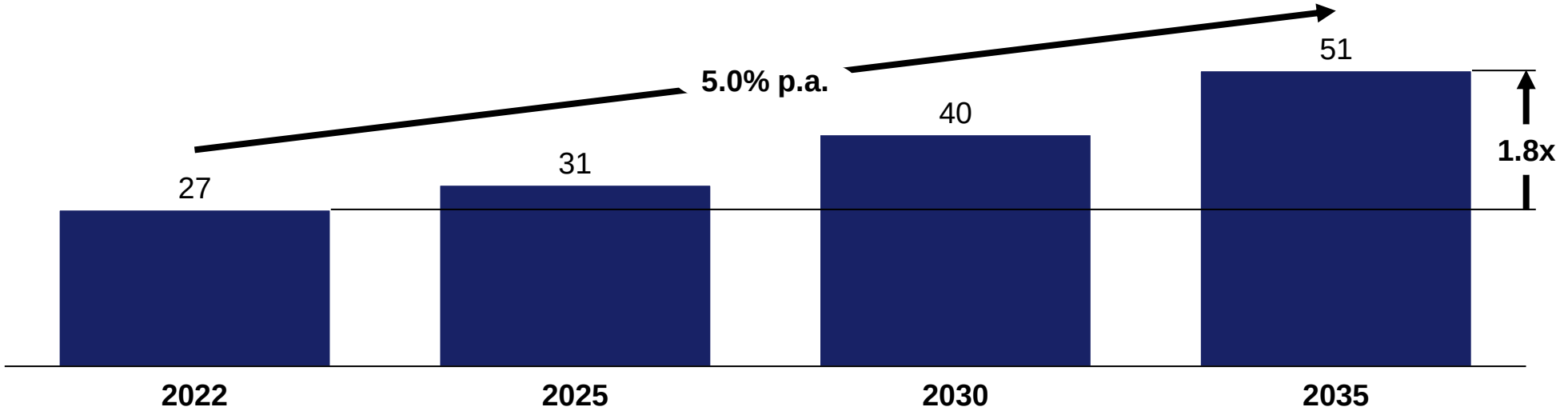
Source: The Global Cement Report, Tradeship Publications Ltd (UK), www.CemNet.com (2023), The Global Cement Report (15th edition), IHSM, economicactivity.org, Our world in data

Cement production in Nigeria is projected to increase by ~1.8x by 2035, and CO_2 emissions from the sector could increase proportionally

Business as usual scenario[1]

Cement production by top 3 players in Nigeria[2]

Mt, 2022 - 2035



	2022	2025	2030	2035
Total CO_2 emissions ($MtCO_2$)	17	20	25	32
Production capacity[3] (Mt)	57	60	69	69

1. This scenario assumes factors such as fuel mix, clinker to cement ratio and energy efficiency remain at 2022 levels
2. Annual growth rate of 5% applied, based on weighted average historical growth rate of the major 3 cement manufacturer sales
3. Based on public statements, Dangote expected to launch 6Mt plant in 2026 and BUA expected to launch 3Mt plants in 2025 and 2029

Source: Company websites, Prospects+ Model, Press Search, GNR database

The clinker and cement manufacturing stage yields most of the CO2 emissions (91%) and energy requirements (88%) in the cement value chain

CO2 emissions per ton of cement | Energy requirement per ton of cement | x% contribution to total

	Raw materials, Energy and Resources	Clinker and Cement manufacturing	Concrete production	Markets – Retail and Construction	Total
Main steps	Limestone, marl, clays and other materials are extracted Quarried material is dried and crushed as input to blending	Crushed materials are heated to form cement clinker Clinker is ground with additives to form cement	Ready-mix products are bagged and mixture-ready to be shaped and hardened at site	Trade customers act as middleman and sell directly to private and smaller companies	
CO_2 kg/t cement	1.2% 11	91% 843	5.3% 49	2.4% 22	100% 925
Energy MJ/t cement	2.2% 85	88% 3,410[1]	7% 285	3% 115	100% 3,895
Main drivers	Diesel fuel to run the heavy machinery	Fuel to heat the kiln and calcination chemical reaction (requires high temperatures of up to 1,500°C)	Electricity consumption of the mill	Transportation of cement	

1. 42% of CO_2 emissions are from burning up fuel to create the heat energy required for the calcification chemical reaction. ~53kg of CO_2 is released per MMBtu of natural gas vs 91kg of CO2 per MMBtu of coal according to US Energy Information Administration

Source: Expert interview

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To reduce emissions, cement players generally employ decarbonization levers along three categories

NOT EXHAUSTIVE

Traditional levers
Innovation levers

A

Traditional production process-related levers

Alternative fuels

Many cement companies are investing in biomass and waste as an alternative source of fuel, focusing on the primary crop of the region as the most viable source of biomass fuel

Energy efficiency

Nearly all players use some form of energy efficiency measure, increasingly this entails the use of automation and robotics, AI (and machine learning), predictive maintenance and other digital tools

B

Material/product-related levers

Clinker substitutes

To commercialize greener concrete, produced using various clinker substitutes (e.g., calcined clays, limestone fillers)

Alternative binders

Industry players are using new types of binders (e.g., alkali-activated cements, flashed metakaolin), to produce low/net-zero concrete

C

New production process-related tech levers

Carbon capture

Industry players are investing in a variety of new technologies to capture CO_2 (e.g., liquid amine solvents scrub CO_2 out of flue gas)

Carbon looping

Pilot demonstrating calcium looping process in Italian plant (CLEANKER initiative). Flue gas is looped continuously through the calciner and a carbonator to enrich CO_2 percentage

Solar

New AI-backed technology is managing to produce cement based on solar energy (using an array of mirrors)

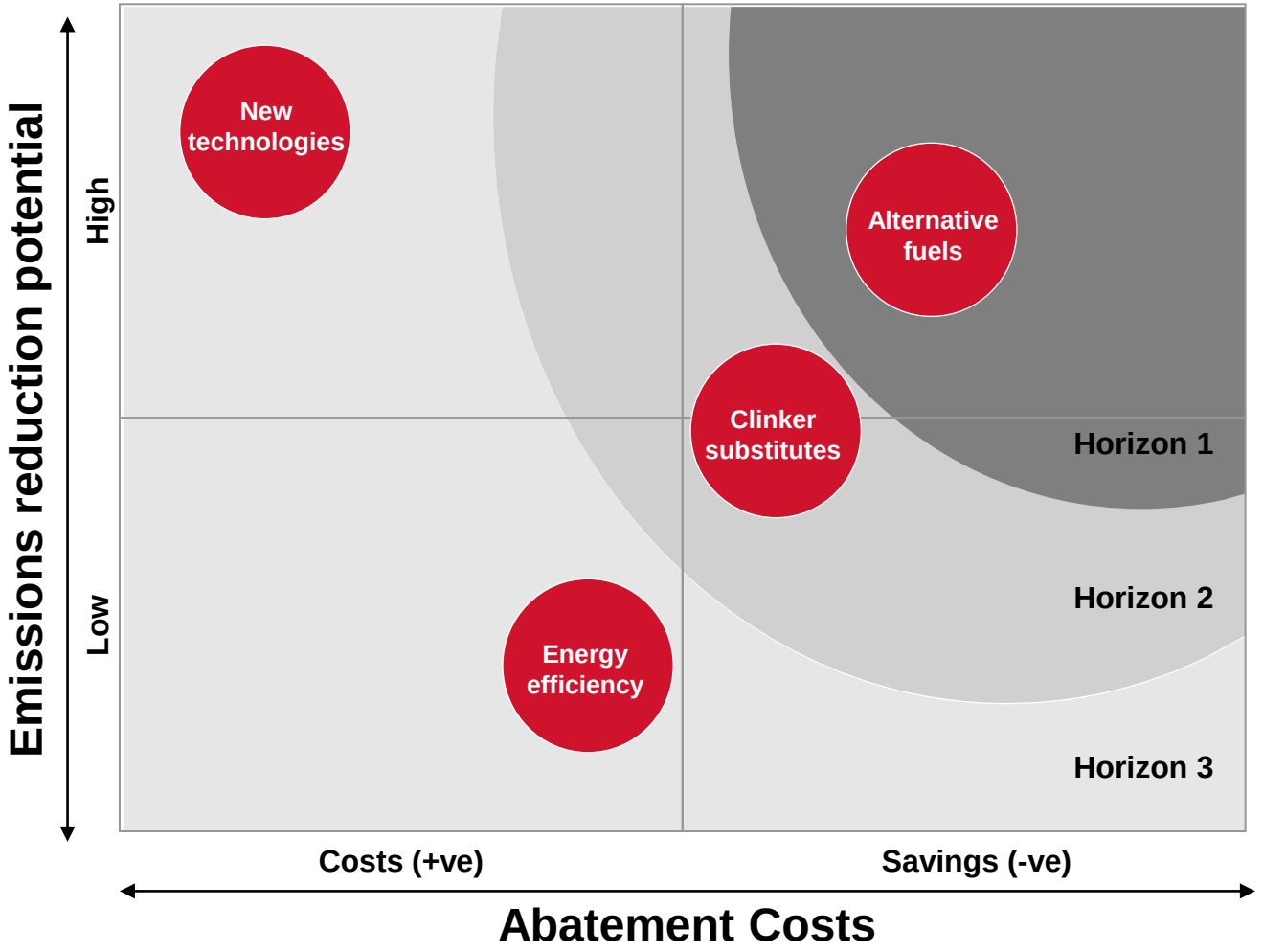
Electrification of kiln and compressor

Electrification of the kiln and compressor, eliminating the need for burning fossil fuels. Successful pilot conducted, with cost estimated at 10-20 EUR/tCO_2 (can address only 30% of total CO_2)

Source: Companies websites

Alternative fuels are the most feasible lever in the short term based on emissions reduction potential and abatement costs

PRELIMINARY – BASED ON BASE CASE

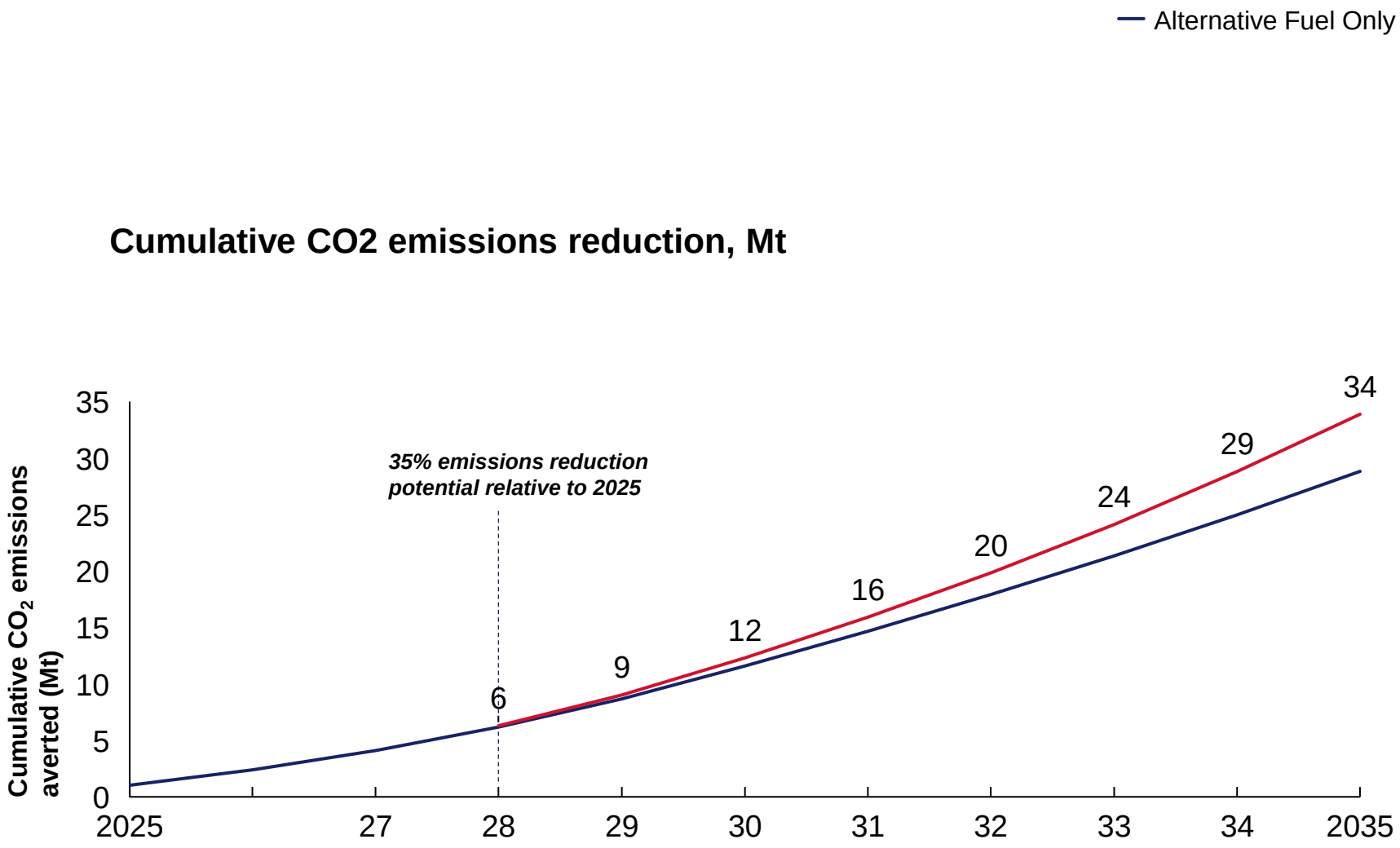


	% CO_2 emissions reduction vs BAU[1]	Maximum abatement cost $/t$CO_2$
Horizon 1 (<3 years)		
Alternative fuels	25%	-35
Horizon 2 (3-10 years)		
Clinker substitutes	16%	-35
Horizon 3 (10+ years)		
New technologies	50+%	+115
Energy efficiency	12%	+25

1. Based on base case in emissions reduction model

Source: McKinsey analysis

Alternative fuels are the focus for the short term, presenting up to 35% emissions reduction potential



- In the **short term** (i.e., over 3 years), **increasing alternative fuel adoption to 30%, could result in 6.3Mt of emissions averted and equivalent to 35% emissions reduction potential relative to 2025**
- In the **medium term, if ONLY alternative fuels is adopted**, and alternative fuel adoption is increased to 50%, **this could result in 28Mt of emissions averted by 2035**
- **In the medium term if BOTH clinker to cement** ratio is reduced from 75% to 70% **and alternative fuel adoption** is increased to 50%, this **could result in 34Mt of emissions averted by 2035**

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Evaluation of Decarbonization Levers

Waste-to-Energy Opportunities & Potential Projects

- Municipal Solid Waste
- Agricultural Waste

High Level Decarbonization Action Plan

Definition of different feedstock used as alternative fuels

Feedstock	Description
Agricultural waste	Waste from production of crops such as rice husk, palm kernel shell, bagasse, coffee husk, cotton stalks etc. Also involves other waste from agro-industries such as chicken litter, glycerin from biofuel production
Municipal solid waste	Municipal solid waste is the waste produced by residents at home, in offices, or in commercial activities. This waste could include commercial waste, non-hazardous produced by industries, green waste, and street cleaning waste
Used tyres	Used tyres originate from the production of tyres and the replacement of tyres from vehicles such as cars, trucks, and buses. Other rubber waste originates from conveyor belts, shoe production, and many other sources.
Plastic waste	Plastic waste is mainly composed of plastic bottles but also includes others such as plastic bags
Saw dust	Sawdust (or wood dust) is a by-product or waste product of woodworking operations such as sawing, sanding, milling and routing
Mixed industrial waste	Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, mills, and mining operations
Animal meal	Animal meal is produced in rendering plants, and also from treating of waste materials associated with cattle slaughterhouses and meat production operations
Waste oil	Waste oil originates from any engine that requires lubrication (for example, car, truck, bus, mining machine/ truck, diesel locomotive, power generator, lawn maintenance equipment).
Sewage sludge	Sewage sludge is produced by sewage plants that receive municipal or industrial wastewater. The wastewater is cleaned using biological treatment, and the pollution is concentrated in the sludge.
Solvents	The hazardous solvents available in the waste market originate from chemical and pharmaceutical processes, manufacturing of paint and other building materials, as well as the use of paint in the automotive industry, furniture production

Source: IFC Report

We analyzed different alternative fuels feedstock against 5 dimensions to determine suitability for Nigeria

Dimensions		Description	Weight (%)
1 **Logistics**	Feedstock availability	Amount of feedstock available to cement manufacturers in the Nigerian market (including potential competition from other industries)	*30%*
	Supply chain management	Efficiency and reliability of supply chain involved in sourcing, transportation and delivering feedstock for cement production	*20%*
2 **Affordability**	Capex	The capital investment required to use each fuel in cement production (e.g., unloading trucks, shredding lines, separators, storage silos etc)	*10%*
	Opex	The recurring costs involved in using the alternative fuel. e.g., cost of fuel, electricity costs, labor and transportation costs etc.	*10%*
3 **Emissions reduction**	CO_2 emissions	The extent to which each fuel can mitigate CO_2 emissions compared to traditional fuels, measured using net CO_2 emissions factor	*10%*
	Non-CO_2 emissions	The amount of non-CO_2 pollutants such as NOx, SO_2, Chlorine, Heavy metals associated with the use of each fuel	*5%*
4 **Technical suitability**		The need for equipment such as calciners, multi-fuel burners and bypass to use feedstock as fuel in cement plants	*10%*
5 **Clinker quality**		The impact of the alternative fuels on the quality of the final cement product. i.e., any potential alterations in clinker characteristics	*5%*

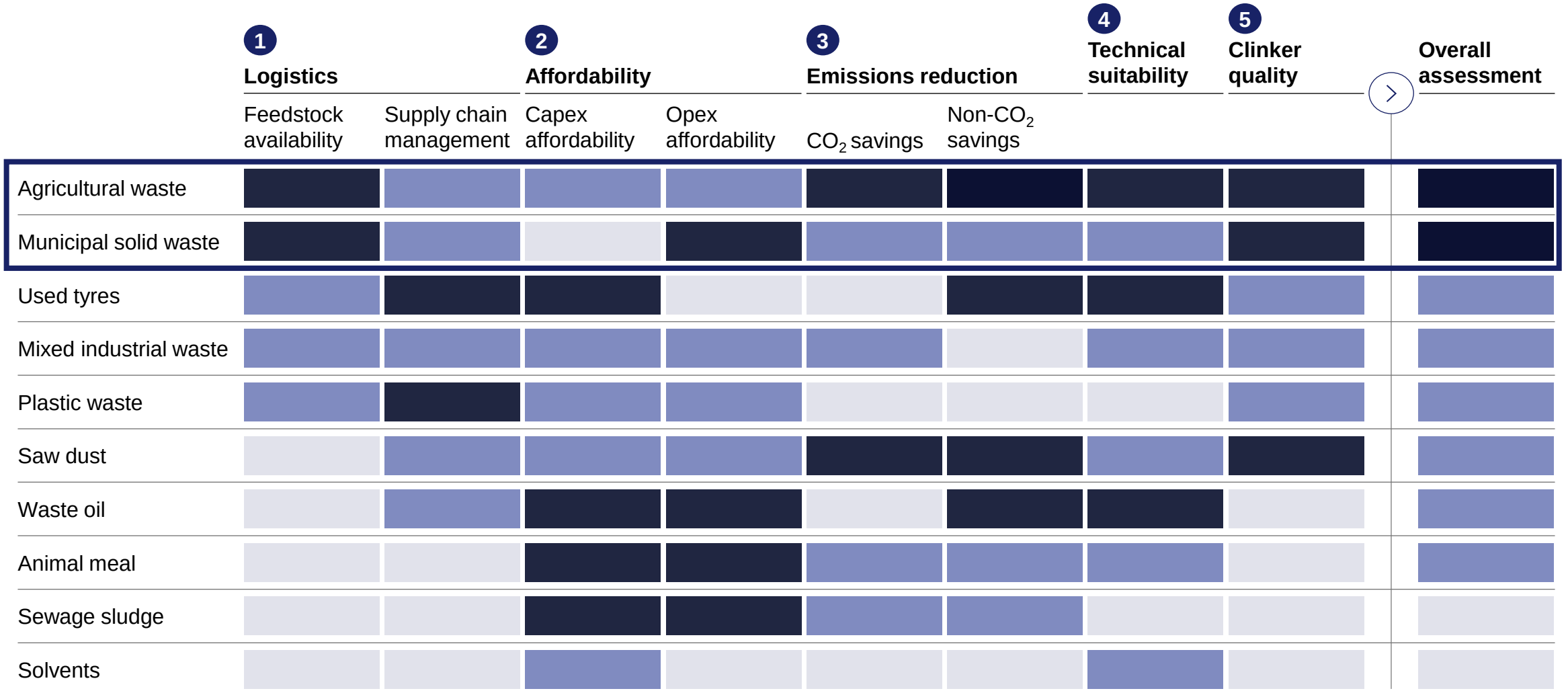
Source: Press Search, Expert interview

Agricultural waste and municipal solid waste have been prioritized for in-depth analysis due to their suitability to the Nigerian cement industry

PRELIMINARY

Suitability to Nigerian cement industry: Low — High

Focus of further analysis

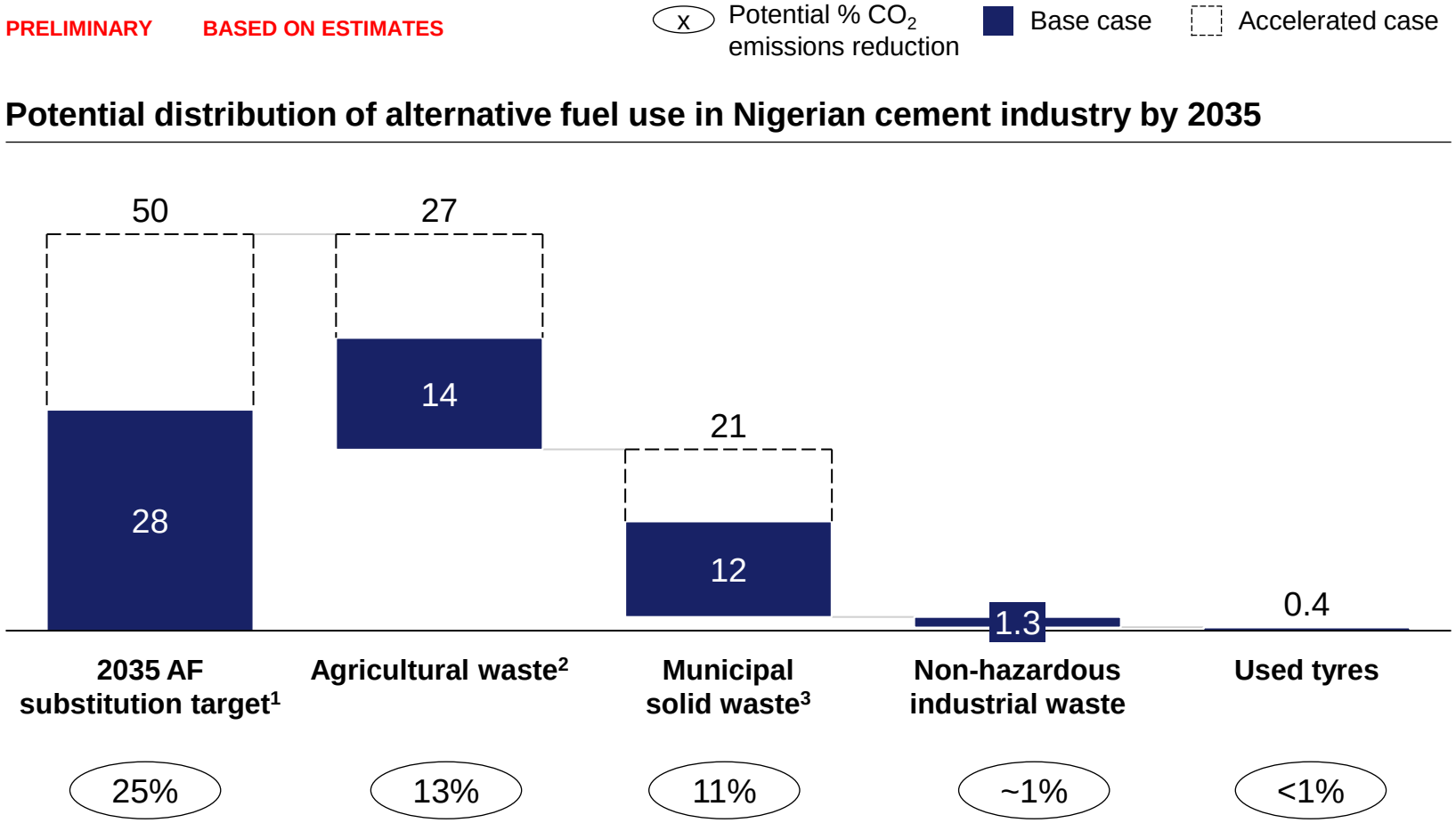


Source: IFC Report, Morgan Stanley Report, Press Search, Research papers

Agricultural waste and municipal solid waste could jointly account for ~30 - 50% of the Nigerian cement industry's fuel mix by 2035

PRELIMINARY BASED ON ESTIMATES

Potential distribution of alternative fuel use in Nigerian cement industry by 2035



1. AF substitution target assumed based on 2 players' commitments due to lack of industry targets
2. Accelerated case for agricultural waste assumes amount of waste captured by cement industry annually, grows from 5% in 2022 to 30% in 2035 (vs 20% in Base case)
3. Accelerated case for MSW assumes waste collection rates increase to 50-70% in focus states by 2035 (vs 25-45% in Base case)

Source: Research papers, Company reports, McKinsey model

Key takeaways

Municipal solid waste could account for **12 – 21% of fuel mix by 2035**, depending on waste collection rates achieved in focus states

Agricultural waste could account for **14 – 27% of fuel mix by 2035**, depending on agricultural waste collection rates and the cement industry's share of waste collected

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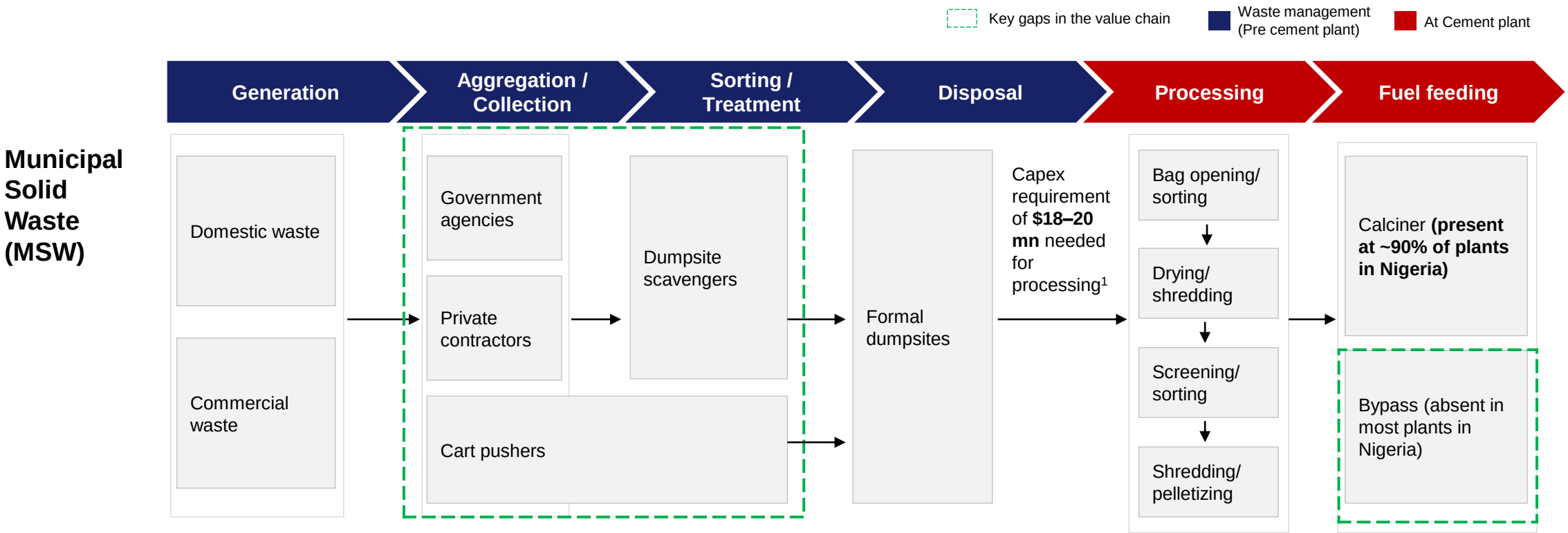
Municipal Solid Waste

Agricultural Waste

High Level Decarbonization Action Plan

Municipal solid waste (MSW): Key gaps in the value chain are at the collection, sorting and fuel feeding steps



Key insights

Domestic waste accounts for ~60% of municipal solid waste in Nigeria

Only **~10% of generated waste is collected** in Nigeria, primarily done by private contractors with their own trucks

Only ~10% of collected waste is sorted (manually) due to **limited mechanical sorting technology**

Due to its low heat content (9 GJ/ton), MSW is fed into the calciner. However, due to typically **high chlorine content** (0.5-1%), using MSW as fuel requires **installation of a chlorine bypass**

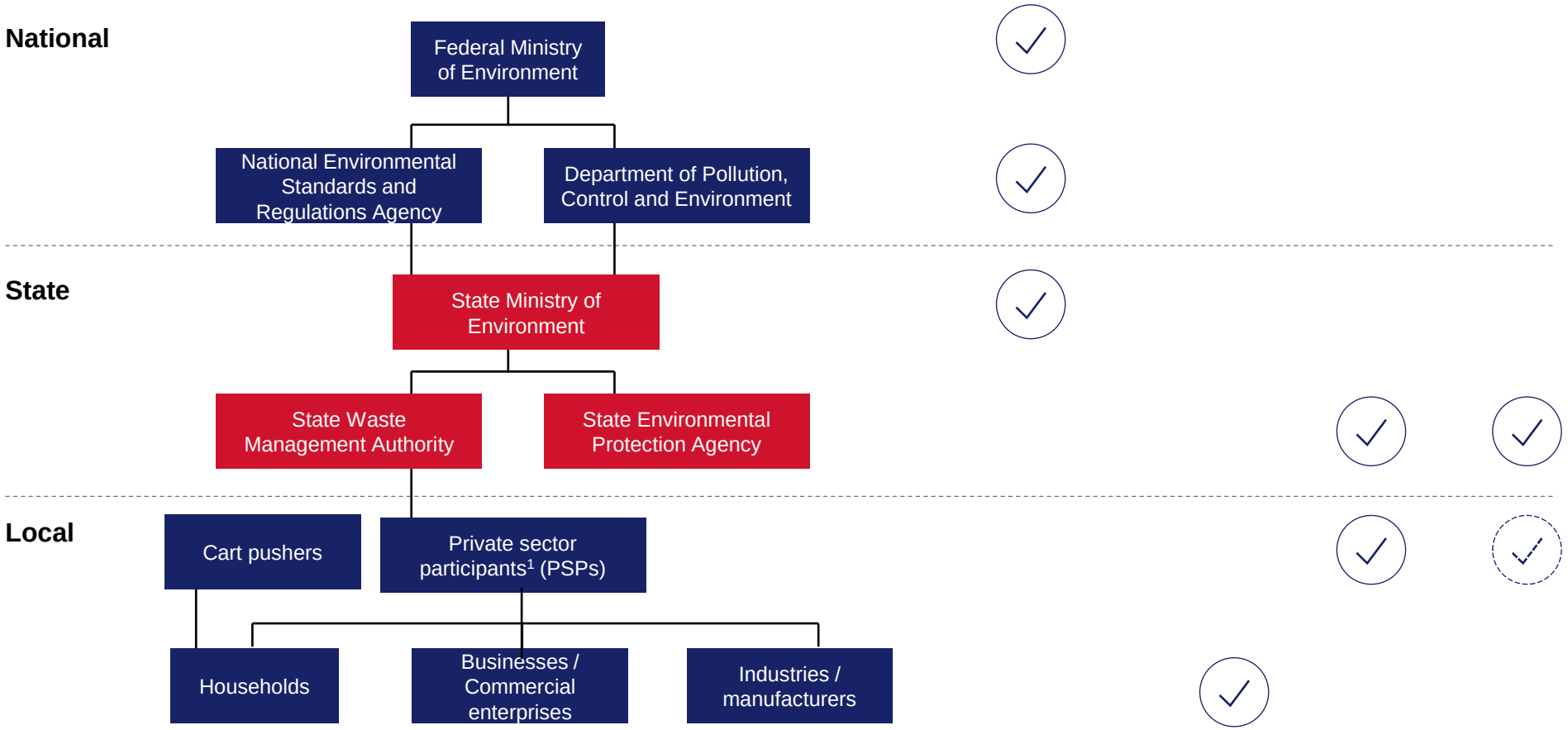
1. Includes costs of chlorine bypass, which is typically about ~$10mn

Source: Press Search, IFC Report, World Bank Report

Municipal solid waste management in Nigeria is decentralized, with each state government charged with management of its own waste

NOT EXHAUSTIVE

Institutional structure for waste management in Nigeria



1. PSPs are private waste collectors contracted by state waste management agencies
2. Some PSPs also have recycling operations (e.g., Wecyclers)

Source: UNIDO Report, Agency websites

Deep dive follows

Comments

The main responsibility of waste management in Nigeria sits with state agencies

State waste management agencies are typically tasked with collecting municipal waste, but in some states, this is **partly outsourced to private sector participants (PSPs)**

PSP collectors are typically **highly fragmented in some states** E.g., >500 PSPs operate across 20 local government areas within some states vs concentrated in some other states with 10-15 in one city alone

Although most states have dedicated waste management agencies, only a few have recently taken active steps to improve MSW collection

Focus states	WMA present	Relevant policies within the past 5 years
Lagos[1]	✓	In 2021, Lagos State Plastic Waste Management Policy was developed to increase plastic waste recovery from ~10% in 2022 to 50% in 2035
Ogun	✓	In 2020, Ogun State passed its Waste Management Authority Bill to improve collection of municipal solid waste and industrial waste in the state
Kogi	✓	In 2022, the Kogi State Sanitation and Environmental Health Law was passed to ban the dumping of waste in unauthorized locations
Edo	✓	In July 2023, Edo State signed it's a waste management policy to increase supervision of private waste collectors by local government authorities[2]
Sokoto	✗	*No recent policies found*
Cross River	✓	*Reported interest in outsourcing waste management to private players*[3]
Benue	✓	*No recent policies found*
Gombe	✓	*No recent policies found*

1. Lagos included due to its proximity to cement plants in Ogun State
2. The new policy is still undergoing final reviews before being publicly announced
3. Based on expert interview with staff of waste management agency

Source: Press search

Example State: Cement players have been unable to adopt MSW and industrial waste at scale due to certain challenges

	Generation	Collection	Aggregation / Sorting	Disposal
Current system		State agency collects **municipal solid waste** in public spaces (e.g., highways) and outsources collection of private municipal and industrial waste to PSPs PSPs remit **25% of revenues generated from fee collections**[1] to state agency	PSPs transport both domestic and industrial waste to state agency-managed dumpsites, where **both waste types are co-mingled** Scavengers at dumpsites pay **~N40 per recovered plastic bottle to state agency** and resell at ~N70 to collectors	
Potential system		Cement players have attempted to **source industrial waste directly from manufacturers**, and proposed exploring revenue-sharing options with government agencies	There is interest to use waste from dumpsites, however cement players are **unwilling to bear the full cost** of developing a sorting line, pre-processing equipment (e.g., shredder) and transportation	

1. Fees range from as low as N500 to as high as N40,000 per month, depending on location

Source: Expert interviews, Press search

Comments

> The waste agencies receive a lot of money from the industrial players which helps them meet their revenue targets…they see cement players coming in as competitors
>
> - ***Industry expert***

> Cement companies can use the waste at dumpsites for fuel, but the government also needs to contribute something because we are offering them a service
>
> - ***Cement industry expert***

Due to inadequate waste treatment, different states have reported challenges with dumpsites

Source: Press search

Comments

"" Olushosun dumpsite in Lagos is one of the biggest dumpsites in the world at over 40 hectares….the waste keeps piling up and is just left there unused

- ***Waste industry expert***

"" We engaged with a state waste management agency to permit us to collect waste directly from manufacturers….we proposed revenue sharing, but the agencies believe they can earn more with the current system

- ***Cement industry expert***

"" Cement companies can use the waste at dumpsites for fuel, but the government also needs to contribute something because we are offering them a service

- ***Cement industry expert***

Project 1: Establishing a 250,000T material recovery facility (MRF) located within 100km of a major cement plant

Assumes MRF serves a 12MT-capacity cement plant

Current maturity vs vision state | Low Medium High

Enablers	Vision state	Current state	
Technology & Technical Knowledge	Availability of **multi-fuel burners** and **chlorine bypass** in cement plants **Know-how** exists for operating mechanical sorting technology, chlorine bypass etc	Most cement plants have multi-fuel burners but **not chlorine bypass** Some players have **experience installing sorting lines** and other plant modifications	
Regulation	National and state policies (in all states) with clear waste collection and processing targets Government policies **mandating delivery of waste to MRFs** instead of dumpsites	**No recent waste management policies** in some states (e.g., Sokoto, Gombe, Benue) **Plastic recycling targets** exist in national policy, but **none for MSW specifically** States **do not have waste collection targets**	
Financial viability	Concessional or grant financing (incl. carbon credits) to support **$20 - $25mn** required for initial capex investment[1] Additional facility revenues generated through **recyclable sales** Track record of heavy industry players **selling carbon credits** in voluntary markets or via CDM[2]	Potential financiers (e.g., IFC) have **previously invested** in Nigerian cement industry There is an **existing market for recyclables** in Nigeria **No example of carbon credits sales in heavy industry** manufacturing	
Ownership/Operation	**7-9 material recovery facilities (MRFs)** present across states with cement plants	Only **2 MRFs** in focus states currently, which are both operated by private entities (WENRG in Lagos and Jubilant Nigeria Ltd in Edo State)	

Key stakeholders required to act

- Cement manufacturers
- State governments / State waste management agencies
- Federal government ministries e.g., environment
- Financiers (e.g., DFIs, commercial banks)
- Manufacturers (e.g., FMCG players)
- Government bodies e.g., NCCC

1. Also includes investment required within cement plants- setting up an MRF alone could require initial capex of $5-$7mn
2. Clean Development Mechanism

There are 3 main business models which cement players generally employ when using municipal solid waste as alternative fuel

Business Model	Description
❶ **Full Integration**	Cement player backward integrates into the municipal solid waste value chain, and engages in collection of waste from households and businesses, processes the waste and uses as RDF in its plants
❷ **Partial Integration**	Cement player backward integrates into the municipal solid waste value chain, and engages in sorting of municipal solid waste already aggregated at the dumpsites, processes the waste and uses as RDF in its plants
❸ **Full Outsourcing**	A private facility operator processes the waste and sells the processed waste as RDF to the cement player which uses the RDF in its plants

Different stakeholders are needed to drive key actions for the successful implementation of this project

NOT EXHAUSTIVE

Key stakeholder groups	Action(s) required
1 Cement manufacturers and/or private MRF operators	• Invest in **material recovery facility for RDF production and/or plant modifications** required for to use RDF as fuel in kiln • Make required **investments in developing project design document (PDD)** to enable issuance of carbon credits
2 Financiers	• Provide **concessional funding** (equity, low interest loans or grant funding) to support development of material recovery facility • Provide **incentives/concessions** from government e.g., tax and levy concessions, land to support development of facility
3 State bodies e.g., waste management agencies	• Develop policies mandating waste collectors or transfer loading station operators to **dispose waste in MRFs** • Promote **domestic and commercial waste collection** through campaigns, investing in collection bins, licensing more PSPs etc
4 National government agencies	• Develop **necessary framework and approvals** to enable successful issuance of carbon credits

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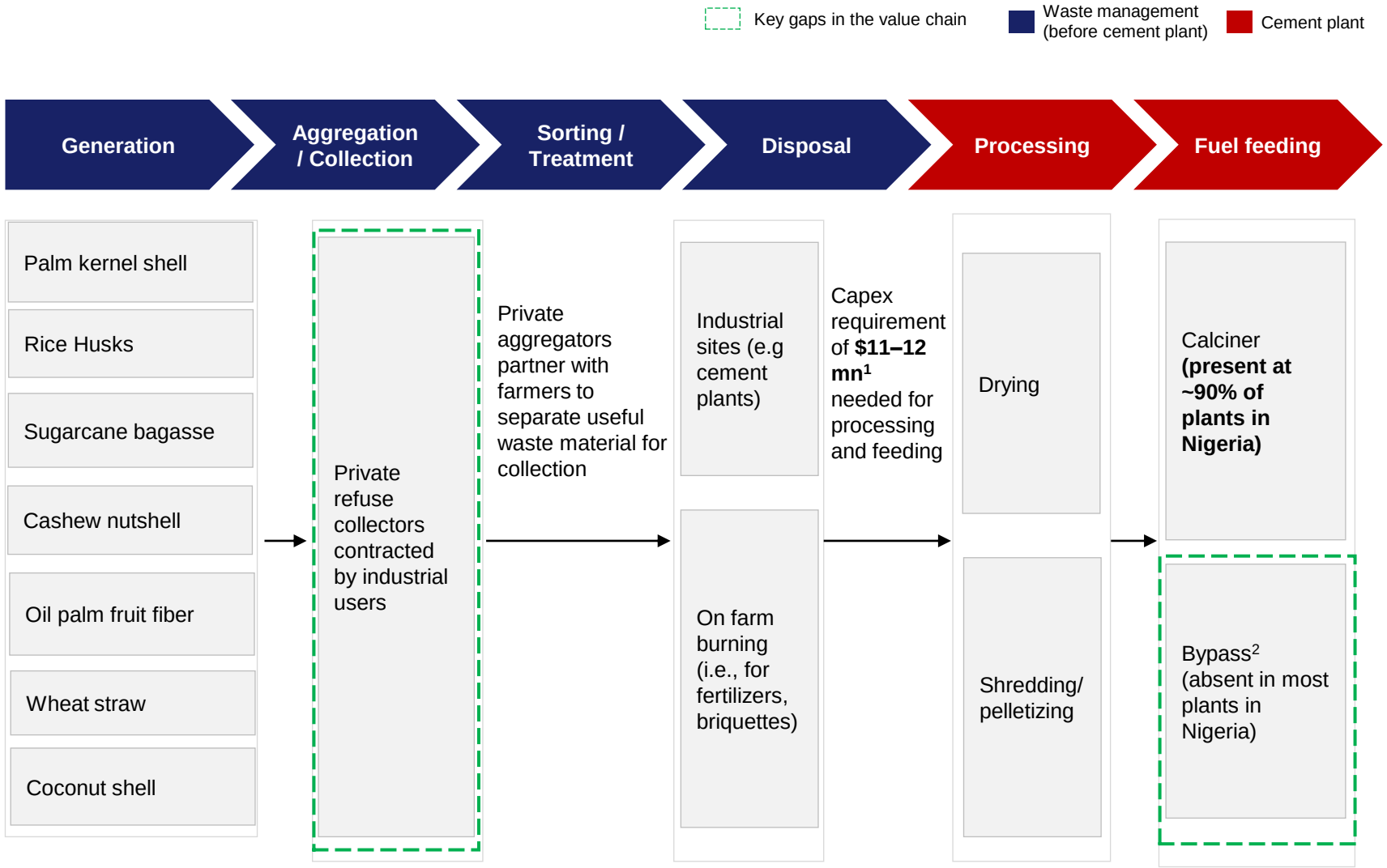
Aggregation/collection and fuel feeding gaps exist within the agricultural waste value chain



1. Includes cost required for chlorine bypass
2. Bypass only required for rice husk and wheat straw due to their high chlorine content (>0.2%)

Source: Press Search, IFC, FAO

Key Insights

- **Palm kernel shell** is the largest available feedstock and is already being used in some cement **manufacturing plants in Nigeria**
- **Coconut shell, rice husks, and oil palm fiber** are also used in **smaller quantities by the players**
- There are opportunities for **investment in the aggregation/collection phase of the value chain**, to standardize the agricultural waste collection process
- The **absence of a chlorine bypass in most plants in Nigeria**, could hinder the use of certain Agricultural-waste e.g., rice husks and wheat straw

Of the various stakeholders in the ecosystem, local stakeholders are the most active in the agricultural waste management process

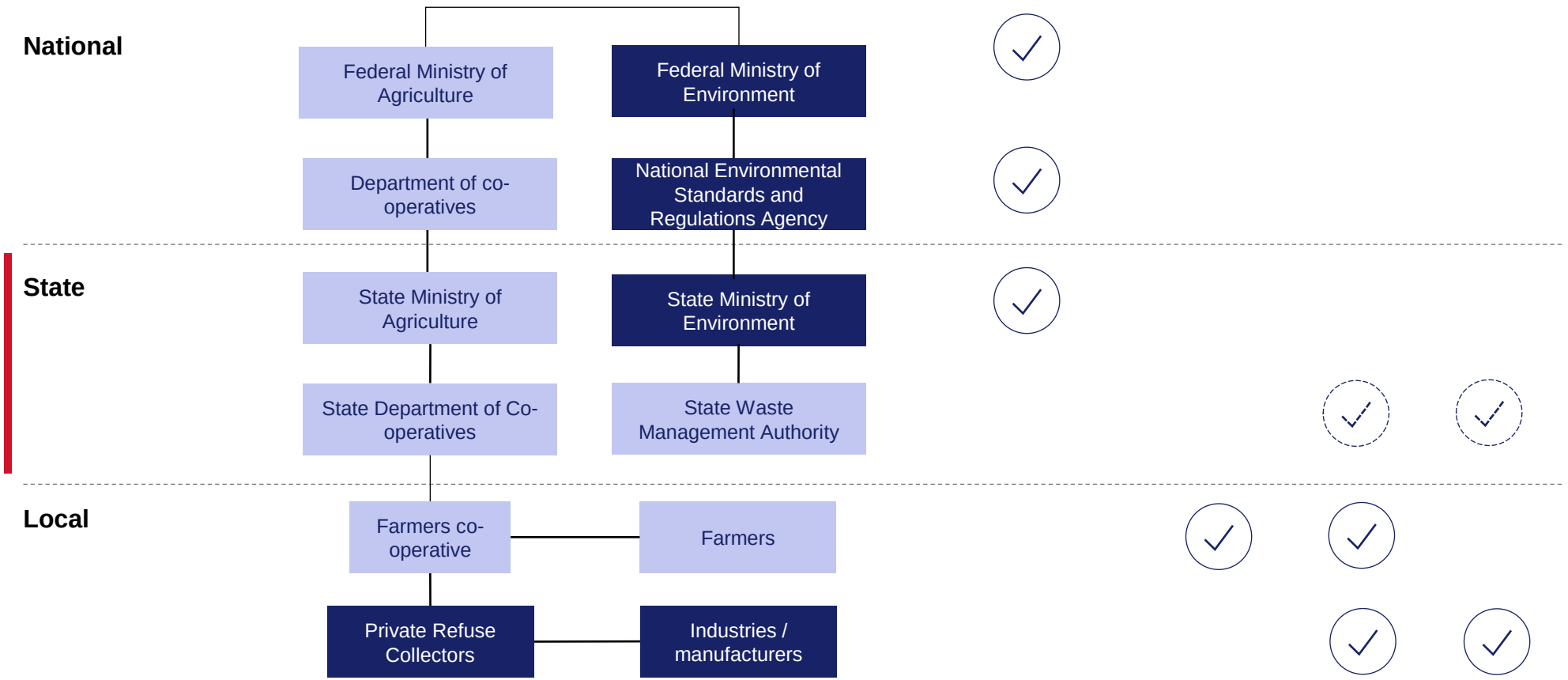
NOT EXHAUSTIVE PRELIMINARY

Minimal activity ✓ Active

Deep dive follows

Specific to Agricultural waste

Institutional structure for waste management in Nigeria



Comments

Agricultural waste management in Nigeria is **predominantly handled by the local players**

Government players at state and national level have **minimal involvement** in agricultural waste management

All agricultural ministries, departments and agencies at national to local level are key actors that are relevant to agricultural waste but not MSW

Source: Press searches, research papers, official website of federal ministry of environment

Most waste management policies have limited implication on agricultural waste

NOT EXHAUSTIVE PRELIMINARY

No implication | Minimal implication | Moderate implication

Focus region	Relevant policies in the last 5 years	Implication on agricultural waste
Lagos	In 2021, Lagos State Plastic Waste Management Policy was developed to increase plastic waste recovery from ~10% in 2022 to 50% in 2035	
Ogun	Ogun state waste management authority bill in 2020 to improve the collection of solid waste and outlining the registration process for private waste collectors	
Kogi	Implementation of Medium-Term Sector Strategy (MTSS) which includes strategies on sanitation and waste management[1]	
Edo	In July 2023, Edo State signed it's a waste management policy to increase supervision of private waste collectors by local government authorities	
Sokoto	*No recent direct policies on general solid waste management*	
Cross River	*No recent policies on solid waste management*	
Benue	*No recent policies on solid waste management*	
Nasarawa	No policy on waste management in the state; 2021 law on waste management and sanitation; no policies guiding agricultural waste management	

1.Specific actions towards strategy implementation include; reducing illegal refuse dumps in the state, strengthening public private partnerships by increasing manufacturing potential in the state

Source: Press search, official federal ministry of environment website, Ogun state environmental policy document

Key Insights

- There is room for improvement in agricultural waste management across the focus regions
- Unlike municipal solid waste, there are limited policies around agricultural waste management, and the existing solid waste management policies have minimal implication on agricultural waste

Comments

Government e.g., state agencies doesn't get as involved in agricultural waste management given a lot of this is in the hinterlands and requires a lot of capacity/resources. The space is still very green and activities are driven by private players

- State Waste Management Agency

Government regulations in the past have been focused on controlling the smoke emitted from the burning of agricultural waste in certain parts of the state

- Private aggregator, Ogun State

Project 2: Establishing a 140,000 tonnes integrated biomass processing facility located within 100km of a major cement plant

ILLUSTRATIVE FOR NIGERIA CONTEXT

What is an integrated biomass facility?

An integrated biomass facility **manages the biomass processing cycle**, starting from waste aggregation to fuel processing

This facility provides **specific (or combination of) services to farmers in exchange for waste** which is processed at the facility

It is **within 100km of the cement plant** and generates **~140,000 tonnes** of agricultural waste annually

What can be offered in exchange for waste?

1 Equipment hiring

Providing farm equipment for hire to farmers (through their farmer associations), at a subsidized rate, in exchange for waste from the crops produced

2 Market linkage

Creating the market for produce of farmers (through their associations) by connecting farmers with offtakers/potential buyers for the produce, in exchange for their waste[1]

3 Mixed

Offering both equipment hiring and market linkage in exchange for waste

1. This service might not require a facility/center and can be done by leveraging existing programs where farmer associations are being connected to potential buyers. Cement players could be a type/category of buyers connected to farmers but for purchasing waste rather than produce

There are several ways to mitigate the risks involved in setting up the integrated biomass facility

Element	Potential Risks	Mitigation
Equipment hiring 	**Equipment mismanagement:** Misuse/improper maintenance of equipment leading to shorter useful life	**Equipment co-financing:** Structure financing for the equipment hire such that it is co-owned and financed by the farmer association so that risk is shared (farmer associations can pay over a period of time)
	Use of equipment for other business: Farmers using equipment other than services agreed for e.g., own side business	**Monitoring & tracking:** Include monitoring and tracking tools and assets with equipment to deter such behaviour patterns
Market linkage scheme 	**Side-selling:** Farmer sells waste to another buyer other than the cement player with whom they have a contract *Farmers can cut you out and sell the product and waste to another person if they need immediate cash between production and harvest. They might provide excuses e.g., the crop didn't yield or grow well which might not be true but they will say this because they have sold to someone else* ***- Industry expert***	**Holistic solutions to manage farmers across crop production lifecycle:** ○ Farm inputs: Provide farmers with inputs ○ Market creation: Make clear to them when they are given inputs, that they are also provided with a market for selling their produce ○ Corresponding targets: Provide farmers with corresponding production/harvest and waste targets to the inputs given and based on the available market they will sell to ○ Financial support: Provide financial support e.g., cash advances to the farmers between planting and harvest but only up to a fixed maximum limit/amount

Source: Stakeholder Interviews

Project 2: Establishing a 140,000 tonnes integrated biomass processing facility located within 100km of a major cement plant

Current maturity vs vision state | Low | Medium | High

Enablers	Vision state	Current state	
Technology & Technical Expertise	Availability of necessary equipment at the different stages of the value chain e.g., **chlorine bypass for the cement plant**	Majority of the cement plants in Nigeria **are not fitted with chlorine bypass**	
	Adequate **technical expertise** among farmers **e.g., on farm machinery**, **proper waste management practices, value of waste**	**Limited widespread knowledge among farmers** on the value of waste and the impact of **best practice waste management on the environment**	
Regulation	Establishment of **target policies to guide agricultural waste management** activities such as registration of private players, targets/commitments on agricultural waste to be turned to value etc **Established carbon** market **frameworks** **Data driven** policy generation and implementation	Although solid waste management policies exist, there are **no specific policies or regulations for agricultural waste management** Unveiling of **Equipment Leasing Registration Authority** by the Federal Government to drive **Equipment Leasing Act of 2015** as an alternative to loans **Nascent s**tage on **carbon market regulatory** guidance **Absence of concrete data** on agricultural waste generation	
Financial viability	Concessional or grant financing to support up to **$~1mn** required for initial capex investment	**Potential financiers** (e.g., DFIs) have previously **invested in Nigerian cement industry**	
Ownership/Operation	Availability of **potential operators** e.g., sizeable standalone biomass collectors and processors	Agricultural **waste management is currently fragmented** – collection is done by small scale private operators and processing is also fragmented- with some done by smaller processors and some processed at the cement plant	

Key stakeholders required to act

- Cement manufacturers
- State governments / State waste management agencies
- Federal government ministries (e.g., environment, agriculture)
- Financiers (e.g., DFIs, commercial banks)
- Industry Associations
- Industrial manufacturers (e.g., FMCG players)
- Farmers co-operatives/associations

Source: Expert interviews, stakeholder interviews

There are 3 main business models which cement players generally employ when using agricultural waste as alternative fuel

Business Model	Description
❶ **Full Integration**	Cement player backward integrates into the agricultural waste value chain, and engages in generation of agricultural produce, extracts the agricultural waste , processes the waste and uses as fuel in its plants
❷ **Partial Integration**	Cement player backward integrates into the agricultural waste value chain, and engages in aggregation of agricultural waste, processes the waste and uses as fuel in its plants
❸ **Full Outsourcing**	A private facility operator aggregates and processes the waste and sells the processed waste as fuel to the cement player which uses the fuel in its plants

Different stakeholders are needed to drive key actions for the successful implementation of this project

NOT EXHAUSTIVE

Key stakeholder groups	Action(s) required
1 Cement manufacturers or private biomass facility operators	• Own and invest in **integrated biomass facility and/or plant modifications** e.g., chlorine by pass[1] required to use as fuel in the kiln • Make required **investments in developing project design document (PDD)** to enable issuance of carbon credits
2 Farmer Associations/Co-operatives	• Implement **capability building**/educational programs **for farmers** on waste management practices and value, farm machinery usage etc. • **Co-invest in biomass facility** equipment (where needed) • **Act as conduit between cement players and farmers** (where needed) for market linkage (with offtakers) for produce • **Establish quality control measures among farmers** e.g., to ensure delivery of agreed output, to prevent mismanagement of equipment etc.
3 Government agencies – state waste management agencies, state ministry of agriculture (department of cooperatives)	• **Establish policies to guide agricultural waste management** e.g., policies on waste disposal, reporting, and collection, state agricultural waste to energy targets etc. • Establish necessary **frameworks for carbon credit sales** through national councils e.g. NCCC[2]
4 Financiers (& state governments where applicable)	• Provide **concessional funding** (equity, low interest loans or grant funding) to support development of biomass facility • Provide **incentives/concessions** from government e.g., tax and levy concessions, land to support development of facility

1. Chlorine bypass is needed for agricultural waste fuel that is high in chlorine content e.g., rice husks and wheat straws so need will depend on the type of agricultural waste being used
2. NCCC= National Council on Climate Change

Overview of Global and Nigeria’s Cement Industry

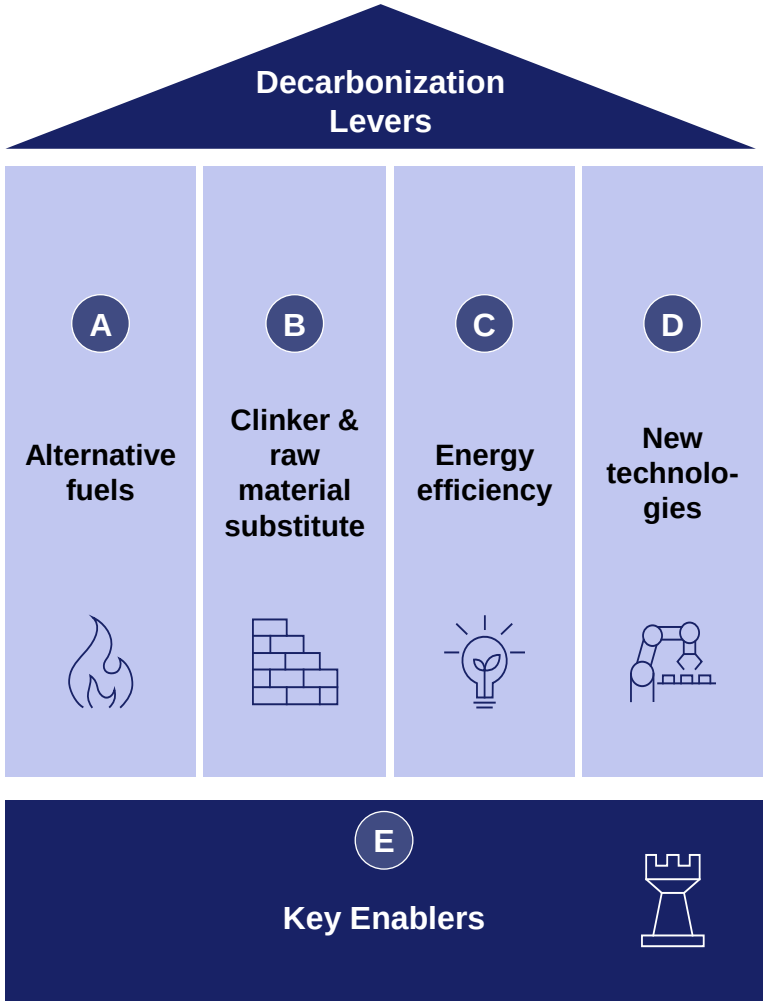
Evaluation of Decarbonization Levers

Waste-to-Energy Opportunities & Potential Projects

High Level Decarbonization Action Plan

We developed a decarbonization implementation plan for the Nigerian cement industry based on 4 main levers and key enablers

Range of emission reduction potential by 2035



Decarbonization Levers		High Level Key actions
A	**Increase the use of alternative fuels**	Increase **availability of and access to waste** through scaling aggregation, collection and management of agricultural waste and municipal solid waste
	20% - 25%	Increase usage of waste through **investment in necessary infrastructure** e.g., material recovery facility, biomass processing facility
B	**Increase adoption of clinker substitutes**	Conduct R&D studies **for low-carbon "green cement"** types
		Establish **standards and regulations** around green cement production
		Invest in access to raw materials for **clinker substitutes**
	15% - 20%	Create awareness and promote **customer education** on green cement
C	**Improve energy efficiency of the plant**	**Analyze opportunity** for energy efficiency present in the Nigerian cement industry
	5% -10%	**Share best practices** among cement manufacturers regarding **operational excellence** and **energy efficiency practices**
D	**Development of new technologies (CCUS[1], Hydrogen and Kiln Electrification)**	Carry out **R&D studies** with collaborative **sectors** and **research organizations**
		Analyze opportunity for new technologies adoption in Nigeria's cement industry
	45% - 60%	Identify and **select potential pilots** for the implementation of new technologies
E	**Key Enablers**	Set overarching **decarbonization vision and agenda** for the Nigerian cement industry
		Develop **carbon emission reduction strategy** for the industry
	-	Institute decarbonization **governance/guidance mechanisms** for the cement industry

1. Carbon Capture, Use and Storage

To make these opportunities a reality, various stakeholders have roles to play

NON-EXHAUSTIVE

Financiers

- Provide suitable financial instruments e.g., long term debt financing, grant and equity for development of material recovery facility and biomass facility
- Provide technical assistance to enhance capabilities and knowledge of waste-to-energy technologies

Government

- Develop policies for improved municipal solid and agricultural waste management e.g., targets for MSW to be converted to energy, mandated MSWs to be delivered to material recovery facilities, targets for agricultural waste usage
- Drive awareness around the value in municipal solid and agricultural waste as alternative fuel
- Provide incentives to potential owners of waste to energy facilities
- Facilitate the development of carbon offset projects in the cement sector

Cement Manufacturers

- Own and manage material recovery and biomass facilities to increase waste feedstock and supply of refuse derived fuels
- Secure government co-investment or support/incentives
- Allocate resources towards acquiring technical expertise to navigate the carbon credit market and develop revenue streams through sales of carbon credit

Waste Management Players

- Own and manage material recovery and biomass facilities to increase waste feedstock and supply of refuse derived fuels
- Allocate resources towards acquiring technical expertise to navigate the carbon credit market and develop revenue streams through sales of carbon credit

Industry Associations

- Drive awareness around value of municipal solid and agricultural waste as alternative fuels to fossil fuels
- Influence stakeholders to take required actions for developing material recovery facilities and biomass facilities

Thank you

March 2024

This programme is funded by UK aid from the UK Government; however, the views expressed do not necessarily reflect the UK government's official policies