LEGAL ANALYSIS OF INCORPORATING WASTE INTO THE NIGERIAN ENERGY SECTOR

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Abstract

Energy from waste might offer a solution to Nigeria's issue with low energy supply and a restricted energy blend, which relies largely on gas and hydropower facilities. The fuel required for running these power stations is plentiful and can be found in dumpsites across the country's main cities. This study considers how through the instrumentality of the law, ecological initiatives that support the transformation of waste into energy for a more sustainable energy system and the environment in Nigeria can be used to reduce greenhouse gas emissions. Based on doctrinal research, the paper suggests that process of waste to energy conversion is affected by a number of factors, including the lack of political will, dearth of waste data, inadequate specialist waste to energy institutions, and lack of cutting-edge technology. The paper submits that through the law, waste-to-energy can be fashioned into a strong renewable source of energy which is socially accepted. This would require adequate enforcement of solid waste management policy, as well as enactment and enforcement of the relevant legal framework.

Key Words – Energy, Environment, Waste-to-energy, Biomass energy

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Introduction

Waste in energy conversion are materials such as paper, plastics, and textiles that no longer have high economic value to the immediate users and are due for disposal. They can also be referred to as materials waiting to be reused. These materials normally result from human, agricultural, and industrial activities. The several forms of waste generated depend on factors such as climate, population, social behavior, size of markets, industrial production, extent of urbanization, work reduction, and effectiveness of recycling.[1] The waste can be in the form of wood or wood products, organic and vegetative materials, metal, glass materials, or plastics or polythene materials. Waste can also be liquid such as sullage and sewage.[2]

The procedure of transforming waste into electricity or heat is referred to as municipal solid waste conversion (MSW conversion) or energy regaining.[3] By turning trash into resources that people may consume, the global community is moving closer to cleaner energy sources. This is one of the basic aims of the "circular economy" which includes the distribution, leasing, reprocessing, fixing, refurbishing, as well as reprocessing current resources and goods. The globular market is meant to address international encounters of waste, contamination, climate change, and biodiversity loss through the eradication of waste and contamination, distribution of goods and resources, as well as the restoration of nature.[4]

Nevertheless, it appears that Nigeria is not making use of its abundant sources of clean energy to produce power to address the issue of a persistent blackout of electricity in the nation.[5] The lack of reliable energy in the nation has slowed the country's economic expansion. Nigeria produces about 4000 Megawatts of power, which is insufficient to meet the needs of its population of about 206.14 million people.[6] Taking advantage of further solutions, like the change of garbage to

[1] Kingsley Egun, "The Waste to Wealth Concept: Waste Market Operation in Delta State, Nigeria," *Greener Journal of Social Sciences* 6 (December 2012): 207.
[2] Babatunde Hammed, "Waste to Wealth in Nigeria: An Overview," *Journal of Human Ecology* (May 2014): 195.
[3] Opaluwa Enebi, "Waste-To-Energy: Killing Two Birds with One Stone" (CPPA Research, 2017). http://cpparesearch.org/nuenpl/wasteenergykillingtwobirdsonestone/.
[4] Olaide Aderoju et al, "Assessment of Renewable Energy Sources and Municipal Solid Waste for Sustainable Power Generation in Nigeria," *IOP Conference Series: Earth and Environmental Science* 95, no. 4 (2017).
[5] Olusola Olujobi et al, "Conversion of Organic Wastes to Electricity in Nigeria: Legal Perspective on the Challenges and Prospects," *International Journal of Environmental Science and Technology* 3, no. 7 (January 2021): 1.
[6] Olujobi et al, "Conversion of Organic Wastes," 1.

electricity to alleviate the nation's electricity constraint, is also justified by the desire to fulfil increasing requests.[7] This has also made it crucial to examine current legal requirements in order to create a strong, thorough legislative structure on clean power at the domestic as well as global sphere.[8]

The Nigerian power sector was privatised with the unbundling of the Power Holding Company Nigeria (PHCN) to form eighteen power stations, but the power supply level is yet to improve. More than half of Nigeria's population are still experiencing low and interrupted power supply.[9] Thus, this research basically seeks to examine the economic importance of waste to electricity sphere of Nigeria. Accomplishing this will entail highlighting the legal framework of renewable energy and the recent developments in the change of garbage to power in Nigeria. Secondly, it will point out the economic importance of waste in the energy sector. The challenges affecting the due utilization of waste in energy conversion will be pointed out and viable strategies proffered.

Modes of Converting Waste to Energy

This section deals with the various ways in which waste can be converted to energy. The several modes for the conversion as discussed below include combustion, depolymerisation, gasification, pyrolysis, plasma arc gasification, fermentation, anaerobic digestion, and mechanical biological treatment. Combustion involves the burning of waste such as paper, plastics, and textiles to generate heat which then turns a turbine to generate electricity.[10]

Depolymerisation involves the use of thermal decomposition to heat organic compounds of plastic and biomass at high temperatures in the presence of water. The scientific term for this process is referred to as Hydrous Pyrolysis, but in the absence of oxygen, it is called Pyrolysis.[11]

[7] Joshua Okeniyi et al, "Waste Characterization and Recoverable Energy Potential using Waste Generated in a Model Community in Nigeria", *Journal of Environmental Science Technology* 5, no. 4 (2012): 232–240.http://dx.doi.org/10.3923/jest.2012.232.240.

[8] Orie, E.G (2018). Examining the Legal Impediments in the Development of Renewable Energy in Nigeria. In: Prof. Usha Tandon (Ed.). *Energy Law and Policy,* 181-214. India: Oxford University Press.

[9] Yemi Oke, *Essays on Nigerian Electricity Law* (Lagos: Princeton and Associate Publishing Co. Ltd, 2016) 93–113.

[10] "Generating Energy from Waste: How it Works," Economic and Sustainability, Energy Saving Trust,last modified November 5, 2020, https://energysavingtrust.org.uk/generating-energy-waste-how-it-works/.

[11] "Waste to Energy: Solution for Tomorrow's Energy," Energy Articles, Conserve Energy Future, accessed January 19, 2022, https://www.conserve-energy-future.com/waste-to-energy.php.

Pyrolysis as a process converts agrarian/carbon-based compost from production sites into energy through thermal decomposition without the use of oxygen.[12] While Gasification involves the use of high temperatures, steam, or oxygen to convert carboniferous materials into carbon dioxide, carbon monoxide, as well as a small quantity of hydrogen.[13] Plasma Arc Gasification, on the other hand uses plasma technologies (torch) to ionize gas to get syngas/synthesis gas. The waste normally compresses in heat generation.

Fermentation is another significant process which extracts energy from carbohydrates through a metabolic process. It basically uses the action of enzymes to produce chemical changes in organic substances.[14] Similarly, Anaerobic digestion is a gradual process that destroys biodegradable content using microorganisms without oxygen. The biogas formed can be used for running a gas engine to produce energy. Finally, Mechanical Biological Treatment is a process which uses a mixed stream of domestic, commercial, and industrial wastes to generate products. It facilitates substance retrieval like plastic as well as mixed trash metal and stabilizes their biodegradable component.[15]

Legal and Theoretical Framework On Renewable Energy

Legal Framework

The National Energy Policy of 2003 aims to decentralize Nigeria's electricity distribution as well as promote clean energy channels in order to give 75% of Nigerians a connection to power.[16] Additionally, the 2005 Electricity Power Sector Reform Act aims to encourage both government as well as private operator's cooperation to deliver electricity in remote areas as well as advancements in clean energy across the country.

However, because of poor implementation plus the absence of sufficient subsidies encouraging ventures into clean power channels that provided guarantee as well as protection to international businesses that they will receive profits on their expenditures, the legislation

[12] Energy Saving Trust, "Generating Energy," 2.
[13] Energy Saving Trust, 2.
[14] Conserve Energy Future, "Waste to Energy," 4.
[15] Conserve Energy Future, 4.
[16] Sunday Oyedepo et al, "Towards a Sustainable Electricity Supply in Nigeria: The Role of Decentralised Renewable Energy System," *EJSDR* 2, no. 4 (2018): 40.

appeared unlikely to have fulfilled the goals it set.[17] It has been claimed it constitutes problematic systems that go above procedural or organizational issues and therefore call for a holistic strategy to successfully solve it.[18]

The Electric Power Sector Reform Act of 2005 established the Nigerian Electricity Regulatory Commission with the objective of establishing, promoting, and preserving efficient energy marketplace arrangements towards the best possible exploitation of energy resources for the provision of electrical utilities. In order to ensure the long-term viability of the energy industry, the Nigerian Renewable Electricity Policy, adopted in 2006, encourages the use of self-generated sustainable energies for the delivery of electricity in areas that are neglected by the central power structure. As a result, it became necessary to encourage funding for alternative electricity channels via public-private collaboration with the objective of increasing power supply throughout the country. The work carried out for this study is justified since, notwithstanding legislative provisions governing the Nigerian energy industry activities, the problem of ensuring adequate energy production, as well as a stable supply of electricity, remains urgent alongside demands constant focus.[19]

Theoretical Framework

The Cradle-to-Cradle theory emphasizes creating savvy goods, techniques, along with platforms through taking into account a good's lifespan, maximizing resource fitness, recycling capacity, clean energy utilization, freshwater effectiveness and reliability, including societal obligation.[20] This philosophy draws motivation from the environment, where every substance may maximize economic worth and protect habitats while also providing dietary supplements to trade as well as

[17] Joshua Olujobi and Olabode Oyewunmi, "Annulment of Oil Licences in Nigeria's Upstream Petroleum Sector: A Legal Critique of the Costs and Benefts," *IJEEP* 7, no. 3 (September 2017): 364–369.
[18] Daniel Ufua et al, "Systemic Lean Intervention: Enhancing Lean with Community Operational Research," *EJOR* 268, no. 3 (August 2018):1134–1148.
[19] Olusola Olujobi et al, "Renegotiation and Stabilisation Clauses in Nigeria's Upstream Petroleum Industry's Contracts: The Issues and the Options," *International Journal of Innovative & Creative Change* 14, no. 2 (2020).
[20] Nii Ankrah et al, "Cradle to Cradle Implementation in Business Sites and the Perspectives of Tenant Stakeholders,"*Energy Procedia* 83, no. 4 (2015): 31–40, https://doi.org/10.1016/j.egypro.2015.12.193.

wildlife.[21] The cradle-to-cradle theory does away with the trash ideology. This theory stands as one of the major principles of a circular economy system as earlier highlighted in the introductory part of this paper.

Cradle-to-cradle development seeks to re-establish ongoing processes of natural and technological nutrition that have positive effects on ecosystems including the well-being of individuals. Most adept cradle-to-cradle products were developed with resources which can securely circulate through natural or technological metabolic processes and be reclaimed or utilized at their fullest potential.[22] The choice of resources is crucial for creating cradle-to-cradle products.[23] Creative persons must be aware of resources' effects on the well-being of people including the environment. The cradle-to-cradle style may be used for a variety of building types across the town.

To integrate the cradle-to-cradle approach into the economy, Braungart and McDonough stipulated the doctrines of the eradication of the notion of waste and the need to maximize renewable energy.[24] The first doctrine indicates that industries should produce materials that can be reused continuously, and society should also deploy mechanisms for the collection and recovery of these materials after they have been used. The second doctrine indicates that recycled power channels like solar and wind are good in promoting perpetual inputs to produce energy.

The criteria for certification of a product in accordance with cradle-to-cradle theory are that the chemical composition of the product should have zero adverse environmental effect; the material components of the products must be easily recoverable and recyclable; not less than 50% of the energy cast-off in construction of these goods must come from clean energy bases like wind and solar; water for production of the products should be used in a sustainable manner with little or no

[21] Helen Kopnina, "Circular Economy and Cradle to Cradle in Educational Practice" *Journal of Integrated Environmental Science* 15 (January 2018) 119–134.

[22] Nikolay Minkov et al, "Characterisation of the Cradle-to-Cradle Certifed Products Program in the Context of Ecolabels and Environmental Declarations," *Sustainability* 10, no. 3 (March 2018): 738.

[23] Vanessa Bach et al, "Assessing the Ability of the Cradle-to-Cradle Certified Products Program to Reliably Determine the Environmental Performance of Products," *Sustainability* 10, no. 5 (May 2018): 1562.

[24] Margaret Corpuz, *Cradle to Cradle: Principles, Examples, Pros, and Cons* (Profolus, 2021), https://www.profolus.com/topics/cradle-to-cradle-principles-examples-pros-and-cons/.

impact on the environment after their discharge; and companies should regard corporate social responsibility as an integral part of their operation process.[25]

From the above analysis, it is evident that the beneficial aspects of the theory propounded by McDonough and Braungart are that cradle-to-cradle promotes sustainable development and the implementation of the circular economy. However, the theory like others is not without its limitations. First, there is a general constraint in recycling waste due to a lack of appropriate technological expertise most especially in developing countries. Another limitation is the issue of cost as inclusion of specific processes and standards within the production phase might be costly for manufacturers. Lastly, the theory is too dependent on a supply chain that can be embedded with disruptions thereby affecting production.

Notwithstanding the limitations of the theory, it can be safely concluded that its advantages outweigh its disadvantages. The cradle-to-cradle idea serves as foundation for this research as it seeks to break the loop of the use-waste-pollute disorder, which argues that some items might be reprocessed into inferior items till their final destination is a dump instead of using them indefinitely to manufacture comparable goods. It suggests items may be utilized, reprocessed, and reused repeatedly while not sacrificing their original substance. The theory suggest that Nigeria can produce electricity using its abundant reprocessed energy resources, consequently resolving the issue of the nation's continuing blackouts.[26] Overall, the theory highlights how the nation's surplus of sunshine, water, plant matter, as well as wind can be fully utilized to address the issue of a lack of reliable power delivery.[27]

Overview of Nigeria's Energy Sector and Recent Developments in The Transformation of Wastes to Electricity

Nigeria's Energy and Electricity Sector

Petroleum-based facilities predominate the nation's electrical grid. Although automobiles (transportation industry) operate exclusively by gasoline or diesel, they constitute eighty-five

[25] Margaret Corpuz,*Cradle to Cradle,* 2.
[26] Oke, *Nigerian Electricity Law,* 95.
[27] Olaide Aderoju et al, "Assessment of Renewable Energy Sources and Municipal Solid Waste for Sustainable Power Generation in Nigeria," *IOP Conference Series: Earth and Environmental Science* 95, no. 4 (2017).

percent of the power generated.[28] Nigeria's power administrators would thus be faced with the challenge of meeting the unfulfilled electrical needs while not escalating carbon dioxide emissions while simultaneously taking into account material limitations. State officials created the National Renewable Energy and Energy Efficiency Policy to address the urgent matter. The suggested strategy would help reduce carbon dioxide while not sacrificing the growth-oriented aims of sustainable development.[29] Regarding acceptance as well as the usage of RE technology, it provides numerous initiatives along with strategies. The NREEEP has goals for integrating wind alongside solar energy to form part of the industrial power system over all three stages of development. 2030 is the ongoing targeted period, and as part of that, the nation's energy industry will have integrated more than six thousand Megawatts of solar generation alongside additional clean energy.[30]

The country possesses significant reserves of both non-RE (conventional fossil) and renewable (RE) resources. But because those assets are not or are being used insufficiently, the nation is suffering from severe lack of electricity. Nigeria is home to sizable reserves of coal, gas, oil, alongside lignite, which are all forms of traditional power or petroleum-based products. There are several possible energy sources for REs, including sun, wind, biomass, and water. The nation additionally has access to extra petroleum-based supplies including tar sand, bitumen, etcetera. Hydro, solar, biomass, geothermal energy, and wind power are Nigeria's main clean power suppliers. According to studies, building windmills in Nigeria's northern alongside offshore areas seems feasible.[31] In Nigeria, certain geothermal energy probable locations were found, although most are yet to undergo extensive practical exploration. Massive petrochemical dumps, a lack of marketplace directness regarding the advantages of renewable electricity to the business community; rebates on petroleum and natural gas; insufficient information regarding accessible

[28] Michael Dioha, "Nigeria's Renewable Energy Policy: A Fantasy or Reality?" *Policy & Regulation* (blog), *Renewable Energy World,* November 28, 2018, https://www. renewableenergyworld.com/solar/nigerias-renewable-energy-policy-a-fantasy-or-reality/#gref.
[29] Ministry of Power Federal Republic of Nigeria, National Renewable Energy and Energy Efficiency Policy (2015).
[30] Mustapha Mukhtar et al, "Effect of Inadequate Electrification on Nigeria's Economic Development and Environmental Sustainability," *Sustainability*13, no. 2229 (February 2021): 3, https://doi.org/10.3390/su13042229.
[31] Mukhtar, "Inadequate Electrification,"3.

monetary assistance structures; and a shoddy power supply system constitute a few of the primary issues restricting the explosive development of renewable energy in Nigeria.[32]

Hydroelectricity has a built and accessible output of 1938.4 Megawatts as well as 1060 megawatt, respectively, and is the sole renewable electricity station that is linked to the electrical system.[33] Additionally, Nigeria's distribution and generating systems are seriously out of harmony. The distribution structure has an output of 5300 megawatts, a figure that's roughly forty-one percent less than the actual producing potential and twenty-nine percent less below the potential production output of 7500 megawatts. Distribution losses are often up to 7.4% due to the clear intrinsic dependability problems in the distribution system.[34] Hunger for electricity continues to be a problem in the country due to a lack of proper technical facilities, distribution problems, no or restricted access to the power grid, along with poor electricity distribution.[35] It is shocking that many Nigerians have no accessibility to or connectivity to the power lines, whereas a sizable portion of people only have accessibility to energy between zero and fifteen hours each day. Due to the low hydropower capacity, it is now extremely challenging to achieve entirely sustainable electricity supply.[36]

Overview of Waste Management in Nigeria

Six main methods are used for processing trash across the world: landfilling, combustion, energy recuperation, resource recuperation, creating compost, and reprocessing.[37] Dumping in public landfills is an increasingly widely utilized technique for treating leftover garbage. This is anticipated that the increased amount and intricate nature of garbage that results from rising numbers of people, the development of cities, and changes in behaviour are going to endanger the

[32] Mukhtar, 4.
[33] National Electricity Regulatory Commission, "Power Generation," 2.
[34] National Electricity Regulatory Commission, 2.
[35] Chukwuka Monyei et al, "Nigeria's Energy Poverty: Insights and Implications for Smart Policies and Framework towards a Smart Nigeria Electricity Network", *Renewable Sustainable Energy Review* 81 (January 2017): 1582–1601.
[36] Udochukwu Akuru et al, "Towards 100% Renewable Energy in Nigeria," *Renewable Sustainable Energy Review* 71 (May 2017) 943–953.
[37] United Nations Environmental Programme, *2011 Report on Green Economy: Pathways to Sustainable Development and Poverty Eradication,* November 7, 2011, http://web.unep.org/greeneconomy/sites/unep.org.greeneconomy/files/field/image/green_economyreport_final_dec2011.pdf.

well-being of individuals, the environment, and the country's financial stability. According to Unaegbu, implementing efficient garbage handling procedures is essential to accomplishing the Sustainable Development Goals number three, seven, eleven, and thirteen, which are focused on positive hygiene and wellness," "accessible and renewable energy," "sustainable municipalities and neighbourhoods," as well as "climate steps," accordingly.[38] Possibilities to improve the garbage industry do abound, however, emerge as a result of the increased demand for long-term viability.[39]

More concerning is the abundance of unkempt garbage sites as well as the dearth of properly designed landfills. Opting to use public disposal techniques, according to Adewole, is a consequence of an enormous technological, monetary, together with sophisticated construction infrastructure required to build designed waste disposal facilities.[40] According to data that currently exists, we have a single landfill gas capture station in the nation, a structure that is seldom operating at Olusosun, Lagos State. It's significant to note that the FCT vision statement has provisions for a properly designed 505-ha garbage processing complex that comprises a dumpsite, a place for decomposition and reprocessing, and power from refuse plants that can produce a combined 120 megawatts of power.[41]

In Nigeria, you may observe trash piles in public areas, on-street ends, in waterways, and so forth. Flooding incidents have been impacted by the unlawful disposal of trash in waterways.[42] The unregulated combustion of trash is a different widespread yet untenable trash disposal technique within the country. For a variety of factors, including avoiding paying the usual garbage pick-up charges or because there is a lack of or subpar garbage pickup assistance, open-air combustion of trash is a common practice in families and towns. Dump piles get lit ablaze, having disastrous

[38] Emmanuel Unaegbu, "Poor Waste Management as Nigeria's Bane to Achieving Sustainable Development Goals," *The Guardian Newspaper*, March 11, 2016, http://guardian.ng/features/youthspeak/poor-waste-management-as-nigerias-bane-to-achieving-sustainable-development-goals/.

[39] United Nations Environmental Programme, *Report on Green Economy,* 20.

[40] Taiwo Adewole, "Waste Management towards Sustainable Development in Nigeria: a Case Study of Lagos State," *International NGO Journal* 4, no. 4 (February 2009): 173-179.

[41] Kadafa Ayuba et al, "Current Status of Municipal Solid Waste Management Practise in FCT Abuja," *Research Journal of Environmental and Earth Sciences*, 5 no. 6 (June 2013): 295-304.

[42] Alexander Cogut, *Open Burning of Waste: A Global Health Disaster* (R20 Region of Climate Action, 2016): 17, https://regions20.org/wp-content/uploads/2016/08/OPEN-BURNING-OF-WASTE-A-GLOBAL-HEALTHDISASTER_R20-Research-Paper_Final_29.05.2017.pdf.

effects on the ecology and the well-being of people, in an effort to reduce the amount of rubbish as well as the stench it emits. Long-lasting environmental pollutants including lead, vinyl chloride, pollutants, and benzene typically build up in high-risk species like mankind.[43]

Waste collectors, who work predominantly in the unregulated industry and recycle the majority of the trash, frequently lack professional schooling, job coaching, availability of the necessary tools, and other chances to work in the regulated industry. It indicates that middle-income and low-income nations frequently engage in this activity. According to the United Nations Environmental Program India and China each have roughly 1,000,000 and 10,000,000,000 garbage hunters, accordingly.[44]

Waste hunters in Nigeria visit different homes and exchange metals, plastics, glassware, as well as newsprints for money. Some collect materials by traveling between bins to landfills. These unregulated gatherers supply what they gather to intermediaries, who afterward resell to recycling firms. Scavengers are crucial to the economical makeup of the trash pickup system, says Adewole.[45] However, there has been a recent increase in tiny but well-organized recycling collecting businesses, mostly in Lagos and Abuja. As rewards for recycling, they provide money or goods. Most of the individuals who are running these businesses are well-educated, younger, and active on the internet.

Current Developments in the Conversion of Wastes to Electricity in Nigeria

In Nigeria, there are several biomass energy channels that may be used to create biofuel, including timber debris from cutting down trees and vegetative matter from municipal as well as agrarian garbage streams.[46] It is believed that turning garbage into power will cut down on carbon dioxide emissions, replace more expensive power channels, and lower waste management and disposal expenses.[47]

[43] Ibid.
[44] United Nations Environmental Programme, *Report on Green Economy*, 20.
[45] Adewole, "Waste Management," 174.
[46] Chima Ngumah et al, "Potential of Organic Waste for Biogas and Bio-Fertilizer Production in Nigeria," *EREM* 1, no. 63 (March 2013): 60.
[47] ZdenaZsigraiová et al, "Integrated Waste-to-Energy Conversion and Waste Transportation within Island Communities," *Science Direct* 34, no. 5 (May 2009) 623–63.

Waste from municipalities must be treated properly to prevent impeding equitable growth.[48] Sadly, scarce supply and variety of feed stocks, expensive investment and operational expenses, as well as feedstock collecting expenses have limited utilization.[49] The problem of creating an effective stable system that creates high-value goods whilst requiring little working labour, upkeep, or substrate adaptability is still present despite revolutionary developments. The method needs to be capable of managing calorie-dense gas to a level that is appropriate for procedure warming, moisture development, or burning in a rotating engine or gasoline turbine to generate power.[50] According to investigators, significant volumes of agricultural waste are produced annually in Nigeria but cannot be maximized for a variety of factors, including the absence of machinery. The seed pod, comprising up to a quarter of the total amount of grains, is an example of agricultural waste. Similar remnants incorporate sugarcane fibres, coconut shells and hulks, groundnut husks, and cereal straw, amid others.[51] Additionally, alongside livestock manures, animal excrement is the main source of biomass power. The materials in question had previously been processed as well provided as fertilizer for fields. Nevertheless, refuse control is unavoidable due to the adoption of strict environmental regulations on air and water effluence, which encourages the transformation of trash into power. Anaerobic decomposition is the most ideal method for converting garbage into valuable assets. It produces natural gas that may be used as fuel for household incinerator equipment, to generate electricity using mini combustion engines, to charbroil food for food service, and to heat water.[52]

Significance of Energy Generation from Waste in Nigeria

In the past, waste was seen as an unwanted product that could no longer be used, but in recent times, managing waste has proven to be beneficial not just to the energy sector but to other sectors of the economy. Waste management can create wealth by serving as a source of income or saving

[48] Olujobi, "Conversion of Organic Waste,"12.
[49] Toochukwu Ogwueleka, "Municipal Solid Waste Characteristics and Management in Nigeria," *Journal of Environmental Health Science & Engineering*6, no. 3 (July 2009) 173–180.
[50] Ngumah, "Potential of Organic Waste," 60.
[51] Saddam Hossain et al, "Rice Husk/Rice Husk Ash as an Alternative Source of Silica in Ceramics: A Review," *JACS* 6, no. 4 (November 2018) 300.
[52] Oke, *Nigerian Electricity Law*, 96.

huge financial expenses in buying new products.[53] Waste as an additional means of generating electricity should meaningfully advance electricity supply plus contribute to subsequent energy access. Some of the significant means to generating energy from waste include the following:

i. **Viable Trash Control Scheme:** collecting waste then converting it to produce energy contributes to eradicating the practice of littering wastes in open dumpsites. This practice of uncontrolled dumping of waste has in the past proven to be a good source for spreading diseases. Thus, effective waste management for energy use invariably means less expenditure on health issues for the government. Improvements in garbage pickup along with a decrease in the quantity of refuse dumps and trash that alter municipalities are expected from the need to ensure an adequate supply of feedstock (trash) for electricity from use up plants. This also means the government needs not to spend much on employing cleaners to regularly keep these defaced cities clean.

ii. **Reduction of Cost of Transporting Waste to Landfill Sites:** it has already been seen that waste produces power that has monetary value. Aside from that, waste to energy helps in reducing the expense of transporting these wastes to landfill sites.[54] They are taken directly to energy factories or plants in need of the waste at the expense of the buyers.

iii. **Job Creation:** waste to energy creates novel experts plus untrained works to several persons, like waste-collectors[55] and waste marketers. Waste collectors are persons who collect waste from dumpsites or buy the waste from households and business enterprises and sell it to designated middlemen known as waste marketers. The waste marketers then resell the waste to energy companies. The local communities around these waste facilities also benefit from the jobs created and from the purchase of their local goods and services.[56]

[53] Conserve Energy Future, "Waste to Energy," 8.
[54] Ibid.
[55] Emmanuel Unaegbu, "Assessing the Potential for Energy from Waste Plants to Tackle Energy Poverty and Earn Carbon Credits for Nigeria," *International Journal of Energy Policy and Management* 4, no. 2 (October 2019): 14-18.
[56] Conserve Energy Future, "Waste to Energy," 8.

iv. **Advanced Recovery of Products for Recycling:** The waste-to-energy process advances the level of recovering harmful as well as non-harmful materials for recycling that would have been buried inside garbage dumps or buried forever if dumped in landfills.[57]

v. **Mitigation of Green House Gases (GHGs) and Decentralization of Power System:** The reduction of greenhouse gas emissions and development of a localized electrical infrastructure through natural gas in the country are two significant advantages for producing power using trash.[58] In terms of mitigating GHGs, waste to energy process generates less methane which normally forms from the decay of garbage creek in dumpsites. This invariably contributes to climate modification because methane is more destructive to the climate compared to carbon dioxide.[59] Waste to energy process is a good mechanism that helps in the decentralisation of the Nigerian power system by reducing the level of consuming fossil fuels to generate power.

To create wealth from waste, individuals and industries should engage in appropriate surplus managing methods like reuse, reprocessing, minimization, as well as reduction, before dumping the remnants in dumpsites. Reuse of used items and waste minimization save costs to the owners or users of the property who could have bought a new property; recycling waste materials serves as a source of income for persons engaged in waste marketing (buying and selling of waste materials); and waste reduction through production of goods with bio-degradable materials, refilling capacities, spare parts, and durability saves consumers from buying new products that may generate waste.[60]

Challenges of Transforming Waste To Energy in Nigeria

[57] Conserve Energy Future, 8.
[58] ObidikeEsae, "A Critical Analysis of the Role of Energy Generation from Municipal Solid Waste (MSW)," *AIMS Environmental Science* 7, no. 5 (May 2020): 387–405, DOI: 10.3934/environsci.2020026.
[59] Conserve Energy Future, "Waste to Energy," 9.
[60] Emmanuel Unaegbu, "Assessing the Potential for Energy from Waste Plants to Tackle Energy Poverty and Earn Carbon Credits for Nigeria," *International Journal of Energy Policy and Management* 4, no. 2 (October 2019): 14-18.

There are myriad of problems that affect the efficient and sustainable conversion of waste to energy in Nigeria. These ranges from political, legal, technical, institutional, financial, social and economic constraints.

Firstly, it appears that the Federal Government of Nigeria lacks the political will and sincere commitment to establish waste to energy conversion facilities or plants.[61] This is because some of the government officials, in their private capacity, benefit more from fossil fuels energy generation. Thus, they feel and accept that supporting the waste to energy process through official measures like allocation of resources, initiation of sustainable policies, and law making will affect their oil and gas business. Even where funds are allocated for waste to energy process or waste management in general, it is not a surprise that these processes are yet to be considerably effective because corrupt public officials divert the funds for their personal use.

There are also legal constraints that appear to limit the efforts at generating energy from waste. The Land Use Act 1978 which delegates title of land on State Governors. Mandates them to hold it in trust on behalf of their citizens. This practice impedes the availability of verse land for large-scale bio-energy crop farming because of challenges in obtaining the consent of the Governor.[62]

Similarly, lack of technological know how is a challenge. Most waste collectors, processors, and managers lack the expertise for waste management and conversion. They do not know how to manage and convert waste because they are not trained in engineering and management of waste safely and efficiently. The local governments rarely initiate waste management training and publicity and waste management is rarely thought of in schools as a major course to develop persons with specialized expertise in that field. Most waste managers are left with no option but to learn about efficient waste management on the job.[63] Lack of proper waste management means less supply of waste for energy generation.

The Government oversees power generation but budgets insufficient funds for generating energy from waste. As seen earlier, waste to energy process is an integral part of waste management.

[61] Abu Imam et al, "Solid Waste Management in Abuja, Nigeria," *Waste Management Review* 28 (2008):468–472,https://doi.org/10.1016/j.wasman.2007.01.006.

[62] Solomon Babatunde et al, "Critical Success Factors in Public–Private Partnership (PPP) on Infrastructure Delivery in Nigeria," *Journal of Financial Management* 8 (July 2012).

[63] John Ogolo, "Waste Management Development to Protect Water Resources in the Niger Delta Region," *W.I.T. Transactions on Ecology and The Environment* 115, (December 2011) 226, doi:10.2495/WS110201.

Thus, without adequate funds to support the process, the capacity for waste management becomes limited. Individuals and industries are left with no option but to dump their waste indiscriminately due to the lack of public waste bins, designated dumpsites, waste collecting vehicles and tools, and waste processing machines. The officers employed to engage in environmental sanitation by the government and persons employed to work in waste facilities are sometimes inadequately paid or not paid for long periods which affect their morals in observing their duties diligently.

The level of stigmatization against waste management workers also limits the efforts at generation of energy from waste. Waste management workers are generally perceived as the poorest of the poor or people who lack means of subsistence. This negative perception invariably discourages persons who might have interest in waste management and weighs heavily on efforts at converting waste to energy inefficient.[64]

Finance is vital in waste to energy conversion because it allows more funds to be allocated for the process. However, developing countries like Nigeria with its' weak economy, lacks the financial capacity and ultimately, technological capacity to engage in proper waste to energy conversion. In Nigeria, providing basic needs like food, shelter and clothing by the government is even difficult talk more of apportioning funds to manage waste and convert it into energy. The devastating impact from the lack of technological machines for conversion is that improper use and management of bioenergy sources will ultimately cause further devastation on the ecosystem. Whenever livestock discharges enter the water system, the results are often severe since they may result in pollutants which have greater concentrations compared to bare household wastewater.[65]

Finally, garbage handling regulations is currently inadequate. Ecological authorities rarely gain access to disclosed garbage collection statistics for the nation. There are numerous agencies involved in one way or the other in waste management but lack a clearly defined role which sometimes breeds clashes in the discharge of their functions. There is also no specific agency or committee saddled with the responsibility of supervising or coordinating the agencies which leads to inconsistency and inefficiency in the discharge of their functions.

[64] Ogolo, "Waste Management Development," 228.

[65] Ikpefan Ochei, "Challenges of Public–Private Partnerships in Infrastructure Financing in Nigeria," *NAHUJ* 4, no. 1 (August 2013): 61–76, http://eprints.covenantuniversity.edu.ng/id/eprint/1330.

Projections on Wastes to Electricity in Nigerian Power Sector

The need to reduce GHG emissions provides a motivation for harnessing biofuel. In addition to serving as a reservoir for carbon, biofuel may also be used in place of oil and gas.[66] Its duty aims at reducing the amount of carbon dioxide within the exosphere, as stated in Articles 3.3 and 3.4 of the Kyoto Protocol. By replacing oil and gas, biofuel ensures lower greenhouse gases as well is unaffected by the potential of managed biomass carbon sinks.[67] Depending on changes in land usage, substitution might result in significant carbon absorption in lands along with unkemptness. The types of plants, additional pertinent administrative practices, as well as soil classifications, are going to decide how much carbon can be replaced and appropriated.

The goal is to decrease emission of greenhouse gases by eight percent after the Kyoto Protocol. By meeting a portion of Nigeria's electricity needs using biofuel, which would subsequently be predominantly supplied alongside oil and gas, carbon dioxide pollutions might be reduced. Swelled consumption of biomass might significantly contribute to the reduction in carbon dioxide emissions therefore meet the Kyoto Protocol's goals.[68] A pair for technological choices are available: traditional steaming process centered around crops and those focused on understanding timber combustion.[69] The foundations for traditional heat cycling generators have long been accepted knowledge. The method's overall production rate ranges from eighteen to twenty-two percent, whereas the capacities that may be achieved using this traditional knowledge vary from ten Kilowatt to just over one hundred MW.[70] It provides electricity efficiency of at least thirty percent for power stations of a typical dimension, makes use of timber combustion-based techniques for biomass-based stations while taking into account Nigeria's scientific feasibility, and

[66] Sunday Ojolo et al, "The Technical Potential of Biomass Energy in Nigeria," *Ife Journal of Technology* 21, no. 2 (January 2012): 60–65.
[67] Oke, *Nigerian Electricity Law*, 45.
[68] Graciela Chichilnisky and Peter Hammond, "The Kyoto Protocol and beyond: Pareto Improvements to Policies that Mitigate Climate Change" (Cage Online Working Paper Series 287, Competitive Advantage in the Global Economy, Coventry, 2016),https://ideas.repec.org/p/cge/wacage/287.html.
[69] Food and Agriculture Organization of the United Nations,*2017 Report on Egypt, Turkey and Ukraine Sustainable Bioenergy Options from Crop and Livestock Residues*, July 2017, http://www.fao.org/3/a-i8150e.pdf.
[70] International Renewable Energy Agency, *Renewable Power Generation Costs in 2017* (Abu Dhabi: International Renewable Energy Agency, 2018).

reveals that facilities using traditional heat process equipment have been compatible with biomass-based power production platforms.[71]

According to known technology, power stations using traditional steaming processes operate more efficiently. Similar to sizable typical combustion engine factories running on automobile petroleum products, biomass-based facilities using classic steaming process technology have a power expense related to them. Rates are likely to fall the quickest given the overall decrease in the initial investment of biomass-based facilities.[72] Therefore, in Nigeria's power generation structure, wherein fossil fuel-based manufacturing constitutes a strong component, biomass-based electricity generation may prove economically viable. Energy needs are increasing, petroleum reserves are depleting, alongside coal, which has serious environmental problems, is not a choice. Considering crops make up the majority of biomass, provided there is access to rich soil, sunlight, water, as well as carbon dioxide, biomass ought to keep expanding.[73]

To increase the utilization of biofuel as a means of clean energy, reduce carbon dioxide emissions, and promote the development of organic pasturelands. A more thorough understanding is required of the financial and environmental effects of the various bioenergy shackles as well as their role in the developing electricity industry and local development. Compared with different means of energy, biofuels are simpler to maintain as an instrument for environmentally friendly growth. Bioenergy is simpler to handle since the majority of the materials required to produce it originate in the trash, making them inexpensive to obtain.[74] Presently, biofuel gets plenty attention as a crucial means for the creation of power. This is due to its potential as a domestic, cheap power alternative in addition to the environmental advantages that accompany biofuel-based manufacturing technology.[75]

[71] Ufua, "Systemic Lean Intervention," 1134–1148.
[72] International Finance Corporation, *Converting Biomass to Energy a Guide for Developers and Investors* (International Finance Corporation, 2017), https://www.ifc.org/wps/wcm/connect/fb976e15-abb8-4ecf-8bf3-8551315dee42/biomass_report_06+2017.pdf?mod=ajperes&cvid=lphgoan.
[73] Raoul Herrmann et al, "Competition between Biofuel Feedstock and Food Production: Empirical Evidence from Sugarcane Outgrower Settings in Malawi," *Biomass Bioenergy*114, (July 2018): 100-111, https://doi.org/10.1016/j.biombioe.2017.09.00.
[74] Aderoju, "Renewable Energy Sources," 7.
[75] Aderoju, 45.

By assisting nations in lowering their carbon footprint rates through oil and gas, the use of biofuel as an alternative green energy resource will assist in the attainment of the Kyoto Protocol's goal.[76] Because of their concerns for the future, safety, as well as number of energy assets used to generate electricity, citizens are calling for an overhaul of their country's electricity strategy. Power from trash factories might have a limited yet improved impact on providing heat and energy throughout neighbourhoods.[77] Power from trash is predicted to become more desirable as a result of an upsurge in the cost of oil and gas. To maximize the advantages of garbage transformation to power in Nigeria, plans for disposal facilities must be driven by a thorough evaluation of power strategy.[78]

The primary advantages that may be obtained through the transformation of trash to electricity include cleaner air, fewer greenhouse gases, promotion of liveable communities, purchase of carbon credits, and adherence to global climatic accords.[79] It is an environmentally friendly means of handling trash that will bring a stop to the practice of collecting garbage then discarding them in a haphazard way. This would significantly advance Nigeria's energy mix as well as promote eventual availability of power.[80]

Conclusion

This paper has reflected on the commercial advantages of converting garbage into power in Nigeria. It lays emphasis on the necessity to investigate alternative power mediums to lessen an overreliance on oil and gas which is unsustainable and finite. The possibility for Nigeria's principal energy source to be supported by biofuel is high. It would however require more than just the desire to reduce electricity dependence. For biofuel to gain significant presence, public and private

[76] Nick Golding, *Municipal Waste Management Statistics 2004/05* (London: Local Government Chronicle, 2006), https://www.lgcplus.com/archive/municipal-waste-management-statistics-2004-05-24-03-2006/.
[77] Abdulazeez Atta et al, "Potentials of Waste to Energy in Nigeria," *Journal of Applied Science Research* 12, no. 2 (March 2016): 1–6.
[78] Peter Oniemola and Ganiyat Sanusi, *The Nigerian Bio-Fuel Policy and Incentives, a Need to Follow the Brazilian Pathway* (Igee, 2007), www.igee.org/en/publication/newsletter.
[79] Raffaello Cervigni et al, *Low-Carbon Development Opportunities for Nigeria* (Washington D.C: World Bank, 2013, http://documents.worldbank.org/curated/en/2907514681 45147306/pdf/Low-carbon-development-opportunities-for-Niger ia.pdf.
[80] Olujobi, "Conversion of Organic Waste," 67.

enterprises must provide the vital components accessible to improve the capacity of electricity production in Nigeria. These contributions from the public or private sector don't always have to be monetary. Examples of such contributions could involve ecological initiatives enhanced through the instrumentality of the law.

Recommendations

i. **Establishment of Waste to Energy Conversion Facilities/Plants:** The Federal Government needs to take a bold step in establishing mega facilities and plants where trash is transformed into power. This will increase energy supply which will in turn boost economic activities. The issues of diversion of public funds meant for projects like this by the political leaders must be decisively addressed in establishing these facilities and plants.

ii. **Reviewing Land Policy –** impediment to verse land access under the Land Use Act needs to be amended by the National Assembly by devolving the ownership of land directly to the people or to be controlled at the local level rather than in the hands of State Governors who have in the time past exercise that power arbitrarily. This has denied potential local investors from making good investments in this sector due to the lack of accessibility to verse land.

iii. **Organizing Waste Management Training and Publicity:** local governments should initiate waste management training and publicity for specialized experts in that field and in schools as a major course to develop students aspiring to practice within that field. This will enable waste collectors, processors, and managers to garner the expertise for waste management engineering and conversion to manage and convert waste in the country safely and efficiently.

iv. **Budgeting More Funds for the Generation of Energy from Waste:** governments at all levels need to increase the amount of money they budget for waste management under the Ministry of Environment. This will stop individuals and industries from dumping their waste indiscriminately because enough materials such as public waste bins, designated dumpsites, waste collecting vehicles and tools, and waste processing machines will be provided where there are more funds for that.

v. **Public Orientation against Stigmatization:** relevant non-governmental organizations engaging in environmental activities and renewable energy need to increase the level of awareness in society about stigmatization made against waste collectors. Also, the increase in waste conversion to energy through the establishment of more facilities and plants by the government will raise the status of waste collectors because the business will become more lucrative due to high demand.[81]

vi. **Institutional Reforms:** there should be proper waste management control mechanisms to ensure environmental regulatory agencies regularly keep records of and publish waste disposal data in the country. These control mechanisms will also clearly define the role of these agencies to prevent clashes in the discharge of their functions.

[81] Joshua Babayemi and Khadija Dauda, "Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria," *Journal of Applied Science & Environmental Management* 13 (January 2009): 83–88.