MARKET POTENTIAL:
BIOETHANOL FOR CLEAN COOKING

NIGERIA

pivot | GLOBAL BIOETHANOL COALITION

Contents

The *Market Potential: Bioethanol for Clean Cooking Nigeria* is the product of a research project initiated by Pivot Clean Energy Co. for the purposes of investigating target geographies in terms of their current state of energy access within household energy, potential rates of transition to bioethanol from current cooking trends, and projected future volumes and associated costs. This country specific report is intended to be used in conjunction with *Market Potential Methodology* in order to understand the conclusions and context.

The country report was prepared by Adam Collins, Master's student at University of Colorado - Boulder (CU), under the overall guidance of Pivot's Executive Director Alicia ElMamouni. Pivot is grateful to Rita Klees for her facilitation of the CU Practicum program, and to the University of Colorado for providing such opportunities for their students.

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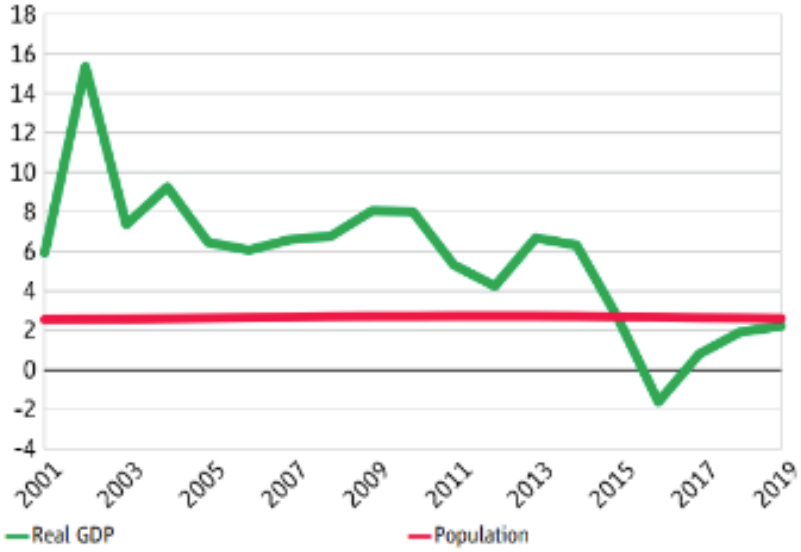
Disclaimer
This document has been prepared as a guide to assess the state of energy access and bioethanol potential for household energy in key geographies. It is not intended to provide professional advice; no representation is given as to the accuracy or completeness of the information provided, and the entities overseeing the research project do not assume any liability for any actions or decisions taken upon reliance on the information contained in this document.

NIGERIA The Market Potential for Bioethanol as a Clean Cooking Fuel

Introduction | Nigeria at a Glance

Africa's most populous country, Nigeria, is suffering from increased poverty and stagnated growth as the population and workforce continue to rise. From 2000 to 2014, Nigeria's real GDP grew around 7 percent annually, past the population growth rate of 2.6 percent during the same period (World Bank, 2022). When 2016 hit, with the global decline in oil prices, Nigeria saw its first recession in almost two decades (World Bank, 2022).

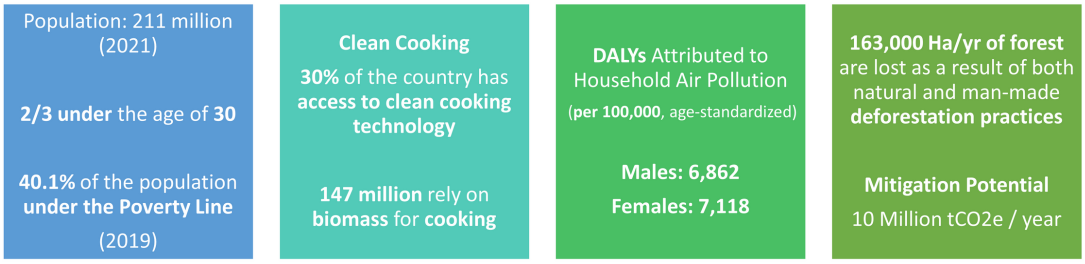
Figure 1 - Real GDP and Population Growth Rate (%)



Note: Graphic retrieved from the World Bank Nigeria Poverty Assessment (2022).

Although the GDP growth rate has since reached 2014 levels, population growth has outstripped real GDP and lowered living standards (World Bank, 2022). This correlation is largely attributed to Nigeria's dependence on oil exports and suggests a need for the country to expand into new economic sectors. While in 2019 oil represented just 10 percent of the GDP, it accounted for 80 percent of total exports with less than 1 percent of Nigerians employed in mining and extracting activities (World Bank, 2022). Most Nigerian workers are engaged in small-scale farm and on-farm household enterprises, with only 17 percent holding wage-focused jobs (World Bank,2022). A 2019 estimate on the poverty count mimics that statistic; 40.1 percent of Nigerians live under the poverty line—4 percent higher than in 2015 (World Bank, 2022). Higher levels of poverty have also generated a gap between the share of men and women working, a reliance on cheaper commodities, and lower life expectancy rates, exacerbating the slow economic growth (World Bank, 2022). In order to bolster growth and decrease poverty, macroeconomic expansion is needed. With Nigeria's dependence on oil, the biofuel sector may be a catch-all transitional market to foster sustainable development and higher living standards. Bioethanol, as a cooking fuel, is the specific focus of this report. To help set the stage, Figure 2 showcases a few important figures related to the clean cooking sector and growth potential in Nigeria.

Figure 2 - Quick Facts about Nigeria



Note: Data retrieved from the World Bank Nigeria Poverty Assessment (2022), FAO (2022), and the WHO (2021 and 2021) assessments.

The Cooking Landscape

Cooking Fuels and Access to Clean Cooking Technology

Access to Clean Cooking Technology (CCT) has been on the rise since the 2011 inauguration of the Nigerian Alliance for Clean Cookstoves (NAAC) (Figure 3) (RMI, 2021). Despite this and considering setbacks from the impact of COVID-19, the **majority of Nigerians still rely on biomass as their primary source of cooking fuel** (Figure 4) (World Bank, 2022 and RMI, 2021). Biomass (69.5%), kerosene (11.6%), and gas (10.9%) remain the dominant cooking fuels in Nigeria (WHO, 2021). With the prevalence of stove and fuel stacking - the practice of using more than one cooking implement on a regular basis in the home based on cultural practices, fuel availability, and/or cost - those numbers may be higher (RMI, 2021, Muazu and Ogujiuba, 2020, Jewitt et. al, 2020 and Ado et. al, 2016). Other fuels (<3%) encompass those not listed, but that still exist, like bioethanol; that number remains low, but is slowly rising.

Figure 3 - Projected Access to Clean Cooking Technology 2000 - 2030

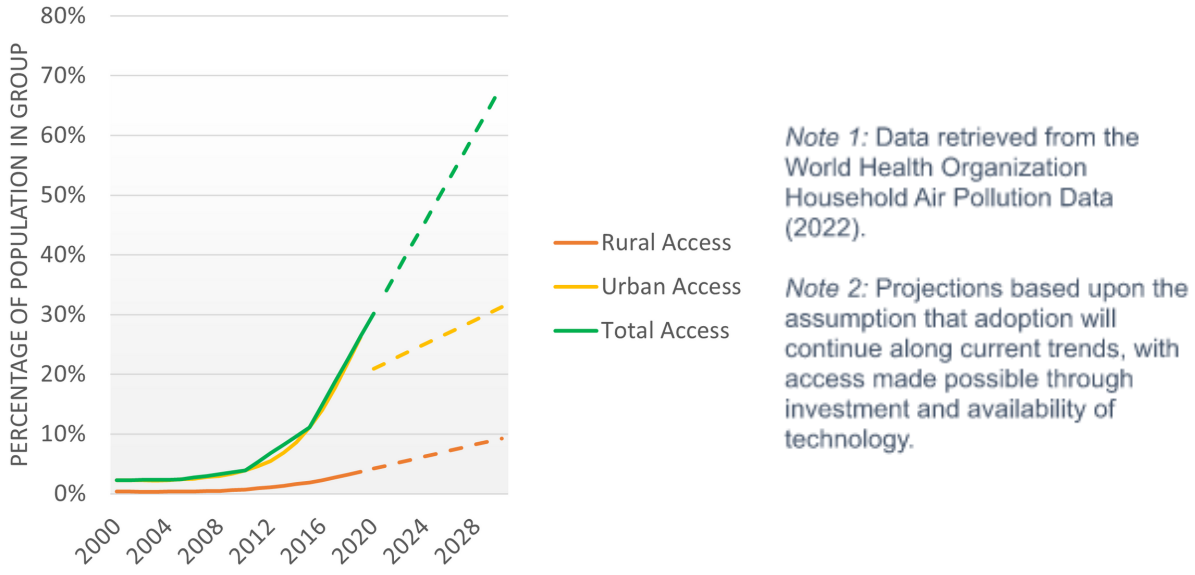
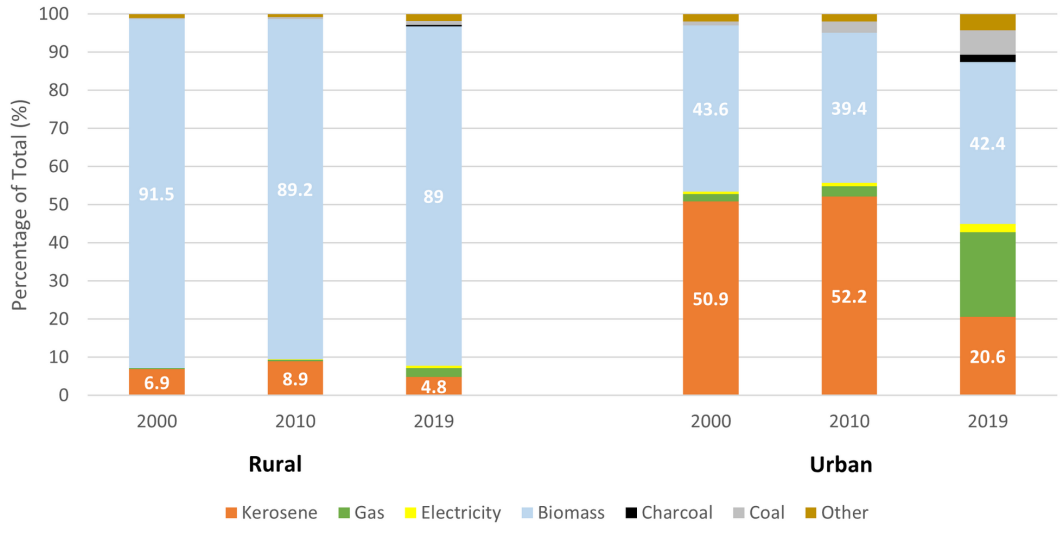


Figure 4 - Urban and Rural Cookstove Fuel Type Distribution 2000 - 2019



Existing Health and Environmental Impacts of Cooking Fuel in Nigeria

Continued dependence on polluting fuels carries with it serious health and environmental risks. A short analysis has been conducted to determine the impact in each of these categories using the assumptions noted in Appendix A. In general, the impact is calculated by looking at the projected number of households that could switch to bioethanol over the next 8 years and attributing the associated impacts to those respective populations.

The associated health impact is calculated using the HAPIT Household intervention tool. HAPIT currently uses background disease rates and relationships between exposure to PM2.5 and health outcomes to provide two outputs: disability-adjusted life years (DALYs) and deaths (HAPIT, 2022). DALYs for a disease or health condition are the sum of the years of life lost to due to premature mortality (YLLs) and the years lived with a disability (YLDs) due to prevalent cases of the disease or health condition in a population (WHO, 2022).

Environmental impacts were calculated using the estimated fuel consumption and dry combustion CO2 emission factors for each fuel. The results of this analysis are shown in Table 1. It is important to note that both of these calculations do not consider the impacts of stove-stacking; the percentages of national fuel use per household only incorporate primary fuel use and do not include users who prefer the use of more than one fuel (ESMAP, 2020). In other words, the impact may likely be larger.

Table 1 - Potential Health and Environmental Impact of Dominant Fuels in Nigeria

IMPACT	Firewood	Kerosene	Charcoal	Coal
Health *(deaths and DALYs due to household air pollution from PM2.5)*	293,387 DALYs 6,258 Deaths	113,056 DALYs 2,403 Deaths	18,388 DALYs 475 Deaths	15,969 DALYs 367 Deaths
Environment & Climate *(GHG Emissions)*	2.5 Million tCO2e	13.7 Thousand tCO2e	80 Thousand tCO2e	8.6 Thousand tCO2e

Note 1: Assumptions are noted in Appendix A.

Note 2: Impact values are the cumulative totals from years 2022 to 2030.

Although Nigeria recognizes the health and environmental harm of the continued use of polluting fuels, the lack of affordable and accessible clean fuel options plays a major role in perpetuating existing trends (Table 2).

Table 2 - Availability and Affordability of Various Cookstoves and Fuel

Cooking Fuel	***Availability Assessment***	***Affordability Assessment***
Biomass	Dominant fuel and easily accessible, especially for rural households (RMI, 2021).	Often collected or bought at a much lower price compared to conventional fuels (RMI, 2021). Cookstoves typically cost as little as $2-$3 USD upfront. Adoption of improved biomass stoves was only 10.6% in 2019 and is attributed to the high cost of duties and long lead times for customs clearance (RMI, 2021).
Kerosene	Easily accessible in both urban and rural areas (RMI, 2021).	In 2016, a kerosene subsidy was phased out, which has only increased the volatility of price associated with its production; kerosene is also frequently used in aviation fuel—supplementing that volatility (RMI, 2021).
Gas	Easily accessible in urban areas and has experienced rapid growth since 2007. Distribution is generally focused on urban and peri-urban areas; rural regions will not have nearly the same access (RMI, 2021). Infrastructure development is now lagging behind production but may increase with the National Gas Expansion Programme.	Compared to kerosene, gas has the entire support of the government and currently sits at half of the price that kerosene does. That said, recent price increases in 2021 (up to 80% increases) have shifted LPG users to switch to unsustainable fuel sources like charcoal at a much lower price (RMI, 2021). Even more, gas cookstoves typically cost as much as $50-$100 USD upfront (RMI, 2021).
Bioethanol	In contrast to LPG and traditional fuels, effective distribution channels are not yet widespread (RMI, 2021).	A 2018 study in Lagos State demonstrated that bioethanol stoves may be comparable to the price of LPG or electric, but the fuel is much harder to find (RMI, 2021).

Cookstove and Cooking Fuel Market

Modern cooking fuels are available, but increased use will be highly dependent on consumer awareness, affordability, and especially accessibility. Table 3 showcases a summary of the existing market players and projects where collaboration may be useful.

Table 3 - Bioethanol Cookstove and Fuel Market in Nigeria

Bioethanol Cookstove	Bioethanol Fuel
Manufacturer, Distributor, or Project	
KIKE Green Cook Stove is the chosen stove for West African Women Association of ECOWAS (WAWA) and has been endorsed by UNDP and Bank of Industry (BOI) under the Access to Renewable Energy Facility Project (Bioethanol Gel) (KIKE). **CleanCook.** Studies conducted by Project Gaia in Delta State, Nigeria, in 2006 and 2007 showed that households preferred cooking with alcohol and the **CleanCook** stove over LPG, kerosene, and firewood (AFDB, 2021). **Project Gaia.** Equator Fuel Project [2012-present]. 2015 partnership with Shell Nigeria Exploration and Production to supply 2,500 Methanol Cookstoves (Project Gaia and AFDB, 2021). In addition, Hinata Energy is working with Project Gaia to distribute CleanCook stoves to 144 Nigerian polytechnics alongside localized fuel kiosks.	**Unicane Industries Limited**, Nigeria's foremost ethanol producer and subsidiary of Unikem Industries Limited, produces 400,000 liters of Extra Neutral Alcohol (ENA) per day in Jamata Village, Lokoja using local cassava fermentation. This production, combined with Unikem Industries Limited, achieves an ENA output of 700,000 liters per day or 210 million liters in bulk packaging and drums (Moses-Ashike, 2021). **Nosak Industries** is a Ghanian based company that produces ENA from agricultural products like sugarcane molasses, grains and cassava; this Nigerian-Spanish venture is a subsidiary of Nosak Group and claims to be the largest manufacturer of ethanol in Nigeria and Sub Saharan Africa (Nosak, 2022). **NABDA 1000 LPD Micro-Distillery Production Plant (EMD)**. The EMD is provided by Green Social Bioethanol (GREEN), a Brazilian family-owned company specializing in small-scale bioethanol technologies for social projects. The NABDA distillery will rely on non-food grade cassava and cassava pieces, as well as the cashew apple, which is discarded when cashew nuts are harvested (AFDB, 2021 and Adebare et. al, 2021). **SMEFUNDS Green Energy & Biofuels (GEB)** has two plants, one in Lagos (which has both a bioethanol distillery and gel production plant) and Delta State (which has a gel production plant only). The project scope includes the construction of (i) a large bio-refinery plant in Lagos – that can produce up to 22 million liters of ethanol per year at maximum capacity – and (ii) 10 biogel micro-plants in strategic locations across the country to carry out the gel production and packaging over the next three years (AFDB, 2021 and Adebare et. al, 2021).
Key Barriers to Scale	
• Market is immature: consumer acceptance and access to improved cookstoves, in general, is slow. The Nigeria Alliance for Clean Cookstoves is conducting an ongoing Behavior Change Campaign to increase consumer awareness, acceptance, and uptake of improved cookstoves (Clasp, 2017). • Prices of improved cookstoves AND biofuel production costs are high compared to traditional practices, partly due to the high tax, tariffs, and weak policy (Clasp, 2017 and Adewuyi, 2020). • Many distributors rely on door-to-door sales models; no coordinated public communication campaigns have been carried out previously to promote improved cookstoves (Clasp, 2017). On the production side, land tenure systems are based on communal ownership which creates bottlenecks and conflict, especially for arable land (Adewuyi, 2020). • Polarized views already exist on the E10 blend for transportation, and have sparked controversy as to whether there is a capacity to support both energy insecurity as well as the food crisis simultaneously; more than 90 percent of cassava production is used for food production, but it is also one of the major ethanol feedstocks in the country in addition to sweet sorghum and sugarcane (Agboola and Agboola, 2011, and Adewuyi, 2020).	

Clean Cooking Related Policy

Policy, as it pertains to the clean cooking industry, is in its nascent stages. Table 4 summarizes key policies that align with or are focused on a specific clean fuel outcome for the future. Table 5 demonstrates the current tariffs and Value Added Tax on both bioethanol fuel and cookstoves for liquid fuel.

Table 4 - Summary of Policies Related to Clean Cooking

Policy	Coordinating Administration	Impacts on Clean Cooking Sector
NREEEP (2015)	Federal Ministry of Power. NREEP, Section 3.1.	Notes the need to transition from firewood to modern alternatives but does not outline a strategy towards implementation. Biomass Programme Targets focus on E10 production to increase from 5.3 ML/day in 2015 to 24.2 ML/day by 2030; the focus is mainly on the transportation sector.
SE4ALL-AA (2016)	SE4ALL Secretariat within the Ministry of Power. Multi-actor steering committee.	Sets requirements for sustainable energy access, provision, and generation. Specifically targets 50% replacement of traditional firewood by 2020 (not met) and 80% by 2030.
NREAP (2016)	Federal Ministry of Power through its Renewable Energy and Rural Power Access Department.	Sets renewable energy targets by sector and years: - 40% population using improved cookstoves by 2020, 59% by 2030. - Charcoal production, 5% more efficient by 2020, 7% by 2030. - Targets don't align with other existing strategies.
NEEAP (2016)	Federal Ministry of Power through its Renewable Energy and Rural Power Access Department.	Suggest actions to reduce firewood consumption and set energy efficiency targets according to SE4ALL goals. Also aligns with the ECOWAS Energy Efficiency Policy.

Table 5 - Bioethanol Fuel Tariffs and VAT

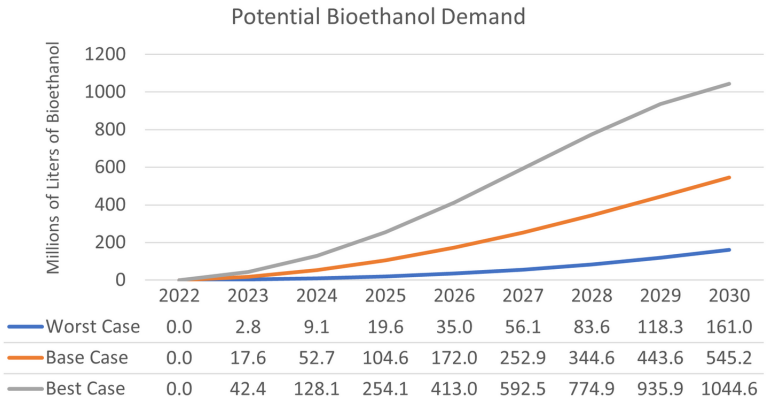
Product Type	WTO Code	Tariffs	VAT	Total
Bioethanol Fuel	220720	5%	7.50%	**13%**
Cookstoves for liquid fuel	732112	20%	7.50%	**28%**

Bioethanol Cooking Fuel Projections and Cost Comparison

Based on the methodology referenced, as well as population, fuel use, and urbanization trends, the following projections were calculated for potential bioethanol cooking fuel demand across three different scenarios (Figure 5). Three scenarios were created to showcase the variability of transitioning from kerosene, charcoal, or gas fuels to bioethanol. Both preference—wanting to use a different fuel despite being able to afford bioethanol fuel—and growth of access—possible uptake and infrastructure growth—are dependent not only on the location but also on the market conditions in the future.

Figure 5 - Potential Bioethanol Demand for Low, Base, and Best Case Scenarios 2022 - 2030

Scenario	Preference to switch to ECF (% of Total HHs by 2030)	Access to Clean Cooking Technology (% Increase from Baseline by 2030)
Worst Case	10%	5%
Base Case	15%	Projected Values
Best Case	35%	25%



Given the conditions above, the uptake of bioethanol as a cooking fuel seems promising. In fact, compared to the cost of conventional fuels like kerosene and gas, bioethanol is more cost-effective for the consumer—just lacking in available infrastructure (Figure 6). While bioethanol has a lower calorific value (27.00 Mj/kg) compared to LPG (46.60 Mj/kg) and Kerosene (43.10 Mj/kg), bioethanol stoves generally have higher efficiency (60% vs. 55% and 35% respectively). On a national level, the same can be seen; overall, the cost for households that may shift to bioethanol is overall less expensive compared to the existing cost of available fuels (Figure 7).

Figure 6 - Average Annual Fuel Consumption to Meet 3,500 MJ Household Consumption

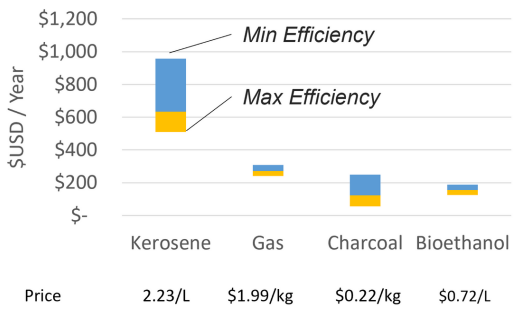
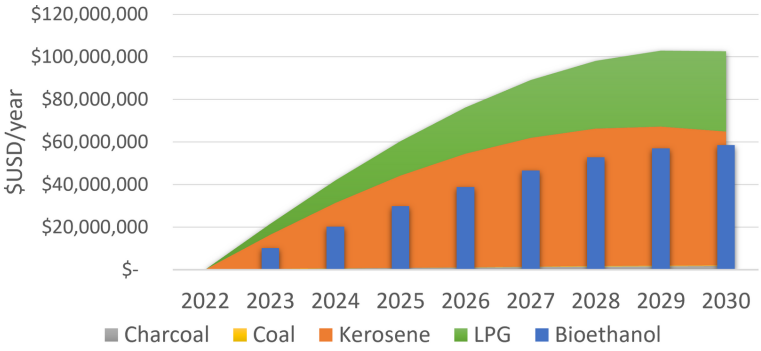
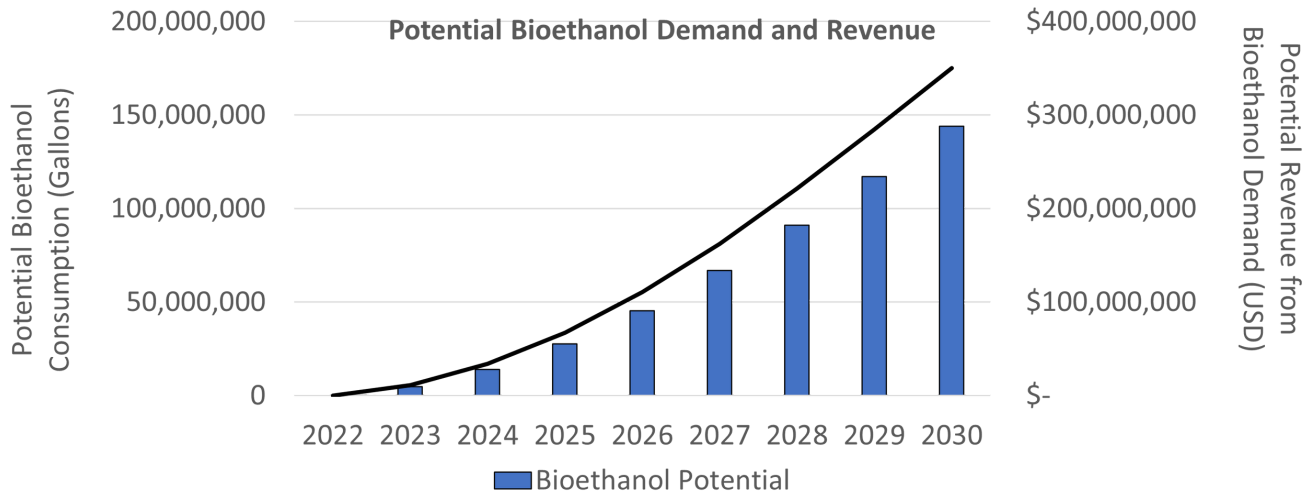


Figure 7 - Dominant vs Bioethanol Fuel Costs for Households Transitioning to Bioethanol



The combined benefits from a lower cost and high potential demand also suggest great revenue for producers. Using Trading Economics, the potential revenue has been calculated over the years (Figure 8). The revenue is based on the existing bioethanol price and base case scenario for potential demand; revenue and potential are calculated in gallons and USD.

Figure 8 - Potential Bioethanol Demand and Revenue



Recommendations and Conclusions

With regard to Nigeria's potential for transitioning to bioethanol cooking fuel as part of their clean energy portfolio, the following considerations should be noted:

1. **Need and demand for improved cookstoves is high in Nigeria**, especially when considering health and environmental impacts. This is a major indicator paving the way for cleaner fuels like bioethanol to grow.
   Recommendation: Collaborate with groups such as ECREEE, NAAC, Clean Cooking Alliance, etc. to demonstrate potential benefits to relevant government ministries that can help enact change and engage in activities such as social campaigns for civic education.
2. **Existing policy, goals, and infrastructure geared towards bioethanol are limited**; where the policy does exist, execution is lacking.
   Recommendation 1: Support government policymakers to understand the multiple benefits of creating parity within their regulatory framework for fuels.
   Recommendation 2: Encourage reduction or exemption of VAT on clean fuels and clean cookstoves.
   Recommendation 3: Encourage reduction or exemption on import duties for bioethanol and clean cookstoves; these could be temporary and serve to create market demand and encourage local production and manufacturing.
   Recommendation 4: Discuss establishing targets specific to clean cooking and bioethanol within national energy policy or NDCs.

3. **Local bioethanol market is saturated by major players rather than small enterprises.** Early-stage businesses often rely on door-to-door sales and are unable to scale quickly to achieve profitability compared to major producers with adequate capital access to additional markets. This allows for market dominance and higher prices from larger producers, even while production is not sufficient to meet demand.

    Recommendation: Greater investment is needed to support small to medium enterprise businesses in the clean energy space. As the bioethanol space develops, more innovative financing mechanisms are also emerging, allowing higher-risk propositions to gain funding. Additionally, local Finance Institutions should be encouraged to partner in some capacity.

5. **While the volatility in the price of fuels like kerosene and LPG remains a strength for bioethanol, higher initial cookstove costs and lack of availability turn down customers.**

    Recommendation 1: Leverage the use of subsidies or cost reductions through programs like Results-Based Financing when possible, to reduce the cost on initial cookstove purchases.

    Recommendation 2: Continue to work with the government to reduce taxes and duties on clean fuel options, resulting in lower distribution and end-user costs.

    Recommendation 3: Favorable government policy will also grow demand, and encourage local production and manufacturing, further driving costs down over time.

6. **A high projected demand for bioethanol and an immature market suggests the potential for revenue from both local and international parties.** There is a great amount of arable land available in the country, with the potential for local bioethanol production to grow significantly; this could also help meet local content requirements that exist, as well as create additional trade opportunities for agricultural inputs.

    Recommendation: Consider a combination of local and international sources of bioethanol in order to grow interest and infrastructure while local production expands to meet demand.

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Appendix A

Projected Number of Households that may Switch to Bioethanol Cooking Fuel

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal
Yearly HHs	0	1,964	4,023	6,109	8,140	10,020	11,633	12,845	13,501
Total HHs	0	1,964	5,987	12,096	20,236	30,256	41,889	54,734	68,234

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	Coal	Coal	Coal	Coal	Coal	Coal	Coal	Coal	Coal
Yearly HHs	0	4,832	10,390	16,485	22,856	29,168	34,997	39,829	43,048
Total HHs	0	4,832	15,222	31,706	54,562	83,730	118,727	158,556	201,605

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene
Yearly HHs	0	25,705	48,742	68,445	84,214	95,529	101,975	103,257	99,220
Total HHs	0	25,705	74,447	142,892	227,106	322,635	424,610	527,867	627,087

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	LPG	LPG	LPG	LPG	LPG	LPG	LPG	LPG	LPG
Yearly HHs	0	18,565	38,589	59,414	80,201	99,916	117,309	130,900	138,957
Total HHs	0	18,565	57,154	116,567	196,769	296,685	413,994	544,894	683,851

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass
Yearly HHs	0	38,752	83,681	135,180	193,652	259,500	333,137	414,975	505,432
Total HHs	0	38,752	122,433	257,613	451,264	710,765	1,043,902	1,458,876	1,964,308

Fuel Characteristic Assumptions

Fuel Type	Unit	Low Fuel Cost (USD) per Unit	High Fuel Cost (USD) per Unit	Average Fuel Cost (USD) per Unit	Net Calorific Value (MJ/kg)	Stove Efficiency	kg/L
Kerosene	Liter	$ 2.05	$ 2.41	$ 2.23	43.10	35%	0.817
LPG	kg	$ 1.93	$ 2.05	$ 1.99	46.60	55%	
Charcoal**	kg	$ 0.19	$ 0.24	$ 0.22	28.20	22%	
Coal	kg	$ 0.02	$ 0.02	$ 0.02	26.70	28%	
Bioethanol	Liter	$ 0.60	$ 0.84	$ 0.72	27.00	60%	0.783

Note 1: Fuel costs are sourced from local experts.

Note 2: Fuel Net Calorific and Efficiency Values are sourced from Dalberg, 2018.

HAPIT Health Impact Calculator Assumptions

Country	Nigeria		
Possible HHs (by 2030)	1,580,777	% Using Intervention	100%
Average HH	5	Intervention Useful Life	5
Kids <5 per HH	1		
Adults per HH	4		
Total Individuals	7,903,885		

Fuel	PM2.5 Emissions (micrograms/m3)
Kerosene	100
LPG	47
Charcoal	160
Coal	82.3
Bioethanol	50
Biomass	500

Appendix A

Environmental Assumptions

Stove	Avg. gCO2/kg Fuel
Charcoal	2740.0
Kerosene	71.3
Gas (LPG)	55.9
Coal	98.3
Ethanol	64.9