Nigeria Integrated Energy Plan

Geospatial model to assess clean cooking opportunity in Nigeria

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Acronyms

Acronym	Meaning
BAR-HAP	Benefits of Action to Reduce Household Air Pollution
BAU	Business As Usual
BUA	Built Up Areas
CBN	Central Bank of Nigeria
CC	Clean Cooking
CCA	Clean Cooking Alliance
DLPGOVP	Domestic LPG Office of the Vice President
DPR	Department of Petroleum Resources
E-cooking	Electric cooking
ECS	Electric Cook Stove
ESMAP	Energy Sector Management Assistance Program
EU NILES	European Union Nigeria LPG Expansion Simulation Model
FGN	Federal Government of Nigeria
GDP	Gross Domestic Product
GRID3	Geo-Referenced Infrastructure and Demographic Data for Development
Ha	Hectares
HHs	Households
HRSL	High Resolution Settlement Layer
IEP	Integrated Energy Plan
Kg	Kilograms
kWh	Kilowatt-hour

Acronym	Meaning
L	Liters
LPG	Liquefied Petroleum Gas
MDCs	Micro Distribution Centres for LPG
MG	Mini-grid
MJ	Megajoules of energy
MoE	Ministry of the Environment
MT	Metric Tonnes of LPG
NABDA	National Biotechnology Development Agency
NBS	National Bureau of Statistics
NGN	Nigerian Naira
NLEP	National LPG Expansion Plan
NLSS	National Living Standards Survey
PAYG	Pay-As-You-Go
REA	Rural Electrification Agency
SEforALL	Sustainable Energy for All
SHS	Solar Home System
SSA	Small Settlement Area
TCO	Total Cost of Ownership
tCO2eq	Tonnes of Carbon Dioxide (CO2) equivalent
TNC	Third National Communication (TNC) from Nigeria, in contribution to the United Nations Framework Convention on Climate Change (UNFCCC)

Executive Summary (1/2)

Context

In 2019, the Federal Government of Nigeria (FGN), through the Rural Electrification Agency (REA), developed a geospatial model to determine the least-cost solution to achieving 100% electrification by 2024 and 2030. SEforALL has prioritized the development of Integrated Energy Plan towards the achievement of Sustainable Development Goal 7 to 'Ensure access to affordable, reliable, sustainable and modern energy for all'. **This geospatial model strives to expand the coverage of the Integrated Energy Plan (IEP) to include other forms of energy use – primarily clean cooking – to ensure universal access by 2030.**

How the model works

Three clean cooking technologies (LPG[1], e-cooking, and biogas) are evaluated based on likelihood of adoption and the infrastructure / equipment required to serve that demand. The model adopts a 4-step process to generate the opportunity for each technology by household:

1. **Defining settlements with limited access to clean cooking:** The model identifies settlements where there is evidence of emissions-intensive cooking activities. To account for fuel stacking behavior, in which households use multiple cooking technologies simultaneously, settlements where more than 50% of households exhibit emissions-intensive cooking are designated clean cooking constrained settlements. These settlements account for 71% of the total population (190 Mn people, 36.6 Mn households), in 715k settlements (92% of total settlement count) spread across the Northern and Southern regions of the country. The clean cooking opportunity is evaluated for this sub-set of the population.
2. **Calculate household cooking energy consumption:** A standard meal composition is assumed (rice and beef stew) based on age of household members, assuming a standard daily calorific intake per meal across households. Household cooking intensity defined as the product of household size and energy requirement (MJ) per meal per individual. All households are assumed to have a daily meal frequency of three meals a day. This translates into an annual per capita cooking energy need of 1,643 MJ. Clean cooking demand is aggregated across all households in a settlement.
3. **Estimate the opportunity for expansion of clean cooking solutions:** First the affordability of each cooking technology is determined. The total cost of ownership (TCO) over 20 years is calculated at a household level for each solution[2]. The available spend on clean cooking for each consumer class is determined using spending breakdowns from survey data. 70%, 56%, and 92% of households are able to afford LPG, e-cooking, and biogas solutions, respectively. These households are then taken through a second filter to determine likelihood of adoption, using female education as a proxy to identify households likely to switch to clean cooking. This results in 10%, 10%, and 12% of households that are able to afford and likely to adopt LPG, e-cooking, and biogas solutions, respectively. Finally, for biogas, access to sufficient agricultural residue from farming activities is determined to ensure access to sufficient feedstock. Using geospatial data on farming activities, the model finds that 99.7% of households likely to adopt biogas are attractive for biogas expansion based on agricultural activity. The combination of these three filters defines geographic demand for clean cooking technologies.
4. **Define infrastructure required to realize opportunity:** For each technology, the infrastructure required to serve this demand is then determined:
   - LPG: An optimization analysis is conducted to estimate required number and placement of LPG filling plants, skids and micro distribution centers. The capacity and catchment areas of LPG facilities are defined, and the model determines the minimum number of facilities required to meet the demand. The analysis finds 74 filling plants, 84 retail skids, and 2,458 micro-distribution centers are required to realize the LPG opportunity of 76k MT.
   - E-cooking: 21% of households with e-cooking opportunity are currently unelectrified (725k of 3.5 Mn households). Therefore, the realization of the universal electrification target will enable e-cooking for these households.

1. Liquefied Petroleum Gas (e.g., propane)
2. For biogas, a community biodigester model is applied for households in both urban and rural areas

Executive Summary (2/2)

How the model works

4. **Define infrastructure required to realize opportunity (cont.)**
   - Biogas: An optimization analysis is conducted to determine the required number, size and placement of community biodigesters to serve household biogas demand. The analysis determines the placement of community biodigesters of various capacity (250L, 500L and 1000L) with a catchment area of 3km. The analysis finds that 7k biodigesters are required to serve 190 Bn L annual demand from 4.3 Mn households

Results and implications

LPG opportunity: 3.7 Mn households (10% of clean cooking constrained population) can afford and likely to adopt LPG cooking solutions. Should all households adopt LPG, this would lead to an annual incremental fuel demand of 76k MT of LPG.

- The LPG opportunity will require an investment of 478 Mn USD by 2030 to cover stoves, accessories, and infrastructure. The Central Bank of Nigeria (CBN) has provided a 250 Bn NGN intervention facility for the natural gas expansion program that can be leveraged to cover some of these costs.
- The Federal Government of Nigeria has a goal to reach 5 Mn MT of LPG demand by 2027, of which 2 Mn MT of demand is meant to come from clean cooking. This goal is likely to be achieved, though mostly through demand growth in households who already have access to LPG.

E-cooking opportunity: 3.5 Mn households (10% of clean cooking constrained population) can afford and likely to adopt e-cooking cooking solutions. Should all households adopt e-cooking, this would lead to an annual incremental electricity demand of 1.1K MWh.

- The e-cooking opportunity will require an investment of 83 Mn USD, mostly for cookstoves.

Biogas opportunity: 4.3 Mn households (12% of clean cooking constrained population) can afford and likely to adopt biogas cooking solutions. Should all households adopt biogas, this would lead to an annual incremental fuel demand of 228 Bn L of biogas.

- The biogas opportunity will require an investment of 847 Mn USD by 2030, of which 303 Mn USD is required for deployment of community biodigesters.

Opportunity constrained households: 32.3 Mn households (88% of clean cooking constrained population) have no opportunities for clean cooking technologies at present. Efforts to increase the affordability or likelihood of adoptions, such as subsidies and educational / outreach efforts, can be considered to expanding clean cooking opportunities to this population

Co-benefits of cleaning cooking: Clean cooking adoption will provide benefits across climate, health, and time saved. Among these benefits, a ~29% annual emissions reduction can be realized from clean cooking adoption.

Path forward: Clean cooking opportunity can be realized through targeted measures on private and public sector stakeholder engagement, increased awareness to households on the benefits of clean cooking adoption, as well as infrastructural expansion to enable realization of clean cooking opportunity

1. Liquefied Petroleum Gas (e.g., propane)

Context & Objectives

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Context and objectives

Context

In 2019, the Federal Government of Nigeria (FGN), through the **Rural Electrification Agency (REA), developed a geospatial model to determine the least-cost solution** to achieving 100% electrification by 2024 and 2030

SEforALL has prioritized the development of Integrated Energy Plan towards the achievement of Sustainable Development Goal 7 to 'Ensure access to affordable, reliable, sustainable and modern energy for all'

Nigeria's IEP goes a long way towards being an exemplar of an Integrated Energy Plan, but has four key limitations that the FGN, in collaboration with SEforALL, now seeks to address: some of its data and analysis is outdated; its not yet a fully open-access tool usable by public and private sector actors; and it does not incorporate clean cooking

Thus, an **updated Nigerian Integrated Energy Plan** incorporating electrification and clean cooking will **play a vital role in assisting the FGN in determining the tactical implementation approach for the relevant interventions**

The clean cooking model is working towards a 2030 scenario for expanded clean cooking access **by assessing the expansion opportunity across three key clean cooking technologies relevant in Nigeria: LPG, e-ccoking, and biogas.** The model does not analyze universal access, but rather tries to assess affordability, adoption, and access to fuels to understand which technologies have adoption potential.

The electrification and clean cooking models interact with each other, particularly in the case of e-cooking, where access to suitable electricity is a requirement of the technology. Additionally, given the requirements for community engagement across electrification and clean cooking, **having a comprehensive perspective on settlement needs and options will allow for more effective public action.**

Objectives of this project

To develop an updated and enhanced Integrated Energy Plan (IEP) for Nigeria, by

- **Updating** the existing geospatial model **data-sets**
- **Building a clean-cooking layer** into the model
- Ensuring the new IEP, including and their underlying **tools and data are well understood**
- **Ensuring that the model is accessible** and usable by external stakeholders

The aim of this model to explore the opportunity for expansion of access to clean cooking fuels in Nigeria

Decisions it can inform…

Identification of high potential markets/settlements for the expansion of clean solutions in 2030

Estimation of associated costs and infrastructure implications for the expansion of each clean cooking solution

Assessment of the potential impact of e-cooking electricity demand in unelectrified settlements on the least-cost technology mix

Decisions it cannot inform…

Demand forecast or projections of clean cooking opportunity in Nigeria before or beyond 2030

Validation of the economic viability of making infrastructure investments to enable clean cooking expansion

Estimation of existing penetration of specific clean cooking solutions in Nigeria

The clean cooking model was built with input from key stakeholders and experts

Key stakeholders consulted

FEDERAL MINISTRY OF ENVIRONMENT

DLPGOVP
Domestic LPG of the Vice President

NABDA

Experts engaged

CLEAN COOKING ALLIANCE

NEXLEAF ANALYTICS

Prof. Marc Jeuland

Associate Professor, Duke University and Clean Cooking Sector Expert with 10+ years of research on issues related to adoption of clean cooking and co-benefits of environmental health interventions in developing countries.

Dr. Victor Osu

Technical advisor on Energy Transition, Environment and Co-Development from the Office of the Vice President (NLEP)

Note: The National Biotechnology Development Agency has led efforts on the development and deployment of household and community biodigesters across rural and urban areas in Nigeria

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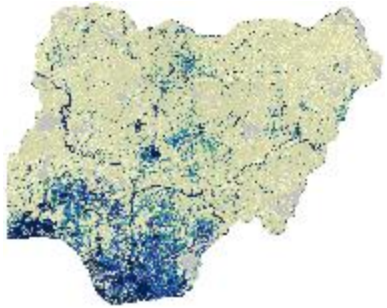
3.7 Mn, 3.5 Mn and 4.3 Mn households have the potential to adopt LPG, e-cooking, and biogas, respectively

Expansion opportunity for clean cooking solutions in Nigeria in 2030, No. of households

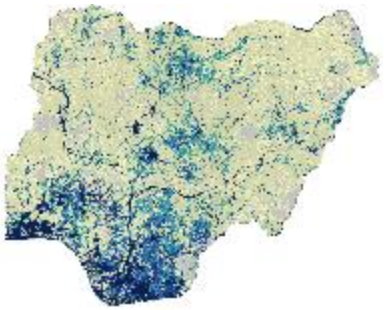
0-25 25-50 50-100 >100 Clean cooking Unpopulated

LPG



E-cooking

Biogas



	Rural	Urban	Total
Households access-constrained from CC[1]	23.6 Mn	13.1 Mn	36.6 Mn
Households with LPG opportunity	1.5 Mn	2.2 Mn	3.7 Mn
Households with e-cooking opportunity	1.3 Mn	2.1 Mn	3.5 Mn
Households with biogas opportunity	2.0 Mn	2.3 Mn	4.3 Mn

		LPG	E-cooking	Biogas
# households	Rural	1.5 Mn	1.3 Mn	2.0 Mn
	Urban	2.2 Mn	2.1 Mn	2.3 Mn
	Total	**3.7 Mn**	**3.5 Mn**	**4.3 Mn**
% of access-constrained house-holds from clean cooking adopting[1]		10%	10%	12%
Incremental fuel demand p.a. (MT/kWh/L)		76k MT	0.9 Bn kWh	190 Bn L
Incremental fuel value p.a., (NGN)		40 Bn	67 Bn	N/A[2]

Note:

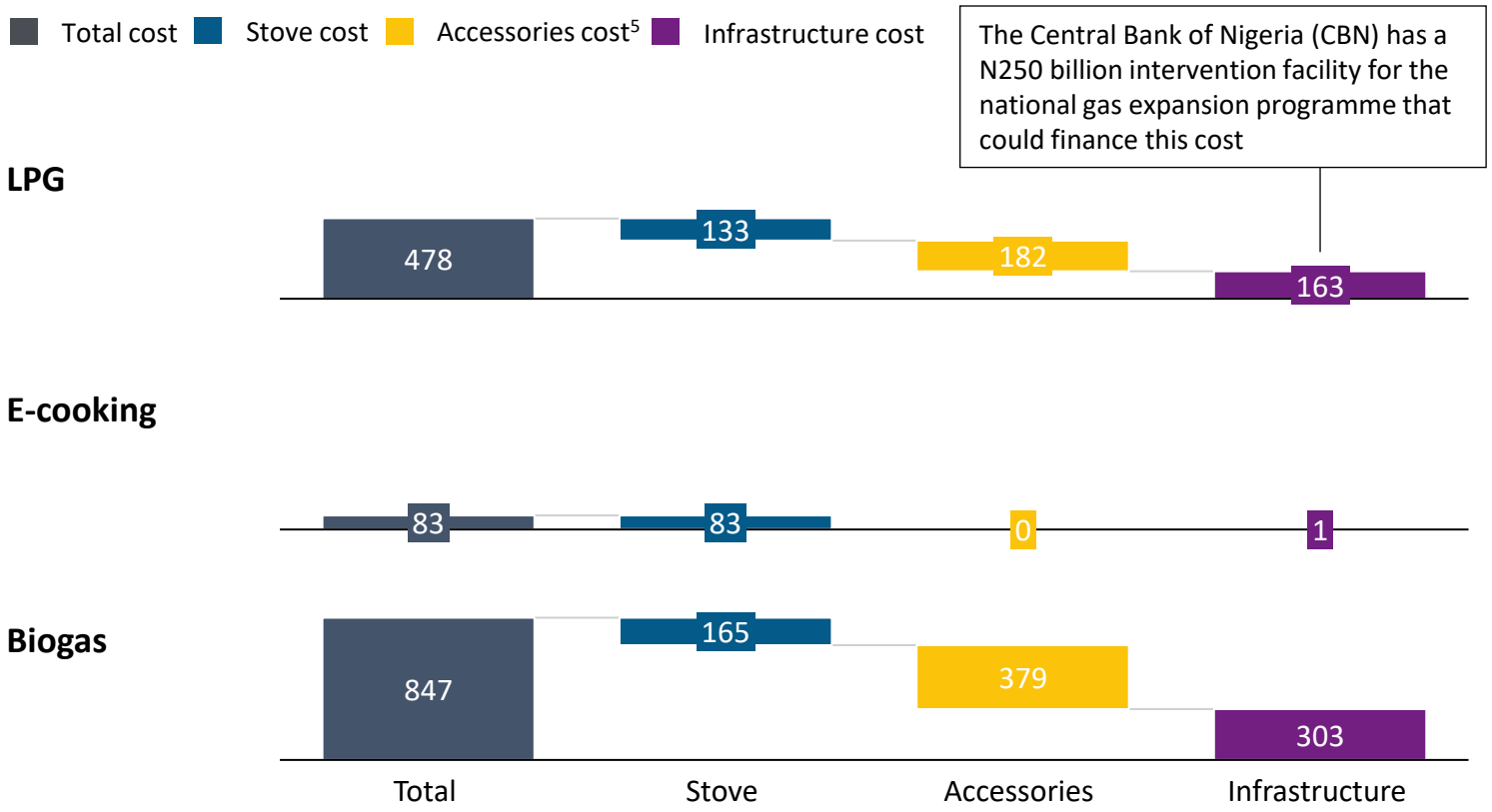
A settlement may be attractive for multiple clean cooking solutions based on household characteristics. For instance, a household may be able to afford all 3 cooking solutions, have an educated adult female (indicating likelihood of clean cooking adoption), and be located in a settlement with sufficient crop waste generation for biogas, as well as either grid or mini-grid connection to enable e-cooking.

Thus, the results of the analysis are considered independently for each of the solutions – accordingly, the opportunities identified across these technologies should not be viewed as additive with each other.

1. Defined as households located in settlements where >/=51% of its population cooks with emissions-intensive fuels
2. Biogas fuel is zero-cost, as it is generated from agricultural residue

Realising the clean cooking opportunity will require investment for appliance and infrastructure costs

Investment required to realise clean cooking opportunity in Nigeria in 2030[1], USD Mn



1. Fuel cost to consumers not included, as this is an ongoing cost over ownership period
2. Expert input from the National Biotechnology Development Agency
3. Equipment cost of LPG infrastructure was obtained from private sector LPG players, excluding town planning, fire services, approval costs, etc. - as these additional cost items would vary based on the location of the infrastructure
4. This is based on the biodigester size, assuming 6 USD cost per liter of digester size - based on guidance from NABDA
5. Associated appliances (e.g., cylinder, hose, and regulator for LPG)

Source: CBN Framework For The Implementation Of Intervention Facility For The National Gas Expansion Programme (August 2020), Expert discussions, Team analysis

Insights

Infrastructure costs account for equipment cost[3] of bottling plants, retail skids and micro-distribution centers for LPG; the incremental cost of universal electrification (grid extensions, and incremental mini-grid battery costs) based on impact of e-cooking demand on LC electrification and the cost of biodigesters for biogas[4]

E-cooking has the lowest total investment required, driven majorly by:

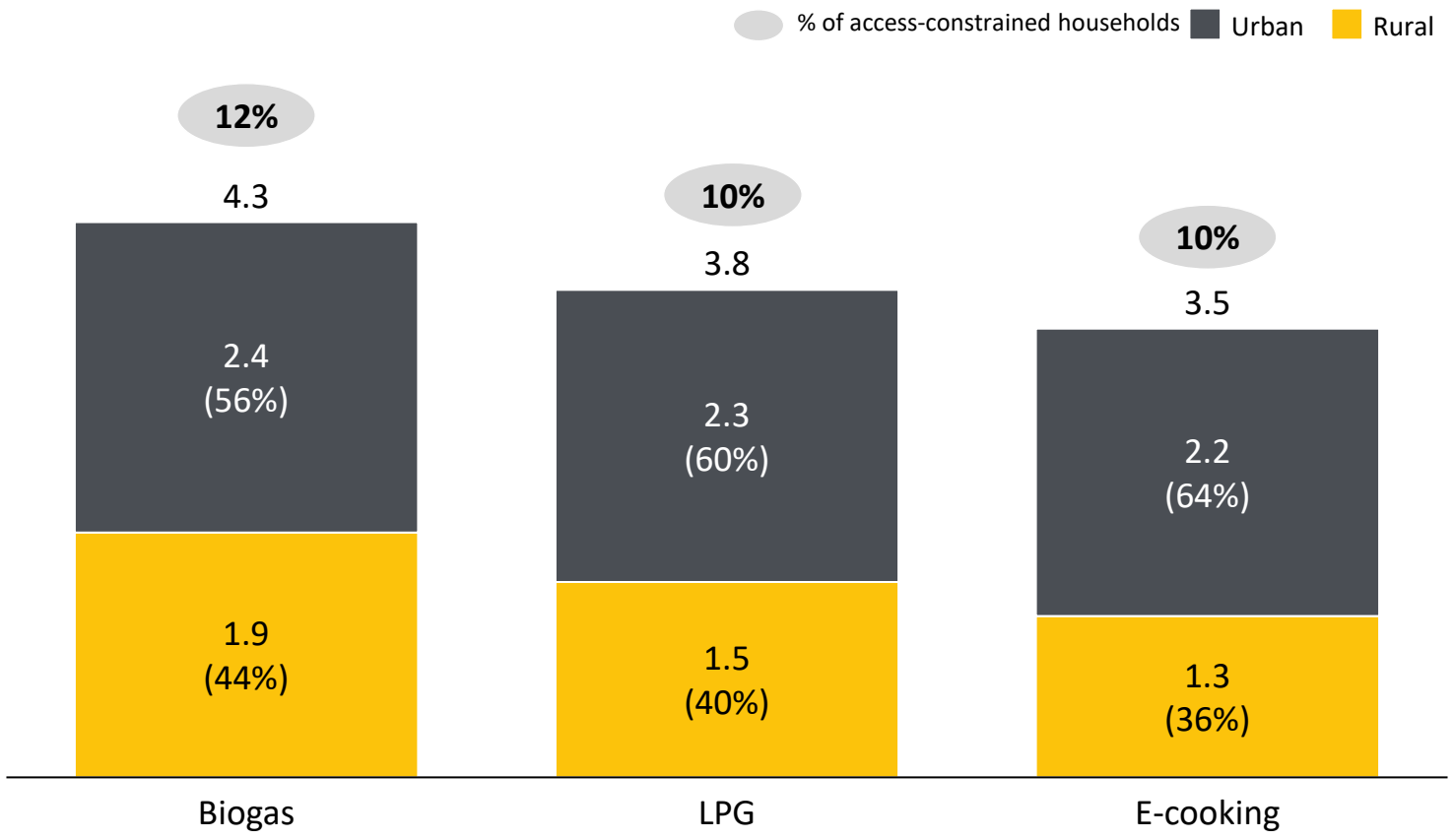
- Cost of the e-cooking kit – this consists only of an e-cookstove, compared to LPG and biogas which require cylinders, hose, etc.
- Cost of e-coking infrastructure – required electrification infrastructure to enable e-cooking is accounted for in the LC electrification assessment, thus the cost represented here incudes only the incremental cost for settlements where additional electricity supply is required to support e-cooking electricity demand

For LPG, the cost of infrastructural expansion will be supported by the CBN intervention facility of N250 billion dedicated to activities across expanding the LPG distribution value chain

Given that biogas is a new clean cooking solution in Nigeria, biodigester costs are commonly sponsored through interventions government or donor agencies[2]

All three technologies have similar overall opportunities, ranging from 10 – 12% of access constrained households

Clean cooking opportunity, Mn households



1. Determined based on % of adult females (15 - 49) with at least secondary education in each settlement

Source: Fraym – Crop and livestock measures geospatial data-set (2019), Team analysis

Insights

The highest opportunity for clean cooking is mapped to biogas

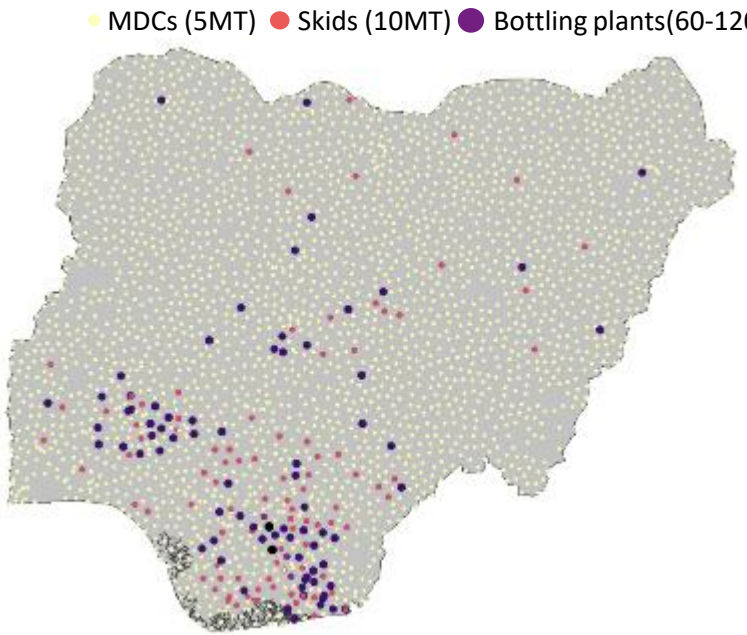
- This is driven partly by the average annual cost of biogas, which is 5k NGN, compared to average cost of LPG and e-cooking (22k NGN and 39.5k NGN respectively)
- Additionally, based on the overlay of a geospatial data-set that maps farm ownership, 99.7% households that are able to afford and likely to adopt biogas can generate sufficient crop waste from farms to enable biogas production

However, the gap between the % opportunity for biogas compared to LPG and e-cooking is low (~2%) as a result conversion rate of households from affordability to likelihood to adopt

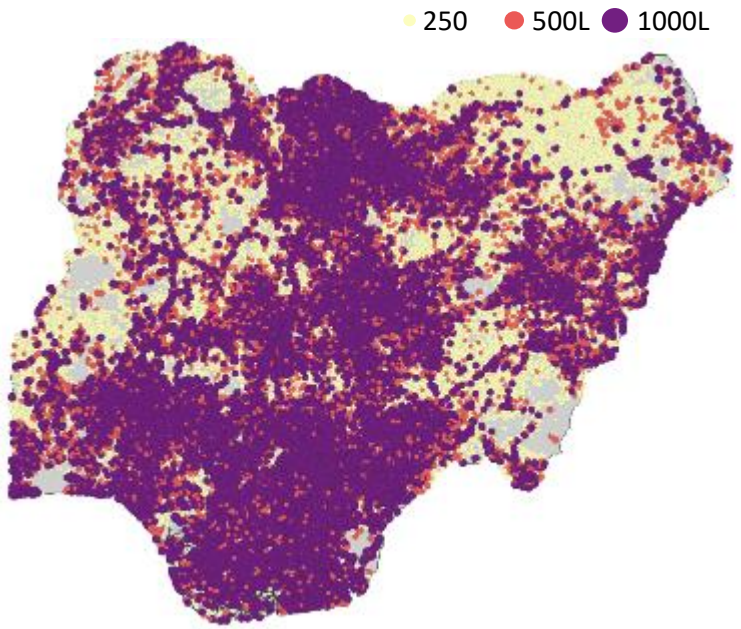
- Based on the ability to pay, 92% of households can afford biogas – compared to 70% and 57% for LPG and e-cooking respectively
- Applying female education criteria, the opportunity for the cooking solutions comes to 12% for biogas and 10% for both LPG and e-cooking
- Additionally, there is a higher opportunity for each of the solutions in urban settings which is driven by higher affordability and likelihood of clean cooking adoption[1] in urban areas

2.6k LPG distribution infrastructure and 77k biodigesters are required to serve associated LPG and biogas demand

Placement of LPG infrastructure, type of infrastructure



Placement of biodigesters, type of infrastructure



No. of infrastructure required

Micro-Distribution Centres (MDCs)	2,458
Retail skids	84
Bottling plants	74
Total	**2,616**

No. of digesters required

250L digester	31,556
500L digester	5,621
1000L digester	39,796
Total	**76,973**

1. The catchment area is defined by drawing out a geospatial radius from the center of a given area
2. Based on discussions with experts

Source: Team analysis

Insights

Optimal placement of infrastructure is determined based on the total demand identified in a given catchment area (15km catchment area[1] of LPG infrastructure, and 5km catchment area of biogas infrastructure[2])

For LPG, retail skids and bottling plants are concentrated in the South based on higher LPG demand in the South – driven by affordability and likelihood of adoption

Biogas digester placement is spread across the country, given the higher affordability and likelihood of biogas adoption across the country

The clean cooking opportunity could drive climate, health and time savings benefits at the national and household level

	LPG	E-cooking[3]	Biogas
Climate[1]	**6.9 Bn** kg Forest loss avoided from renewable & non-renewable biomass collection **29.9%** Emissions reduction, compared to BAU[2]	**6.6 Bn** kg Forest loss avoided from renewable & non-renewable biomass collection **30%** Emissions reduction, compared to BAU	**8.2 Bn** kg Forest loss avoided from renewable & non-renewable biomass collection **30%** Emissions reduction, compared to BAU
Health[4]	**12.1k** Illnesses avoided annually & **551** Deaths avoided annually	**11.5k** Illnesses avoided annually & **524** Deaths avoided annually	**14.3k** Illnesses avoided annually & **649** Deaths avoided annually
Time savings (hr./HH)[5]	**107 hrs.** Of cooking and fuel preparation time saved[7] annually per household		

Time savings is same across each of the solutions as a standard clean cooking use rate is applied (30%), which results in same reduction of firewood collection and clean fuels have same time efficiency parameter (85%) according to the BAR-HAP[6]

In addition to these benefits, clean cooking adoption will drive socio-economic development through its contribution to the formal economy (tax revenues), value added to GDP, employment

1. Forest loss calculated based on no. of households cooking with biomass from the baseline; differing based on the no. of households with high opportunity for each solution
2. Assuming sustained use of emissions-intensive fuels by households
3. Includes grid and mini-grid connected households
4. Annual illnesses and deaths from Acute lower respiratory infections (ALRI) , Chronic obstructive pulmonary disease (COPD), Ischemic Heart Disease (IHD), lung cancer and stroke
5. Fuel prep time saved only calculated for households with clean cooking opportunity that are transitioning from biomass, assuming that collection and preparation time for other fuels is minimal
6. Benefits of Action to Reduce Household Air Pollution (BAR-HAP)
7. Fuel prep. for biogas may have time costs to the households, however minimal as households have existing uses of crop waste, thus gathering residue will not be a new activity and relative proximity of digesters to users (3km catchment area) will minimize transportation time. Additionally, there is a lack of rigorous research to determine exact time costs

Source: TNC (March 2020) – Pg. 142, WHO BAR-HAP Tool (July 2021), Benefits and Costs of Improved Cookstoves (Jeuland, Pattanayak – 2012), The carbon footprint of traditional wood fuels (Bailis et al, 2015), EU NILES (2021), Expert input, Team analysis

Clean cooking fuels are cost-competitive with emissions-intensive fuels, particularly charcoal

Annual cooking fuel cost for a sample household based on fuel type

Category	Fuel type	Annual consumption per household[1]	Average price per unit (NGN)[2]	Annual cost per household (NGN)[3]
Clean cooking fuel	LPG	89.5kg	477	42.699
	E-cooking	1,118kWh	59	65.972
	Biogas	91.3kg	0	0
Emissions-intensive cooking fuel	Charcoal	91.5kg	72	6.589
	Kerosene	108kg	485	52.382

1. Calculated by study team based on average cooking intensity per household (from step 2 of analysis)/energy content of associated fuel (MJ/kg)*Stove efficiency(%)
2. LPG unit price derived as average price of LPG across all states as at July 2021 - see appendix; electricity tariff based on cost-reflective tariff - assuming household is grid connected; biogas fuel is zero-cost to household based on feedstock for payment model - see Step 3A; charcoal cost derived from press sources, based on lack of official data on charcoal price; kerosene price obtained from NBS July 2021 data
3. Calculated as fuel consumption * unit price of fuel

Note: Firewood is not included in this analysis based on the lack of data on a standard measure for quantifying fuelwood consumption. Firewood is commonly sold in sticks, handfuls,etc. and not by kg.

Insights

Assuming a standard annual cooking intensity of a sample household, this analysis reveals that clean cooking, particularly biogas and LPG are cost-competitive with kerosene

Based on the distribution of cooking fuel use reported by the TNC (2020), kerosene represents the 2nd highest share of emissions-intensive fuel use (19% of households)

Thus, households where kerosene is used display sufficient annual purchasing power on cooking fuels to adopt LPG or biogas

Households currently cooking with charcoal are equally primed for the adoption of biogas as the common biogas model in Nigeria is based on feedstock for payment – with no cash cost of fuel to users

The clean cooking model is most sensitive to the likelihood of clean cooking adoption assumptions

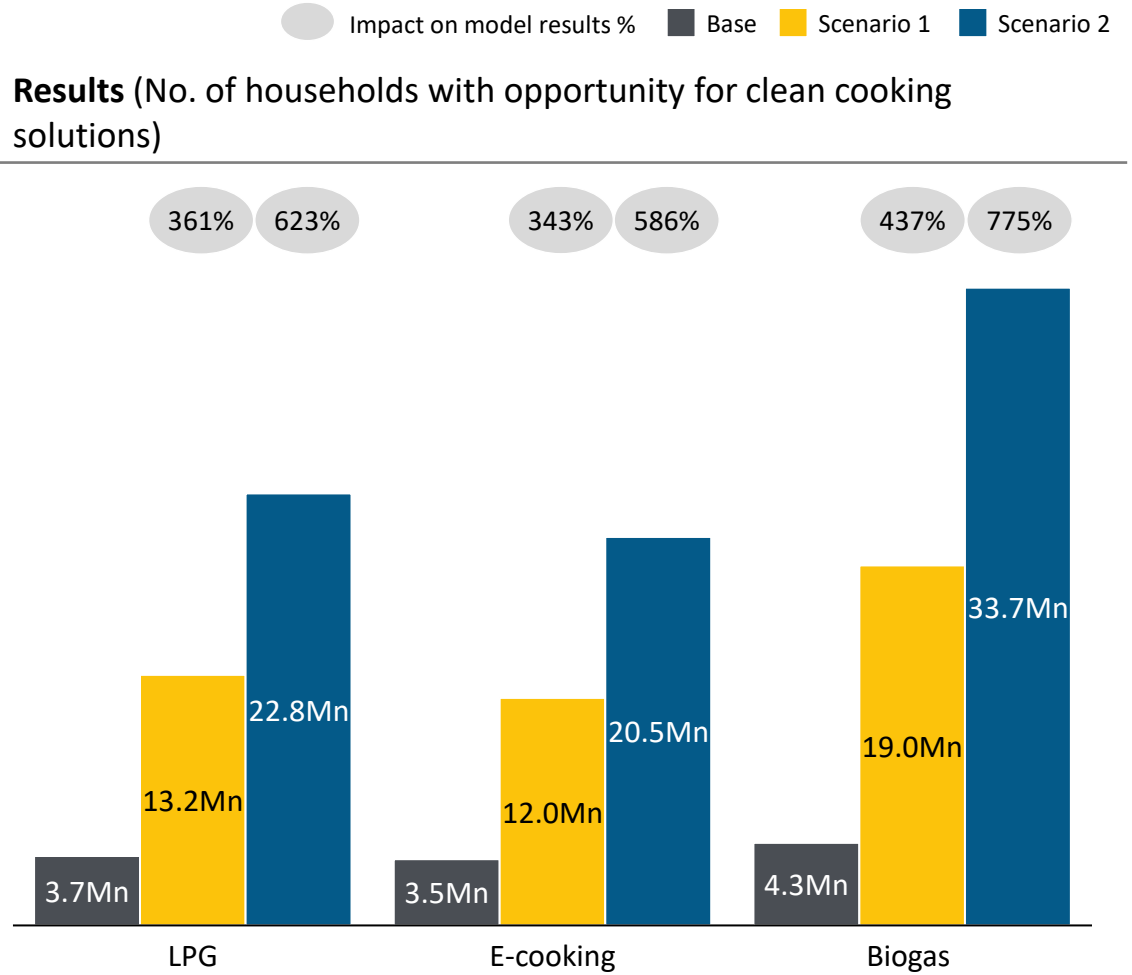
Methodology & input

Key inputs of the clean cooking model were assessed to determine which inputs the results (i.e., no. of households with opportunity for each of the clean cooking solutions would be most sensitive to

To test the sensitivity of the likelihood of clean cooking adoption, two scenarios are applied:

- Aggressive adoption (Scenario 1) – 50% of households that can afford, and are not likely to adopt clean cooking from the base analysis will adopt
- Total adoption (Scenario 2) – All households that can afford clean cooking will adopt

Results (No. of households with opportunity for clean cooking solutions)



Insights

The expansion opportunity for clean cooking is highly dependent on the rate of clean cooking adoption

- Based on research on the drivers of clean cooking adoption, the affordability of a given cooking technology is not the only determinant of a household adoption, as this is influenced by other demographic and social factors such as cultural preferences, gender, educational level, household size, social environment, etc.

Therefore, maximizing the clean cooking opportunity in Nigeria will be dependent on targeted efforts to drive education and awareness of clean cooking benefits, in order to drive adoption and sustained usage

Source: Who Adopts Improved Fuels and Cookstoves? A Systematic Review – Lewis, Pattanayak (2012), Assessing the Use and Determinants of Households' Adoption of Improved Cook Stove in Nigeria: Empirical Evidence from Enugu State (Onyekuru, 2017) Team analysis

Context & Objectives

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Appendix

Taking the clean cooking plan forward: What to focus on next? (1/2)

1

Drive a joint narrative in Nigeria with regard to clean cooking expansion

Create a stakeholder engagement plan with a highlighting the clean cooking gap and opportunity in Nigeria, as well as the required role of public, private sector players and donor agencies in realizing the clean cooking opportunity

2

Drive awareness of end-users on the benefits of clean cooking adoption through education and outreach efforts

Define a community-level outreach strategy to drive awareness of the benefits of clean cooking adoption to households and community in order to encourage cookstove adoption and subsequent stove usage

3

Improve affordability of clean cooking technologies through subsidization and provisions of free appliances

Coordinate among the FGN and international donor community to determine the extent to which resources can be provided to subsidize fuel prices or provide households with free appliances to enhance the affordability of the total cost of ownership.

4

Train local communities for installation, operation and maintenance of clean cooking appliances

Safety concerns have been cited as a restraint from household use of LPG. It will be important to train households on the use of LPG canisters and stoves in order to alleviate safety concerns.

Specifically, young adults in communities where biodigesters are deployed should be trained to install, operate and maintain the digesters .

Taking the clean cooking plan forward: What to focus on next? (2/2)

5

Focus on industrial uses of LPG to ensure NLEP targets are achieved by 2027

Identify interventions to increase non-household demand for LPG. Between growth in household demand for those already using LPG and incremental household demand from clean cooking expansion, the FGN looks on target to meet its 2 Mn MT goal for demand from households. The FGN is not on target with current growth rates in industrial demand.

6

Build out LPG infrastructure to serve increased demand

Compare optimal locations for filling stations, skids, and micro distribution centers with existing infrastructure to determine what needs to be build next. Identify new infrastructure with largest surrounding demand to be prioritized for private sector development, so that public resources can be directed towards infrastructure unlikely to attract private sector investment in the near term.

7

Launch pilot projects to test the viability of community biodigesters

Introduce biodigester programs in communities with different levels of biogas clean cooking potential to determine: (1) the willingness of households to use agricultural residue for biogas (as opposed to alternative uses), and (2) the likelihood of households to adopt to clean cooking using biogas

8

Enhance stability of electricity provision from grid to ensure viability of e-cooking

Increase hours of supply and reliability of supply on grid to ensure that power is available during mealtimes for e-cooking.

Appendix

Approach to modelling the opportunity for expansion of clean cooking solutions in Nigeria

1 Define base layer for analysis

- Identify settlements with limited access to clean cooking

2 Estimate household cooking energy consumption

- Estimate cooking intensity of households and associated energy consumption[1]

3 Estimate the opportunity for expansion of clean cooking solutions

- a. Determine no. of households that can afford clean cooking solutions in each settlement
- b. Determine no. of households likely to adopt clean cooking solutions in each settlement - using female adult education as a proxy
- c. Identify settlements with sufficient crop waste for biogas production

4 Define infrastructure required to realize opportunity

- a. Determine no. and placement of LPG distribution infrastructure – bottling plants, skids, MDCs - to serve associated demand
- b. Determine electricity access gap for e-cooking
- c. Determine no. and placement of biodigesters to serve demand

1. Number and size of meals cooked daily in each household/health center


SUSTAINABLE
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FOR ALL