Scaling eCooking in Nigeria

Gap Analysis for Programme Development

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1. Executive Summary

Access to clean, affordable energy and the appliances to use it is key to global sustainable development and the energy transition. Clean cooking is critical to this transition, as 4 billion people globally continue to use polluting, unhealthy fuel options for their cooking needs.[1] The Modern Energy Cooking Services (MECS) programme is helping lead the charge to change this situation, actively working to do so in 15 countries around the world.

As the largest economy and population on the African continent, Nigeria represents a uniquely significant challenge and opportunity for clean cooking. This report is the first component of MECS initialization of work in the country. Based on a review of the existing literature, along with interviews with key stakeholders in the Nigerian clean cooking sector, the report provides an overview of the current state of the cooking sector in Nigeria, describes insights into relevant aspects of the broader electricity and policy environment, and identifies major gaps that are preventing adoption at scale. This first phase of MECS engagement in Nigeria will inform further programme development and lay the groundwork for future collaboration across stakeholders to dramatically accelerate the use of clean cooking technologies in Nigeria, with a particular focus on electric cooking (eCooking).

Overview of the Nigerian landscape and policy environment

Despite Nigeria's size and potential, as a market-oriented country with a rapidly growing population of over 200 million, there is still much to be done to achieve the widespread adoption of clean cooking technologies. Electricity access, especially in rural areas, is limited and even for those with access to electricity, low reliability is often a challenge. As a result, major government initiatives are underway to rapidly electrify unserved and underserved Nigerians through a variety of means. This includes a number of efforts focused on addressing the country's national electric grid challenges. In the near term, an innovative effort is the rapid development of the minigrid sector by Nigeria's Rural Electrification Agency. As of 2018 there were ten commercial minigrids operating in Nigeria, and in the years since at least a dozen additional projects have come online, with far more in development.[2] Complementing this accelerated electrification, parallel efforts are matching primarily agro-processing productive use applications such as grain milling to minigrids are increasing, which may present an opportunity and lessons for the development of an eCooking sector.

In contrast to the recent acceleration in off-grid electrification, the development of the clean cooking sector has had mixed results and significant regional variation. Over the past decade, wood biomass has steadily remained the most popular cooking fuel, with over 60% of Nigerians using wood as their primary cooking fuel. At the same time, the population has continued to rapidly urbanise and a government kerosene subsidy was removed, both of which have contributed to the decline of kerosene use and the rise of LPG as a cooking fuel. The popularity of biomass is higher in rural areas, and charcoal is used at higher rates in the arid, northern region of the country. LPG and kerosene are more popular in urban areas, and LPG distribution infrastructure, in particular, has limited its use to mostly urban and periurban areas in the central and southern regions. While the potential for eCooking is high, fewer than 1% of households in Nigeria use electricity as their primary cooking fuel. The nascent state of the eCooking market, in combination with the sheer need for modern energy cooking services, means that the opportunity to improve livelihoods and for private sector companies and investors to serve the need, is quite large.

The present policy environment in Nigeria does not provide a clear direction for the cooking sector broadly, or eCooking in particular. This stems from several factors. There is no coordinating body for clean cooking or eCooking. Among recent energy strategy documents, most clean cooking targets are

not accompanied by plans for implementation and do not have dedicated funding. Furthermore, appliance standards and regulations cover few clean cooking technologies, missing an opportunity to provide guidance to developers, manufacturers, and distributers, and to provide assurance to investors. More rapid growth of the eCooking sector will necessitate a clearer, more supportive policy environment.

Recommendations

The market and policy landscape for clean cooking in Nigeria suggests particular challenges and opportunities for the growth of eCooking. Among the challenges, grid-connected eCooking adoption will likely lag until underlying reliability issues are addressed. Off-grid areas present a clearer opportunity for eCooking, but the higher cost of electricity off-grid will test consumer price sensitivity. Along with strong eCooking policy coordination and implementation support, more reliable national data is needed for a large-scale eCooking program. Regarding opportunities, the robust private sector, both in the form of entrepreneurs and investors, will likely play a leading role in eCooking growth. Additionally, there is an opportunity for eCooking to take advantage of the recent success of the minigrid sector, working in partnership with leading government agencies and coordinated donor support.

In the first half of 2021, MECS plans to lead several activities to align with stakeholders active in Nigeria's clean cooking sector and to refine the programme's planned activities. In particular, this will include:

- A preliminary convening of stakeholders considering existing or future clean cooking programmes in Nigeria, with an objective of aligning on priority gaps to address and defining collaborative research agendas to maximize collective speed and efficiency.
- Identifying potential programme options for testing eCooking appliances and strategies in Nigeria, in order to fill critical data gaps and to drive experimentation with new business models.

Following these near-term activities, the MECS programme will define a second phase of work in Nigeria building on preliminary insights and findings. This phase of work should seek to unlock market growth by demonstrating a viable business case, support local clean cooking business development, facilitate the development of a Nigerian eCooking taskforce, and support the development of an improved Nigerian eCooking policy environment.

2. Introduction and Context

Access to clean, affordable energy and the appliances to use it is key to global sustainable development and the energy transition. Clean cooking is critical to this transition, as 4 billion people globally continue to use polluting unhealthy fuel options for their cooking needs.[3] The Modern Energy Cooking Services (MECS) programme is helping lead the charge to change this situation, actively working to do so in 15 countries around the world.

This report is the first component of MECS initialization of work in Nigeria. The report provides an overview of the current state of the cooking sector in Nigeria, describes insights into relevant aspects of the broader electricity and policy environment, and identifies major gaps that are preventing adoption at scale.

This first phase of MECS engagement in Nigeria will inform further programme development and lay the groundwork for future collaboration across stakeholders to dramatically accelerate the use of clean cooking technologies in Nigeria, with a particular focus on electric cooking (eCooking). The intended audience is the subset of development partners, government agencies, community organizations, and researchers who are actively considering clean cooking development in Nigeria, as both a useful reference and a preface to potential collaboration with the MECS programme.

The MECS programme's work in Nigeria is part of a much broader strategy to address clean cooking challenges globally. MECS recognizes that existing strategies are struggling to solve the problem of unsustainable and unhealthy but enduring cooking practices (which place a particular burden on women) and looks to accelerate a shift away from business as usual. In particular, the MECS programme has identified eCooking as a set of technologies with significant potential to provide cleaner and lower-cost cooking services. This is particularly true in Nigeria. Despite Nigeria's size and potential, as a market-oriented country with a population expected to grow from 206 million in 2020 to 329 million by 2040, relatively limited progress has yet been made in achieving adoption of clean cooking technologies (see **Section 3.1**).[4]

Nearly half of the Nigerian population resides in rural areas (approximately 49%).[5] The electricity grid either does not reach these rural communities, where the electrification rate is 31%, or is unreliable and typically provides only a handful of hours of power per day (see **Section 3.1**). As a result, major initiatives are underway to rapidly electrify unserved and underserved Nigerians through a variety of means (see **Section 3.1.2**).

Fewer than 1% of households in Nigeria use electricity as their primary cooking fuel, which is low relative to similar countries in Africa.[6] The nascent state of the eCooking market, in combination with the sheer need for modern energy cooking services, means that the opportunity to improve livelihoods and for private sector companies and investors to serve the need, is quite large. The most recent household data shows that Nigeria spends more than US$1.3 billion on cooking fuel each year, much of which could be redirected towards cooking with cleaner fuels.[i]

It is the confluence of these rapid changes, clear needs, and emerging opportunities that has led MECS to prioritize eCooking expansion in Nigeria. The MECS programme is uniquely situated to establish a clear understanding of the cooking landscape in Nigeria, to convene and coordinate the key stakeholders and development partners in the sector, and to develop a plan for rapidly addressing testing, data, and other gaps that stand in the way of eCooking adoption. MECS can lead in these areas building on its global experience and scope and its relationships with major international financiers

[i] Based on 43 million households and a monthly expenditure of 1,000 naira.

and suppliers. At the same time, the programme's current lack of commitments in the country afford it a high degree of freedom to develop an innovative approach.

Similarly, the MECS programme is well positioned to align efforts between clean cooking technologies and eCooking. This report uses the Multi-Tier Framework for Measuring Access to Cooking Solutions tiers 4 and 5 to define access to modern energy cooking services and clean cooking generally.[7] Tiers 2 and 3 of the MTF, typified by improved biomass stoves, are uncommon in Nigeria, and for the sake of focusing on eCooking—as well as the MECS programme's focus on electric solutions—are not discussed in detail here. eCooking is defined in this report as clean cooking with electricity. Typically, in Nigeria, this means induction stoves, rice cookers, or electric pressure cookers using either grid electricity or running on an isolated minigrid.

While the MECS programme has a particular focus on testing and demonstrating the viability of eCooking technologies, the holistic perspective of the programme will allow MECS to help drive eCooking testing while also facilitating necessary strategy development amongst stakeholders for interrelated approaches such as fuel stacking.

To develop this report, MECS partnered with RMI, a non-profit organization that includes Nigeria as a focus geography as part of its Africa Energy Program. RMI led research during October to December 2020 to synthesize existing resources and establish a clear understanding of industry perspectives on the status and viability of clean and eCooking technologies in Nigeria.[ii] RMI performed:

- An extensive literature review, the results of which are referenced throughout and include:
  - Summary of RMI staff knowledge from partnerships in Nigeria.
  - Review and discussion of policy documents.
  - Studies conducted across the MECS programme and other academic literature.
  - Review of datasets from Nigeria's National Bureau of Statistics.
- Video and phone interviews with 23 stakeholders representing the Nigerian government, development agencies, project developers, nongovernmental organizations, and industry associations. Insights from these interviews are included throughout the report (particularly in **Section 3.3**). (Due to the ongoing COVID-19 pandemic at the time of this research, in-person meetings with stakeholders were not possible.)

As noted above, the MECS programme's work in Nigeria is only beginning. In the first half of 2021, MECS plans to lead several activities to align with stakeholders active in Nigeria's clean cooking sector and to refine the programme's planned activities. In particular, this will include:

- A preliminary, multiday convening of stakeholders considering existing or future clean cooking programmes in Nigeria, with an objective of aligning on priority gaps to address and defining collaborative research agendas to maximize collective speed and efficiency.
- Identifying potential programme options for testing eCooking appliances and strategies in Nigeria, in order to fill critical data gaps and to drive experimentation with new business models.

Subsequent to these near-term activities, the MECS programme will define a second phase of work in Nigeria building on preliminary insights and findings.

[ii] This research was supported in part by Garner Advisors, a consultancy with more than a decade of experience in the clean cooking industry globally.

3. Overview of the Nigerian Landscape

Nigeria is the largest economy in sub-Saharan Africa, with an annual GDP of $448 billion (27% greater than South Africa), and is also Africa's largest nation by population, with more than 206 million residents.[8] Nigeria encompasses a diverse set of geographic, climatic, religious, and cultural characteristics. To reflect this diversity, in 1995, Nigeria's 32 states were divided into six different regions, or geopolitical zones largely along ethnic and historical lines: South-East, South-South, South-West, North-Central (or Middle Belt), North-East, and North-West (Exhibit 1).[9]

These zones are not typically used for formal governance purposes but do play a role in federal policy and decision-making, particularly as a tool to ensure that undue preference is not being given to particular regions of the country. (For example, this is a consideration in allocation of power sector funding and pilot project development by federally administered programs). Within these zones, Nigerians are spread between a number of high-density urban pockets, scattered medium-density peri-urban areas, and vast tracts of low-density rural areas (Exhibit 2).[10]

Exhibit 1: Map of Nigeria's six geopolitical zones. Source: NIMC

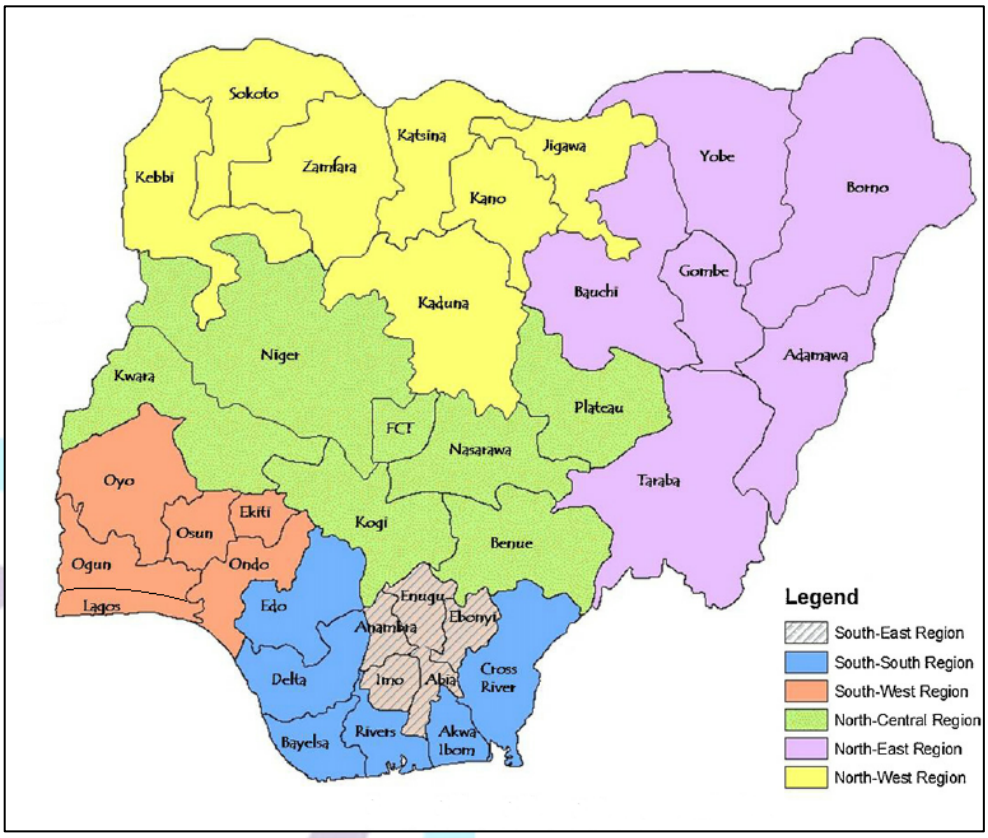
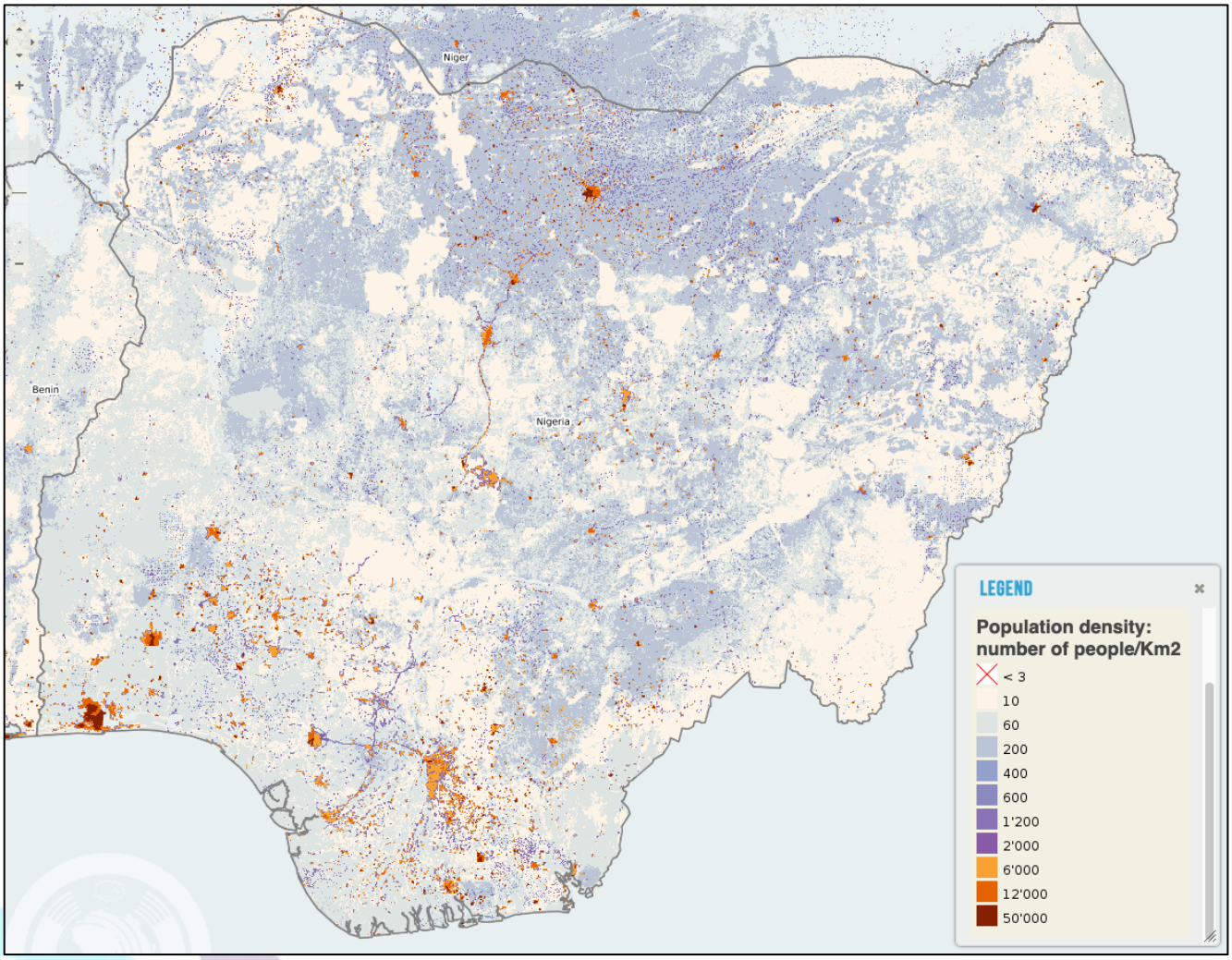


Exhibit 2: Population density across Nigeria as of 2010. Source: ECREEE



Oil deposits were discovered in the Niger River delta in the 1950s, and oil and gas revenues have played a major role in Nigeria's economy since. As of 2021, Nigeria is the largest oil and gas exporter in Africa. The oil and gas sector generate 86% of export revenues, and the resulting politics and revenues play a determining role in the country.[11] That said, Nigeria's economy has taken steps towards diversification in recent years, increasing non-oil exports particularly in agro-processing, technology, and creative industries.[12]

This section provides details on three aspects of Nigeria's energy landscape important from a MECS and clean cooking perspective: the electricity sector (both on-grid and off-grid), cooking (clean and otherwise), and key stakeholders. The following subsections delve into each of these aspects individually.

3.1 Electricity

As the MECS programme considers the possibilities for eCooking in Nigeria, it does so in the context of an electricity sector that is rapidly evolving, but which faces challenges on multiple fronts. From an eCooking perspective, there are three first-order metrics to consider: access, reliability, and cost.

- Access: As of 2018, just 57% of Nigerians had access to electricity, which is concentrated among urban populations, where 81% has access to electricity. Only 31% among the rural population has electricity access.
- Reliability: The central electricity grid approaches 18–20 hours of supply per day for wealthy urban areas although outages are common; in rural communities, supply is often just 1–3 hours per day.
- Cost: Grid tariffs are relatively affordable, ranging from ₦30/kWh–₦70/kWh (US$0.08/kWh–US$0.19/kWh)[iii] for residential customers depending on a pre-determined reliability level provided by the utility, but supplementary generation is much more expensive (as explained below).

From these three metrics alone, it is plain to see that electrifying cooking in Nigeria is not a straightforward proposition. In the near term, success will be linked to targeting the appropriate combination of access, reliability, and cost where eCooking appliances are economically and technically viable. As time progresses, however, it is likely that these dynamics will change.

The problems that currently plague Nigeria's electricity sector are not lost on policymakers, development agencies, or private companies. There is a clear national directive to expand access, improve the operation of the central grid and commercial viability of its operators, and reduce the cost burden that Nigerians currently face. To that end, major initiatives have been undertaken in the past decade, and even in the past year, to inject new life and innovation into the sector. However, the sector is complex and even these significant efforts will not lead to overnight change—to make progress in the near term, MECS should design around the sector as it exists today.

To explore where the ideal set of conditions may exist, and how the evolving Nigerian electricity sector may affect them, the remainder of this section is divided into background on and discussion of (1) the on-grid sector and (2) the off-grid sector. Implications for eCooking testing are included throughout, and further highlighted in **Section 6.2**.

3.1.1 On-Grid

Background

Nigeria's on-grid sector has changed dramatically over the past two decades, but these changes have not yet led to the substantial service improvements that were intended. The most notable of these changes is the privatization of portions of the on-grid value chain. Since Nigeria gained independence in 1960, up until 2005, the federal government had been responsible for ownership and operation of

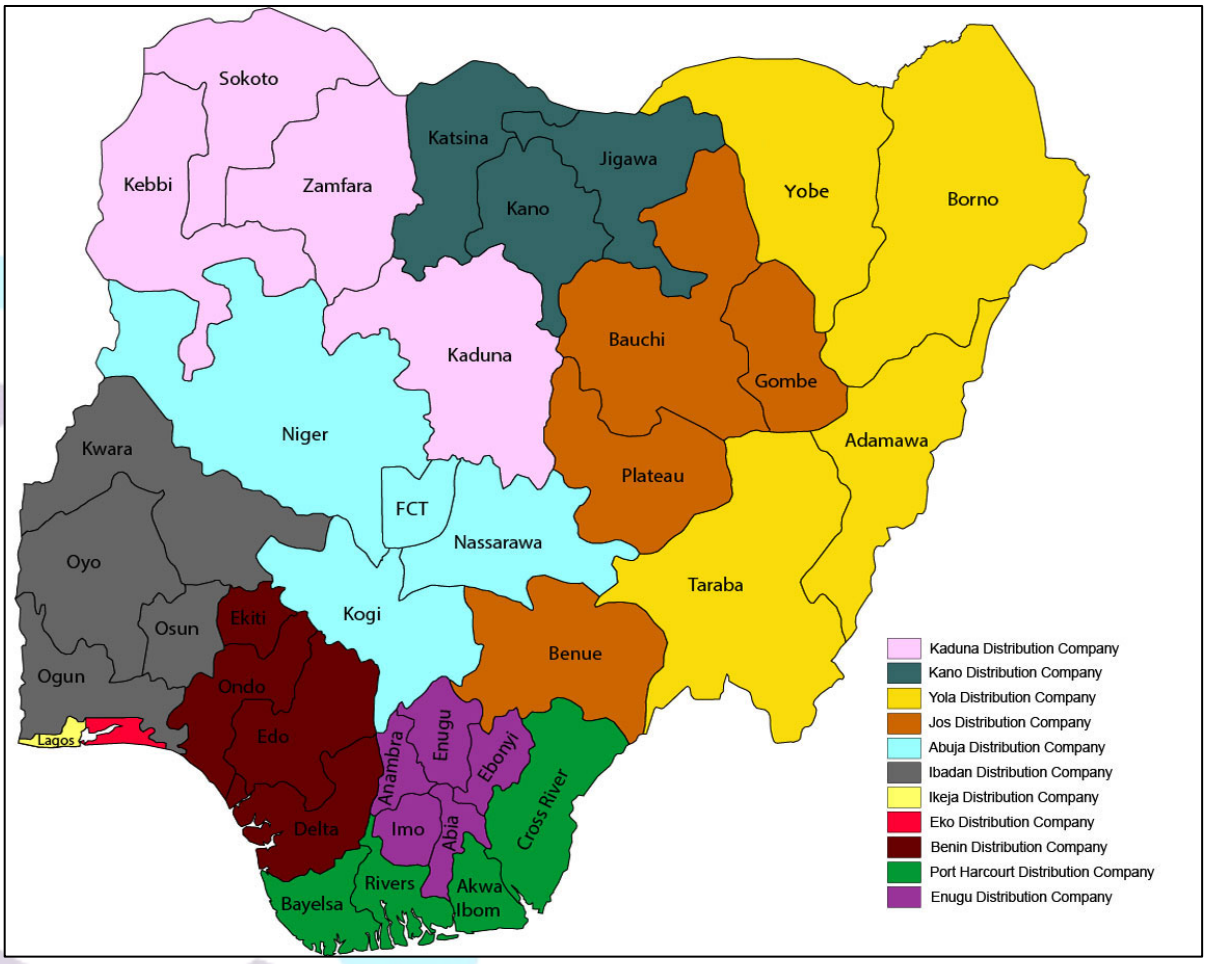
[iii] Throughout this report we refer to financial figures in Nigerian currency, naira (₦), and convert to US dollars ($) for ease of international reference. While Naira foreign exchange rates are, at the time of this writing, in a period of flux, we apply an exchange rate of ₦360 to US$1, which was the relatively consistent rate between August 2017 and March 2020, a period during which the majority of figures referenced in this report originated (www.xe.com/currencycharts/?from=USD&to=NGN).

the electric grid. This operated under many names but was most recently known as the National Electric Power Authority (NEPA).

In 2005, the government enacted the Electric Power Sector Reform Act (EPSRA), which was intended to facilitate a transition from government ownership and operation of the grid to the private sector. Policymakers, with the encouragement of international advisors who saw success in recent privatization efforts in the UK, United States, and elsewhere, believed that privatization would enable increased investment in the power sector, addressing major challenges with reliability, collections, and operational modernization. A key outcome of the EPSRA was the creation of the Nigerian Electricity Regulation Agency (NERC), which now oversees the electricity industry as an independent regulator.

The EPSRA resulted in the formation of the Power Holding Company of Nigeria (PHCN) to take control of assets from NEPA. PHCN unbundled these assets, allowing the government to mostly divest from generation in the country by 2013, to maintain control of transmission assets (through the current Transmission Company of Nigeria), and to partially divest from distribution ownership. Distribution companies (DisCos) now occupy the keystone of Nigeria's power system, as they sit at the interface of customers and the transmission network, with the country split between 11 DisCo service territories (Exhibit 3).[13] The DisCos were privatized in 2013–14 as part of PHCN's unbundling, with the federal government retaining 40% ownership of the companies.[14]

Exhibit 3: Map of Nigerian DisCo service territories. Source: Nigerian Electricity Regulation Agency



To date, DisCos have struggled to significantly improve the power system as planned. Despite improvement efforts, aggregate technical, collections, and commercial (ATC&C) losses have remained high (as discussed below). Coupled with tariffs that were not properly cost reflective, this has created massive revenue shortfalls. In the first three quarters of 2018, for example, it is estimated that just 48% of the revenue requirement was collected—a ₦356 billion ($989 million) gap.[15] This under collection of revenue has not only affected DisCos, however, as the gap is shared across transmission and generation stakeholders as well, with lower than anticipated remittances. For MECS eCooking programme purposes, the key aspects of the industry's recent history become clear when considering current operational dynamics.

Current Infrastructure

Nigeria's transmission and distribution infrastructure is largely outdated, and is a significant contributor to both ATC&C losses and outages. Beginning at the transmission level, coverage is limited and there is minimal redundancy within the network (Exhibit 4).[16] The network is most dense in the southern regions and in central Nigeria around the Federal Capital Territory. There is limited capacity across the network generally, but specific bottlenecks also contribute to customer outages as centralized power plants cannot generate to full capacity.

Exhibit 4: Nigeria's electricity transmission network. Source: World Bank

Distribution infrastructure is much more variable across Nigeria. Key overarching problems are dilapidated infrastructure, limited planning visibility and mapping (even at the medium voltage level), limited situational awareness of system conditions, and limited metering. In certain areas, DisCos have managed to focus their budget on keeping reasonably well-maintained poles, wires, and transformers. These tend to be higher-income districts within their service territories, where meters are present and ATC&C losses are relatively low, making the investment financially justifiable. However, in rural areas infrastructure tends to be in various states of disrepair, often with improvised poles and without metering.

Mapping of distribution networks for planning purposes is improving, but still incomplete. In 2020, GIZ and the Federal Ministry of Power released the *Nigeria SE4ALL* tool, which has begun providing manually collected geospatial data for medium-voltage networks in a number of states (Exhibit 5). System visibility for both planning and operational purposes is likely to continue improving, but significant change is unlikely in the near term. Metering, however, has been a top priority for DisCos and for NERC in recent years, and coverage has improved to 40.4% of those with electricity service as of 2020. Data accuracy is questionable (for instance, 2018 reporting estimated coverage at 44.5%), so exact changes are unknown, but recent tracking has shown a gradual quarterly increase.[17] The level of metering is highly variable by DisCo, however (Exhibit 6).

Exhibit 5: Map of medium-voltage distribution network in Oyo state. Source: Nigeria SE4ALL

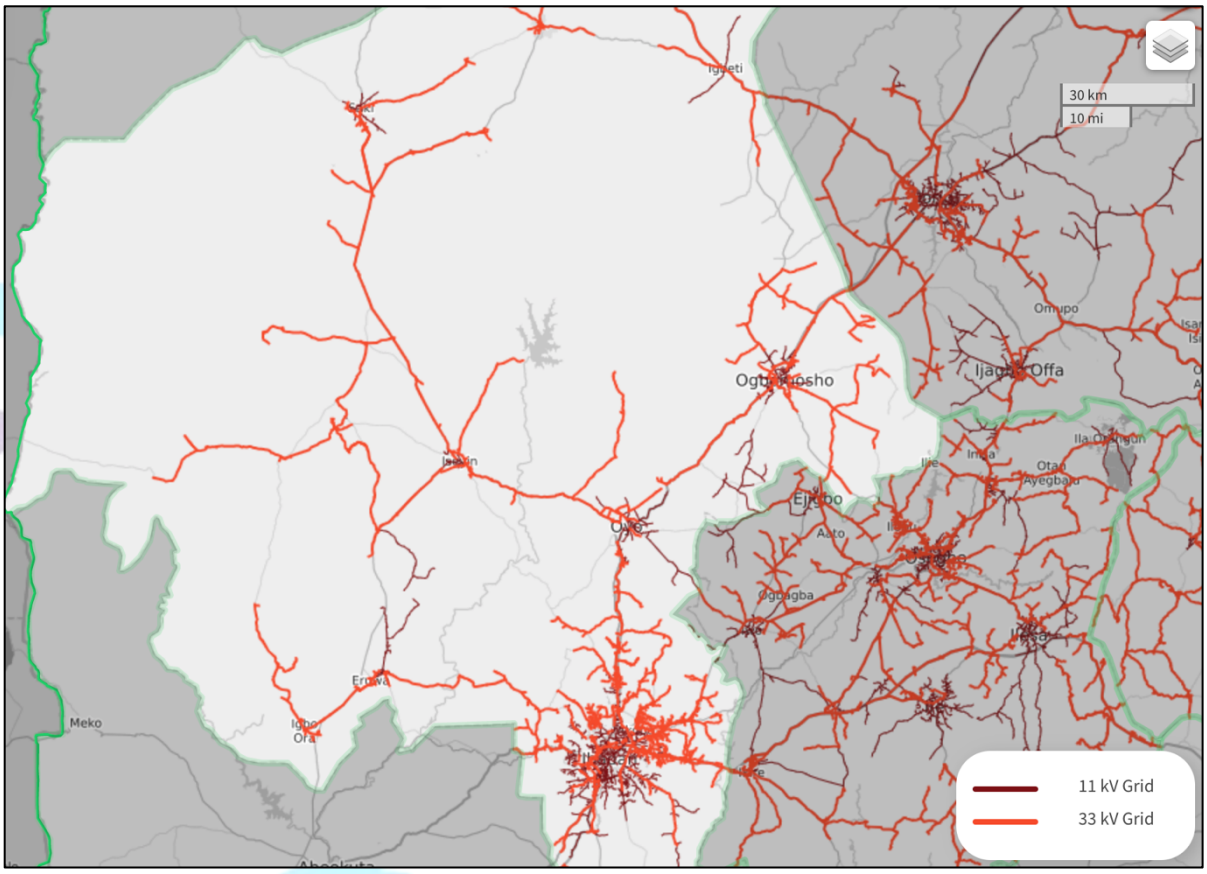
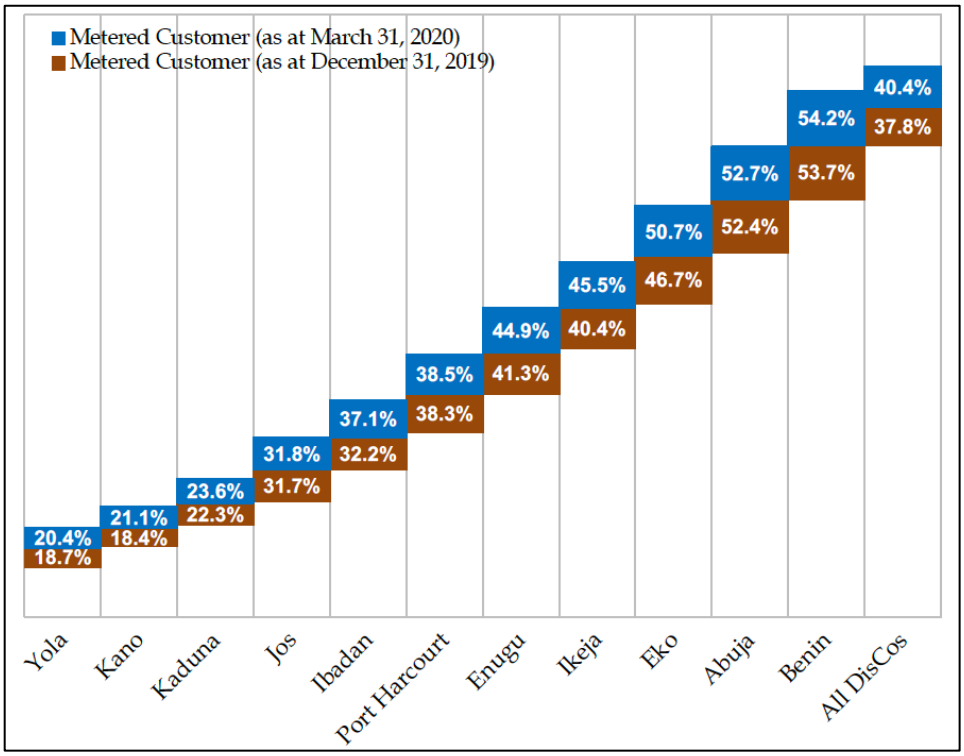


Exhibit 6: Reported metering rates for Nigerian DisCos in 2020. Source: NERC



Centralized generation in Nigeria is dominated by gas-fired thermal power plants, which make up 81% of the 12,522 MW installed nationwide, with the remainder being hydroelectric.[18] However, at any given time only 3,500–5,000 MW of this capacity is available, due to maintenance and gas supply issues, as well as transmission constraints.[19] There is a significant amount of additional generation capacity that exists beyond the centralized grid in the form of backup diesel, petrol, and compressed natural gas generators. Data on these generators is not centrally collected, and estimates vary widely, but place the additional capacity from these generators at a minimum of 14,000 MW. A2EI estimates that only in small gasoline generators up to 4 kVA, there is 42,000 MW of capacity in Nigeria.[20]

Regardless of the actual amount of capacity, it is clear that a majority of Nigerians rely on these backup generators for a significant amount of their electricity needs. While reliable data is unavailable, anecdotal evidence shows this to be true across a range of urban and rural settings.[21] In urban settings where grid reliability is higher, some customers also supplement the grid with battery backup systems, though this is less common. The cost implications for customers using these fossil-fueled backup generators is discussed later in this section.

Operations and Customer Costs

As demonstrated by the vast differences in infrastructure coverage discussed above, on-grid electricity provision across Nigeria is not uniform. Within DisCo service territories this provision is variable as well. Precise data on grid reliability is sparse, but on average between 2013 and 2015, the World Bank estimates that in Kano City (in Northern Nigeria) the system average interruption duration index (SAIDI) was 1,666 hours per year, and the system average interruption frequency index (SAIFI) was 185 events per year. In Lagos City, in Southern Nigeria, SAIDI was 3,433 hours per year and SAIFI was 540 events per year for the same period.[22] For comparison, Dar Es Salaam in Tanzania had SAIDI and SAIFI scores of 69 and 61, respectively, for that period.

In addition to the reliability of the grid, DisCos' ability to recover revenue for electricity delivered varies widely. Exhibit 7 shows the variation in ATC&C losses across Nigerian DisCos, and how those losses differ from the targets included in their tariffs set through NERC's multi-year tariff order (MYTO) process.[23] Because of these losses, one of the few tools available to DisCos in the near term to manage revenue recovery is to direct power to areas of their network where ATC&C losses are lowest. Exhibit 8 shows an illustrative breakdown of metering by service zone for a typical Nigerian DisCo, based on RMI experience.

Again, while detailed data is not publicly available, the metering levels tend to correlate with service level and reliability—areas with greater metering can be served with lower losses, and therefore are prioritized for available supply. Rural zones where other challenges are prevalent (infrastructure issues, theft, etc.) tend to have lower metering rates at present. The cumulative effect of these dynamics is that rural and lower-income areas tend to have poorer reliability than higher-income areas with lower ATC&C losses.

Exhibit 7: ATC&C losses by DisCo for 2019–2020, compared with MYTO targets. Source: NERC

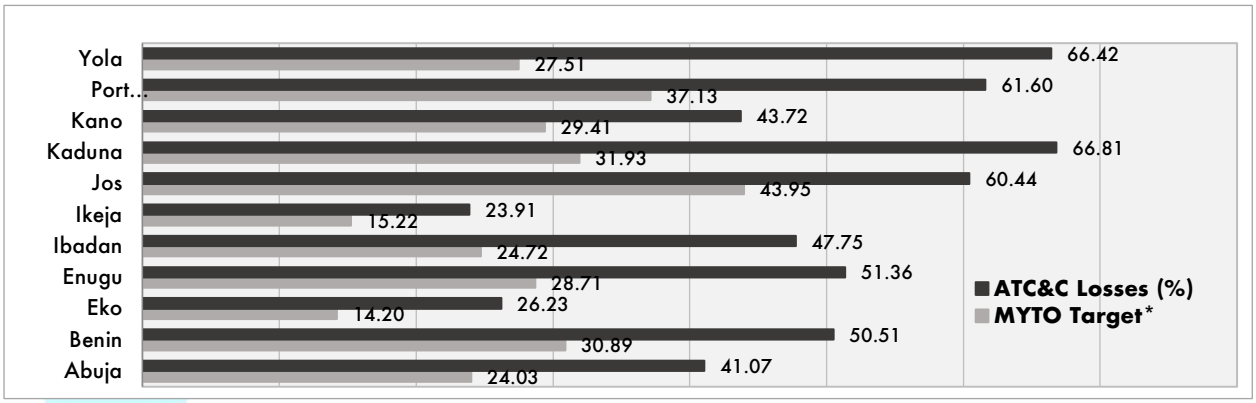
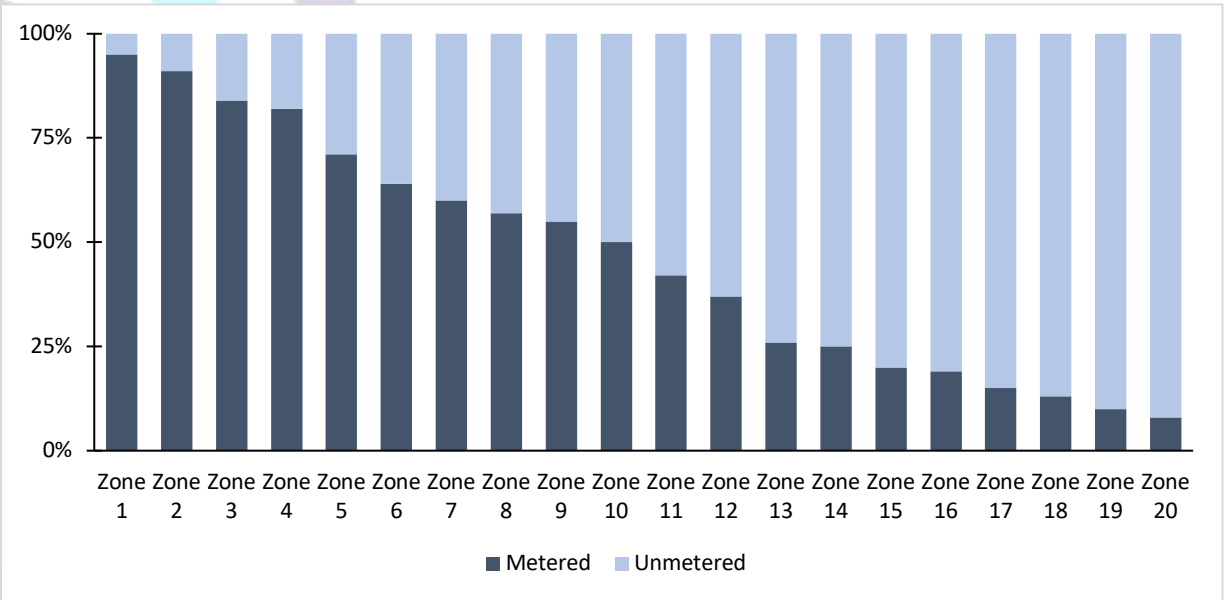


Exhibit 8: Illustrative metering levels for a typical Nigerian DisCo, by geographic zone

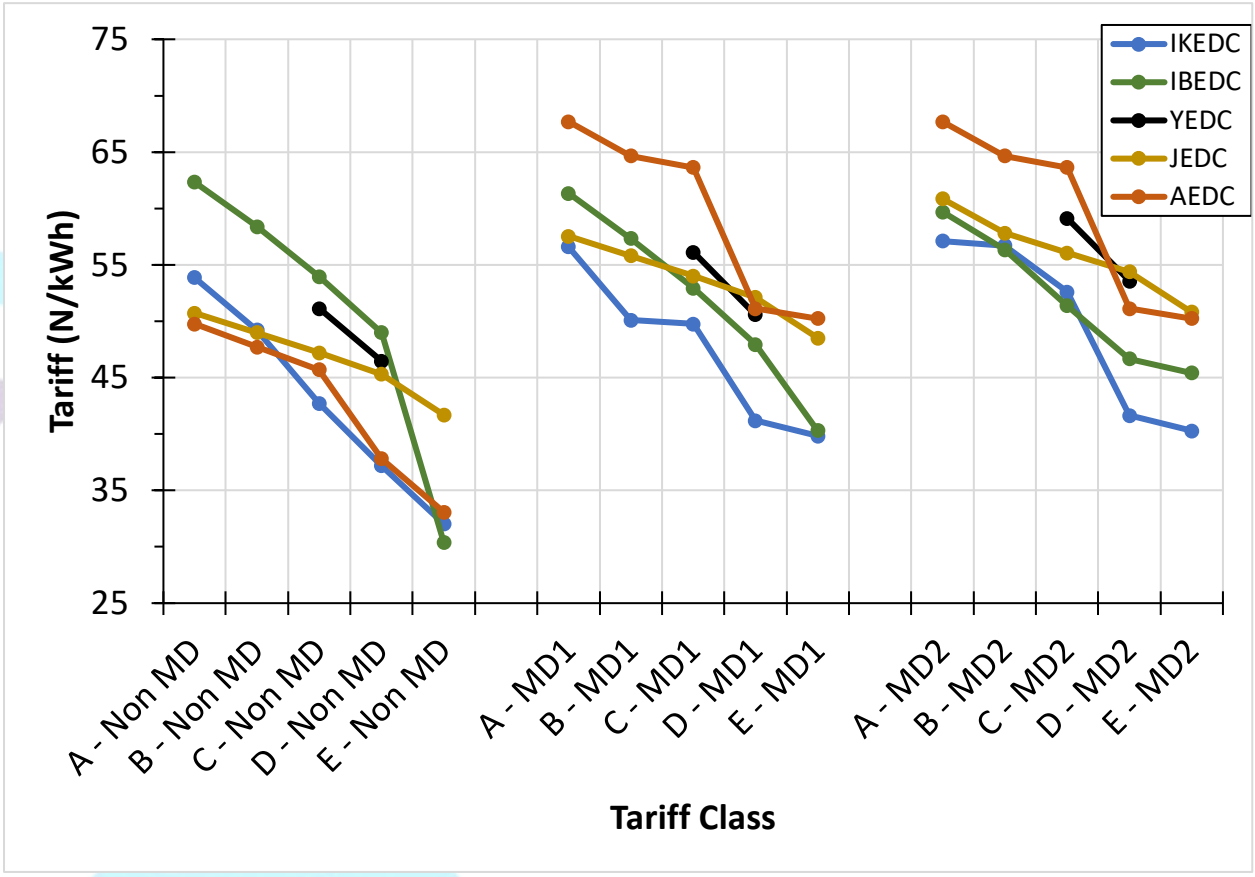


DisCo tariffs have historically varied by customer type, and are set through the MYTO process with NERC approval. Tariffs are revised infrequently through a formal review process to reflect changing costs, but implementation of those changes tend to be slowed by political and equity considerations. In 2020, NERC approved a minor tariff review for DisCos, which resulted in adopting a revised structure for tariff classes and a recommitment to including cost-reflective assumptions. Instead of differentiating primarily by customer type (residential, commercial, maximum demand, etc.), the new structure also differentiates tariff classes by service level.

New "A band" tariffs require service at a minimum of 20 hours per day, while bands B, C, D, and E call for 16, 12, 8, and 4 hours per day. Tariffs are proposed and set for each DisCo individually, and while they do vary between DisCos the revised tariffs follow a consistent trend with variations typically less than ₦10/kWh (Exhibit 9).[24] DisCos also offer a standard "lifeline" tariff of ₦4/kWh for very low-income customers with maximum usage of 50 kWh per month (this is required by EPSRA). Naira exchange rates are in a period of flux but, at a rate of ₦360:$1, these tariffs range from roughly $0.08/kWh–$0.19/kWh.

As of January 2021, these revised tariffs have yet to go into effect due to ongoing negotiations with various customer unions and political considerations. These revised tariffs will reduce DisCo losses in rural and high-loss areas. However, without rapid ATC&C loss reductions it is still expected that DisCos will lose money on every kilowatt-hour sold to customers in these areas.

Exhibit 9: Comparison of revised MYTO 2020 tariffs across DisCos by tariff class (Medium and large commercial and industrial customers are referred to as "maximum demand" or "MD" customers)



Innovation and Sectoral Outlook

While immediate improvements across the on-grid sector are unlikely, there is increasing and significant attention from policymakers and development agencies to drive change. Several recent initiatives have been developed by various agencies, including more operationally minded efforts from NERC, and larger-scale approaches through the President's office. A unifying feature among them is a departure from the status quo, and a fairly significant emphasis on attempting innovative approaches, recognizing the severity of the current challenge.

Two especially notable policy edicts in recent years have come through the Federal Ministry of Power (FMP) and NERC. The first—the "willing buyer, willing seller" policy—is more ethos than policy but has had a significant impact on the approach taken by Nigerian policymakers and sector stakeholders.[25] In effect, this policy has served as notice that the Federal Government of Nigeria is open to all options for improving the supply of power; if two parties are in agreement, the government will seriously consider support even if an approach falls outside the bounds of existing regulation or policy.

While formally announced by FMP and the Vice President in 2019, this approach has effectively been taken for several years within Nigeria's electricity sector, and has opened the doors to several innovative approaches through recent regulation:

- In rural areas, an "undergrid" minigrid model utilizes the NERC Minigrid Regulation to allow partnerships between a DisCo, community, and third-party minigrid developer to improve supply and operate using cost-reflective tariffs. Ibadan Electricity Distribution Company has led the way on this model, developing a pilot project in the community of Mokoloki with Nayo Tropical Technologies supported by RMI.[26]
- In urban areas, the Minigrid Regulation is also being used to enable DisCo-enabled projects with commercial and industrial customers, where a third-party provider installs generation and serves the customer while remaining interconnected to the grid. Abuja Electricity Distribution Company has been a leader in exploring these models, with a pilot project underway at Wuse Market in Abuja, and ongoing programme development with RMI funded by USTDA.[27]
- NERC has recently proposed a franchising regulation, which opens the door to a broader approach being explored by the company Konexa in partnership with Kaduna Electricity Distribution Company, wherein Konexa will take responsibility for serving a feeder within the DisCo's territory through a subfranchising agreement.[28]

A second recent policy effort has been the development of DisCo performance improvement plans (PIPs) required by NERC.[29] These PIPs are intended by NERC to help the DisCos identify and prioritize investment plans, operational improvements, and targets to improve service in their area. The formal process was initiated in 2019 and completed in 2020, with plans developed by each DisCo for the years 2020–2024.

In the longer term, the FGN is facilitating partnerships that may result in significant investment into Nigeria's electricity sector. A recently announced public-private partnership (PPP) with Siemens could enable investment of $2 billion into transmission and distribution improvement projects through a bilateral loan with the German government.[30] Initial investment targets would include new substations and lines at both transmission and medium-voltage distribution levels, which could significantly improve service reliability in a number of areas. The timeline for implementation is unclear, as a roadmap was developed in 2019 but has not been updated to reflect changes in the time since. In addition, investment is contingent on a number of financial contributions by FGN and by DisCos, which would sign convertible loan agreements rather than provide capital.

A similar effort with the World Bank was initiated in 2017 as the Power Sector Recovery Program (PSRP), which would have leveraged a $1 billion performance-based loan along with FGN investment to execute over $6 billion of improvements across the power sector. The PSRP stalled in 2018 when Nigeria's National Assembly refused to approve the loan. This approach has recently been resuscitated as the Power Sector Recovery Operation (PSRO), which would seek a $750 million World Bank performance-based loan. The PSRO is in active development, but unlikely to close before 2023.[31]

On balance, the PIPs and "willing buyer, willing seller" policy underscore the current focus of the sector: reduce financial losses and improve supply to customers. The need to improve both of these areas is very nearly the sole focus of DisCos and most others in the power sector, and issues like demand-side management and appliance efficiency have received much less attention by comparison. The Siemens PPP, PSRP, and PSRO reflect the FGN's focus on attracting a large-scale capital injection to the sector for infrastructure improvement.

3.1.2 Off-Grid

Background

As with the on-grid sector, the challenges plaguing access to energy in Nigeria are not a recent phenomenon. Exhibit 10 shows the trends in Nigeria's population growth and access to electricity in both urban and rural settings over the past three decades.[32] As of 2018, approximately 50% of Nigeria's population were urban dwellers. Recognition of these challenges is not new either; while there has been incremental progress on electricity access for rural communities, population growth has complicated efforts to increase the overall electrification rate.

In the past decade, electricity access for Nigeria's rural population has stayed relatively constant near 30%, while that for urban populations has hovered just over 80% since 1990. Given the reliability challenges of Nigeria's grid, "electricity access" can be a misleading term, especially in rural areas. As discussed in **Section 3.1.1**, many of these communities receive minimal electricity from the grid, even if technically connected (a similar problem to that observed in other countries, such as India). Electrification varies significantly by region, as Nigeria's states have access rates ranging from about 10% in Taraba State to nearly 100% in Lagos State as of 2015 (Exhibit 11).[33]

Exhibit 10: Annual electricity access rates and total population in Nigeria from 1990 to 2018. Data source: World Bank

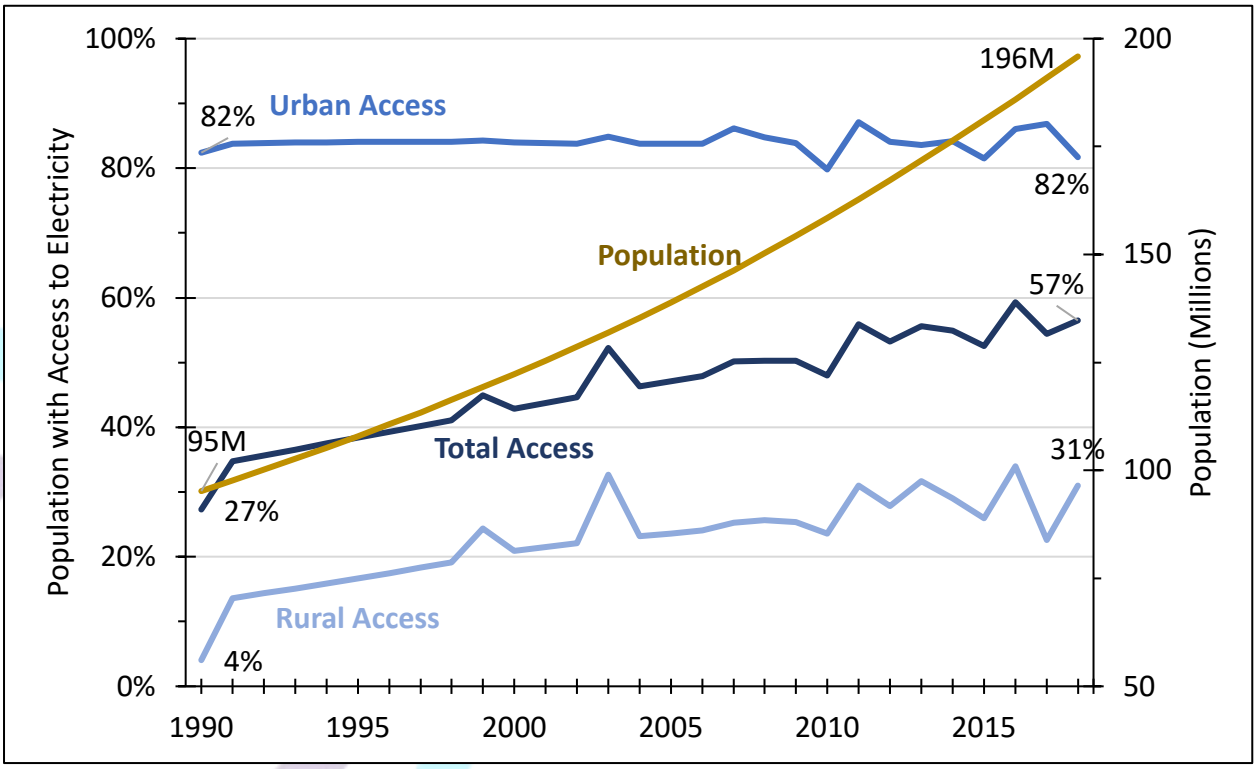
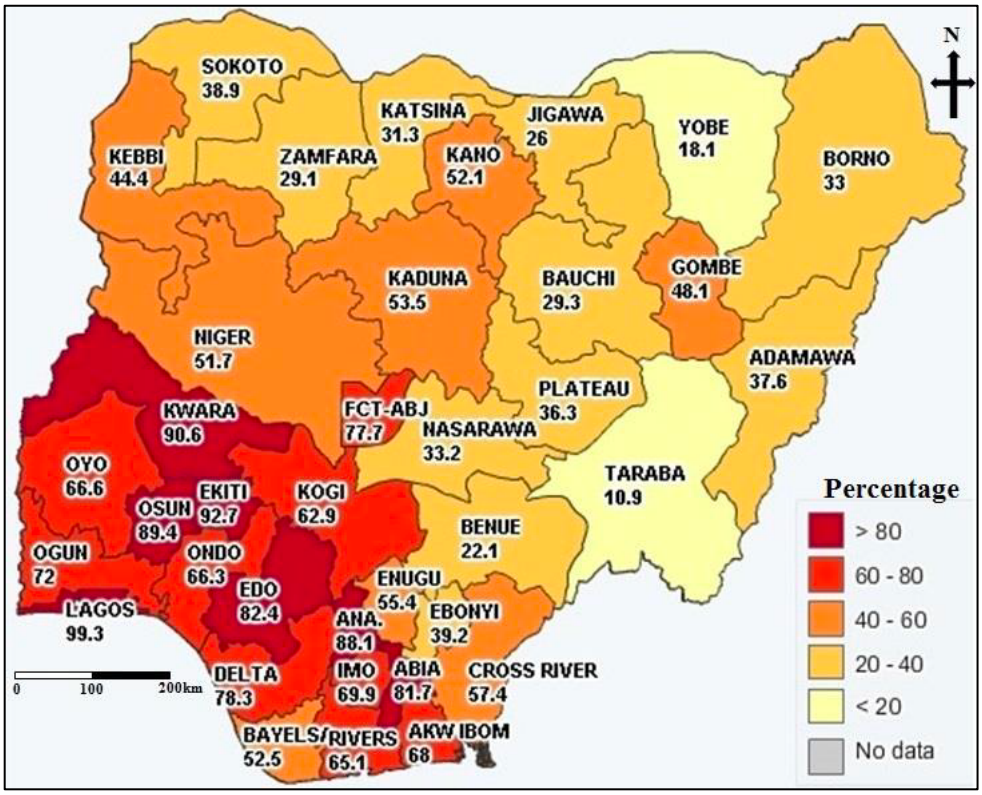


Exhibit 11: Percentage of Nigerian households with electricity access, by state, as of 2015. Source: Akpan Uduak



The primary government agency responsible for addressing electricity access in Nigeria is the Rural Electrification Agency (REA), which sits under the Federal Ministry of Power. The REA was established in 2006 as part of the EPSRA and is tasked with promoting and coordinating electrification in Nigeria, as well as direct implementation of projects through its Rural Electrification Fund (REF). Since the 2017, the REA has been particularly effective, with new leadership, new programmes, and new implementation strategies (discussed below).

International development agencies also play an important role in supporting rural electrification in Nigeria, including Deutsche Gesellschaft Internationale Zusammenarbeit (GIZ), Foreign, Commonwealth & Development Office (FCDO), United State Agency for International Development (USAID), the African Development Bank (AfDB), the World Bank, and numerous philanthropic foundations. These agencies have supported reform efforts, advised on regulation, and in many cases provided direct grants to enable project development. The most relevant active efforts are discussed later in this section.

Current Infrastructure

Grid extension projects have been limited in recent years in Nigeria, due in part to the minimal capital that DisCos have available to invest in infrastructure expansion.[iv] Instead, in the past decade rural electrification efforts have taken advantage of global cost declines in solar and battery storage technologies to focus on solar minigrid and solar home system (SHS) projects. These modular

[iv] Some grid extension projects are conducted by REA through capital appropriation projects, as well as by state agencies.

technologies have enabled a rapid shift in strategy—the majority of rural electrification efforts are currently focused on these two technologies.

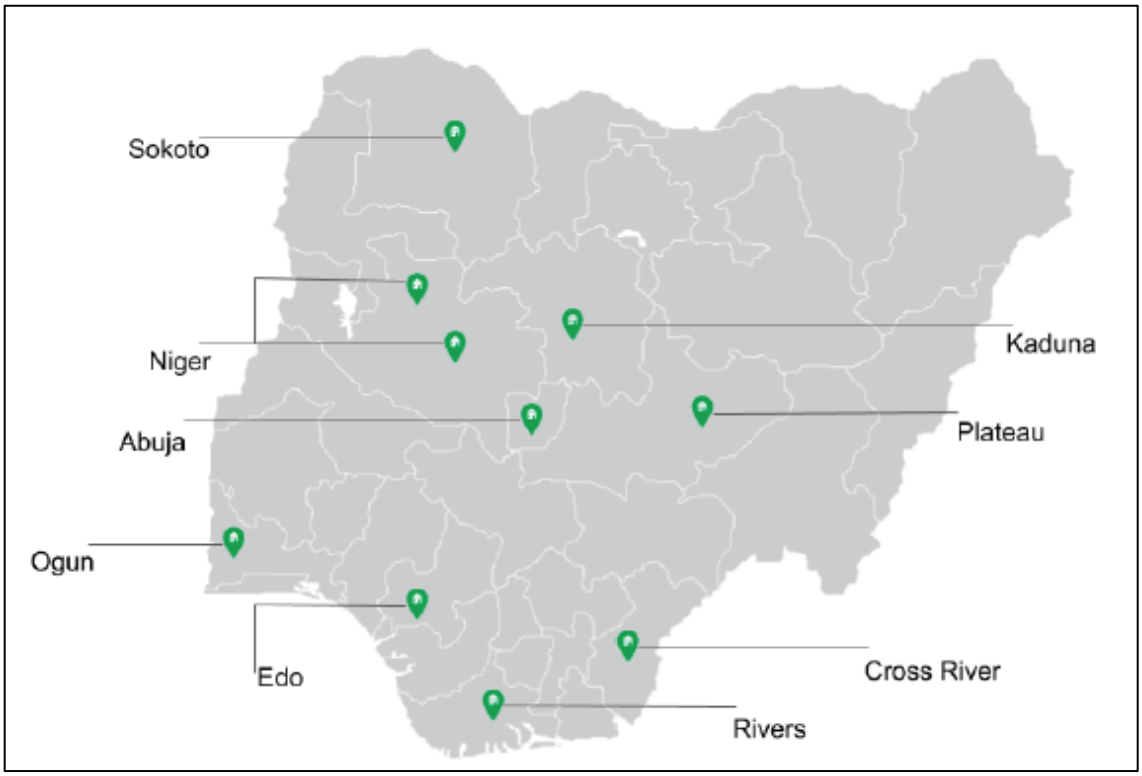
SHSs have expanded rapidly in Nigeria, as their lower cost makes them accessible to individual consumers, and therefore they have been highly commercialized (Exhibit 12).[34] GOGLA estimates over 300,000 systems were sold in Nigeria in 2019 alone, by far the largest market in West Africa.[35] Because these SHSs are relatively small, usually under 200 W, they are not appropriate for supplying power-intensive eCooking appliances without significantly oversized batteries.[36] For example, the *Prime* and *Eco* Lumos units in Exhibit 12 are 160 W and 80 W, respectively (some larger capacity SHS units exist, but are much less common). This drives up the capital cost of the SHS, compromising one of its main advantages and complicating the existing commercial business model. While there may be opportunities for technological innovation to reduce the cost of these systems, in the near-term they would not appear to be a strong path to commercially viable eCooking expansion in rural Nigeria.

Exhibit 12: Illustrative advertisement from Nigerian SHS provider Lumos, common on social media and print advertisements. Source: Lumos.

Nigerian minigrids, on the other hand, can be anywhere up to 1 MW in capacity, but development of these systems remains much more nascent. While the exact number of operational minigrids has not been recently or comprehensively tallied, as of 2018 there were ten commercial minigrids operating in Nigeria (Exhibit 13), and in the years since, verbal sources and press releases indicate that at least a dozen additional projects have come online.[v37]

[v] Exact counts require detailed data collection, as the term "minigrid" is often used incorrectly to describe small projects, and because in some cases projects that were entirely grant funded are not functionally operational after commissioning.

Exhibit 13: Operating commercial minigrid projects in Nigeria as of 2018. Source: NESG and RMI



There is, unfortunately, not a north star electrification plan for Nigeria as of yet.[vi] A number of geospatial mapping efforts have been undertaken to move towards a comprehensive understanding of rural communities, but there have been significant data gaps.

Exhibit 14 shows one such mapping effort by the REA, pinpointing communities appropriate for either a minigrid or solar home system.[38] Exhibit 15 shows another approach, taken by GIZ's Nigeria Energy Support Programme (NESP), which attempts to optimize the technology used for communities based on satellite-derived data in select states.[39] Exhibit 16 shows a similar approach by the International Energy Agency (IEA) in its 2019 Africa Energy Outlook, which optimizes between technologies while factoring in planned transmission extensions.[40] There are significant differences between these mapping and planning efforts, the details of which are beyond the scope of this study. For MECS purposes, however, it is notable that all of these plans show significant use of minigrid systems in the coming decade, and REA has a general target of enabling 10,000 minigrids.

[vi] SEforALL has, as of January 2021, initiated procurement for an integrated planning study for electrification, clean cooking, and other sectors in Nigeria and Sierra Leone, which may provide a more-holistic planning assessment.

Exhibit 14: Potential communities appropriate for SHS or minigrid systems, as modelled by REA

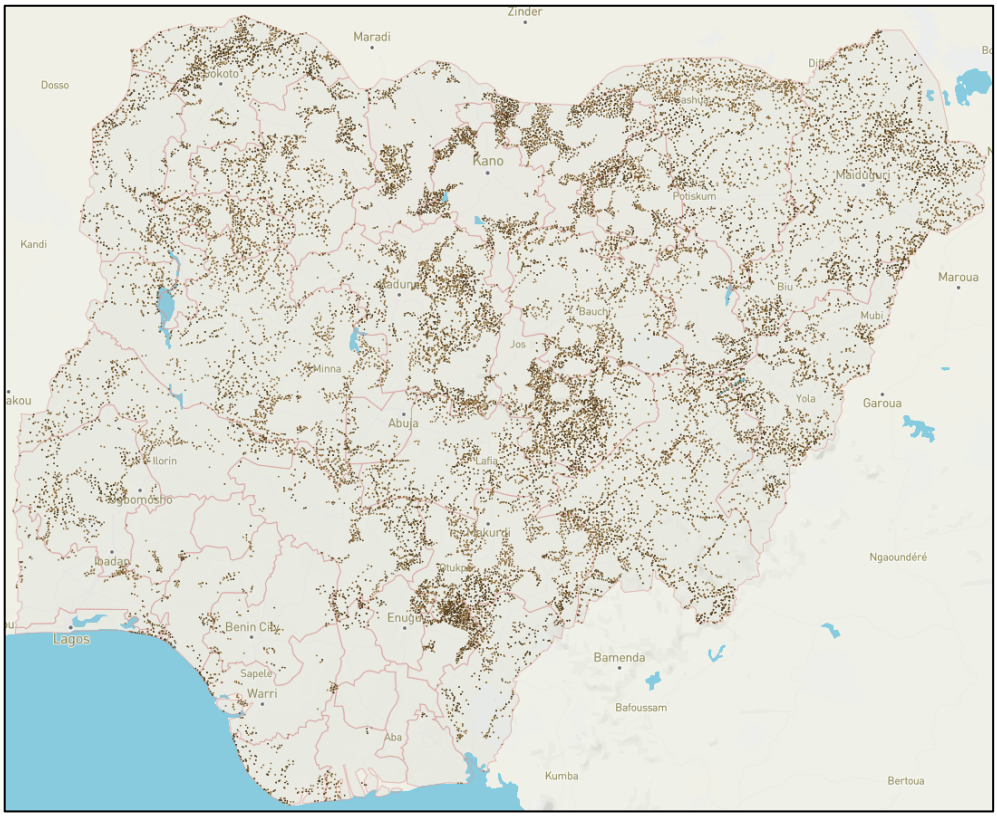


Exhibit 15: Phase 2 electrification technologies for communities in Plateau State, as modelled by GIZ

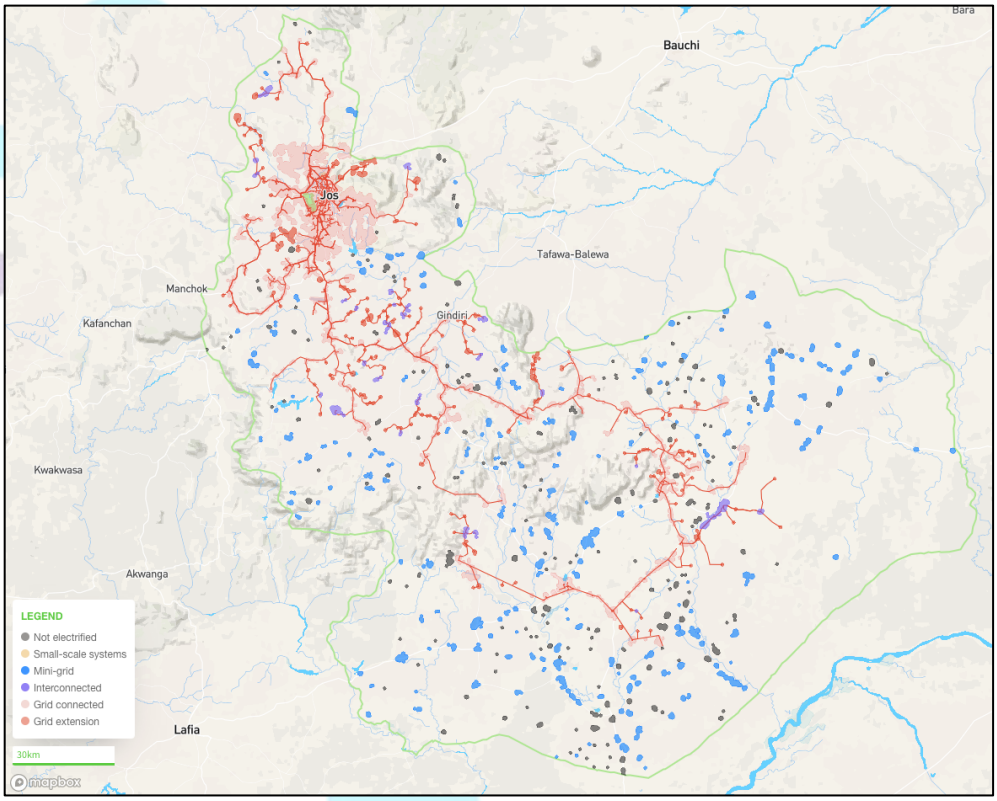
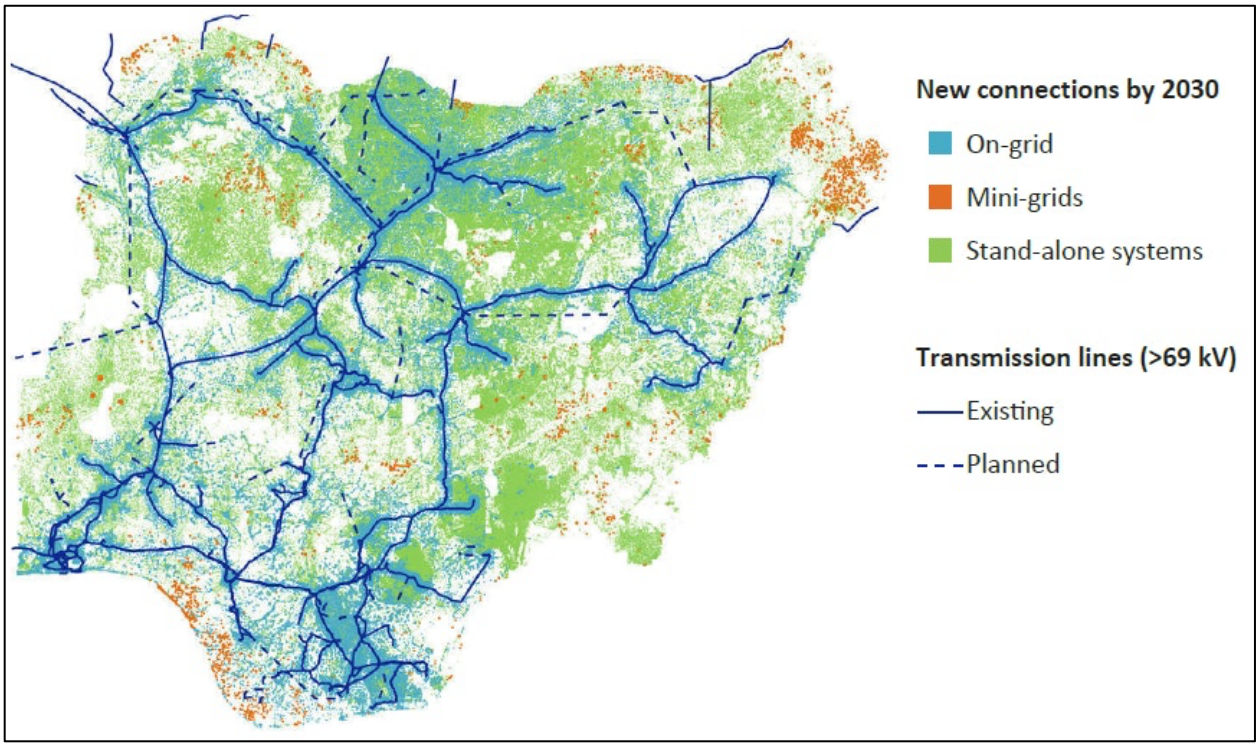


Exhibit 16: Electrification technologies in Nigeria by 2030, as modelled by IEA



Operations and Customer Costs

As noted above, customer cost is a primary metric to consider for the MECS programme and future testing. In rural Nigeria, it is common for off-grid communities to utilize fossil-fueled generators to power their homes and businesses (this is true in most grid-connected rural communities as well). Small "pass my neighbour" 1 kVA generators are common in rural households, while wealthier households and small shops and artisans may have 5–6 kVA generators. Larger commercial businesses in these communities have larger gensets, on the order of 10–30 kVA.

In a typical community, there are both diesel and petrol generators, which impacts the operational cost. Also affecting the operating cost is the fact these generators are usually old, have not been optimally maintained, and are frequently suboptimally operated at poor fuel efficiency. Given these factors, a universally accurate levelized cost estimate for these gensets does not exist. What is clear, however, is that Nigerians that rely on fossil-fueled generators for their electricity pay a very high cost for power. For MECS purposes, this means that eCooking is unlikely to be a viable option in these communities.

Minigrids, as noted above, are truly changing the rural electrification landscape in Nigeria. The majority of these minigrids are solar-battery hybrid systems between 40 and 200 kW, with most including diesel backup generation.[vii] Current commercial minigrid tariffs in Nigeria are as low as ₦120/kWh ($0.33/kWh). From private interviews with minigrid developers, tariffs in most for new projects are ₦150/kWh–₦200/kWh ($0.42/kWh–$0.56/kWh). On the high end, at least one older, over-sized minigrid charges a tariff of ₦300/kWh ($0.83/kWh).[41] Given that no comprehensive survey has been conducted since 2018 (when a median tariff of ₦200/kWh was identified), based on the range of known costs, ₦160/kWh ($0.44/kWh) is a reasonable benchmark tariff for comparison purposes.

[vii] There may be a limited number of opportunities for minigrids using run-of-river hydro generation in Nigeria, and there has been interest in biomass for generation, but neither of these is expected to be commonly used in the near future.

Minigrid costs have significant room for reduction. RMI analysis of minigrid cost components in 2018 found that tariffs near $0.20/kWh should be readily achievable in Nigeria, while ESMAP in 2019 estimated an opportunity to reach $0.25/kWh by 2025.[42] While the industry has matured more slowly than expected, costs have declined since RMI's 2018 analysis, at which point the typical tariff was above $0.20/kWh. Regardless, the tariffs on Nigerian minigrids are significantly lower than those of their East African counterparts. For example, recent eCooking analyses by ESMAP and A2EI assumed tariffs of $1.35/kWh and $1.00/kWh, respectively, for Tanzanian minigrids.[43] This difference is thanks in part to the size and density of rural Nigerian communities, and their ability and willingness to pay for power as demonstrated by their existing use of fossil-fuelled generators.[44]

Innovation and Sectoral Outlook

Despite the slow progress towards increased electricity access in Nigeria, there is reason to expect rapid progress soon. In 2016, Nigeria adopted the SEforALL Action Agenda, which set energy access targets of 75% by 2020 and 90% by 2030.[45] While the country has not met the unrealistic 2020 target, this agenda has helped shape a much broader push by Nigeria's federal government to drive increased electricity access. There are several notable initiatives within this push, including the Nigerian Electrification Project (NEP), NERC minigrid regulations, the Nigeria Energy Support Programme, and the Solar Power Naija scheme. As part of, and in addition to, these initiatives, there is also an emerging focus on productive uses of electricity that is applicable to eCooking and MECS.

The NEP is Nigeria's flagship electrification program, implemented by the REA and backed by a $350 million performance loan from the World Bank and a $150 million sovereign loan from the AfDB. Each funding source within the NEP has its own project management unit (PMU), and focuses on a predefined set of activities:

- The World Bank portion of the NEP includes four components: (1) solar hybrid minigrids; (2) stand-alone solar systems for homes and micro, small, and medium enterprises; (3) energizing education to power public universities and associated teaching hospitals; and (4) technical assistance to support implementation and capacity building. Of these, component 1 is the most relevant to MECS given the potential intersection of eCooking and minigrids. The solar hybrid minigrids component has a $150 million allocation with targets to electrify 300,000 households and 30,000 local enterprises. The component aims to accelerate development of minigrids by providing financial incentives to commercial developers through a competitive subsidy. There are two subsidy programs:
    - A *minimum subsidy tender*, in which REA pre-selects and bundles a set of off-grid communities and solicits bids from minigrid developers.[46] Developers specify the amount of subsidy requested, and REA awards the qualified bidder requesting the minimum amount of subsidy. To date no projects have been funded through this program.
    - A *performance-based grant (PBG)*, in which developers may propose individual minigrid projects to receive a $350 per connection subsidy.[47] The REA PMU evaluates each proposal individually, including specific criteria around productive use and long-term sustainability. Several projects have been funded through the PBG program.
- The AfDB portion of the NEP similarly includes four components: (1) minigrid systems targeted at 250 sites, (2) productive use targeting 24,500 appliances installed, (3) energizing education to install minigrids at eight universities, and (4) technical assistance for capacity building.[4849] Of these, component 1 is relevant to MECS and eCooking given the potential

intersection of eCooking and minigrids. AfDB NEP component 1 will focus on a minimum subsidy tender for the 250 sites and has a $70 million allocation. To date it has not made any awards. Component 2 is also relevant to MECS, as the AfDB has allocated $20 million to award a predetermined subsidy in the form of a performance-based grant to minigrid and SHS projects that install productive use appliances. The exact mechanics of the component remain under development, but the REA PMU solicited developer applications for a seven-project pilot in 2020. Results-based financing, as has been widely used under the EnDev program and others elsewhere, could play a role in the implementation of this productive use program.[50]

In 2017, NERC issued its *Regulation for Minigrids*.[51] This policy has been transformative as it laid out clear rules governing minigrid development, and has been hailed as a "best practice" for other countries to follow. RMI and the Nigerian Economic Summit group summarized the policy as follows:

> *The NERC Mini Grid Regulation, 2017, governs the development and operation of electricity supply systems of under 1 MW, either in isolation from or interconnected to DisCo network infrastructure. This regulation seeks to incentivize and simplify the process for private sector participation in the minigrid sector, which will in turn contribute to increased access to electricity in unserved and underserved parts of Nigeria. It provides for a compensation mechanism to protect the rights of minigrid permit holders from early encroachment of the central grid, defines a multi-year tariff order (MYTO) methodology for calculating cost-reflective tariffs (for permitted systems), and includes standardized contract templates, forms, and guidelines to promote uniformity across the sector.*

While the NERC minigrid regulation does not address eCooking or other specific appliances, it is an important policy foundation that enables the minigrid development on which these appliances may depend.

Development of the NERC minigrid regulation was supported in part by GIZ. Beginning in 2013, GIZ began executing the EU-funded Nigerian Energy Support Programme (NESP) in partnership with FMP, and this program has proven highly influential.[52] Among numerous other activities, NESP supported the development of Nigeria's first commercial minigrid projects through partial capital grants, and has since supported the minigrid operators in monitoring and evaluation of those projects and ongoing performance improvements. As part of that, GIZ has provided technical assistance to the minigrid projects to support productive use development and testing. The NESP gave initial consideration to a clean cooking component, but eCooking has not been a focus of electrification efforts within the program.

Most recently, in November 2020, the REA announced the launch of the *Solar Power Naija* program.[53] This program is supported by the FGN implemented in collaboration with the Central Bank of Nigeria (CBN) and targets a total of 5 million new connections in off-grid communities through either minigrids or SHSs. Through the program, CBN will partner with local financial institutions to backstop loans to qualifying projects, capping interest rates at 10% or less (which is significantly lower than current commercial rates for Naira-denominated debt, which are typically closer to 20%).[54] As above, this program does not directly target eCooking, but in enabling minigrid development at lower cost may have implications on the viability of future eCooking pilots.

Embedded within these various initiatives is a focus on productive use. Even where not explicitly financed as part of the program, as in the AfDB NEP Component 2, most minigrid programs consider a developer's productive use demand stimulation strategy as a criterion for approval. This is born of a recognition that long-term demand growth is both the desired outcome of projects (representing

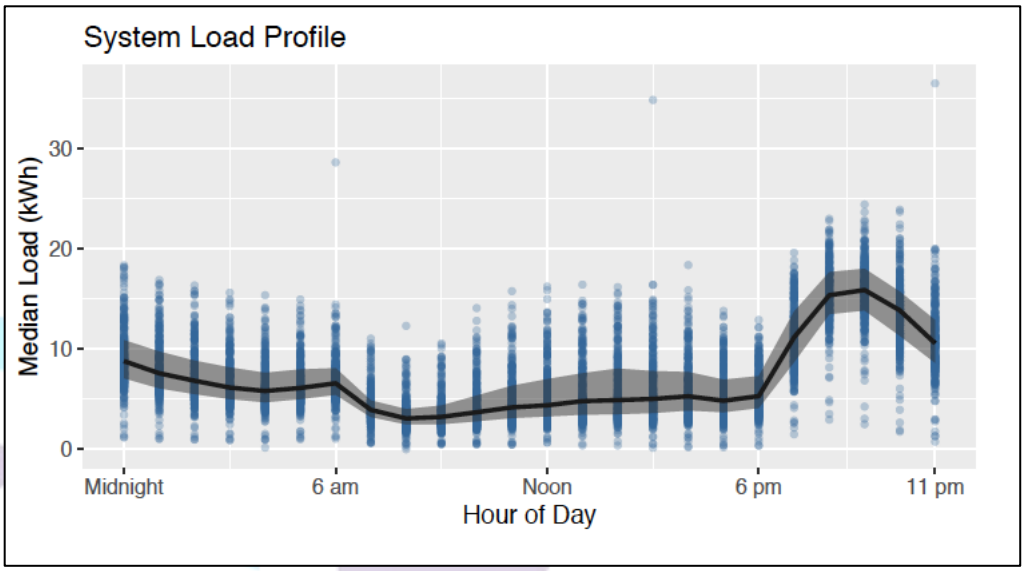
economic development) and a necessary strategy for reducing minigrid tariffs by increasing capacity utilization, particularly of zero-marginal cost daytime solar generation.

This focus on daytime consumption has increasingly led efforts towards a focus on commercial uses, including agricultural processing activities and appliances for local shops and artisans. For example, USAID's Nigeria Power Sector Program (NPSP) partnered with RMI to evaluate priority agricultural processing electrification opportunities (and REA is developing an *Energizing Agriculture* program to expand on this).[55] Furthermore, the CrossBoundary Innovation Lab has tested commercial appliances on minigrids in Nigeria and elsewhere.[56]

Implications for the Scaling-up of eCooking on Minigrids

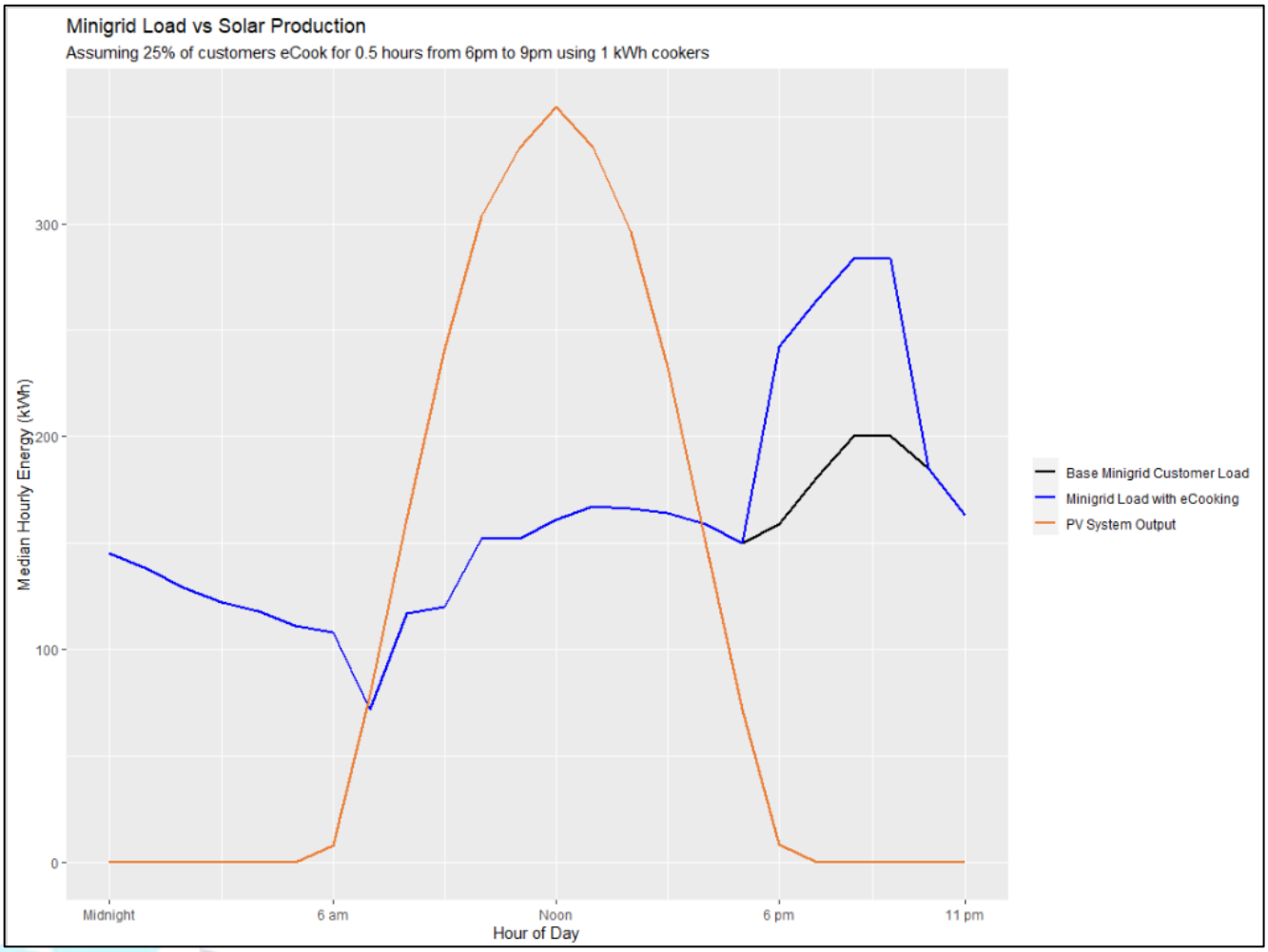
Most of these programs, with the exception of CrossBoundary's initial pilot in 2018, have not focused on household appliances. This is in part due to the desire to stimulate economic activities, but also due to the timing of household use. Most recently electrified Nigerian communities have shown an evening peak load, as commercial activities continue into the evening and residential uses increase (Exhibit 17).

Exhibit 17: Daily load curve, with variation bars, for an illustrative Nigerian minigrid over its first year of operation. Source: RMI



This is problematic, as to serve that load with a solar hybrid minigrid after the sun sets requires battery storage or diesel generation. Adding load coincident with this evening peak therefore increases the overall operational cost of the minigrid by either (1) requiring increased battery storage capacity, (2) increasing battery cycling and decreasing their lifespan, or (3) increasing the use of diesel generation. Ultimately, these increased operational costs will require the minigrid operator to raise customer tariffs, which could dampen demand and further increase tariffs. Exhibit 18 shows a hypothetical impact of adding eCooking to an existing minigrid's load, assuming 25% of residents cook for 30 minutes between 6 p.m. and 9 p.m. using 1 kW appliances.

Exhibit 18: Minigrid load with and without the hypothetical addition of eCooking appliances, compared with PV system output.



Preliminary research has provided early insights into the real-world impact of eCooking on minigrids in sub-Saharan Africa. MECS-supported field testing by the minigrid developer PowerGen from 2019 to 2020 showed promising results from a test of electric pressure cookers (EPCs) among a small portion of customers in two communities in rural Tanzania.[57] A subsequent field test by PowerGen and A2EI in 2020, documented in their December 2020 report, "Clean Cooking: Data Release Report," led to two notable conclusions regarding coincident loading and price sensitivity. For the minigrids on which A2EI was testing in Tanzania, the study found that coincident loading was not a problem. The field testing also concluded that price sensitivity had a significant effect on eCooking adoption, and the authors suggest that tariff subsidies may be necessary to support eCooking adoption on minigrids.[58] Both coincident loading and price sensitivity are likely to be market-specific, impacted by local economics and cooking behaviour. While informative, these insights represent a narrow sample and should not necessarily be extrapolated at this stage. The 2019 PowerGen study looked at 25 EPC users representing less than 10% of minigrid customers across two minigrids, and less than 1% of the households in those two communities. The larger subsequent A2EI study also looked at Tanzania and expanded to consider 100 EPC users across six minigrid sites. A broader field test will be needed to identify minigrid costs, cooking behaviours, and competing fuel type costs across a variety of Nigerian regions.

Ahead of additional field testing, based on RMI's own work with minigrids in Nigeria, it is worthy of note that modular capacity additions to a minigrid can be difficult and expensive if not part of the minigrid's original design and expansion strategy, so readjusting generation and storage on renewable hybrid minigrids to accommodate significant eCooking adoption will present a challenge to minigrid developers and operators. Similarly, demand-side management (e.g., time-of-use pricing or behind-the-meter battery storage) is in the early stages of development for the minigrid sector in Nigeria.[59] Both approaches may eventually play a role in the scaling-up of eCooking, but any modular additions to system sizes or demand-side strategies will need to be demonstrated through field testing ahead of widespread adoption.

As eCooking stakeholders plan next steps for the sector, minigrid tariffs, their cost-competitiveness with local alternative fuels, and cooking behaviour will be the three determining factors in eCooking adoption. At scale, eCooking adoption in Nigeria would likely occur on minigrids that were not designed with evening EPC loads in mind. Most of these systems are presently oversized, to varying degrees, but this may change over time for developers as incentives and financing shift. For systems that are not oversized, they may not be able to serve high levels of eCooking adoption due to lack of available capacity. As MECS proceeds in Nigeria, a testing programme to begin to formulate an approach to these challenges is described in recommendations in **Section 6.1**.

3.2 Cooking

In marked contrast with the great strides made in the development of the minigrid sector over the past several years, the state of clean cooking in Nigeria is nascent and progress has been uneven. Only 10% of households had access to clean cooking in 2018. And while there have been notable improvements in the past several years, regulatory indicators and levels of both energy access and clean cooking access remain low compared with leading African countries such as Kenya.[60]

Some of the delay in progress can be attributed to uneven support from government, and the donor support that has been enabled or discouraged as a result. In 2014, there was a strong push for government leadership under the "National Clean Cookstove Scheme," which saw a parallel push from donor partners. As a result of implementation challenges, despite securing funding an ambitious target of distributing 750,000 improved biomass and LPG stoves to rural households resulted in fewer than 50,000 stoves being distributed.[61]

Outside donor and NGO support has similarly waxed and waned, as evidenced by the Clean Cooking Alliance, formerly the Global Alliance for Clean Cooking, which dedicated substantial funding to Nigeria from 2012 to 2015. That support has since decreased, and the most recent funding was disbursed in 2017.[62]

While it is in an early stage of development relative to comparable African markets, clean cooking in Nigeria is a remarkably diverse sector, both across fuel types and across regions. To better understand the cooking sector, this section provides detail in several areas:

- **Market size and user numbers by fuel type**
- **The cost of cooking in Nigeria**
- **Cooking behaviour**
- **eCooking appliance availability**

Regarding the particular opportunity presented by eCooking, Batchelor et al write in their 2018 report *eCook Global Market Assessment: Where will the transition take place first?* that "Nigeria represents the largest market, however its viability score is one of the lowest [...], indicating that although a transition to PV-eCook could have a big impact, it is not likely to occur very quickly."[63]

Simultaneously, Nigeria has both the largest potential of both on-grid and off-grid eCooking target markets of any country in sub-Saharan Africa. The size of the need and opportunity is matched only by the challenges and extreme regional variation of the country.[64] In the two years since this report, great strides have been made in both the off-grid minigrid sector and the energy access regulatory environment, though they are just beginning to yield fruit. Support for LPG cooking from some quarters of government and in limited areas of the country have driven moderate growth in LPG cooking adoption. In contrast, the observation that eCooking is unlikely to be adopted quickly without support remains largely true.

3.2.1 Market size and user numbers by fuel type

The Nigerian cooking sector is large and highly varied by region. The most widely used fuel is wood, the primary fuel type for over 60% of all households in Nigeria.[65] Most households use more than one type of fuel. Rural households primarily depend upon "three-stone fires" and wood as their primary cooking method, while some use locally made kerosene cookstoves. A study conducted in rural northern Nigeria estimated the average household spends about 25.5 hours on cooking and 26.6 hours on firewood collection per week.[66] On the other hand, urban households use both traditional and

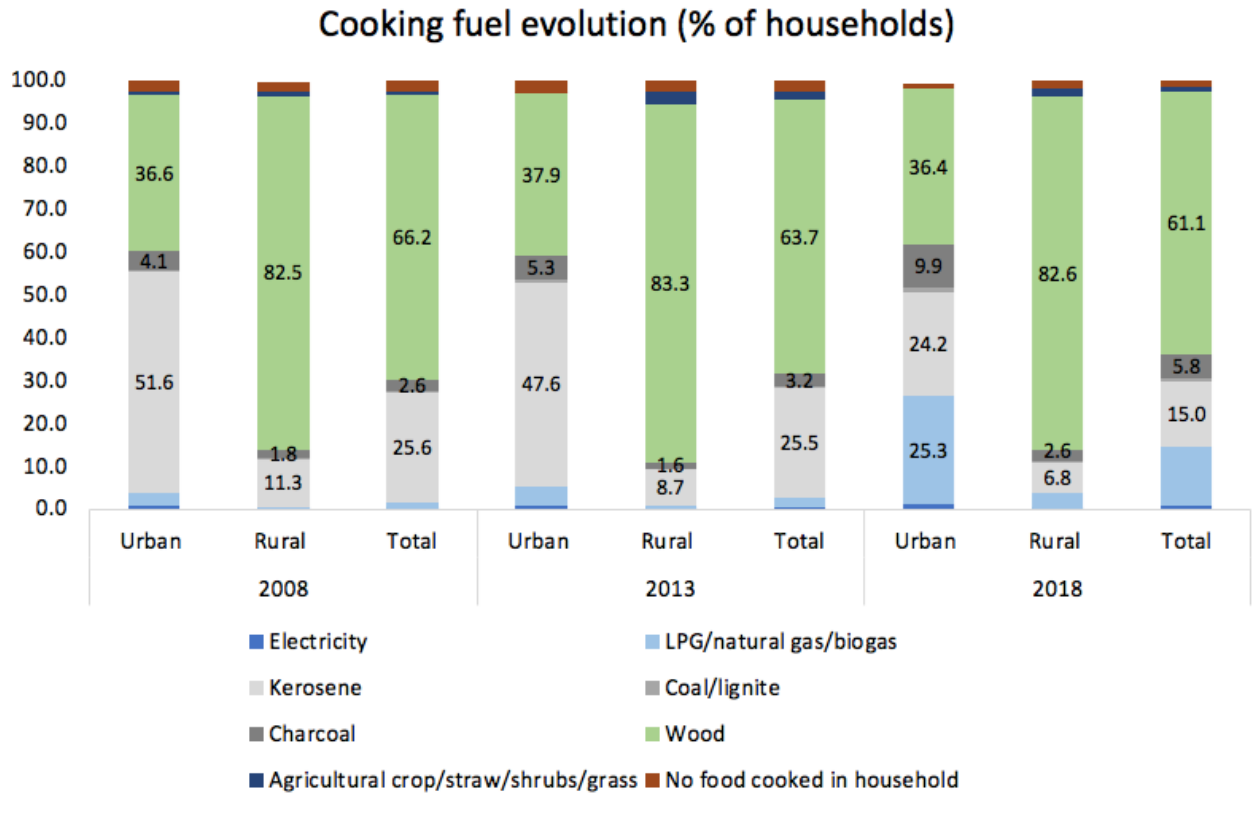
modern stoves with a diverse array of fuels including purchased wood, charcoal, LPG, and, to a small extent, electricity.

Biomass

The proportion of total households across Nigeria using solid fuels (i.e., coal, wood, charcoal, and agricultural residue) remained relatively constant from 2008 to 2018, at around 70% of the population.[67] Exhibit 19 shows a comparison of changes in cooking fuel between 2008 and 2018.[68] Biomass is the dominant fuel type for rural households.

Among those households using biomass, the rate of adoption of improved biomass stoves was 10.6% as of 2019 according to the Nigeria Bureau of Statistics. Improved cookstoves remain relatively expensive and domestically manufactured stoves have not achieved volumes to benefit from economies of scale. The cost of duties and long lead times for customs clearance also increase the cost of imported improved stoves.[69] Though standards for improved biomass cookstoves were approved by the Standards Organization of Nigeria in 2017, they have not been enforced.[70]

Exhibit 19: Primary cooking fuel use in Nigeria in 2008, 2013, and 2018. Source: National Population Commission



Kerosene

In 2016, the government of Nigeria phased out a kerosene subsidy that made the fuel affordable for lower-income households, resulting in higher costs for consumers (see cost discussion below). This decision was driven by budgetary constraints rather than a conscious strategy to reduce kerosene usage. The dramatic reduction in kerosene use between 2013 and 2018 is attributable, in part, to this change in policy. Kerosene in Nigeria has also been subject to access and price volatility challenges. Oil company pipelines experience frequent attacks that contribute to the fuel shortages in the country.

These fuel shortages can result in a tripling of kerosene prices over a short period of time. Access to kerosene is frequently interrupted in Nigeria as it is also used as an aviation fuel.[71]

LPG

Currently, 10.5% of Nigeria's population uses LPG as its primary cooking fuel. At a business-as-usual pace, this is forecasted to gradually increase to 19% by 2030, though government and private sector leadership and investment could increase the rate of adoption.[72]

From 2007 to 2017, there was rapid growth in the market resulting in an increase in LPG consumption from 5,000 metric tonnes to about 600,000 metric tonnes.[73] Several stakeholder interviews suggested that while data may not be available, growth since 2017 has been significant.[74] The growth over this period could be attributed to increases in income, a rapidly urbanizing population, and strong government support for LPG. LPG distribution is mostly confined to urban and peri-urban areas. As of December 2020, the cost of a 5 kg cylinder of LPG was ₦1,947 naira or $5.11.[75] This price is slightly higher than the global average, but lower than the African average.[76]

Despite this growth, LPG penetration in Nigeria remains far smaller than it could be. Nigeria's consumption of LPG per capita is among the lowest in Africa at 1.8 kg per capita.[77] Brazil, which has a similar population size but far greater LPG adoption, consumes more than 7 million MT of LPG per year, over ten times more than Nigeria.[78]

There is wide disagreement about the barriers to LPG market growth in Nigeria. In interviews with stakeholders, the relatively slow growth was variously attributed to low cylinder numbers, lack of a branded cylinder re-circulation model, perceived safety concerns, high local production costs and low volume, or inadequate infrastructure. It is fair to say that on the supply side, a lack of bottling plants across the country makes logistics expensive and challenging. Nigeria also continues to adhere to an end-user cylinder ownership model, which creates a cost barrier to lower-income users and perpetuates an unsafe LPG supply chain that drives consumer safety concerns and discourages investment, both domestically and internationally.[79]

Despite mixed results, LPG currently receives the bulk of focused government support and leadership in the clean cooking sector, and in some quarters the clean cooking goal of the government has been framed as the "universal use of LPG."[80] The Office of the Vice President's LPG Expansion Programme is the leader for Nigeria's LPG cooking efforts, and has partnered closely with the Nigerian LPG Association, the main advocate for the LPG private sector. According to the Nigerian Association for Clean Cooking, which is closely involved with the effort, improved biomass is a transitional fuel source as the country progresses toward the universal use of LPG. A disparate set of initiatives across multiple ministries was brought under the concerted direction of the Vice President Yemi Osinbajo in 2016.[81]

Planning and progress since 2016 has been less clear, but in February 2021, the Office of the Vice President's LPG Expansion Programme proposed the following seven activities, four to drive supply side growth and three to stimulate demand:

- Build at least one cylinder manufacturing plant in each of Nigeria's six geopolitical zones
- Promote domestic production of LPG to reach 80% of supply by 2025
- Establish 7,400 skid plants, or filling stations, across the country, including 200 in each state
- Establish at least three new gas storage plants across the country by 2025
- Launch a communications campaign around the safety of LPG
- Increase the number of cylinders in circulation from 2.5 to 20 million by 2025

- Transition all government facilities to LPG cooking by 2025

Funding and plans for the implementation of the above government activities also remain to be determined.[82]

Ethanol

A small-scale study of ethanol stove use was conducted by researchers from the University of Chicago and the Berkeley Air Monitoring Group in Lagos State in 2017 and 2018. As an alcohol stove, the health benefits compared with traditional fuels are clear. Users in the study responded positively to the stoves and their cost is comparable to an LPG or electric stove, although the fuel is currently difficult to source.[83] Another study of bioethanol stove use in Ibadan, Nigeria, provided subsidized fuel in order to compete with other fuel types, an intervention that may prove challenging to bring to national scale.[84] In contrast to LPG, electricity, and traditional fuels, effective distribution channels for ethanol are not yet as widespread in the country. However, there has been speculation by researchers that ethanol could be affordably produced at scale in Nigeria using cassava waste, a by-product of a staple crop, and warrants further investigation.[85]

eCooking

The lack of grid reliability highlighted in **Section 3.1.1** presents significant challenges to the adoption of eCooking, and may help to explain the extremely low rate of eCooking in the country. To underscore this point, the prevalence of eCooking in Zambia, where grid reliability in terms of SAIDI and SAIFI is 25 hours per year and three events per year (see **Section 2.1.1** for more detail on reliability), is 12%.[86] This is far greater than the 0.9% eCooking rate determined by the Nigerian Bureau of Statistics in 2018. Other factors could also be at play, such as a lack of public awareness around the dangers of alternative fuels, a lack of cooking behaviour-appropriate appliances, or insufficient consumer financing to make appliances affordable.

eCooking on off-grid minigrids is currently rare, but interviews with three Nigerian minigrid developers indicated that anecdotally, all have seen rice cookers, induction stoves, or electric pressure cookers in use by a small number of customers. Off-grid minigrids with high enough capacity, which still account for only a small fraction of Nigerians with energy access, typically provide greater reliability but present new challenges of a higher cost of energy and potential coincident loads. Although minigrid costs are projected to dramatically decline, and the coincident load problem has potential solutions, such as energy storage or time-of-use pricing, these are not simple or proven solutions in any clean cooking market, let alone in Nigeria. A deeper exploration of current and future eCooking in Nigeria is needed.

Regional variations in fuel type use

Regional variations in fuel type use, shown in Exhibit 20, can also be attributed to variations in climate, socioeconomic factors, and politics.[87] Charcoal is most commonly used in the northern Sahel region, where trees are scarce. LPG is most commonly used in the South South and South West geopolitical zones and in major cities where incomes are higher and LPG distribution networks are accessible. Kerosene is the predominant fuel type in South East and South West geopolitical zones. Biomass stoves of all varieties are most common in the heavily rural South East, North East, and North West regions.

It bears noting that data on cooking market sizes and costs were inconsistent. Thorough, authoritative, and up-to-date studies are needed to confirm the fuel type use and cost data provided here.

Exhibit 20: Primary cookstove type. Source: Nigerian National Bureau of Statistics

Region	Three-Stone/Open Fire	Self-Built Biomass	Manufactured Biomass	LPG/ Natural Gas	Kerosene	Electric	Other	Does Not Cook
North Central	56.7	13.3	8.8	6.9	12.2	1.1	0.8	0.2
North East	50.3	29.1	18.8	0.3	1.2	0.0	0.1	0.2
North West	65.9	13.0	12.8	2.4	5.4	0.5	0.0	0.0
South East	25.8	18.6	12.3	6.4	36.5	0.5	0.0	0.0
South South	34.3	9.9	7.2	18.0	29.0	1.6	0.0	0.0
South West	21.2	9.8	6.3	26.8	32.5	1.5	0.1	1.7
Urban	19.1	10.2	6.3	24.4	37.9	1.3	0.3	0.6
Rural	54.1	16.6	12.6	4.2	11.5	0.7	0.1	0.2
NIGERIA	43.1	14.6	10.6	10.5	19.8	0.9	0.2	0.3

3.2.2 The cost of cooking

Upfront cost of stoves

Even where households are willing to adopt improved and clean cookstoves and fuels, they often lack the ability to pay for the stove and fuel due to insufficient disposable incomes and/or the lack of savings. This affordability challenge is particularly acute for clean cooking solutions. The high upfront costs of higher-end cooking appliances ($75–$100 for fan gasifiers and $50–$100 for LPG and electric stoves) and the high ongoing costs of modern-fuel use relative to traditional biomass alternatives constrain the size of the clean cooking market.

Ability to pay is likewise consistently rated as the top demand constraint by manufacturers and distributors of industrially manufactured, high-quality intermediate improved cookstoves, such as rocket wood and charcoal stoves in the $15 to $50 range. Basic wood or charcoal stoves, in contrast, can be as low as $2 and $3, respectively. With electric and LPG options nearing the median monthly Nigeria income, affordability is a challenge. Efficient consumer financing will be essential to making clean cooking stoves affordable for most Nigerian households.[88]

Fuel costs

In addition to the upfront cost of acquiring a stove, continuous fuel cost is the second most crucial factor in household cooking decision-making. Lower income households prefer wood and charcoal partly because in areas with forests wood can be gathered for free or bought in small quantities by poor urban households. Similarly, low-income households can also buy charcoal in small quantities. This makes these fuels accessible to low-income households even if they are more expensive than cleaner fuels like LPG on cumulative-cost basis in the long run. Exhibit 21 shows a cost comparison of fuels based on the typical purchase units that a household can access on the market.[89]

Exhibit 21: Cookstove fuel and cost, by fuel type and geopolitical zones. Source: Nigerian National Bureau of Statistics

Region	Kerosene		Charcoal/Coal/Coal Briquette		Wood		LPG/Cooking Gas		Other	
	% of HH Using	Monthly Cost (Naira)	% of HH Using	Monthly Cost (Naira)	% of HH Using	Monthly Cost (Naira)	% of HH Using	Monthly Cost (Naira)	% of HH Using	Monthly Cost (Naira)
North Central	14.0	1,026	9.0	946	74.6	1,071	6.7	3,336	2.7	808
North East	1.3	1,348	11.6	1,466	95.7	1,222	0.3	2,762	3.4	1,838
North West	5.6	2,569	6.0	1,445	89.2	1,325	2.4	3,028	8.0	322
South East	37.9	1,477	0.8	837	55.8	692	6.0	3,763	1.9	1,206
South South	31.6	810	0.1	786	50.8	647	17.9	3,188	3.4	708
South West	35.6	694	2.7	736	35.9	476	25.7	2,130	3.0	2,067
Urban	41.7	903	9.1	1,292	31.7	1,441	23.6	2,733	3.3	1,194
Rural	12.0	1,204	2.6	1,086	82.3	937	4.1	2,928	4.4	679
NIGERIA	21.3	969	4.7	1,212	66.5	1,012	10.2	2,786	4.1	783

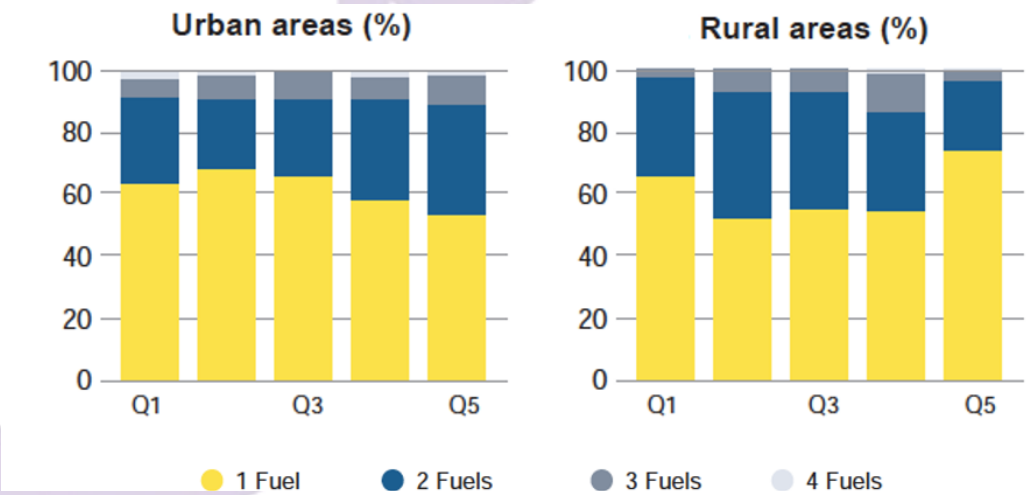
Most Nigerian consumers pay for their immediate energy needs on a limited daily budget, which presents a challenge when considering clean cooking services such as LPG or electricity that can be tied to higher price single purchases such as cannisters in the case of LPG or the cost of connection and monthly payment in the case of electricity.[90]

3.2.3 Cooking behaviour

Fuel stacking

Fuel stacking is common in Nigeria, with approximately 50% of rural households and 40% of urban households using two or more fuels (Exhibit 22). As ESMAP notes of Nigeria in its 2020 report *The State of Access to Modern Energy Cooking Services, "*urban populations that stack with charcoal tend to use wood as their primary fuel, while those that stack with kerosene or paraffin mainly use charcoal."[91] Seasonality of some fuel availability, large cooking sizes in rural areas, and unreliability of electricity, LPG, and kerosene availability have been cited as reasons for fuel stacking. Households cite energy security concerns as a chief reason for using a combination of fuels rather than a single fuel type. These energy security fears result in most households holding on to traditional stoves after transitioning to modern ones.[92]

Exhibit 22: Fuel stacking, urban (L) and rural (right) by income quintile. Source: World Bank



Cooking habits

Cooking habits in Nigeria have a degree of uniformity across the country, although rural households maintain complex and time-consuming traditional methods while urban households prefer faster cooking. Most households around the country consume starch-based foods using yams or cassava (as well as rice in urban areas motivated by its cooking speed) and stews. Stews are typically cooked in large pots because they require considerable stirring, while the starchy foods require long boiling times in their preparation.

Most households cook two or three meals a day except low-income households that earn less than $1 per day. These households typically cook one or two meals daily. Rural households cook on outdoor open fires, in their houses, and in some instances in buildings detached from the main house. Most urban household cooking takes place inside the home.[93] Much of the food consumption is determined by local agricultural production. Because of the wide range of climate types in Nigeria, from tropical coastal areas in the southwest to desert areas in the north, local production varies widely, and therefore, cooking habits also change. The success of a large-scale clean cooking program will depend on understanding and reacting to these variations.[94]

The average household size in urban and rural Nigerian communities is 4.3 and 5 persons respectively.[95] A 2016 "cooking landscape analysis" found that the larger the household the greater likelihood of fuel stacking. This is probably because the household can easily cook greater amounts of food over an open fire, without restrictions on size of pots common in other type of stoves.[96] Social events are frequent (Nigerians have a strong social culture of cooking for events constituting more than 50 people once or twice a month) and require large volume of cooking for which wood is the preferred fuel. In addition, institutional cooking that includes large portions also often relies on wood. This includes schools, agro-processors like shea butter and palm oil cooperatives, catering businesses, fish smokers, and others.[97]

Researchers from the University Putra Malaysia observed in northern Nigerian communities that biomass cooking typically occupied 25.5 hours per week.[98] At a national level, other researchers claim 90% of Nigerian households purchase biomass cooking fuel rather than collect themselves, in contrast to many other markets in Africa.[99] This would suggest that nearly all Nigerian households pay for biomass cooking fuel, which will require verification. National-level data on time spent cooking across various fuel types does not seem to be readily available for Nigeria, but research in East African markets showing a 20 to 40 minute cooking time savings per householder per day (2.5 to 6.5 hours per week) for household shifts away from biomass to modern alternatives may be a reasonable assumption.[100]

Image 1. Traditional 3-stone fire, Nasarawa State, Nigeria. Source: RMI

3.2.4 eCooking appliance availability

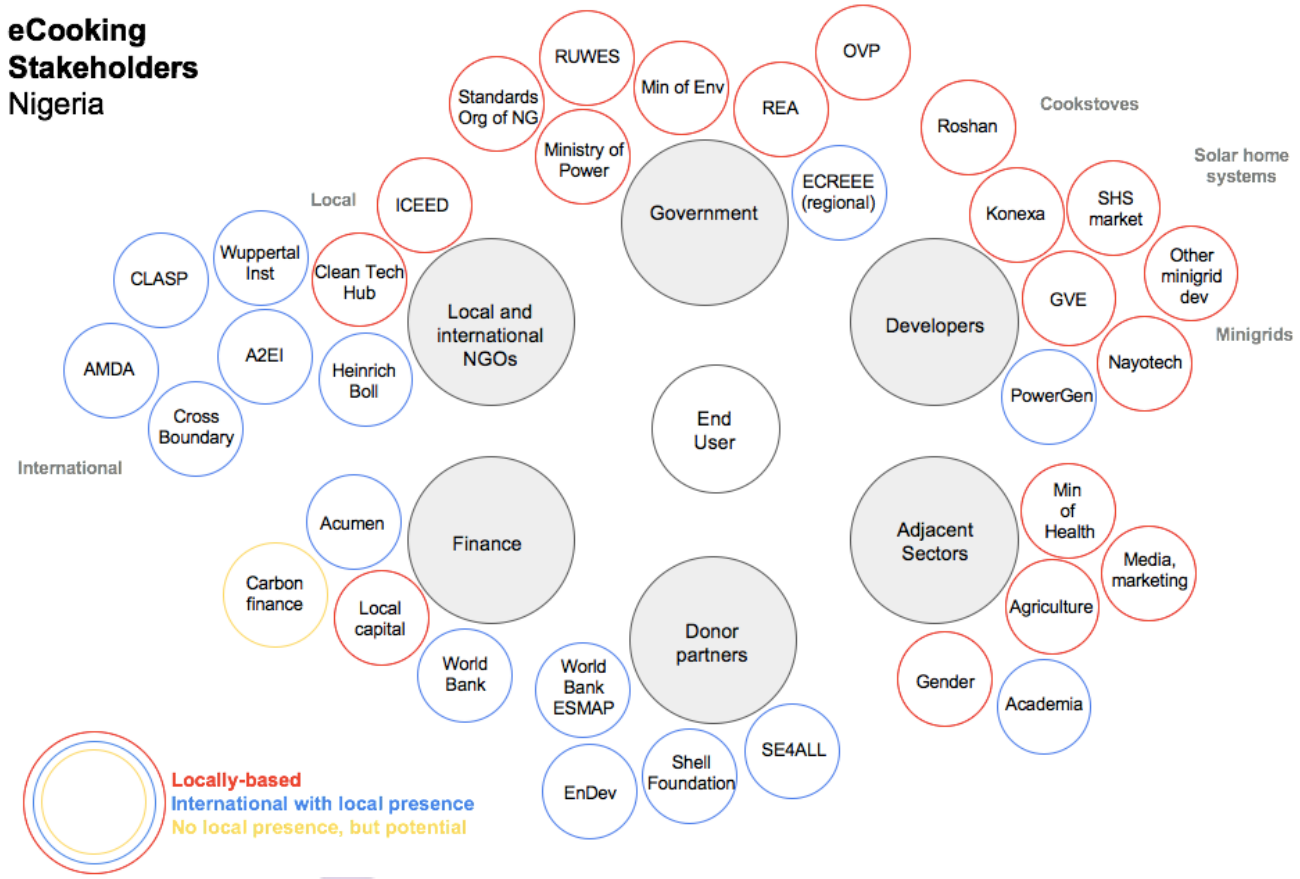
Distribution and retailers

According to ESMAP's 2020 report *The State of Access to Modern Energy Cooking Services*, Nigeria has the highest concentration of cookstove designers, manufacturers, retailers, and distributors in West Africa, and only slightly less than Kenya and Uganda. This includes higher tier or "cleaner" stoves along with more traditional stoves, so more granular information is needed to determine how much of this activity can help drive a local transition to clean cooking. Regardless, it is certainly a testament to Nigeria's capacity to support manufacturing and domestic enterprises focused in this sector.[101] More granular data regarding eCooking appliance availability in the country does not appear to be currently available, and would be a necessary step in designing a largescale eCooking program.

3.3 Stakeholders

RMI organised interviews with key stakeholders in Nigeria's clean cooking sector. The guide for these interviews focused across the three topics of energy policy, cooking development, and financing, with a particular focus on the expertise of each stakeholder. Interviews were conducted remotely over telephone, or video call when possible. Interviews had a particular focus on the gaps and opportunities for eCooking in Nigeria. Over a three-month period, RMI conducted 23 interviews. The results of the interviews were used in conjunction with a thorough literature review to inform the basis for the gap analysis and recommendations in this document. Key stakeholders are shown by category in Exhibit 23.

Exhibit 23. Key eCooking stakeholders.



Key takeaways

Private sector

- Aside from the observation that Nigeria has an unusually high number of cooking designers, manufacturers, distributors, and retailers across fuel types, momentum and coordination among cookstove and appliance companies is not apparent.[102]
- Among minigrid developers, Nigerian developers are cautiously curious about eCooking, and interested in seeing cooking behaviour data, cost data, and demonstrated customer interest in the regions where they operate. Several indicated an interest in participating in eCooking

testing. International developers with experience with East African eCooking testing are more familiar with eCooking, and showed a keen interested in participating in testing.

Government

- Government leadership on clean cooking would benefit from more coordination across fuel types, and more detailed, funded plans for implementation are needed.
- The Office of the Vice President is enthusiastic about the prospects of LPG, though outside investment in the sector and its long-term success may require the adoption of a Branded Cylinder Recirculation Model (BCRM) to ensure safety.
- Rural Women Energy Security (RUWES), a non-profit with ties to the Ministry of Environment, is unique in working across fuel types.

Local and international NGOs, CSOs

- ICEED oversees the local Nigerian Clean Cooking Alliance, which was founded in 2011. The NCCA includes a wide range of relevant stakeholders, though to-date it has not focused on eCooking.
- There is significant disagreement about the prospects of off-grid as opposed to on-grid eCooking among the most knowledgeable stakeholders. In the case of off-grid eCooking, some interviewees articulated concerns about the cost per cooking event and the slow rate at which off-grid tariffs will decline. In the case of on-grid eCooking, interviewees pointed to the deep reliability challenges faced by on-grid customers, the high cost of batteries, and the barrier these pose to eCooking adoption.
- Heinrich Böll Stiftung and the Wuppertal Institute, both NGOs with a local presence, have been involved in clean cooking initiatives in the past.

Donor partners

- There is a strong interest in supporting clean cooking from donor partners, but for now most are waiting for the right opportunity to commit resources.
- There is an appetite for further eCooking testing and clean cooking testing more generally.
- There is strong interest in working towards a large-scale clean cooking program in the country.

4. The Policy Environment

The policy environment in Nigeria as it pertains to clean cooking is a work in progress. A comprehensive review of the applicable policies, along with perspectives from Nigerian stakeholder interviews, found that there are five key policies covering clean cooking activities in Nigeria. While these documents provide a degree of framing for the sector and the FGN's goals at a high level, there is a lack of definition at the next level of detail. Specific strategies, implementation plans, and funding are generally lacking at present. Overall, given the numerous development initiatives being championed by the FGN and its agencies, it appears that expanded use of clean cooking is a genuine objective, but the detailed implementation plans necessary for execution have not yet been developed.

To provide more detail on this landscape, this section includes several components:

- **Key policies in clean cooking**, which provides a summary of each of the five major policies pertaining to clean cooking in Nigeria.
- **Policy environment by fuel type**, which highlights noteworthy policy considerations for each of the primary cooking fuel types used in Nigeria.
- **Discussion of gaps**, which identifies several remaining gaps in the policy landscape based on takeaways from the documents and best practices.

In addition to these, Appendix B provides a full list of other policies that exist in Nigeria with potential implications for the clean cooking sector, but that were not found to be essential.

4.1 Key Policies in Clean Cooking

This section presents the findings of a policy literature review that identified five policy documents with the most relevance to Nigeria's clean cooking sector. Summarized in Exhibit 24, these include: the National Renewable Energy and Energy Efficiency Policy (NREEEP), the Rural Electrification Strategy and Implementation Plan (RESIP), the Sustainable Energy for All Action Agenda (SE4ALL-AA), the National Renewable Energy Action Plans (NREAP), and the National Energy Efficiency Action Plan.

Exhibit 24: Summary of policy documents related to clean cooking

Policy	Coordinating Administration	Impacts on Clean Cooking/eCooking
NREEEP (2015)	Federal Ministry of Power	Stresses the importance of transitioning from firewood-based cooking to modern fuel alternatives. Contains no detailed discussion of eCooking, but one of the objectives is provision of abundant electricity access for domestic use and cooking.
RESIP (2016)	Rural Electrification Agency	No direct consequences to the clean cooking sector, but aims to improve the living conditions in rural areas through clean energy and acknowledges indoor air pollution as an important problem.
SE4ALL-AA (2016)	SE4ALL Secretariat within the Ministry of Power Multi-actor steering committee	Sets energy access, provision, and generation targets linked to sustainable development. In clean cooking, targets 50% replacement of traditional firewood

		consumption with improved cookstove technology by 2020 and 80% by 2030.
NREAP (2016)	Federal Ministry of Power through its Renewable Energy and Rural Power Access Department (RRD)	Sets specific renewable energy targets by sector and years. Sets specific targets for domestic cooking (see main document).
NEEAP (2016)	Federal Ministry of Power through its Renewable Energy and Rural Power Access Department (RRD)	Specific targets on energy efficiency to achieve SE4ALL goals. No specific targets for clean cooking but suggests actions to reduce firewood consumption. Aligns with the ECOWAS Energy Efficiency Policy (EEEP).

4.1.1 National Renewable Energy and Energy Efficiency Policy (NREEEP)

The NREEEP is an authoritative and broad energy policy affecting more specific policies on the clean cooking sector. The NREEEP acknowledges the necessity of a transition from firewood-based cooking to modern alternatives, and notes that future energy efficiency and clean energy access measures will support this transition. It does not outline any strategy or steps towards implementation or funding, which has been left to federal ministries.

The NREEEP was approved in 2015 by the Federal Executive Council and forms the overarching policy. The NREEEP is the Nigerian government's blueprint to increasingly harness the country's renewable energy (RE) and energy efficiency resources in driving sustainable development across the country (considering both on-grid and off-grid electricity). Developed in line with the country's national energy policy, the NREEEP outlines the government's programs and measures for deploying renewable energy and energy efficiency technologies and practices that will facilitate Nigeria's green transition.

The document takes the initials steps of aligning the Nigerian renewable energy and energy efficiency policy with the ECOWAS renewable energy policy (EREP) and ECOWAS energy efficiency policy (EEEP). In doing so, the NREEEP leads to the national renewable energy action plan (NREAP) and the national energy efficiency action plan (NEEAP).

Relevant objectives

1. Guarantee of adequate, reliable, affordable, equitable, and sustainable supply of renewable energy at cost-reflective and appropriate prices, as well as in an environmentally friendly manner.
2. Promotion of investments for the renewable energy and energy efficiency sector.
3. Provision of abundant electricity access to Nigerians, including more sustainable provisions for domestic use and cooking.
4. Establishment of appropriate financing mechanisms that support private investment in the renewable energy and energy efficiency subsectors.

Institutional support and coordination

The NREEEP considers the role of energy in national development to be vital, and for this reason requests the support of the National Planning Commission, the Federal Ministry of Finance, and the

Federal Ministry of Petroleum Resources. The Federal Ministry of Power—which is responsible for policymaking within the electricity industry—is tasked with ensuring the coordination and implementation between itself, the Federal Ministry of Water Resources, the Federal Ministry of Science and Technology, the Federal Ministry of Environment, and the Energy Commission of Nigeria.

Specific ties to clean cooking

Policy objective IX states, "*To bring abundant electricity access to almost half of the Nigerian population that is currently electricity abstinent, including more sustainable provisions for domestic use and cooking,*" which implies eCooking as an objective.

In Section 3, dedicated to energy efficiency, sub-section 3.1 states, "*In the household sector, there is considerable energy loss due to inefficient household appliances, in particular for lighting and refrigeration, productive use but as well due to inefficient technologies such as the traditional three-stone stoves used mainly for cooking in the rural areas.*" To address this energy loss, in sub-section 3.1.3 strategy VI recommends, "*Encouraging the production and use of improved and more-efficient cooking stoves.*"

4.1.2 Rural Electrification Strategy and Implementation Plan (RESIP)

The RESIP establishes the Rural Electrification Fund, which is managed by the Rural Electrification Agency (REA). The policy, which indirectly deals with clean cooking, recognizes the negative health impacts associated with traditional cooking fuels.

The RESIP was prepared by the Federal Ministry of Power, Works, and Housing to be implemented by the Rural Electrification Agency (REA) and was approved in 2016. It sets the FGN's strategy to accomplish the goals established in the EPSRA and Rural Electrification Policy. It provides the implementation framework and measures for driving rural electrification across the country through on- and off-grid solutions.

Relevant objectives

1. Promote the use of domestic electrical appliances to reduce the toll of household tasks typically allocated to women.
2. Promote cheaper, more convenient, and more environmentally friendly alternatives to the prevalent kerosene, candle, and vegetable oil lamps and fossil fuel-powered generating sets.
3. Protect the nation's health and environment by reducing indoor pollution and other energy-related environmental problems.

Institutional support and coordination

In 2006, EPSRA established the Rural Electrification Agency (REA) as the agency accountable for the coordination of rural electrification activities in Nigeria. The REA is responsible for carrying out the RESIP. As part of this coordination, every year the REA organizes a forum, and the Ministry of Power and the NERC ensures the participation of stakeholders.

Specific ties to clean cooking

There are no particular references to clean cooking in the RESIP. However, the policy is still notable because of its focus on improving the standard of living of the rural population through the adoption of clean energy technologies and affordable clean appliances.

4.1.3 Sustainable Energy for all Action Agenda (SE4ALL-AA)

The Sustainable Energy for All Action Agenda for Nigeria touches directly on the problem of traditional cooking and firewood consumption. The SE4ALL-AA sets general but clear targets to replace traditional cooking fuels. The Action Agenda bases its targets on figures from the NREEEP and RESIP documents.

The SE4ALL-AA was adopted in 2016 by the Inter-Ministerial Committee on Renewable Energy and Energy Efficiency (ICREEE) and approved by the National Council on Power. The key objectives of the SE4ALL initiative globally are to ensure universal access to modern energy services; double the global rate of improvement in energy efficiency; and double the share of renewable energies in the global energy mix by 2030 compared with a 2010 baseline. The SE4ALL-AA is the national implementation tool for the Sustainable Development Goal on energy (SDG 7). Thus, the objectives of the SE4ALL initiative are considered in tandem with the goals of the national energy agenda, which places a high priority on providing access to safe, reliable, and affordable energy to citizens in both urban and rural areas.

Relevant objectives

1. Ensure universal access to modern energy services.
2. Double the global rate of improvement in energy efficiency.
3. Double the share of renewable energy in the energy mix by 2030.

Institutional support and coordination

As noted in the Action Agenda, the management of Nigeria's SE4ALL-AA was meant to be built on the already established ICREEE. The Federal Government was charged to put in place the SE4ALL Secretariat within the Ministry of Power as the local focal point for Nigeria's SE4ALL Activities to coordinate activities, which is scheduled to be in place later in 2021.[103] The steering committee includes the ICREEE team, FMF, FME, CBN, TSP/SO/OM, state and local governments, DisCos, and GenCos. International Partners EU, GIZ, ECREEE, UNDP, AfDB, Civil Society Representative, National Banks, Private Sector, SME Reps etc. will serve as Donors Executive Committee.[viii]

Specific ties to clean cooking

As part of the SE4ALL-AA 2030 energy access targets, Nigeria will replace 50% of traditional firewood consumption for cooking by improved cookstove technology by 2020 and 80% by 2030. As the Action Agenda states, "*The use of modern cooking fuels as electricity, LPG, kerosene, biogas and solar cookers will increase significantly under the energy access target.*"

[viii] This is the language used in the SE4ALL-AA.

4.1.4 National Renewable Energy Action Plan (NREAP)

The National Renewable Energy Action Plan lays out a national implementation strategy to achieve the objectives and targets established in the NREEEP and SE4ALL-AA. However, the final document remains unclear on a specific target for domestic cooking energy. The listed targets come from the Federal Ministry of Environment and include an increasing percentage of the population using improved cookstoves while a decreasing percentage of the population has access to "modern fuel alternatives," which is broadly defined. These opposing targets may be an error. The NREAP does not describe any specific strategies or implementation instruments for cooking.

The NREAP was approved in 2016 by the National Council on Power, adopted by the Interministerial Committee on Renewable Energy and Energy Efficiency (ICREEE), and sets out the implementation strategy for the NREEP. It provides an overview on concrete policy and measures to be implemented to achieve Nigeria's renewable energy targets for 2020 and 2030.

Relevant objectives

1. Total renewable energy share of the total installed grid capacity to reach 52% by 2020 and 45% by 2030.
2. Renewable energy share for grid-connected generation to be 38% by 2020 and 31% by 2030.
3. Share of population connected to the grid to reach 70% by 2020 and 80% by 2030.
4. Share of rural population served by renewable energy and hybrid minigrids to reach 5% by 2020 and 10% by 2030.
5. Share of rural population served by standalone renewable energy systems to reach 4.7% by 2020 and 5% by 2030.
6. Renewable minigrid capacity target of 180 MW by 2020 and 5.3 GW by 2030.
7. Hybrid minigrid capacity target of 4 MW by 2020 and 171 MW by 2030.
8. Pico-hydro capacity target of 3.5 MW by 2020 and 60 MW by 2030.
9. Total off-grid renewable energy installed capacity to reach 187.5 MW by 2020 and 5.5 GW by 2030.

Institutional support and coordination

The Federal Ministry of Power has a mandate for renewable energy electricity development through its Renewable Energy and Rural Power Access Department (RRD). The RRD coordinates the efforts with partners and stakeholders involved in providing technical assistance as well as with states and local governments.

Specific ties to clean cooking

Domestic cooking targets include 40% of the population using improved cookstoves by 2020, and 59% by 2030. Charcoal production targets include that 5% should be produced using efficient production techniques by 2020 and 7% by 2030. The NREAP shows declining targets over time for other fuel types (non-wood, non-charcoal), which includes LPG, biogas, kerosene, presumably electricity, and other fuel types, although this does not align with targets set in other strategy documents. For this final reason, these targets may be interpreted with some scepticism.

4.1.5 National Energy Efficiency Action Plan (NEEAP)

The National Energy Efficiency Action Plan is the NREAP sister policy in the energy efficiency sector. Similar to the NREAP, the NEEAP shows a commitment to the targets from the NREEEP and SE4ALL-AA but does not provide a strategy, roles and responsibilities, or tools to achieve the targets. It is notable that the NEEAP describes kerosene as a "modern fuel alternative."

The NEEAP sets out the implementation strategy for the National Renewable Energy and Energy Efficiency Policy (NREEEP), and like the NREAP was approved in 2016. It provides an overview of policies to be implemented to achieve Nigeria's energy efficiency targets and the SE4ALL-AA goals.

Relevant objectives

1. Forty percent of the households will use efficient lighting by 2020, and almost 100% by 2030.
2. For high-energy consuming sectors (transport, power and industrial sectors), efficient energy will increase by at least 20% by 2020 compared with the baseline, and 50% by 2030.
3. Achieve 10% biofuel blends by 2020.
4. Improve the efficiency of the bioenergy sector by 2020, and curb firewood demand below supply capacity by 2030.
5. Distribution loss reduction target to 15%–20% by 2020 and less than 10% by 2030.

Institutional support and coordination

As with the NREAP, the Federal Ministry of Power has the mandate to oversee renewable energy electricity development through the RRD.

Specific ties to clean cooking

The NEEAP does not set up any specific target for clean cooking, but it does set more general targets that suggest clean cooking actions, such as reducing firewood demand below supply capacity. Nevertheless, the document itself aligns with regional initiatives and actions in energy efficiency such as the ECOWAS Energy Efficiency Policy (EEEP), which includes targets such as "*Achieve Universal access to safe, clean, affordable, efficient and sustainable cooking for the entire population of ECOWAS, by 2030.*" In addition, one of the regional actions was the creation of the West African Clean Cooking Alliance (WACCA).[ix]

4.1.6 Background prior to NREEEP (2015)

Exhibit 25 summarizes the policy landscape prior to the adoption of the NREEEP in 2015. These policies are, by and large, not the primary drivers of decision-making today, but are helpful to be aware of the broader context and the recent evolution of the policy landscape.

[ix] The EEEP includes a full chapter dedicated to "Safe, Sustainable, and Clean Cooking."

Exhibit 25: The policy landscape prior to NREEEP

Year	Policy	Brief description
2001	National Electric Power Policy (NEPP)	Moves policy towards multi-actor market liberalization from the vertically integrated state company, NEPA.
2003	National Energy Policy (NEP)	Frames the energy sector's contribution to the country's economy, considering development, exploitation, and supply of all resources, including renewable energies, energy efficiency, and rural electrification.
2004	National Economic Empowerment and Development Strategy (NEEEDS)	Policy focused on development challenges, promotes infrastructure privatization and stresses increased RE in the energy mix, as well as the need for a Renewable Energy Agency.
2005	Electric Power Sector Reform Act (EPSRA)	Provides a new legal and regulatory framework for the power sector, including privatization of NEPA and complete liberalization towards a competitive market. Establishes the REA, consumer's rights and obligations, and performance standards, and founds NERC.
2006	Renewable Electricity Policy Guidelines (REPG)	Issued by the Federal Ministry of Power, targets 5% of RE penetration in the energy mix and favourable pricing mechanisms. Sets the Renewable Electricity Trust Fund to be governed by the Rural Electrification Fund.
2006	Renewable Electricity Action Programme (REAP)	Issued by the Ministry of Power, sets out a roadmap to implement the REPG. Targets technologies and applications, and outlines the financing procedures via the Renewable Electricity Fund.
2007	National Biofuel Policy and Incentives	Biofuel support programme aimed at integrating the agricultural sector with the petroleum sector. Refers to ethanol and biodiesel.
2009	Vision20:2020	Holistic transformation of the economy to place the country among the top 20 world economies, outlined by the National Planning Commission. Among the goals was "replacing 50% of firewood consumption for cooking with biomass energy technology by 2020."
2012	Renewable Energy Master Plan (REMP) (Update)	Sets out a roadmap for increasing the role of RE in achieving sustainable development. Targets high electrification rates of 60% (2015) and 75% (2025)

4.2 Policy Environment by Fuel Type

This section describes how each fuel type is covered, considered, or commented in the aforementioned documents. Of note is a recent non-energy policy document, the Nigeria Economic Sustainability Plan (NESP), established in 2020, which is the strategic economic response to the consequences of the COVID-19 pandemic. The plan includes the National Gas Expansion Programme (NGEP) that includes targets for LPG as a substitute for kerosene and wood. To summarize:

- **LPG**: Nigeria was expected to be the flagship of LPG transition, but opaque market regulation and lack of infrastructure investment has slowed the pace of development.
- **Biomass**: Biomass has been considered not only for the domestic cooking sector transition (as improved biomass), but also for on-grid electricity production. Despite many targets to create a transformative biomass industry in the country, progress has been slow.
- **Ethanol**: There is initial interest in ethanol as an alternative fuel for cooking, electricity generation, and in the transportation sector to be mixed with gasoline. However, at present there is very limited local commercial production.
- **Kerosene**: The existing specific regulatory policies in the energy sector classify kerosene as a "modern fuel alternative," which suggests policies were drafted before the change of consideration by the WHO in 2014
- **eCooking**: There is no explicit mention of eCooking or cooking with electricity among the policies reviewed.

4.2.1 LPG

As a major oil and gas exporting country, LPG has long held promise as a potential local cleaner cooking fuel alternative to biomass and kerosene. However, relative to targets, local production has been slow to increase, and the many strategies, targets, and programs developed by various government ministries have had mixed results.

The growth trajectory of LPG and the challenges it has faced are outlined in the SE4ALL-AA. While the LPG market was deregulated in the late 1990s, the introduction of VAT on domestically produced LPG, in combination with the higher cost of local production, favoured imported LPG. By 2006 there was a particular mandate from the FGN to ExxonMobil to make available 350,000 MT of LPG that stalled due to inadequate upstream and downstream LPG infrastructure. Between 2008 and 2010 the government increased tariffs and taxes applicable to LPG. Currently, LPG remains unsubsidized and subject to VAT.[104]

The SE4ALL-AA describes Nigeria as a leading country on LPG and commits the government to become a regional and national model by accelerating the growth of the LPG sector.

Neither the NREAP nor NEEAP set LPG targets. The ECOWAS Energy Efficiency Policy (EEEP) does refer to the efficiency issue of cooking with traditional fuels and promotes LPG as an alternative. However, there is no particular regional programme or strategy defined to achieve that.

One recent plan that includes LPG is the Nigeria Economic Sustainability Plan (2020) in its track 2 of the National Gas Expansion Programme (NGEP). This plan tries to coordinate "all the disparate efforts undertaken by industry stakeholders." It aims to support the conversion from traditional fuels to LPG (30 million homes) by promoting the domestic manufacturing of cylinders and other accessories (this includes the provision of 5–10 million cylinders in pilot states), while implementing an education and awareness campaign. An eleven-member inter-ministerial committee for LPG expansion has been

created by the Office of the Vice President to coordinate the implementation of the programme. In addition to representation from the Office of the Vice President, the committee includes the Ministry of Budget and National Planning, the Ministry of Agriculture and Rural Development, the Ministry of Environment, the Ministry of Finance, the Ministry of Information and Culture, the Ministry of Industry, Trade, and Investment, the Ministry of Petroleum Resources, the Ministry of Power, Works, and Housing, the Ministry of Transportation, and the Ministry of Women Affairs and Social Development.[105]

4.2.2 Biomass and improved biomass

Biomass (waste) is defined in the NREEEP as an abundant but underutilized renewable energy source in Nigeria. The same document points out the problem of firewood being up to 50% of overall domestic primary energy consumption. Non-wood biomass could serve as an alternative energy resource for generating electricity, especially in rural areas, mostly as an off-grid power generation source. Doing so would require: 1) facilitating the use of new biomass electricity technologies; 2) promoting R&D in biomass technology and fuels; and 3) incentivizing local entrepreneurs among others. The Biomass Programme Targets for Electricity are: 5 MW by 2015, 57 MW by 2020, and 292 MW by 2030. Neither biomass nor improved biomass is explicitly described in the reviewed policies as an alternative cooking fuel.

The SE4ALL-AA also states the urgency to rethink the use of wood biomass since it represents 80.9% of the total primary energy supply in Nigeria. It identifies it as the single largest factor accounting for the change in the country's deforestation and desertification. As a fuel for electricity generation, biomass was targeted to achieve 3% of Nigeria's power generation capacity by 2020 and maintain that level through 2030. Opportunities to improve biomass as cooking fuel are identified as developing "financing schemes to provide credit to households that cannot afford the upfront costs for efficient biomass stoves," and promoting the development of new and improved biomass fuels.

NREAP establishes feed-in-tariffs from 1 MW to 5 MW for renewable biomass electricity capacity generation. However, there is no particular consideration of biomass/improved biomass for cooking purposes.

NEEAP again refers to the regional EEEP for any mention of biomass. It states that "Specific objectives of the safe and sustainable cooking initiatives" can be achieved by "creating a self-sustaining entrepreneurial network of rural microenterprises for delivery of improved biomass fuels" and "establishing the use of improved biomass fuels as a common practice for rural households."

4.2.3 Ethanol

There are very few mentions of ethanol as a fuel in the energy policies in Nigeria. In NREEEP the only mention is within the Biomass Programme Targets, which state an expectation to increase bio-ethanol (E10) production from 5.3 ML/day in 2015 to 24.2 ML/day by 2030.

One of the actions needed to achieve the overarching objective of energy efficiency in the SE4ALL-AA, in the transportation section, is to achieve 10% of bioethanol from cane sugar in the gasoline mix. It also includes ethanol as new biomass energy source but does not specify if for cooking purposes or other uses.

In the NREAP, ethanol is classified as a modern fuel alternative for domestic cooking energy. It is therefore included in the "*Use of Modern fuel alternatives for cooking*" and shares the same target as

LPG: utilized by 55% of the population in 2020 and 34% in 2030. For transportation purposes, NREAP goes beyond the SE4ALL-AA and establishes a share in the gasoline of 33% in 2020 and 57% in 2030.

The only mention of ethanol in the NEEAP is its classification as a modern fuel alternative for cooking. There are no specific targets, strategies, or incentives described.

4.2.4 Kerosene

The SE4ALL-AA for Nigeria includes kerosene as a modern cooking fuel and is therefore included in the targets of the percentage of population using those fuels: 50% by 2020 and 80% by 2030. It also identifies kerosene and firewood as the major competitors to LPG, especially in rural areas. The document states that kerosene is subsidized by the government, though the subsidy was eliminated in 2016.[106]

Kerosene is also considered a modern fuel alternative for domestic cooking by NREAP and NEEAP, and shares the same utilization target: 55% in 2020 and 34% in 2030. However, there are no specific strategies and policies for its promotion. More recently, the 2020 Nigeria Economic Sustainability Plan (NESP) classifies kerosene as a "traditional dirty fuel" that should be substituted by the use of cleaner LPG fuel in the National Gas Expansion Programme (NGEP) in its track 2.

4.2.5 eCooking

eCooking or cooking with electricity is not directly referenced in any of the reviewed documents. Although it could be interpreted as part of the modern fuel alternative group found in the SE4ALL-AA, NREAP, and NEEAP, eCooking is not listed in the definitions. However, one of NREEEP's policy objectives is "to bring abundant electricity access to almost half of Nigerian population that is currently electricity abstinent, including more sustainable provisions for domestic use and cooking." But it is unclear if this considers the use of electricity specifically for cooking.

The relative absence of regulations on, or even affecting, eCooking is also an opportunity for the FGN to make a clear, bold plan to support eCooking. This is a chance for government leadership to harness the power of the private sector, attract companies and financing, get donor support, and contribute to the improvement of livelihoods in low energy access areas of the country.

4.3 Discussion of Gaps

Across the various policies, there is a need for alignment on shared targets and strategies for the clean cooking sector. Key overarching gaps include:

- **Lack of a coordinating body**. There is no *de facto* organization or agency responsible for ensuring collaboration cross the cooking sector. Most of existing policies are under the Ministry of Power, but some targets were established by the Ministry of Environment or reference the regional ECOWAS framework. In the past, GACC relied on the Ministry of Environment, while ECOWAS and SE4ALL relied on the Ministry of Power. There are historical reasons for this but, going forward, a clear clean cooking coordinator or central body needs to be defined and empowered to drive alignment across the sector.
- **Targets without a plan for implementation and funding**. The strategy and resources to ensure goals are met has been a missing element from many policies. This may be driven in part by the lack of a central coordinator. For example, in The Nigeria Clean Cooking Forum held in 2016, the Federal Ministry of Environment was identified as the leading government agency to develop implementable work programs and to ensure budgetary allocations for the clean cookstoves sector in the country.[107] This, however, contradicts the NREEEP, which assigns a key strategy of "Encouraging the production and use of improved and more-efficient cooking stoves" to the Ministry of Power as responsible for coordinating and implementing to achieve the targets.
- **Limited appliance standards and regulation**. Some efforts have been made to create specific standards and labelling for cooking appliances, but they are not widespread and require coordination. However, there is an emerging foundation to enable this to happen. In 2015 the Standards Organization of Nigeria created the *Standard for Clean Cookstoves, Part 1: Biomass Type;* and in a 2017 report, CLASP pointed out the importance and market-transforming potential for establishing clear standards and labelling policies in Nigeria. In 2018, the Nigerian Alliance for Clean Cookstoves published a document with the motivation to synthesize the existing tests and standards globally.[108] There are two globally recognized stove testing laboratories in the country: the Nigeria Clean Cookstove Design and Testing Centre established by the GACC and ICEED, and the National Stove Eligibility Laboratory at the University of Nigeria Nsukka. The latter is managed by the National Centre for Energy Research and Development, an arm of the Energy Commission of Nigeria.

Overall, a successful eCooking sector in Nigeria will benefit from an improved policy landscape. Updated or new policies, regulation and standards, and clear long-term plans with associated funding would benefit the sector. Given the inconsistencies between policies, there is also an opportunity to reset the national dialogue on clean cooking technologies. Experts focused on clean cooking, such as MECS, CCA, Shell Foundation, and ESMAP, can play an important role in helping the FGN in this regard.

5. Implications and Opportunities for eCooking in Nigeria

The preceding account of the electricity and cooking sectors, stakeholder landscape, and policy landscape relevant to eCooking makes clear a number of gaps and opportunities to consider in developing a programme focused on Nigeria. It is clear both that there is a potential significant role that eCooking can play in Nigeria's energy transition, but also that a number of challenges will need to be addressed before that can happen. The following five major insights are especially important to consider in advance of designing a programme, and inform the recommendations included in the following section.

1. Grid-connected areas will be challenging for eCooking adoption

eCooking will almost certainly be adopted in grid-connected areas of Nigeria eventually. However, given business model challenges for DisCos and reliability issues faced by customers, this will be difficult to achieve in the near- or mid-term future. Potentially, eCooking could be part of a utility-enabled distributed energy resource program, but even then it will likely be through a third-party intermediary rather than the utility itself.

This is likely to be more challenging than it has been in parts of South Asia and East Africa because grid reliability in Nigeria is lower, and most DisCos face fundamental business challenges before reliability will significantly improve. There is currently no affordable grid-connected work-around, such as a grid-tied battery system, for customers to choose eCooking in the face of frequent power outages. As a result, even in wealthy, grid-connected areas, customers almost universally choose other fuel types—increasingly LPG where it is available—and eCooking has 1% adoption rate. However, it should be noted that on-grid tariffs are often half, or even one-third the price of minigrid tariffs, which works in favour of eCooking on-grid, if either reliability were improved or a cost-effective, affordable battery work-around were developed.

2. Off-grid areas present a clearer opportunity for eCooking, though with challenges

Off-grid electrification efforts through minigrids in Nigeria offer a very clear link to eCooking. Impressive government leadership on minigrids, support from financiers, higher reliability for off-grid systems than the grid, and an interest from minigrid developers in exploring eCooking business models all work in favour of eCooking in off-grid areas.

As shown above, the REA is increasingly focused on stimulating demand among new users on minigrids, to make cost-saving and income-generating use of the available capacity of minigrids. The REA of 2017–2020 has established a track record of setting ambitious targets through clear strategy, marshalling the resources to implement, and following through. Similarly, donor partners have demonstrated a clear interest in supporting this progress, as evidenced by the available subsidies and the number of minigrids in the development pipeline.

eCooking can build on this success by integrating with existing productive use and minigrid development efforts. As RMI found through stakeholder interviews, minigrid developers are keen to better understand how eCooking appliances could be incorporated into their business models. A risk in eCooking use in a minigrid context is driving coincident peak load in the evenings, when power is provided by relatively expensive batteries or diesel generation. Developers could potentially use tools such as time-of-use pricing or on-bill financing for energy efficient appliances to address these challenges, but the application of these tools for

eCooking is a gap at present. The other notable risk for eCooking on minigrids is the relatively high cost of cooking as a result of cost-reflective tariffs.

3. Private-sector companies and investors will play a leading role in eCooking growth

Nigeria's government, and Nigerians at large, have a mentality that leans strongly toward market-led solutions. While the FGN and its agencies provide leadership, an enabling environment, and support to commercialize technologies, there is little expectation that the government should be the long-term driver of industries. The off-grid minigrid sector's growth in the past several years is an example of this. While the REA's leadership and coordination with donor partners to foster growth of the minigrid sector have supported initial development of the sector, doing so has also been with an intent to strengthen and support local developers. More so than most countries in sub-Saharan Africa, the private sector in Nigeria is likely to take a leading role in the growth of eCooking in the country, and it will be important to incorporate this dynamic in programme planning.

4. More reliable national data is needed for a large-scale eCooking program

As has been stated earlier in this report, Nigeria is a large country with diverse populations and cultures across its regions. Finding trends across these diverse groups would be challenging in itself, but at present the relevant cooking data for the country is thin. Government and multilateral statistics frequently contradict one another. Existing academic studies typically look at small sample sizes or isolated regions. The World Bank's *Multi-Tier Framework Energy Access Diagnostic Report*, which gathers crucial cooking data, has only been completed for one of the country's six geographical zones. Some of the strongest data available is from GACC's 2011 *Accenture Development Partners'* report. However, in a country changing as rapidly as Nigeria, that data is increasingly unreliable ten years from publication. The development of a large-scale eCooking program will depend on reliable, up-to-date national cooking data.

5. eCooking policy coordination, support for implementation, and funding follow-through is needed

Over the past decade, there has been a lack of coordination across clean cooking actors, which has resulted in lost momentum in the clean cooking sector. There is a clear need for coordination of policy efforts, including encouraging the use of shared definitions, agreeing to consistent targets, and most importantly linking planning to implementation and funding. As is clear in the above policy analysis, this is not likely to be a simple task and policy efforts are likely to remain largely siloed by fuel type. For eCooking in particular, there is an opportunity to take advantage of the recent success of the minigrid sector. This is a gap that MECS and others can certainly play an important role in helping policymakers to fill. However, it will also be important to prioritize between addressing the policy environment and other gaps (which may be more pressing).

6. Recommendations

The gaps and opportunities identified in the previous section are a starting point for organizing the next phase of action research by MECS and others. This set of recommendations is divided into three phases according to priority. The first phase, to test and price the market through field research, is a prerequisite to phase 2, demonstrating a viable business case, and phase 3, supporting business development.

6.1 Phase 1: Develop Prerequisite Data through Testing

The most important step to grow the clean cooking sector in Nigeria is to immediately deploy relatively large-scale testing and user data collection regarding eCooking solutions and competing alternatives. Designing this eCooking test programme will benefit from discussion with stakeholders—a preliminary outline of key questions is included here for consideration as part of subsequent MECS-organized convenings.

An eCooking testing programme should include both off-grid and on-grid applications with a particular focus on rural minigrids. Any dedicated focus on on-grid applications should examine the extraordinary challenge of grid reliability, and potential ways of addressing it. Testing should be conducted across the six geopolitical zones, and ideally in combination or parallel with the testing of other fuel-types. This testing will provide information on load usage, grid impacts, cooking events, and consumer preferences. In addition, price mapping of fuels should be conducted all six zones and include rural, urban, and peri-urban end-users. The approach taken by ESMAP and MECS for case studies in Myanmar and Tanzania in the 2020 report, "Cooking with Electricity: A Cost Perspective," offers a template for this preliminary data collection.[109] This crucial information will determine the direction of other support. This test should engage with partners, such as GIZ, Shell Foundation, and the World Bank's ESMAP group, that can help lead on LPG cooking testing and help in gathering regional data from across the country.

Key questions to address

The objective of a successful eCooking test will be the evidence-based design of a national eCooking program likely to successfully bring eCooking to scale in Nigeria. The need for national action on clean cooking in Nigeria is urgent, and eCooking, as a likely major component of clean cooking in Nigeria, is subject to the same urgency. An eCooking test should be designed to answer the following questions, divided into pre-testing and testing components.

Prior to testing, the groundwork for a robust large-scale test should be laid by addressing the following questions, which could be answered through a combination of surveying and field observation:

- *At a granular level, what is the baseline cooking behaviour across the six geopolitical zones, and across urban, peri-urban, and rural areas?*
- *What is the ability to pay across these six zones and three community types?*
- *What are the precise costs of existing fuel types across regions?*
- *What is the level of consumer interest in eCooking appliances?*
- *What is the regional availability of appropriate appliances?*

The eCooking test itself should seek to answer the following questions:

- *What is the customer adoption rate of eCooking? How are eCooking appliances used?*

- *Is there a viable business model for eCooking on minigrids? What does this business model look like?*
- *Are there demand-side management approaches that can effectively address the coincident load challenge of eCooking on minigrids? (e.g. time of use pricing)*
- *What are the key roles for a successful eCooking program? (e.g., developer, third parties, financiers, government agencies, etc.)*
- *What is the impact on livelihoods of eCooking on minigrids?*
- *And ultimately, what should a full-scale national eCooking program look like?*

Scale of test and timeline

The results of this report will be shared with key stakeholders during MECS's planned virtual convening in 2021. These stakeholders will include leaders in the Nigerian government, experts from the private sector, investors, local and international NGOs active in Nigeria's cooking sector, and donor partners looking for ways to support clean cooking. The convening will be used to test the findings of the gap analysis and gather from participants their insights on how to begin to address these gaps.

Based on the findings described in this report, RMI recommends that the eCooking test focus primarily on minigrids, which hold a more immediate promise and likelihood of success given the challenges faced by eCooking on the grid, while reserving the possibility of also testing on-grid eCooking. A comprehensive eCooking test should begin as soon as possible and run for at least one calendar year to account for seasonal variations in customers' ability to pay, variations in the availability of competing fuels, and the breadth of household cooking behaviour.

6.2 Phase 2: Unlock Market Growth by Demonstrating a Viable Business Case

The testing programme described in Phase 1 will enable expansion of eCooking by demonstrating both technical viability and providing data on consumer preferences. This will address concerns expressed by developers and could open the door to integration with productive use programmes. This should leverage data and insights from pilots deployed in Step 1 above, in order to give confidence in the recommendation. It should answer questions around coincident peak loading on minigrids from simultaneous cooking usage, around tariff strategies to shift demand while meeting customer needs, and around likely levels of adoption as programs scale.

Establishing a strong business case will also help to identify the strategic partnerships that are needed between off-grid developers and clean cooking enterprises in order to scale eCooking. The opportunity for clean cookstove operators to bundle services could drive the development of a clean stack, with the offering of eCooking solutions as the highest tier in a stacking scenario.

Business case analysis should also support policy and development program decision-making. With Phase 1 market and pilot data in hand, this analysis should deeply probe the efficiency of investments in infrastructure for various fuel types (e.g., increased peak minigrid capacity for eCooking, etc.) relative to customer preferences and use patterns. This analysis can then inform government-driven investment or subsidy programs, and direct capital towards the most cost-effective solutions for customers in the long term. For example, hypothetically, this analysis might find that a mild tariff

subsidy for minigrid customers to use eCookers would be more cost-effective at stimulating a clean cooking market than subsidizing investment in LPG infrastructure.

6.3 Phase 3: Support Local Clean Cooking Business Development

To help business sustainability, future work can develop a plan for businesses to prioritize engagement with consumers. This engagement, including after-sales customer service, should be an integral part of the design of eCooking businesses and solutions. This will require leadership from the private sector and government in the form of regulations, standards, and quality control. GOGLA's work in the solar lighting and solar home system market offers a strong model, and the taskforce and association recommended in Step 2 could provide the necessary infrastructure and buy-in for local leadership.

To help businesses select effective technology options, a buyer's guide should be made available to businesses interested in eCooking appliances, including technical details on their efficiency, safety, and cooking uses. This should include determining whether locally produced eCooking appliances are critical as a key driver for success in Nigeria or if imported appliances provide a better value proposition to businesses and consumers, particularly in the near-term.

In addition to the interventions identified here, several best practices have emerged from clean cooking programs in other geographies. In particular, *taxation policy* should be mapped for eCooking solutions. High-level meetings or workshops can be used to facilitate favourable taxation frameworks for cooking appliances. *Standards and labels* should be extended to eCooking to safeguard the consumer and provide transparency for the available technologies in the marketplace. Further *local health studies* should clearly show the benefits of eCooking to reduce health costs for individuals and government-funded programs in Nigeria. The government should explore financing eCooking interventions through the prepayment of positive health outcomes.

6.4 Domestic and International Activities to Support the Enabling Environment

Developing the knowledge base and market-led business models should be the priorities in a near-term programme focused on Nigeria. However, there are additional opportunities to support the enabling environment for eCooking development, which can be conducted with other clean cooking stakeholders in Nigeria and in concert with broader international efforts. These include the following two areas.

6.4.1 Facilitate the development of a Nigerian eCooking taskforce

Within eCooking itself there are a number of disparate efforts across government agencies and ministries, and a private sector with shared interest in understanding the value of eCooking, but no clear voice with which to marshal political or donor partner support. While it would be ideal for a Nigerian government agency to lead eCooking efforts, as discussed above, in lieu of that a sectoral taskforce can play this role. MECS could support the development of either a new eCooking taskforce, or help strengthen the Nigerian Alliance for Clean Cookstoves to take the lead. The taskforce would provide needed coordination between ministries, ECREEE, private sector operators, eCooking companies and off-grid developers, researchers, and funders. This entity should work closely with existing efforts from the REA, the Ministry of Environment, and the Ministry of Power.

6.4.2 Support definition of improved Nigerian clean cooking policy

As discussed in **Section 4.3**, there is not currently a comprehensive national policy governing and directing the clean cooking sector in Nigeria. Helping the FGN to create a clear clean cooking policy, or even a clearer focused eCooking policy, would provide sectoral stakeholders with clarity on the government's objectives, and could help better marshal federal agencies and implementation support for an aggressive clean cooking and eCooking agenda.

Micro-level policy interventions should be considered as well, such as potential integration with productive use programmes implemented through (or alongside) the NEP. However, it is very likely that interventions at this scale will flow naturally from the development of an evidence base and commercial business models through the above program. The NEP and other electrification programmes are predominantly flexible in the types of activities they support—a commercially viable electric appliance that benefits minigrid customers and helps reduce the minigrid's tariffs will be embraced and will not require dedicated policy support. Macro-level policies are less likely to happen without a focused effort, based on the experience to date.

7. Conclusion

Two immediate next steps will build on the recommendations in this report:

Clean Cooking Knowledge Hub design convening

To build on this gap analysis and define a shared vision for the path forward, MECS and RMI will convene key stakeholders. The convening will share identified gaps in the clean cooking sector with Nigerian and international sector leaders through a pre-read, then use a multi-session virtual format, facilitated by RMI, to test those findings and solicit additional input from participants. This expert input will improve the depth and quality of these initial findings, help to direct the implementation of recommendations, and garner buy-in from stakeholders in collaborative execution.

Design testing for Phase 1

As a prerequisite for the implementation of other recommendations, further testing and pricing of the market should begin as soon as possible. This test should explore eCooking in depth, while also identifying partners that can help compare findings with other fuel type data and assist in gathering regional data on clean cooking prices, appliance availability, and fuel penetration.

8. Appendices

a. ***Policy documents*:** An annotated bibliography of identified and relevant policy documents, including a brief explanation of why key documents matter for eCooking.

b. ***Acronym list***

Appendix A: Policy Documents

National Electric Power Policy (NEPP)

Type	Policy
Administration	Promoted by the Electrical Power Implementation Committee and the National Council on Privatization Approved by the Federal Executive Council
Date	April 2001

Notes:

The key objective of the NEPP is to ensure the Nigeria electricity industry meets the needs of its citizens in the 21st century through a three-stage regulatory reform: i) **Transition Stage**: private power generation through Independent Power Producers (IPPs) and Emergency Power Producers (EPPs); NEPA privatization through sale or licensing the power plants to private operators; ii) **Medium-term** competition among the companies and energy trading between generation and distribution companies via bilateral contracts; iii) **Long-run Competition Structure,** during which time generation, transmission and distribution companies will be in optimal operation.

National Energy Policy (NEP)

Type	Policy
Administration	Redacted by the Energy Commission of Nigeria and Revised-Approved by the Inter-Ministerial Committee
Date	April 2003
URL	http://rea.gov.ng/wp-content/uploads/2017/09/National_Energy_Policy_Nigeria.pdf

Notes:

The NEP is an overall policy targeting the development of the energy sector and its contribution to the national economy. The NEP describes the multi-dimensional nature of the energy sector and, accordingly, identifies where activities regarding research and development, exploitation, energy pricing and financing, legislation, energy efficiency, and the environment are needed. The document covers renewable energy resources, rural electrification, and the expansion of electrification.

National Economic Empowerment and Development Strategy (NEEDS)

Type	Policy
Administration	Redacted by the Nigeria national Planning Comission
Date	2004
URL	http://documents1.worldbank.org/curated/en/234301468290438608/pdf/33305.pdf

Notes:

Policy focused on steps needed to address the progressive social, political, and economic challenges faced since 1999. The NEEDS aims to consolidate previous legislative period achievements in poverty reduction, employment generation, wealth creation, and value reorientation. Regarding infrastructure, the strategy promotes privatization but directs government to play a role in funding high investment-need, low-attractiveness projects for private investors (i.e., rural areas). The document also stresses increased renewable energy in the energy mix, and identifies the need for a Renewable Energy Agency.

Electric Power Sector Reform Act (ESPRA)

Type	Policy
Administration	Enacted by the National Assembly of the Federal Republic of Nigeria
Date	2005
URL	http://rea.gov.ng/wp-content/uploads/2017/09/Electric-Power-Sector-Reform-Act-2005.pdf

Notes:

The ESPRA outlines the privatization and shift toward market competition for the Nigeria power sector. ESPRA provides a frame for the formation of companies to, “take over the functions, assets, liabilities and staff of the National Electric Power Authority (NEPA) to develop a competitive electricity market”. It created the Nigeria Electricity Regulatory Commission (NERC); the ESPRA also structured the licensing and regulation of the generation, transmission, distribution, and supply of electricity. It established performance standards, consumers rights and obligations, and tariffs, and created the REA.

This law is the most important recent legislation in the sector. It founded new government institutions, restructured public bodies, and set a new direction for the energy sector.

Renewable Electricity Policy Guidelines (REPG)

Type	Policy
Administration	Issued by the Federal Ministry of Power and Steel
Date	December 2006
URL	https://www.iceednigeria.org/resources/dec.-2006.pdf

Notes:

This document is the federal government's overarching policy on all electricity derived from renewable energy sources. It establishes the federal government's vision, policies, and objectives for promoting renewable energy in the power sector. Renewable energy is seen as an instrument to increase and extend electricity access to the unserved. The REPG targeted 5% renewable energy penetration in the energy mix with a minimum of 5 TWh of electric production by 2016.

The policy identifies additional generation, increasing stability by mitigating local disruptions, and reduction of emissions as advantages of increased renewable energy deployment.

Renewable Electricity Action Program (REAP)

Type	Program
Administration	Issued by the Federal Ministry of Power and Steel
Date	December 2006
URL	https://www.iceednigeria.org/resources/dec.-2006-2.pdf

Notes:

The document describes electricity access as critical to achieve economic and social development goals defined in the NEEDS and the Millennium Development Goals (MDGs). The FGN fully commits to mobilize the electricity sector and considers renewable energy a unique opportunity to scale-up access to electricity. The REAP also provides a framework to implement the REPG.

The REAP describes the potential for renewable energy, along with associated technologies and markets, as well as targets and strategies for fulfilling this potential. The REAP describes a process for financing renewables via the REF, and sets roles of different government agencies.

National Biofuel Policy and Incentives

Type	Policy
Administration	Issued by the Nigerian National Petroleum Corporation (NNPC)
Date	July 2007

URL	https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/laws/1517.pdf

Notes:

The National Biofuel Policy and Incentives aims to develop the biofuel industry in order to gradually reduce dependence on imported gasoline and reduce greenhouse gas emissions, while promoting economic development. Concrete measures outlined include the introduction of a biofuel blend (10% ethanol) and various measures aimed at stimulating market demand for biofuels and promoting their production (i.e. through tax exemptions, import duty waivers, tax exemption, etc.). The policy establishes the Biofuel Energy Commission and Biofuel Research Agency and sets as a target that by 2020, 100% of biofuels consumed in the country come from domestic production.

The document refers to ethanol and bio-diesel made from biomass; understanding biomass as agriculturally produced raw materials available on a recurring basis, like trees, crops, fibers, cellulose. The policy appears to have declined in relevance since 2012, and amid criticism of the conflict between crops for food and fuel. The biofuel projects remained marginal in the country[x]

Nigeria Vision 20:2020

Type	Policy
Administration	Issued by the National Planning Commission + National Council on NV20:2020
Date	December 2009
URL	https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/laws/1516.pdf

Notes:

The NV20:2020 is a long-term plan for stimulating Nigeria's economic growth and launching sustained and rapid socio-economic development. This blueprint document articulates the economic growth and development strategies for the period between 2009 and 2020, and will be implemented using a series of medium-term national development plans. The document envelops the principles of the National Economic Empowerment and Development Strategy (NEEDS).

NV20:2020 identifies some energy related barriers to achieve this economic development: unreliable power supply, poor infrastructure, and dependence on the oil sector. The energy provision is considered a key component and it describes energy sector development as being led by the private sector in a liberalized market, with a limited role for government and agencies in providing legal and regulatory frameworks.

The dependence on exploration and exportation of petroleum is seen as an economic vulnerability and the document points out the need to diversify the national income. The impact of the energy sector on

[x] Ohimain, E. (2013) "Can the Nigerian biofuel policy and incentives transform Nigeria into a biofuel economy?". Energy Policy 54: 352-359.

the economy is seen as a primary driver for change, as opposed to climate change and environment protection.

NV20:2020 recognizes the importance of renewable energy resources in achieving the national electricity targets. One goal raises the issue of clean cooking, and sets the target of, "*replacing 50% of firewood consumption for cooking with biomass energy technology by 2020.*"

Renewable Energy Master Plan (REMP) Update

Type	Policy
Administration	Issued by the Energy Commission of Nigeria and the United Nations Development Programme (UNDP)
Date	2005 and 2012
URL	https://www.energy.gov.ng/Energy_Policies_Plan/Draft%20(Reviewed)%20NEMP%20-%202014.pdf

Notes:

The REMP describes the role of renewable energy in achieving sustainable development, and establishes a road map for achieving it. The document makes no differentiation between off-grid and on-grid generation, but refers to renewable energy integration in buildings and electricity grids. The REMP targets high electrification rates, from 42% in 2005 to 75% in 2025. It emphasizes the importance of solar energy in the country's energy mix, and sets the goal of increasing the supply of renewable electricity from 13% of total generation in 2015 to 36% by 2030.

Appendix B: Acronym list

A2EI	Access to Energy Institute
AfDB	African Development Bank
AMDA	Africa Minigrid Developers Association
ATC&C	Aggregate Technical, Commercial, and Collection
BCRM	Branded Cylinder Recirculation Model
CLASP	Collaborative Labeling and Appliance Standards Program
CBN	Central Bank of Nigeria
CCA	Clean Cooking Alliance
COVID-19	Coronavirus Disease 2019
DisCos	Distribution Companies
eCooking	Electric Cooking
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EEEP	ECOWAS Energy Efficiency Policy
ESMAP	Energy Sector Management Assistance Program
EnDev	Energising Development
EPSRA	Electric Power Sector Reform Act
FCDO	Foreign, Commonwealth & Development Office
FGN	Federal Government of Nigeria
FMP	Federal Ministry of Power
FMoE	Federal Ministry of Environment
GACC	Global Alliance for Clean Cooking
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOGLA	Global Off-Grid Lighting Association
ICEED	International Centre for Energy, Environment and Development
IEA	International Energy Agency
kVA	Kilovolt amperes
kW	Kilowatt
kWh	Kilowatt hour
LPG	Liquefied Petroleum Gas

MECS	Modern Energy Cooking Services
MT	Metric-tons
MTF	Multi-tier Framework
MW	Megawatts
MYTO	Multi-year Tariff Order
NBPI	National Biofuel Policy and Incentives
NCCA	Nigerian Clean Cooking Alliance
NEEAP	National Energy Efficiency Action Plan
NEEDS	National Economic Empowerment and Development Strategy
NEP	Nigerian Electrification Project
NEP_2	National Energy Policy
NEPA	National Electric Power Authority
NEPP	National Electric Power Policy
NERC	Nigerian Electricity Regulation Authority
NESP	Nigerian Energy Support Programme
$NESP_2$	Nigeria Economic Sustainability Plan
NGEP	National Gas Expansion Programme
NGO	Non-Governmental Organization
NPSP	Nigeria Power Sector Program
NREAP	National Renewable Energy Action Plan
NREEEP	National Renewable Energy and Energy Efficiency Policy
NV20:2020	Nigeria Vision 20:2020
OPV	Office of Vice President
PBG	Performance-based Grant
PHCN	Power Holding Company of Nigeria
PIP	Performance Improvement Plans
PMU	Project Management Unit
PPP	Public Private Partnership
PSRO	Power Sector Recovery Operation
PSRP	Power Sector Recovery Program
PV	Photovoltaic
REA	Rural Electrification Agency
REAP	Renewable Electricity Action Program

REF	Rural Electrification Fund
REMP	Renewable Energy Master Plan
REPG	Renewable Electricity Policy Guidelines
RESIP	Rural Electrification Strategy and Implementation Plan
RMI	Rocky Mountain Institute
RUWES	Rural Women Energy Security
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SE4ALL	Sustainable Energy for All
SE4ALL-AA	Sustainable Energy for All Action Agenda
SHS	Solar Home System
USAID	United States Agency for International Development
USD	United States Dollar
VAT	Value-added tax
W	Watt

Endnotes

[1] Energy Sector Management Assistance Program, *The State of Access to Modern Energy Cooking Services*, ESMAP, World Bank, 2020.

[2] Mini-Grids Partnership, *State of the Global Mini-grids Market Report 2020*, BloombergNEF and Sustainable Energy for All, 2020, https://www.seforall.org/publications/state-of-the-global-mini-grids-market-report-2020.

[3] Energy Sector Management Assistance Program, *The State of Access to Modern Energy Cooking Services*, ESMAP, World Bank, 2020.

[4] United Nations Department of Economic and Social Affairs, *World Population Prospects 2019*, UNDESA Population Dynamics, 2019, https://population.un.org/wpp/DataQuery/.

[5] The World Bank, "Rural Population (% of total population) – Nigeria," World Bank Open Data, 2020, https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=NG.

[6] Nigerian National Bureau of Statistics, *LSMS Integrated Surveys on Agriculture: Nigeria General Household Survey-Panel Wave 4*, 2018/2019, World Bank Microdata Library, https://microdata.worldbank.org/index.php/catalog/3557/related-materials.

[7] Energy Sector Management Assistance Program, *Multi-Tier Framework: Cooking*. Multi-Tier Framework, (ESMAP, 2020), https://mtfenergyaccess.esmap.org/methodology/cooking.

[8] The World Bank, *GDP (current US$) – Nigeria,* World Bank Data, accessed February 10, 2021, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=NG; and United Nations, Department of Economic and Social Affairs, *World Population Prospects 2019*, Population Dynamics, (UNDESA, 2019), https://population.un.org/wpp/DataQuery/.

[9] National Identity Management Commission, *NIMC Enrolment Centres,* Federal Republic of Nigeria, 2020, https://nimc.gov.ng/nimc-enrolment-centres/ ; Mike Odiegwu, Ozioma Ubabukoh, Leke Baiyewu, and Allwell Okpi, "Six political zones divide North, South," *Punch*, August 12, 2012, https://web.archive.org/web/20141227144218/http://www.punchng.com/news/constitution-six-geopolitical-zones-divide-north-south/.

[10] Ecowas Centre for Renewable Energy and Energy Efficiency, *ECOWREX GeoNetwork Catalog,* ECREEE, 2020, http://www.ecowrex.org:8080/geonetwork/srv/eng/catalog.search#/metadata/2e8036fa-5c9c-4a98-a90c-49e943179871.

[11] Organization of the Petroleum Exporting Countrie, *OPEC: Nigeria*, 2020, https://www.opec.org/opec_web/en/about_us/167.htm#:~:text=The%20oil%20and%20gas%20sector,Its%20currency%20is%20the%20naira.

[12] H.E. Yemi Osinbajo, "Reviving Nigeria's Economy Through Diversification," Brookings, The Brookings Institution, January 25, 2019, https://www.brookings.edu/blog/africa-in-focus/2019/01/25/reviving-nigerias-economy-through-economic-diversification/.

[13] Nigerian Electricity Regulation Agency, *DisCos*, 2020, https://nerc.gov.ng/index.php/contact/discos.

[14] Ibid.

[15] Jose Javier Guerra Roman, *NESI's Challenges and a Way Forward*, Nigeria Power Distribution Capacity Building and Technical Assistance Project, 2020.

[16] The World Bank Group, "Nigeria – Electricity Transmission Network – Datasets," World Bank, 2020, https://energydata.info/dataset/nigeria-electricity-transmission-network-2015.

[17] Nigerian Electricity Regulation Agency, *NERC Quarterly Reports,* NERC, 2020.

[18] Power Africa, *Power Africa in Nigeria – Fact Sheet*, U.S. Agency for International Development, 2020, https://www.usaid.gov/powerafrica/nigeria.

[19] GET Invest, "Nigeria Energy Sector," GET.invest, 2020, https://www.get-invest.eu/market-information/nigeria/energy-sector/.

[20] Access to Energy Institute, "Putting an End to Nigeria's Generator Crisis: The Path Forward," A2EI, 2019.

[21] RMI site visits.

[22] Arlet, J., *Electricity Tariffs, Power Outages and Firm Performance: A Comparative Analysis*, Global Indicators Group, Development Economics, The World Bank, 2017.

[23] Nigerian Electricity Regulation Agency, "Key Operational and Financial Data of the Nigerian Electricity Supply Industry," NERC, 2020.

[24] Nigerian Electricity Regulation Agency, NERC, 2020.

[25] Babalwa, Bungane, "Nigeria: Willing Buyer, Willing Seller Arrangement to Solve Power Challenges," ESI Africa, January 24, 2019, https://www.esi-africa.com/industry-sectors/generation/nigeria-willing-buyer-willing-seller-arrangement-to-power-challenges/.

[26] Rocky Mountain Institute, *Nigeria's First Commercial Undergrid Minigrid*, RMI, 2020.

[27] The Rockefeller Foundation, "Electrifying Economies," 2020, https://www.electrifyingeconomies.org/.

[28] Konexa, "Powering Africa's Future," Konexa, 2020, https://www.konexa.io/.

[29] Nigerian Electricity Regulation Agency, *Performance Improvement Plans,* NERC, 2020.

[30] Siemens, *Roadmap for Nigeria: Technical and Commercial Proposal*, 2019.

[31]The World Bank, "Power Sector Recovery Performance Based Operation," The World Bank, 2020, https://projects.worldbank.org/en/projects-operations/project-detail/P164001, http://documents1.worldbank.org/curated/en/115731517496257028/pdf/124328-PGID-P164001-Appraisal-PUBLIC.pdf.

[32] The World Bank, "Urban Population – Nigeria," World Bank Data, 2020, https://data.worldbank.org/indicator/SP.URB.TOTL?end=2018&locations=NG&start=1990.

[33] Uduak, Akpan, "Technology Options for Increasing Electricity Access in Areas with Low Electricity Access Rate in Nigeria," *Socio-Economic Planning Sciencies*. Elsevier, 2015, https://www.researchgate.net/figure/Percentage-of-households-with-electricity-access-in-the-different-States-in-Nigeria_fig1_277959845.

[34] Lumos Nigeria, Facebook, Facebook Post, December 5, 2020, https://www.facebook.com/LumosNigeria/posts/2604862293139110.

[35] Global Off-Grid Lighting Association, *Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data*, GOGLA, 2019, https://www.gogla.org/sites/default/files/resource_docs/global_off_grid_solar_market_report_h22019.pdf.

[36] Energy Sector Management Assistance Program, *Cooking with Electricity: A Cost Perspective,* The World Bank, 2020.

[37] Rocky Mountain Institute and Nigerian Economic Summit Group, *Minigrid Investment Report: Scaling the Nigerian Market*, RMI and NESG, 2018.

[38] Rural Electrification Agency, *REA Energy Database,* REA, 2020, https://rea.gov.ng/energydatabase/.

[39] Nigeria Energy Support Programme, "Least-cost Geo-spatial Electrification Modelling Map," NESP, GIZ, 2021, http://rrep-nigeria.integration.org/.

[40] International Energy Association, "Nigeria Energy Outlook from Africa Energy Outlook," IEA, 2019, https://www.iea.org/articles/nigeria-energy-outlook.

[41] Rocky Mountain Institute and Nigerian Economic Summit Group, *Minigrid Investment Report: Scaling the Nigerian Market*, RMI and NESG, 2018.

[42] Rocky Mountain Institute, *Minigrids in the Money*, RMI, 2018; ESMAP 2019

[43] Energy Sector Management Assistance Program, *Cooking with Electricity: A Cost Perspective,* The World Bank, 2020; A2EI, Clean Cooking: Data Release Report, December, 2020, https://a2ei.org/resources/uploads/2020/12/A2EI_CleanCooking_DataReleaseReport.pdf.

[44] Rural Electrification Agency, *Minigrid Investment Brief*, REA, 2017.

[45] Sustainable Energy for All, *Sustainable Energy for All Action Agenda/SE4ALL-AA,* Federal Republic of Nigeria, 2016, https://www.seforall.org/sites/default/files/NIGERIA_SE4ALL_ACTION_AGENDA_FINAL.pdf.

[46] Rural Electrification Agency, *Nigeria Electrification Project (NEP) Technical Workshop Report*. REA, 2019, http://rea.gov.ng/NEP_Technical_Workshop_Report_6.0_23.05.19.pdf.

[47] Rural Electrification Agency, *Nigeria Electrification Project. Development of Solar Hybrid Mini Grids for Rural Economic Performance-Based Grant Program*, REA, 2019, https://rea.gov.ng/wp-content/uploads/2019/07/Log-of-PBG-Clarifications-1672019-v0.2.pdf.

[48] African Development Bank, *Nigeria Electrification Project,* AfDB, 2019, https://projectsportal.afdb.org/dataportal/VProject/show/P-NG-F00-020.

[49] African Development Bank, *Nigeria Electrification Project Appraisal Report*, AfDB, 2018, https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/PESR_NG_NIGERIA_ELECTRIFICATION_PROJECT_CORR_EN-final.pdf.

[50] "Energising Development (EnDev) – Programme for Energy Access," Gesellschaft für Internationale Zusammenarbeit, 2020, https://www.giz.de/en/worldwide/40417.html.

[51] Nigerian Electricity Regulatory Commission, *Regulation for Mini-Grids 2016,* NERC, 2016, http://rea.gov.ng/wp-content/uploads/2018/07/NERC-Mini-Grid-Regulation.pdf.

[52] Gesellschaft für Internationale Zusammenarbeit, *Nigerian Energy Support Programme II,* GIZ, 2019, https://www.giz.de/en/downloads/NESP%20II_Factsheet.pdf.

[53] Rural Electrification Agency, *FG Launches* 'Solar Power Naija' *a 5 Million Solar Connection Programme to Off-Grid Communities,* REA, 2019.

[54] Central Bank of Nigeria, *Framework for Implementation of the Solar Connected Facility,* CBN, 2020, https://nep.rea.gov.ng/wp-content/uploads/2020/10/Solar-Connections-Facility-Guidelines-1.0.pdf.

[55] Rocky Mountain Institute and Deloitte Consulting, *Agricultural Productive Use Stimulation in Nigeria: Value Chain & Mini-Grid Feasibility Study*, 2020.

[56] CrossBoundary, *Study Design: Appliance Financing 3.0 Energy-Efficient Productive Use,* CrossBoundary LLC, 2020, https://www.CrossBoundary.com/wp-content/uploads/2020/03/CrossBoundary-Innovation-Lab-Study-Design-Appliance-Financing-3.0-Energy-Efficient-PU-Anonymized-04- Mar-2020.pdf.

[57] PowerGen, "MECS-TRIID Project Report (public version): Accelerating uptake of electric cooking on AC microgrids through business and delivery model innovation," February 21, 2021, https://mecs.org.uk/wp-content/uploads/2020/12/MECS-TRIID-PowerGen-Project-Report.pdf.

[58] A2EI, Clean Cooking: Data Release Report, December, 2020, https://a2ei.org/resources/uploads/2020/12/A2EI_CleanCooking_DataReleaseReport.pdf.

[59] RMI interviews.

[60] The World Bank, *Regulatory Indicators for Sustainable Energy Report*, 2019, https://rise.worldbank.org/reports.

[61] Spaces for Change, *The National Clean Cookstove Scheme: Challenges from Within*, 2015, https://spacesforchange.org/the-national-clean-cookstove-scheme-the-challenges-within/.

[62] Clean Cooking Alliance, "Nigeria," 2020, https://www.cleancookingalliance.org/country-profiles/focus-countries/3-nigeria.html.

[63] Batchelor et al., "eCook Global Market Assessment: Where will the transition take place first?" 2018, https://www.researchgate.net/publication/326489706_eCook_Global_Market_Assessment_Where_will_the_transition_take_place_first.

[64] Ibid.

[65] National Population Commission (NPC), "Nigeria Demographic Health Survey 2018," The DHS Program, ICF Rockville, Maryland, USA, 2018, 748, https://dhsprogram.com/publications/publication-fr359-dhs-final-reports.cfm.

[66] Ibrahim Kabir et al., "Assessing the Extent of Traditional Biomass Cookstove Usage and Related Cooking Practices: Evidence from Rural Households in Northern Nigeria," *IOSR Journal Of Humanities And Social Science (IOSR-JHSS* 23, no. 3 (2018): 39–46, https://doi.org/10.9790/0837-2303013946.

[67] Corfee-Morlot, Jan, Paul Parks, James Ogunleye, and Famous Ayeni, "Achieving Clean Energy Access in Sub-Saharan Africa," 2019, https://www.oecd.org/environment/cc/climate-futures/case-study-achieving-clean-energy-access-in-sub-saharan-africa.pdf.

[68] National Population Commission (NPC), "Nigeria Demographic Health Survey 2018," https://dhsprogram.com/publications/publication-fr359-dhs-final-reports.cfm; "Nigeria Demographic and Health Survey 2013," 2013; "Nigeria Demographic and Health Survey 2008," 2009, http://www.measuredhs.com.

[69] Accenture Development Partners, "Nigeria Market Assessment: Sector Mapping," 2011, https://www.cleancookingalliance.org/resources_files/nigeria-market-assessment-mapping.pdf.

[70] World Resources Institute and ICEED, "Report of Clean Cooking Workshop: Clean Cooking in Nigeria's Revised NDC – ambition, mitigation implications and the way forward," February 25, 2021.

[71] Megbowon, Ebenezer, and Peter Mukarumbwa, "Household Cooking Energy Situation in Nigeria: Insight from Nigeria Malaria Indicator Survey 2015," *International Journal of Energy Economics and* Policy, October 2018, Vol. 8, Issue 6.

[72] World Resources Institute and ICEED, "Report of Clean Cooking Workshop: Clean Cooking in Nigeria's Revised NDC – ambition, mitigation implications and the way forward," February 25, 2021.

[73] Corfee-Morlot, Jan, Paul Parks, James Ogunleye, and Famous Ayeni, "Achieving Clean Energy Access in Sub-Saharan Africa," 2019, https://www.oecd.org/environment/cc/climate-futures/case-study-achieving-clean-energy-access-in-sub-saharan-africa.pdf.

[74] RMI interviews.

[75] Uche, Johnson, "LPG: Nigerians paid more to refill 12.5kg gas cylinders in December," *Nairametrics.* 2020*,* https://nairametrics.com/2021/01/18/lpg-nigerians-paid-more-to-refill-12-5kg-gas-cylinders-in-december/#:~:text=The%20average%20price%20for%20refilling,N4%2C154.28%20in%20December%202020.

[76] Uwandu, Emmanuel, "Retail LPG Pricing in Nigeria," LinkedIn, May 21 2017, https://www.linkedin.com/pulse/retail-lpg-pricing-nigeria-uwandu-ifeanyi/.

[77] Ihemtuge, Tochukwu, and Victor Aimikhe, "Optimization of Liquified Petroleum Gas Distribution in Nigeria." *International Journal of Engineering and Technical Research.* May 2020, Vol 10, Issue 5.

[78] WLPGA, *Accelerating the LPG Transition*, 2018, https://www.wlpga.org/wp-content/uploads/2018/10/Accelerating-the-LPG-Transition.pdf.

[79] Clean Cooking Alliance, "LPG Safety, Innovation, and Market Growth," May 30, 2020, https://www.cleancookingalliance.org/binary-data/RESOURCE/file/000/000/586-1.pdf.

[80] World Resources Institute and ICEED, "Report of Clean Cooking Workshop: Clean Cooking in Nigeria's Revised NDC – ambition, mitigation implications and the way forward," February 25, 2021.

[81] "VP Osinbajo at Domestic LPG Implementation Stakeholders Workshop 29/11/2016," Office of the Vice President, https://www.yemiosinbajo.ng/vp-osinbajo-at-domestic-lpg-implementation-stakeholders-workshop-on-29-11-2016/.

[82] World Resources Institute and ICEED, "Report of Clean Cooking Workshop: Clean Cooking in Nigeria's Revised NDC – ambition, mitigation implications and the way forward," February 25, 2021.

[83] Ozier et al., "Building a consumer market for ethanol-methanol cooking fuel in Lagos, Nigeria," Energy for Sustainable Development, 46 (Oct. 2018): 65-70, https://www.sciencedirect.com/science/article/pii/S0973082618302813.

[84] Northcross, Amanda, Matt Shupler, Donee Alexander, John Olamijulo, Temitope Ibigbami, Godson Ana, Oladosu Ojengbede, and Christoper O. Olopade, "Sustained usage of bioethanol cookstoves shown in an urban Nigerian city via new SUMs algorithm," *Energy for Sustainable Development* 35 (2016): 35-40.

[85] Anyanwu et al, "Sustainability of cassava (*Manihot esculenta Crantz)* as industrial feedstock, energy and food crop in Nigeria," Renewable Energy 81(Sept 2015): 745-752.

[86] European Union, "The Study for Development of the Rural Electrification Master Plan," Energy Sector Management Assistance Program (ESMAP), 2020, ttps://europa.eu/capacity4dev/file/30325/download?token=kqi3iIru; Energy Sector Management Assistance Program, *Cooking with Electricity: A Cost Perspective,* The World Bank, 2020.

[87] Nigerian National Bureau of Statistics, *LSMS Integrated Surveys on Agriculture: Nigeria General Household Survey-Panel Wave 4*, World Bank Microdata Library, 2018-2019, https://microdata.worldbank.org/index.php/catalog/3557/related-materials.

[88] Energy Sector Management Assistance Program, *Cooking with Electricity: A Cost Perspective,* The World Bank, 2020.

[89] Nigerian National Bureau of Statistics, "*LSMS Integrated Surveys on Agriculture: Nigeria General Household Survey-Panel Wave 4*," 2018/2019, World Bank Microdata Library, https://microdata.worldbank.org/index.php/catalog/3557/related-materials.

[90] Global Alliance for Clean Cookstoves, "The Truth About Cooking Landscape Analysis," 2016, https://www.cleancookingalliance.org/resources/499.html.

[91] Energy Sector Management Assistance Program, *Cooking with Electricity: A Cost Perspective,* The World Bank, 2020.

[92] Global Alliance for Clean Cookstoves, "The Truth About Cooking Landscape Analysis," 2016, https://www.cleancookingalliance.org/resources/499.html.

[93] Accenture Development Partners, "Nigeria Market Assessment: Sector Mapping," 2011, https://www.cleancookingalliance.org/resources_files/nigeria-market-assessment-mapping.pdf.

[94] FEWS Network, "Revised Livelihoods Zone Map and Descriptions for Nigeria," 2018. Available at https://fews.net/sites/default/files/documents/reports/Nigeria_LH_zoning_report.pdf.

[95] National Population Commission (NPC), "Nigeria Demographic Health Survey 2018."

[96] Global Alliance for Clean Cookstoves, "The Truth About Cooking Landscape Analysis," 2016, https://www.cleancookingalliance.org/resources/499.html.

[97] Accenture Development Partners, "Nigeria Market Assessment: Sector Mapping," 2011, https://www.cleancookingalliance.org/resources_files/nigeria-market-assessment-mapping.pdf.

[98] Kabir, Ibrahim, Mohd Rusli Yacob, Mariani Ariffin, Diana Emang, and Abdullahi Adamu, "Assessing the Extent of Traditional Biomass Cookstove Usage and Related Cooking Practices: Evidence from Rural Households in Northern Nigeria," *IOSR Journal of Humanities and Social Sciences* 23, no. 3 (March 2018): 39-46, http://www.iosrjournals.org/iosr-jhss/papers/Vol.%2023%20Issue3/Version-1/E2303013946.pdf.

[99] Corfee-Morlot, Jan, Paul Parks, James Ogunleye, and Famous Ayeni, "Achieving Clean Energy Access in Sub-Saharan Africa," 2019, https://www.oecd.org/environment/cc/climate-futures/case-study-achieving-clean-energy-access-in-sub-saharan-africa.pdf.

[100] Dalberg, "Scaling up clean cooking in Kenya with LPG & Bio-ethanol: A market and policy analysis," June 2018, https://dalberg.com/wp-content/uploads/2018/06/Dalberg_Long-form-report_FINAL_PDF_0.pdf.

[101] Energy Sector Management Assistance Program, *Cooking with Electricity: A Cost Perspective,* The World Bank, 2020.

[102] Ibid.

[103] RMI stakeholder interviews

[104] Federal Republic of Nigeria, "Sustainable Energy for All Action Agenda (SE4ALL-AA)," 2016.

[105] Office of the Vice President of Federal Republic of Nigeria, "LPG Expansion," http://www.dlpgovp.org/.

[106] Ogundari, Ibikunle & Momodu, Abiodun & Akarakiri, Joshua & Siyanbola, Willie & Jesuleye, Olalekan, "Kerosene Subsidy and Oil Deregulation Policy Development in Nigeria," *Journal of Resources, Energy and Development* no. 13 (2018): 23-33.

[107] Jose Javier Guerra Roman, *NESI's Challenges and a Way Forward*, Nigeria Power Distribution Capacity Building and Technical Assistance Project, 2020.

[108] Nigerian Alliance for Clean Cookstoves, "Stove Testing and Standards," 2018, https://fscluster.org/sites/default/files/documents/safe_wg_stove_testing_and_standards_by_nigerian_alliance_for_clean_cookstoves_19032018.pdf.

[109] Energy Sector Management Assistance Program, *Cooking with Electricity: A Cost Perspective,* The World Bank, 2020.