

OCTOBER 2019

Off-Grid Solar Market Assessment

Côte d'Ivoire

Power Africa Off-grid Project

ABOUT POWER AFRICA

The Power Africa Off-grid Project is a four-year program that launched in November 2018 to accelerate off-grid electrification across sub-Saharan Africa. RTI International implements the project in collaboration with Fraym, Norton Rose Fulbright, Practical Action Consulting, and Tetra Tech. Power Africa is comprised of 12 U.S. Government agencies, over 145 private companies, and 18 bilateral and multilateral development partners that work together, supporting sub-Saharan governments to increase the number of people with access to power.

Power Africa aims to achieve 30,000 megawatts of new generated power, create 60 million new connections, and reach 300 million Africans by 2030.

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Abbreviations and Acronyms

ADERCI	Agency for Renewable Energy Development in Côte d'Ivoire (Agence de Développement des Énergies Renouvelables en Côte d'Ivoire)
AfDB	African Development Bank Group
AIENR	Ivorian Association of Renewable Energies (Association Ivoirienne des Énergies Renouvelables)
AMIFA	Atlantic Microfinance for Africa
ANARE-CI	National Regulatory Authority of the Electricity Sector of Ivory Coast (L'Autorité Nationale de Régulation du secteur de l'Électricité de Côte d'Ivoire)
BACI	Atlantic Bank Ivory Coast (Banque Atlantique Côte d'Ivoire)
BCEAO	Bank of West African States (La Banque Centrale des États de l'Afrique de l'Ouest)
BGFI Bank	Gabonese Bank and French International (Banque Gabonaise et Française Internationale)
BHCI	Housing Bank of Ivory Coast (Banque de l'Habitat de Côte d'Ivoire)
BIAO-CIV	BIAO Côte d'Ivoire
BICICI	International Bank of Commerce and Industry of Côte d'Ivoire (Banque Internationale pour le Commerce et l'Industrie de la Côte d'Ivoire)
BNI	National Investment Bank (Banque Nationale d'Investissement)
BNP Paribas	National Bank of Paris (Banque Nationale de Paris)
BOAD	West African Development Bank (la Banque Ouest Africaine de Développement)
CAC	African Credit Company (Compagnie Africaine de Crédit)
CCF	Commercial Credit of France (Crédit Commercial de France)
CEPICI	Investment Promotion Center of Côte d'Ivoire (Centre de Promotion des Investissements en Côte d'Ivoire)
CGECI	General Business Confederation of Côte d'Ivoire (Confédération Générale des Entreprises de Côte d'Ivoire)
CIE	Ivorian Electricity Company (Compagnie Ivoirienne d'Électricité)
CI-ENERGIES	Côte d'Ivoire Energies
CIPREL	Ivorian Electricity Production Company (Compagnie Ivoirienne de Production d'Électricité)

CIV	Côte d'Ivoire
CME	Center of Electricity Professions (Centre des Métiers de l'Electricité)
DHS	Demographic and Health Survey
E2iE	Ivorian Energy Integration Company (Entreprise Ivoirienne d'Intégration Energétique)
ECOWAS	Economic Community of West African States
ECP	Emerging Capital Partners
EDF	Electricité de France
EIFP	International School of Vocational Training (Ecole International de Formation Professionnelle)
EU	European Union
FCFA	Franc Communauté Financière Africaine
FENASCOVICI	National Federation of Cooperative Food Crops Societies of Ivory Coast (Fédération Nationale de Sociétés Coopératives de Vivriers de Cote d'Ivoire)
FIDRA	African Fund Company for the Development of Active Retirement (Fonds International pour le Développement de la Retraite Active)
FIRCA	Interprofessional Fund for Agricultural Research and Advisory Services (Fonds Interprofessionnel pour la Recherche et le Conseil Agricoles)
GDP	Gross Domestic Product
GES-CI	Savings and Support Group in Ivory Coast (Groupe d'Epargne et de Soutien en Côte d'Ivoire)
GIZ	German Society for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit)
GoCI	Government of Côte d'Ivoire
GW	Gigawatt
GWh	Gigawatt hour
IFAD	International Fund for Agricultural Development
INPHB	Félix Houphouët-Boigny National Polytechnic Institute (Institut National Polytechnique Félix Houphouët-Boigny)

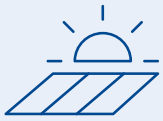
INS	National Statistics Institute (Institut National de la Statistique)
IPP	Independent power producer
IT	Information technology
JICA	Japan International Cooperation Agency
KfW	Credit Institute for Reconstruction (Kreditanstalt für Wiederaufbau), the KfW Development Bank
km	Kilometer
kVA	Kilovolt amperes
kW	Kilowatt
kWh	Kilowatt hour
LBTP	Laboratory for Building and Public Works (Laboratoire du Bâtiment et des Travaux Publics)
MA2E	Mutual of Water and Electricity (Mutuelle de l'eau et de l'électricité)
MFI	Micro-finance institution
MICS	Multiple Indicator Cluster Survey
MPEER	Ministry of Petroleum, Energy, and Renewable Energy (Ministère du Pétrole, de l'Energie et des Energies Renouvelables)
MVN	Medium voltage network
MW	Megawatt
NDC	Nationally determined contributions (Paris Climate Agreement)
NG	Natural gas
PAMF	First Microfinance Agency (Première Agence de Microfinance [PAMF]) Côte d'Ivoire
PAOP	Power Africa Off-grid Project
PDCI	Democratic Party of Ivory Coast (Parti Democratique de la Cote d'Ivoire)
PDER	Rural Electrification Master Plan (Plan Directeur d'Electrification Rurale)
PEPT	Electricity for All (Programme Electricité Pour Tous)

PNIASE-CI	National Investment Program for Access to Energy Services in Côte d'Ivoire (Le Programme National d'Investissement Pour l'Accès aux Services Energétiques en Côte d'Ivoire)
PRONER	National Program for Rural Electrification Programme (National d'Electrification Rurale)
RCMEC-CI	Network of Mutual Savings Banks and Credit (Réseau des Caisses Mutuelles d'Epargne et de Crédit Côte d'Ivoire)
RDR	Rally of Republicans (Rassemblement des Republicains)
RePP	Renewable Energy Performance Platform
ROGEP	Regional Off-Grid Electrification Project
SGBCI	General Bank Corporation of Côte d'Ivoire (Société Générale de Banques en Côte d'Ivoire)
SHS	Solar home system
SocGen	Société Générale

SODEN	Société des Energies Nouvelles
S-TEL	Services in Telecommunication and Energy Ltd.
UBA	United Bank for Africa
UNACOOPEC-CI	National Union of Savings and Credit Cooperatives of Ivory Coast (Union Nationale des Coopératives d'Epargne et de Crédit de Côte d'Ivoire)
UNICEF	United Nations Children's Fund
USAID	U.S. Agency for International Development
USTDA	U.S. Trade and Development Agency
VAT	Value-added tax
WAEMU	West African Economic and Monetary Union
Wp	Watt-peak
ZECI	Zola EDF Côte d'Ivoire

INTRODUCTION

This report by Power Africa provides insights into the opportunities and risks associated with Côte d'Ivoire's off-grid solar energy market and gives companies, investors, governments, and other stakeholders a deeper understanding of the market. While there are other market assessments conducted by other stakeholders (i.e., development partners), Power Africa recognizes a gap in available market assessments. This report bridges that gap with the following:



A comprehensive and detailed review of solar home systems (SHSs), mini-grids, productive use, and other aspects of the off-grid solar value chain that Power Africa is engaged in is covered. Additionally, this report includes details on policy and regulatory issues, structure and historical context of the energy sector, and gender mainstreaming.



The most up-to-date sales and investment data from GOGLA in order to keep pace with the ever-changing dynamics of the off-grid solar sector. This report also includes a geospatial analysis that highlights potential areas for off-grid solar market expansion.



Insights serve as an input to the Power Africa Off-grid Project's (PAOP) planning and help to prioritize activities within the policy and regulatory; market intelligence; business performance; access to finance; and cross-sectoral integration work streams that PAOP advisors across sub-Saharan Africa are engaging in.

The report also serves as a baseline for Power Africa's technical advisors to guide their continuing work. It provides a snapshot that can be used to determine market growth and dynamics that change over time. Insights include characteristics of Côte d'Ivoire's electricity sector, electrification targets, government regulations, donor-funded activities, and details on subsectors of the off-grid solar energy market. Additionally, this report includes expert knowledge from Power Africa's lead advisors, information gathered from stakeholder interviews, and data from the Global Off-Grid Lighting Association (GOGLA). For five countries (Cameroon, Côte d'Ivoire, the Democratic Republic of the Congo, Ethiopia, and Niger), the project performed a geospatial analysis that leveraged machine learning to identify potential local markets for off-grid solar energy. The geospatial analysis provides granular details (i.e., latent electricity demand by household income) that will help companies prioritize how to expand into new geographic markets.

About Power Africa and the Power Africa Off-grid Project (PAOP)

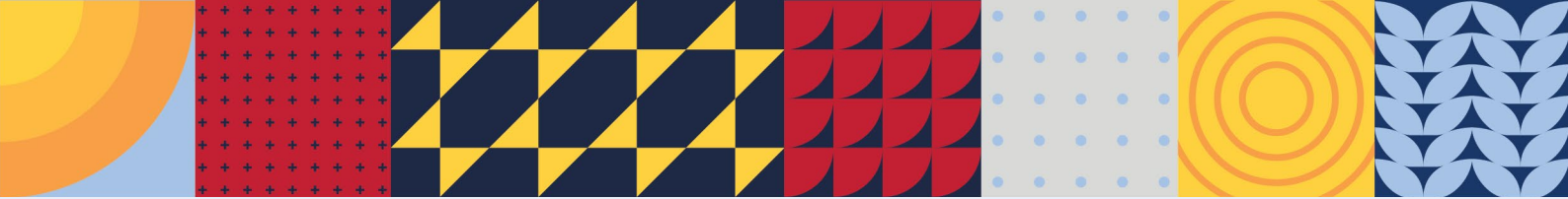
Power Africa aims to accelerate off-grid electrification across sub-Saharan Africa through targeted, context-specific interventions with private-sector companies, governments, investors, and donors. Power Africa's goal is increase electricity access by adding 30MW of new generation capacity, and 60 million new connections through grid and off-grid solutions by 2030. The goal of the Power Africa Off-grid Project is to provide support to private off-grid companies and make the markets in sub-Saharan Africa more attractive for investment and operations. Power Africa defines "access" as the direct or actual number of new households and businesses connected to electricity via an on- or off-grid solution. The project focuses on

accelerating off-grid energy access through household SHSs and mini-grids, with the goal of facilitating 6 million new connections by 2022. The project aims to accelerate off-grid electrification across 10 focus countries in Africa: Cameroon, the Democratic Republic of the Congo, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Niger, Rwanda, Senegal, and Tanzania. Figure ES-1 identifies the countries in Africa receiving Power Africa support, with the focus countries highlighted. The pins represent the locations of the project's in-country advisors.

FIGURE ES-1. THE PROJECT PROVIDES SUPPORT TO 20 COUNTRIES IN AFRICA



The Power Africa Off-grid Project (PAOP) is a Power Africa project funded by the U.S. Agency for International Development (USAID). Power Africa brings together technical experts with stakeholders from the public and private sectors to increase energy access rates in sub-Saharan Africa. The Power Africa Off-grid Project is implemented by RTI International, and headquartered in Pretoria, South Africa.



I EXECUTIVE SUMMARY

Côte d'Ivoire - the world's largest producer of cocoa and cashew nuts, a net oil exporter, with a rapidly growing manufacturing sector - has enjoyed remarkable economic success since 2012 and is a major economic power in the West Africa region.¹ However, Côte d'Ivoire is still challenged by issues of poverty, financial inclusion and literacy, inequitable distribution of wealth, and universal access to goods and services that are required for a modern economy, including reliable and affordable electricity.

To understand Côte d'Ivoire in broad terms, the following points are key:

- › In 2015, approximately 46.3 percent of the population lived below the poverty line. Despite recent economic growth, wealth is not equitably distributed.
- › In 2017, the Gross Domestic Product (GDP) was approximately \$37 billion, which is anticipated to grow annually by more than 7 percent during the next 5 years. Continued economic growth will put additional demands on an already strained national grid.
- › In 2018, the estimated population was 24 million residents, with approximately 50.8 percent living in urban areas; however only approximately 64 percent of residents have access to electricity, irrespective of reliability.
- › In Côte d'Ivoire, 49.3 percent of men and 45.4 percent of women are self-employed in agriculture, making agriculture perhaps the most important sector to the health the country's economy. Electricity access can provide substantial productivity gains to one of Côte d'Ivoire's most important sectors.
- › Côte d'Ivoire is the world's largest exporter of unprocessed cocoa beans. Off-grid productive use of energy for agriculture, including processing cocoa beans, could increase economic activity in Côte d'Ivoire, thereby increasing economic growth and rural development.

Grid Electrification. The main provider of electricity is the state-owned energy company, Côte d'Ivoire Energies (CI-ENERGIES), which controls the planning, operational management, and control of finances. The Ivorian Electricity Company (Compagnie Ivoirienne d'Electricité [CIE]), which sits under CI-ENERGIES, handles part of the generation, transmission, and distribution of electricity. The other portion of generation is provided by AZITO, CIPREL, and AGGREKO. In 2016, the total net generation of electricity was 9,935 gigawatt hours (GWh), and 82.6 percent of electricity produced was from fossil fuels, mostly natural gas. Regarding total generation, hydroelectric power accounted for 15.6 percent and biomass and waste for 1.8 percent. Only 0.1 percent was from solar power.

Total generating capacity is 2,199 megawatts (MW), the third largest in West Africa after Nigeria and Ghana, with 1,320 MW and 879 MW of generating capacity from natural gas and hydroelectric power, respectively. By 2030, \$16.5 billion investments from the Government of Côte d'Ivoire (GoCI) is expected to increase the total installed capacity to 6 gigawatts (GW). However, grid penetration is only 54 percent,

¹ The World Bank, "Cote d'Ivoire | Data."

with an overall access rate of 64 percent varying greatly between urban (92 percent) and rural (38 percent) populations. In 2018, the planned electrification rate was 73 percent, but the actual rate was only 55 percent. CI-ENERGIES created the Rural Electrification Master Plan (Plan Directeur d'Electrification Rurale [PDER]) to tackle rural electrification, which is a key issue for the country's electricity sector. While the official target is 100 percent electrification by 2025, so far, actual electrification rates have lagged.

Power Africa Geospatial Analysis. The analysis indicates that adults in households without electricity have the capacity and desire to purchase assets that use electricity. However, these assets may significantly vary across households, highlighting an unmet demand for reliable electricity from households without grid access.

Support Programs. GoCI and a variety of donors are supporting the growth of the off-grid solar sector through several programs. As the leading energy ministry in Côte d'Ivoire, the Ministry of Petroleum, Energy, and Renewable Energy (Ministère du Pétrole, de l'Énergie et des Énergies Renouvelables) is prioritizing regulatory change to promote off-grid solar and include it in the rural electrification plan. Additionally, the Ministry of the Environment and Sustainable Development is responsible for implementing and enforcing GoCI's environmental and sustainable development policies, including drafting a set of regulations for handling and disposing of electronic waste (including solar equipment).

Donor agencies include the German Society for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ]), the African Development Bank Group (AfDB), the European Union (EU), the World Bank, the French Development Agency (Agence Française de Développement [AFD]); the Credit Institute for Reconstruction (Kreditanstalt für Wiederaufbau [KfW], also known as the KfW Development Bank; the U.S. Agency for International Development (USAID); and U.S. Trade and Development Agency (USTDA). Donor activities include supporting rural electrification, investing in transmission and distribution upgrades, providing technical assistance to private and public stakeholders in the off-grid solar sector, providing support to connect investors with off-grid solar home system (SHS) companies, and conducting feasibility studies in various areas of the overall energy sector.

However, because of governance issues and the inability of the Ivorian Association of Renewable Energies (Association Ivoirienne des Énergies Renouvelables [AIENR]) to tackle the problems of the renewable energy sector, a second association (APER-CI) recently emerged at the initiative of about 20 companies and with the support of several donors, including EU, IFC, and AfDB. At the national level, AIENR promotes renewable energy and energy efficiency throughout Côte d'Ivoire. AIENR aims to achieve three key goals by 2030: (i) ensure universal access to modern energy services, (ii) double the share of renewable energy, and (iii) double the overall energy efficiency throughout the energy sector. Members of AIENR include installers, retailers, and distributors of renewable energy products and systems.

Pico-Solar Sector Overview. Côte d'Ivoire's solar sector is young and growing. Recent growth is directly tied to a fast-growing economy, and a large potential market continues to attract SHS companies. Before 2014, only two SHS companies were in operation. However as of 2018, 14 SHS companies were active in Côte d'Ivoire. The SHS companies include: AD Solar, Baobab+, Lifi-LED, Yandalux, Fenix International, Ivorian Energy Integration Company (Entreprise Ivoirienne d'Intégration Énergétique [E2iE]), Aphelion Energy CIV, Schneider Electric, S-Tel, Phaesun Côte d'Ivoire, PEG Côte d'Ivoire, Zola EDF Côte d'Ivoire (ZECI), MTN/Lumos Côte d'Ivoire, and Orange Énergie.

To provide additional insights into the off-grid solar sector, this report includes sales and investment data from the Global Off-Grid Lighting Association (GOGLA). From the GOGLA data, solar systems with less than 20 watt-peak (Wp) make up all recorded sales prior to 2018. However, in 2018, sales shifted towards larger systems and approximately doubled in volume. In addition, 2018 was an exceptional year for off-grid solar sector fundraising in West Africa, primarily in equity, with debt transactions substantially lagging. Another impressive shift was the increase in the number of off-grid

solar financial transactions, which rose from 4 in 2017 to 24 in 2018. Because more companies in West Africa can access finance, the median reported transaction size decreased dramatically because new stakeholders and smaller SHS companies could close finance transactions. The primary uses of funds raised for West African SHS companies were for geographic market expansion and the addition of new products, collectively accounting for 89 percent of funding. A smaller portion of funds (9 percent) was used for bridging working capital needs. For-profit financial institutions dominated the sources of funding, with a sizeable portion of capital coming from crowd-funders and unknown (unspecified) sources.

Despite recent growth, the off-grid solar sector is still experiencing the following challenges:

- › Access to finance and the difficulties associated with securing financing hindering the ability for SHS companies to expand to new markets or invest in improving its operations.
- › The uncertainty of the importation process with a value-added tax (VAT) that is 9 percent compared with the standard 18 percent VAT.
- › The logistical hurdles of operating in rural and remote areas of Côte d'Ivoire is confounded by the expense associated with expanding a SHS company's operations into rural and remote communities.
- › There is a lack of local capacity and qualified technicians to maintain systems along with a slow response from GoCI to reduce regulatory barriers.
- › There is low consumer purchasing power, exacerbated by a lack of consumer financing options. There are low levels of consumer awareness of solar solutions, particularly in rural areas.
- › Market data is often incomplete for consumer electricity needs, usage or experience.

Although GoCI does not have specific policies to promote the off-grid solar sector, there are electricity access targets within its rural electrification plan. As part of the PDER, combined systems of off-grid solar power and diesel back-up generators are intended to electrify areas where the grid will not extend. Similarly, the National Program for Rural Electrification (National d'Electrification Rurale [PRONER]) does not have any specific plans for promoting the off-grid solar sector. GoCI is currently working toward adopting an off-grid solar power strategy, including updating PRONER. However, GoCI recognizes its limitations, including budgetary constraints that can cause long wait times for electrification of localities (i.e., 6,000 to 8,500 localities are estimated to not have access with no certain connection dates), and the high cost of connections, which poses a barrier for less affluent populations.



One of the fastest growing sectors in Côte d'Ivoire is the microfinance sector. From 2012 to 2017, the sector grew 347 percent, from 72 billion Franc Communauté Financière Africaine (FCFA) to 250 billion FCFA.

Most microfinance institution (MFI) loans are for working capital requirements, investment credit (e.g., purchase of equipment, commercial development, purchase of goods), and consumer credit (e.g., personal loan, fast credit, school loan). Although no MFI currently provides loans for pico-solar purchase, Credit Access and First Microfinance Agency (Première Agence de Microfinance [PAMF]) Côte d'Ivoire are planning to develop loans for productive use appliances and equipment purchases. Mimoye Finance is an MFI dedicated to providing financing to women, although it does not currently provide loans for pico-solar. In recent years, Côte d'Ivoire has been a mobile money leader in West Africa. With the highest penetration rate of any West African country, mobile money has spread throughout various industries. With more than 19 million mobile subscribers and 9.8 million mobile money subscribers (the fifth highest in the world), the mobile money market is expected to continue growing. Mobile money is already playing a significant role in the country's economy and is likely to be equally important in the growth of the off-grid sector.

Despite the sectors nascency in Côte d'Ivoire, partnerships in the off-grid solar sector have already formed, and opportunities exist for new ones. For example, Orange Côte d'Ivoire is the largest telecommunications company in the country, and is currently partnering with other companies operating in the SHS market, including Baobao+ and Schneider Electric, to form a cooperative agreement and leverage each company's respective areas of expertise. Another potential collaboration is with the National Federation of Cooperative Food Crops Societies of Ivory Coast (Fédération Nationale de Sociétés Coopératives de Vivriers de Côte d'Ivoire [FENASCOVICI]). Operating since 2000, FENASCOVICI has more than 600 members who are interested in using solar power for agriculture.

Currently, no specific initiatives exist in Côte d'Ivoire to support gender mainstreaming in the energy sector. However, there are gender mainstreaming initiatives within the mobile and information technology (IT) sector that overlap with portions of SHS value chains.

In 2014, mobile telephone operator Moov launched a program called “Weena” to promote women-led savings and community-based financing for community projects. In 2016, Orange Côte d'Ivoire, launched the “She Is the Code” initiative to provide free training and IT equipment to unemployed women. Additionally, Orange Énergie opened a network of centers to provide female entrepreneurs with access to IT equipment, a variety of training programs, and free co-working space. Since 2019, some companies, such as Baobab+ and PEG Côte d'Ivoire, have demonstrated interest in introducing a gender strategy into their business.

Mini-Grid Sector Overview. The current regulatory environment in Côte d'Ivoire makes it infeasible for the private sector to provide mini-grid solutions to rural communities. Currently, the only private mini-grids operating in Côte d'Ivoire are from development projects supported by donor agencies. However, the regulatory constraints that the mini-grid industry is experiencing in Côte d'Ivoire will ease in 2020. With the expected decrease of barriers, both incumbent and new mini-grid companies are preparing for future market expansion in the country.

Productive Use Sector Overview. In Côte d'Ivoire, a variety of productive uses for off-grid solar exist, with most SHS companies in the country focusing their efforts in the agricultural sector (Table ES-1). The geospatial analysis indicates that approximately 50 percent of households without electricity own livestock and approximately 70 percent own agricultural land.

TABLE ES-1. SHS COMPANIES OFFERING PRODUCTIVE USE APPLICATIONS OF SOLAR POWER

COMPANY NAMES	PRODUCTIVE USE(S)
ZECI	Water pumping
PEG Côte d'Ivoire	Water pumping
Baobab+	Water pumping
Aphelion	Refrigeration
Phaesun	Refrigeration, solar mills and grinding.
STEL	Refrigeration, schools, health centers, petrol stations, and other businesses
Yandalux	Agricultural processing

Note: Information provided by the Power Africa technical advisory team.

There are four categories of barriers to off-grid solar for agriculture and productive use in Côte d'Ivoire (i.e., political, regulatory, finance, and capacity), and no clear strategy has been established for fostering and supporting their use. Likewise, high taxes and a lack of subsidies create a disincentive for SHS companies to expand into new solar productive use technologies. Additionally, SHS companies are hindered by the difficulty in accessing finance and a shortage of skilled labor in the off-grid solar sector

2 INTRODUCTION AND COUNTRY CONTEXT

After more than a decade of political instability and the end of a civil war, Côte d'Ivoire is on a path of recovery and economic growth for its seventh consecutive year. In 2017, the country's GDP was approximately \$37 billion, an increase of more than \$12 billion from its 2010 value of only \$25 billion. Similarly, GDP growth in Côte d'Ivoire was 7.7 percent in 2017 compared with two percent in 2010.² During this seven-year period, real GDP per capita grew by more than 32 percent.³

Despite strong economic growth and a positive macroeconomic outlook for Côte d'Ivoire, a large portion of its population—estimated at 24,083,312 residents in 2018 (with an average annual population growth of 2.4 percent)⁴—lives below the poverty line, and economic growth is not equitably distributed.⁵ Even with the recent economic growth, the total number of individuals in the country living below the poverty line has remained the same since 2008.⁶ As of 2015, the Côte d'Ivoire Living Standards Survey found that 46.3 percent of the population lives below the poverty line, with 56.8 percent of the impoverished population living in rural areas.⁷ As Côte d'Ivoire continues along its path of growth, the distribution of wealth will be important in determining the economic prospects of the country. Additionally, understanding how the population is distributed geographically and how they are employed is key in understanding the potential market for off-grid solar.

Most of the population lives in the southern, forested portion of the country, particularly in and around coastal cities. Out of the total population, 50.8 percent of residents live in urban areas, with an expected annual rate of urbanization from 2015 through 2020 of 3.4 percent.⁸ The national average household size is 5.4 people per home.⁹

TABLE 1. COMPOSITION OF EMPLOYMENT BY GENDER AND RESIDENCE IN CÔTE D'IVOIRE

	GENDER		RESIDENCE		RURAL, BY GENDER		URBAN, BY GENDER	
	Men	Women	Urban	Rural	Men	Women	Men	Women
Agricultural self-employment	49.3	45.4	8.1	72.6	74.8	69.8	8.6	7.4
Nonagricultural self-employment	19.8	41.9	50.8	16.3	9.1	25.2	36.8	67.7
Agricultural wage employment	4.5	0.8	1.1	4.0	6.3	1.1	1.7	0.5
Nonagricultural wage employment	26.4	11.9	40.0	7.1	9.7	3.9	52.9	24.4

Source: ENSETE 2013; authors' display

² The World Bank.

³ The World Bank, "Côte d'Ivoire Economic Outlook," February 21, 2019.

⁴ The United Nations Population Fund, "UNFPA Cote D'Ivoire 2018."

⁵ African Development Bank, "Côte d'Ivoire Economic Outlook."

⁶ The World Bank, "Côte d'Ivoire Economic Outlook," February 21, 2019.

⁷ The United Nations Population Fund, "United Nations Population Fund: Country Programme Document for Côte d'Ivoire."

⁸ Central Intelligence Agency, "The World Factbook: Africa :: Cote D'Ivoire."

⁹ Central Intelligence Agency, "The World Factbook: Field Listing :: Urbanization."

Côte d'Ivoire is a diverse country, with cultural influences from areas throughout the region. As a former French colony, Côte d'Ivoire's official language is French, although there are approximately 60 native dialects spoken within the country.¹⁰ Dioula (Jula) is the most common native language in Côte d'Ivoire and is also spoken in Burkina Faso and Mali.^{11 12}

Despite Côte d'Ivoire's diverse population and recent economic expansion, most of the population is self-employed in agriculture, with women and men participating in agriculture at approximately the same rates (Table 1). Additionally, across all categories, more women are self-employed and are less likely to be employed with a paying wage.

Total area for Côte d'Ivoire is 32,246,000 hectares with a land area of 31,800,000 hectares. Of the land area, 20,600,000 hectares is agricultural area, and 10,400,600 hectares are covered by forest. As of 2019, 25 percent of the country's GDP is attributable to agriculture. Additionally, approximately two-thirds of the population is employed in the agricultural sector.

The top ten crops by land use are also some of the main agricultural exports for Côte d'Ivoire. A sizeable portion of the country's agricultural production is exported, with 60 percent of all exports being from the agricultural sector. According to a statement by the U.S. government in 2019, the main crops for export are cocoa, coffee, rubber, cotton, palm oil, cashew nuts, and bananas.¹⁴ As shown in Table 2, these cash crops for export are also the largest users of land in Côte d'Ivoire. However, most agricultural products destined for export are left raw or unprocessed. By exporting agricultural products in their raw and unprocessed forms, the country is losing an opportunity for industrial development.¹⁵

TABLE 2. TOP 10 CROPS BY LAND USE (IN HECTARES) IN 2017

CROPS	LAND USE (IN HECTARES)
Cocoa (whole bean)	4,147,459
Cashew nuts (in shell)	1,675,899
Yams	1,239,249
Coffee (green)	925,442
Cassava	874,312
Rice	829,142
Maize	523,538
Plantains and others	427,797
Natural rubber	354,868
Oil palm fruit	354,236

Source: FAO STAT

¹⁰ Central Intelligence Agency, "The World Factbook: Field Listing :: Languages."

¹¹ Ethnologue, "Côte d'Ivoire - Country."

¹² A map of languages by region in Côte d'Ivoire can be found at <https://www.ethnologue.com/map/CIV>

¹³ FAO, "FAO Country Profiles."

¹⁴ U.S. Embassies abroad, "Cote d'Ivoire - Agricultural Sectors."

¹⁵ U.S. Embassies abroad.

GoCI recognizes the economic potential of processing products before export, and it has recently initiated incentives for processing cashews before export. However, agricultural processing requires equipment, power, and human capital. Given the energy and resource constraints that rural communities experience, government incentives alone will not be enough. A holistic approach for spurring agricultural processing is needed (i.e., solar-powered milling, refrigeration, and irrigation).

Given its economic importance to Côte d'Ivoire, as well as its potential as a source of additional economic growth, a variety of organizations are actively involved within the agricultural sector. Table 3 summarizes some of the organizations that have recently been active in agriculture. Their activities include investments for rural development; projects to expand e-commerce, increase yields, and increase processing capacity; and programs to expand the inclusion of youth and women throughout the entire sector.

TABLE 3. DONOR ACTIVITIES IN THE AGRICULTURAL SECTOR

ORGANIZATION	AREA OR SCOPE	FUNDING	FINANCING
International Fund for Agricultural Development (IFAD)	Rural development via agriculture (11 projects)	\$411.8 million	\$178.4 million
World Bank	E-agriculture project, aimed to connect smallholder farmers to the digital economy	—	\$70 million
	Project to help CIV increase cashew nut productivity and promote the cashew nut processing industry.	—	\$200 million
	Project to increase the 2018 cocoa processing rate of 31% cocoa to at least 50%.	—	\$300 million
European Union (EU)	Project to support the development of the cassava industry as well as supporting the cultivating of other vegetables in CIV.	\$19.6 million	—
African Development Bank Group (AfDB)	Financing of three agricultural projects, aimed at developing industrialization in CIV, while promoting youth employment and women's involvement, through the intensive use of new technologies.	—	\$120 million
West African Development Bank (la Banque Ouest Africaine de Développement [BOAD])	M'Bahiakro hydro-agricultural development project in Ivory Coast, with a total cost of 12.130 billion (in Franc Communauté Financière Africaine [FCFA]), with a contribution of BOAD of 10 million FCFA.	—	\$10 million
Oikocredit	Project to support smallholder farmers in the cocoa sector by providing access to loans, equity investments and capacity building for agricultural cooperatives, producers, processors and distributors.	—	—

Note: Information provided by the Power Africa technical advisory team.

2.1 OVERALL POLITICAL LANDSCAPE

With a period of peace and the end of a 13-year United Nations peacekeeping mission in 2017, Côte d'Ivoire's recent economic growth is partly attributable to the political and civil stability of the past few years. The recent stability was made possible by a political alliance between the country's two largest political parties: the Rally of Republicans (Rassemblement des Republicains [RDR]) and the Democratic Party of Côte d'Ivoire (Parti Democratique de la Cote d'Ivoire [PDCI]). However, this political alliance may be at risk because of a conflict over which party's candidate would be put forth for the general election in 2020. Recent local elections tested civil tensions. Fortunately, campaigning for the local elections remained peaceful.¹⁶ The next test of the Côte d'Ivoire's political and civil stability will be the run up to the 2020 general election.

2.2 ENERGY SECTOR

For Côte d'Ivoire to maintain its economic growth, equally paced growth throughout the energy sector is a necessity. To facilitate this growth, there must be either energy potential within the country or the ability to access energy from abroad. Fortunately for Côte d'Ivoire, the country is both rich in oil and gas reserves and has substantial potential for renewable energy.



With 15 million metric tons of biomass feedstock per year, 1,620 megawatts (MW) of potential additional hydroelectric power, and an average of six hours per day of solar radiation, Côte d'Ivoire is well positioned to become a regional leader in renewable power generation.¹⁷

The main provider of electricity is the state-owned energy company, Côte d'Ivoire Energies (CI-ENERGIES). CI-ENERGIES controls the planning, operational management, and control of all finances. The Ivorian Electricity Company (Compagnie Ivoirienne d'Electricité [CIE]), which sits under CI-ENERGIES, handles the generation, transmission, and distribution of electricity. The private sector participates in the energy sector in two ways. First, independent power producers (IPPs) have a buyer–seller relationship with CI-ENERGIES. The IPPs are the Ivorian Electricity Production Company (Compagnie Ivoirienne de Production d'Electricité [CIPREL]), Azito Energie, and Aggreko. Second, natural gas suppliers provide a supply chain of natural gas to CIE and CI-ENERGIES. The natural gas supplies are Petroci Holding (state-owned), FOXTROT International, and Canadian Natural Resources.¹⁸ These suppliers are essential to the national grid because approximately 79 percent of net generation is from natural gas.

In 2016, gross electricity generation was 9,935 gigawatt hours (GWh), an increase from the 8,536 GWh generated in 2015. Additionally, consumption power in 2016 (net of energy losses and exports to neighboring countries) was approximately 6,400 GWh, eight percent higher than in 2015. Of the power generated in 2016, 82.6 percent of electricity produced was from fossil fuels, mostly natural gas. Hydroelectric power generation accounted for 15.6 percent, and 1.8 percent of total generation was from biomass and waste. Only 0.1 percent of electricity produced in Côte d'Ivoire was from solar power.¹⁹

¹⁶ Ross and Aboa, "Political Rift in Ivory Coast Raises Concerns for 2020."

¹⁷ Tanoh, "Compact with Africa: Côte d'Ivoire Leveraging the Compact with Africa to Catalyze Private Sector Investment."

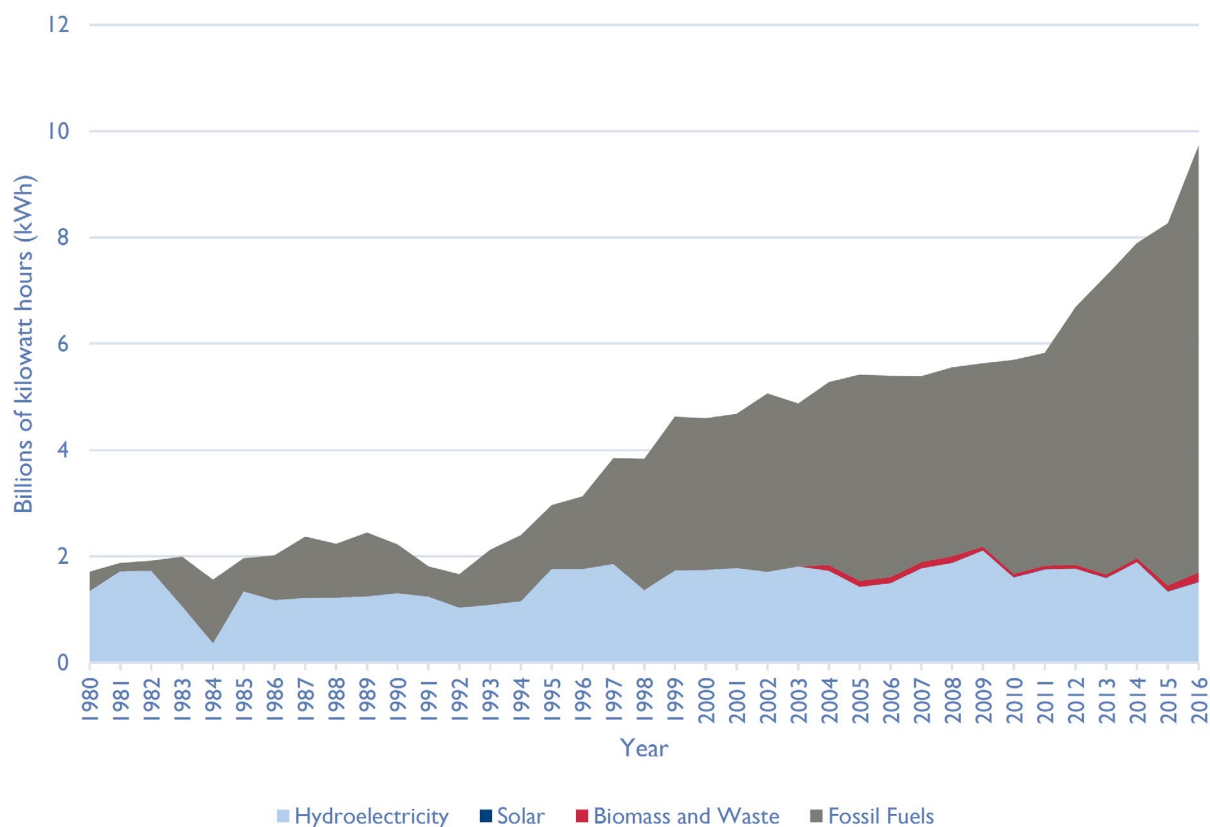
¹⁸ CI-ENERGIES, "CI-ENERGIES | Côte d'Ivoire Institutional Frame."

¹⁹ U.S. Energy Information Administration, "International Energy Statistics."

With an installed generation capacity of 2,199 MW, Côte d'Ivoire's electrical system is the third largest in West Africa, after Nigeria and Ghana. Generation capacity is mostly natural gas-fired generators (1,320 MW) and hydroelectric power (879 MW). Despite this significant hydropower capacity, net generation is mostly by natural gas-fired power plants. Natural gas IPPs represent 60 percent of total production in Côte d'Ivoire (with a 68-percent capacity factor), whereas hydropower production is 40 percent (with a 27-percent capacity factor). Traditionally, contract structures have favored natural gas producers. As natural gas capacity increases under the same contractual framework, it is difficult to displace generation from natural gas with renewables.

The 2013 Master Plan for Generation and Transportation of Electricity (Plan directeur Production-Transport 2014-2030) aims to increase the total installed capacity from 2,199 MW to 3,000 MW by 2020.²⁰ This increase will be achieved through public-private partnership arrangements, with hydropower, solar power, and biomass and waste power as priority technologies. The increased capacity will allow Côte d'Ivoire to meet the growing domestic demand and maintain the country's status as a regional energy hub.

FIGURE I. GENERATION BY FUEL TYPE FOR CÔTE D'IVOIRE



Source: US Energy Information Administration. July 9, 2019

As shown in Figure I, before 1997, most electricity generation in Côte d'Ivoire was from hydroelectric power plants, which meant that the country's electricity sector was vulnerable to droughts. To contend with this vulnerability, the CIPREL power plant completed construction in 1994, making Côte d'Ivoire the first country in sub-Saharan Africa to have an IPP power plant.²² As a pioneer of IPPs in sub-Saharan Africa,

²⁰ CI-ENERGIES, "Développement Du Secteur de l'électricité de La CIV."

²¹ Oxford Business Group, "Governments in Cote d'Ivoire and Africa Turn to Independent Power Producers to Create Much-Needed Generation Capacity."

²² U.S. Embassies abroad, "Cote d'Ivoire - Energy."

private-sector energy production has expanded to a total of 1,206 MW of capacity across three companies: CIPREL, Azito Energie, and Aggreko.²³ Additionally, Côte d'Ivoire has increased its fossil fuel-powered generating capacity since 1997. This expansion in fossil fuel-powered generation has lessened dependence on hydroelectric power while also increasing the electricity sector's dependence on fossil fuels.

Since 2011, net electricity demand has grown at an average rate of 11 percent per year, outpacing the average yearly GDP growth rate, which was almost nine percent from 2011 to 2016. Due to increasing access to electricity, industrial activity, and higher energy exports, peak demand has grown at an average rate of 6.9 percent since 2011, reaching almost 1,300 MW by the end of 2016. Keeping pace with economic growth, energy demand is expected to grow annually by seven percent through 2025.²³

In addition to the electricity needs of an expanding and more inclusive economy, the growing industrial and gold-mining sectors in Côte d'Ivoire rely on natural gas. The country is also a net exporter of electricity to neighboring Benin, Burkina Faso, Ghana, and Togo. Overall exports of electricity are expected to increase as commitments to the West African Power Pool increase and the Côte d'Ivoire-Liberia-Sierra Leone-Guinea transmission line is completed in 2019. As the demand on the country's energy sector increases (for both electricity and natural gas) GoCI and CI-ENERGIES have developed a plan to diversify Côte d'Ivoire's energy portfolio to ensure energy security and resilience.

In the near term, emphasis is being placed on fossil fuels to meet the immediate needs of Côte d'Ivoire's growing economy, with 1,340 MW of new natural gas power plants and a new 700 MW coal-fired power plant in San Pedro. Furthermore, issues with energy access stem from a grid penetration rate of 54 percent and an overall access rate of 64 percent.^{24,25} However, the needs of an expanding and more inclusive economy, combined with limited fossil fuel reserves and untapped potential renewable energy, create an opportunity for off-grid solar power.

2.3 GOVERNMENT INSTITUTIONS

The Ministry of Petroleum, Energy, and Renewable Energy (Ministère du Pétrole, de l'Énergie, et des Énergies Renouvelables [MPEER]) is the leading energy ministry in Côte d'Ivoire. MPEER oversees almost all of Côte d'Ivoire's energy sector and manages the country's endowment of energy resources (e.g., natural gas reserves). MPEER has direct influence over the state-owned public utility CI-ENERGIES. Recent initiatives within the ministry prioritize regulatory change to promote off-grid solar and include off-grid solutions in the rural electrification plan.

The Ministry of Economy and Finance (Ministère de l'Économie et des Finances) ensures the implementation of the government's economic, financial, and monetary policies. The Minister of the Economy and Finance is responsible for the budget and management of government assets (e.g., government-owned real estate and natural resources). Additionally, this minister is responsible for the finances of state-owned operations, including state-owned companies in the energy sector. As such, the Ministry of Economy and Finance has a seat on the boards of energy sector agencies, such as CI-ENERGIES and the regulator, the National Regulatory Authority of the Electricity Sector of Côte d'Ivoire (L'Autorité Nationale de Régulation du Secteur de l'Électricité de Côte d'Ivoire [ANARE-CI]).

²³ African Energy, "Côte d'Ivoire: Slow Pace of Gas Developments Risks Electricity Shortfall."

²⁴ index mundi, "Access to Electricity (% of Population)."

²⁵ Definition: Access to electricity is the percentage of population with access to electricity. Note, the 64-percent access rate is different than the government defined access rate of 82 percent listed in Figure 1. The 64-percent access rate is the effective access rate and considers the entire population of Côte d'Ivoire.

Closely linked to MPEER is the Ministry of the Environment and Sustainable Development. The ministry is responsible for implementing and enforcing GoCI’s environmental and sustainable development policies. Recently, the Ministry of the Environment and Sustainable Development drafted a set of regulations for handling and disposing of electronic waste.

2.4 GRID ELECTRIFICATION SUMMARY

Although the national electricity access rate in Côte d’Ivoire is one of the highest in sub-Saharan Africa, access greatly differs between urban and rural populations: 92 percent for urban and only 38 percent for rural.²⁶ Rural penetration of the national grid and access to electricity are key issues for the country’s electricity sector. Despite recent progress, the industry is experiencing a few challenges as it continues to grow.

One major challenge is that the current grid needs repairs and updates. The current transmission and distribution infrastructure is aging and needs funding. Estimates of transmission losses for the high-voltage grid are approximately six percent, and the estimated losses in distribution are approximately 17 percent.²⁷ Compared to average transmission and distribution losses of 15 percent for SSA,²⁸ the transmission and distribution loss rates in Côte d’Ivoire are high.

Another challenge is that tariffs are a political issue and are not set by a third party. Table 4 lists tariffs by customer group. For residential electricity users, the tariff is 74.54 FCFA per kWh. By presidential decree, low-income users have been able to qualify for a reduced rate of 29.20 FCFA per kWh for the first 80 kWh since January of 2019. The reduced rate increases to 73.99 FCFA per kWh for use greater than 80 kWh. While the electricity tariffs in Côte d’Ivoire are lower than the average of 150 FCFA per kWh for the West African region,²⁹ the current tariffs are not cost-reflective and are a risk to the financial health of the energy sector.

TABLE 4. ELECTRICITY TARIFFS BY CUSTOMER TYPE

USERS	GRID COST (TARIFFS) PER KWH
Low-income users	Up to 80 kWh: 29.20 FCFA Greater than: 73.99 FCFA
Households	74.54 FCFA
Businesses	Up to 180 kWh: 92.59 FCFA Greater than: 78.75 FCFA
Medium voltage	Normal: 61.28 FCFA Peak: 83.55 FCFA Valley: 50.70 FCFA
Other user groups	Normal: 38.46 FCFA Peak: 47.91 FCFA Valley: 35.98 FCFA

Source: ANARE CI: Electricity Tariffs

²⁶ SEforALL Africa Hub, “Côte d’Ivoire.”

²⁷ The World Bank, “Côte d’Ivoire - Electricity Transmission and Access Project (PI57055): PROJECT APPRAISAL DOCUMENT.”

²⁸ Streatfeild, “Low Electricity Supply in Sub-Saharan Africa: Causes, Implications, and Remedies.”

²⁹ World Bank, “Regional Power Trade in West Africa Offers Promise of Affordable, Reliable Electricity.”

As GoCI takes steps toward privatizing the electricity sector, the government has set forth a plan to address the issue of tariff setting.³⁰ One step has been to task the regulator, ANARE-CI, with proposing electricity tariffs. However, the MPEER and the Ministry of the Economy and Finances have the final say in the tariff schedule. Because tariffs are a politically contentious topic, there is hesitation to change the tariffs to reflect the cost of electricity.

An expanding economy, electricity demand, and an aging electricity infrastructure lead to grid reliability issues. Although the electricity sector was resilient throughout the recent civil war period, the unrest delayed necessary investments in the electricity infrastructure.³¹ As a result, there are issues of reliability regarding transmission and distribution constraints. For example, in 2015, load shedding occurred to relieve overloaded transformers across three substations. Total load shed was approximately 4.15 GWh.³² Recent investments by donors aim to increase access to modern energy services.

AFDB: By 2021, GoCI aims to electrify all localities of more than 500 inhabitants. To achieve this goal, the country received, in 2018, a loan of €42.3 million from the AfDB to finance the project to improve access to electricity. This is part of the National Rural Electrification Program (PRONER) developed by GoCI in 2013.

AFD: In December 2016, AFD granted financial assistance worth 101 billion FCFA (about \$170 million), consisting of a sovereign loan of 79 billion FCFA and a European Union grant of 22 billion FCFA from the eleventh European Development Fund and the ENERGOS project.³³

BOAD has financed 18 renewable energy projects, eight of which are solar energy projects (from 2013 to 2018) worth 187 billion FCFA (\$322 million). These projects have also catalyzed support for others from BOAD, including two regional off-grid electrification projects in the advanced appraisal phase. One of these projects is supported by the World Bank and the other by the Green Climate Fund.

EIB put forth funds in 2016 to support the development of the ENERGOS project and focus on institutional and strategic framework support for renewable energies and energy efficiency. This project, worth a total of €188 million, co-financed by EDF (€71 million) and the European Investment Bank (€117 million), encourages, among other things, the involvement of the private sector in electrification via renewable energies. Since 2010, the EIB has loaned €1.45 billion to 39 projects across 16 West African countries. The aim of these projects is to support growth and job creation in key sectors of the economy, including energy. When the EIB's headquarters agreement was concluded in Abidjan in March 2016, the Vice President of the Bank affirmed his institution's commitment to devote 35 percent of its activities to climate action.³⁴

The EU's Country Strategy Paper and the National Indicative Programme (2014–2020)³⁵ detail the priorities for €273 million of funding under the 11th European Development Fund (2014–2020).³⁶ Support to macroeconomic development and sectoral policies strengthening in various sectors, including in the energy sector, are the main aims of EU cooperation with Côte d'Ivoire for the period. Programs include financing projects for infrastructure development as well as implementing the follow-on to the ENERGOS project.

³⁰ The World Bank, "Côte d'Ivoire - Electricity Transmission and Access Project (PI57055): PROJECT APPRAISAL DOCUMENT."

³¹ The World Bank, "Combined Project Information Documents / Integrated Safeguards Datasheet (PID/ISDS)."

³² The World Bank, "Côte d'Ivoire - Electricity Transmission and Access Project (PI57055): Project Appraisal Document."

³³ The ENERGOS project supports creation of a nationwide dispatch facility in Yamoussoukro as well as the repairing and extension of the grid in Abidjan, San Pedro and Bouaké.

³⁴ EU, "Note d'Information sur les actions en Infrastructures."

³⁵ EU, "Programme indicatif national 2014-2020 Côte d'Ivoire."

³⁶ EDF, "European Development Fund (EDF)."

IFC has partnered with MPEER to develop a roadmap to help the country meet its renewable energy targets. This innovative approach is one of the first of its kind. This partnership strongly supports the World Bank Group's Maximizing Financing for Development approach, which seeks to mobilize the private sector in a sustainable way to strengthen limited public resources. This approach meets the twin objectives of reducing poverty and promoting shared prosperity.

KfW decided in 2014 to invest approximately 20 billion FCFA (\$33.5 million) in Côte d'Ivoire. The German Investment Corporation (Deutsche Investitions- und Entwicklungsgesellschaft [DEG]) provides financial support to the renewable energy sector in Côte d'Ivoire and is particularly interested in rural electrification and SME financing.

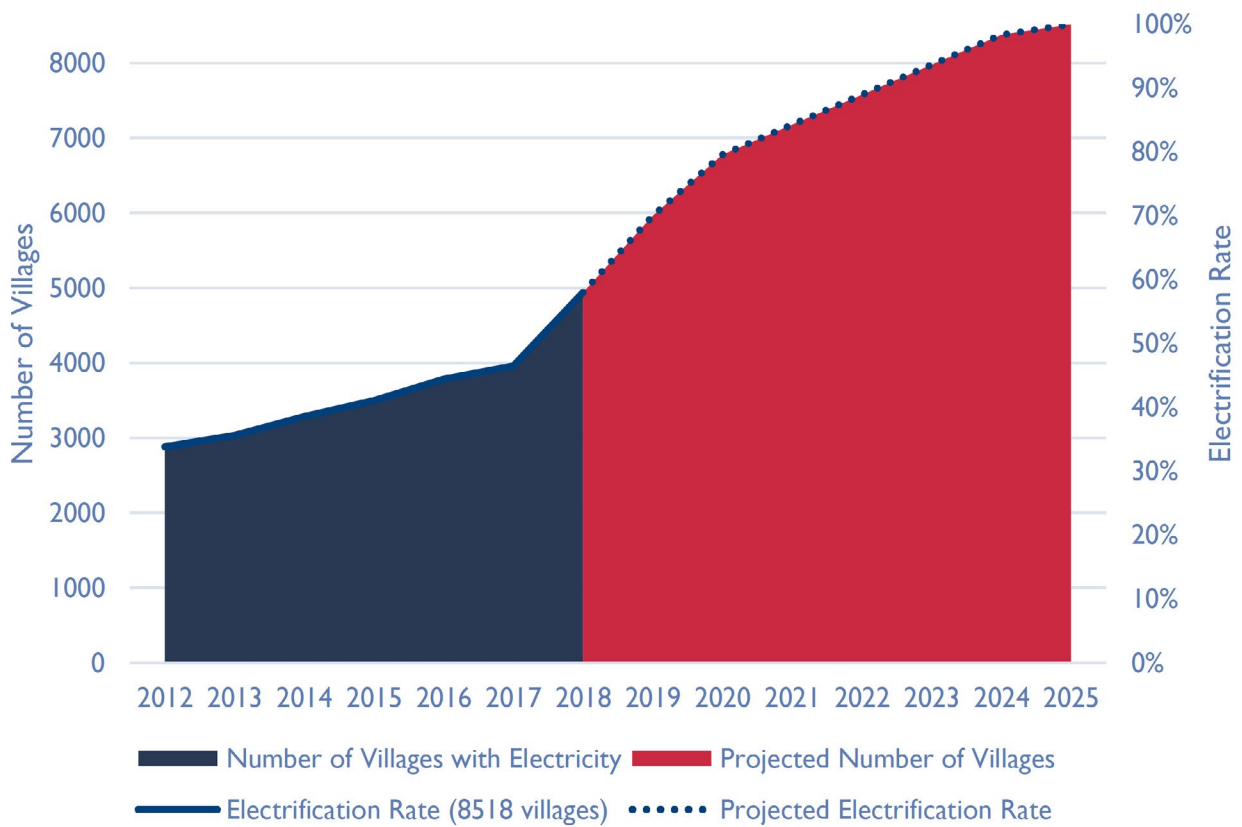
With uncertainty over tariffs, the need for investment in the national grid, and the potential issues of reliability challenging the national grid, off-grid solar power may be the best option for some households. When thinking of households in rural and remote areas, the option of off-grid solar power becomes even more attractive than extending the national grid.

2.4.1 FUTURE ELECTRIFICATION TARGETS

GoCI has set forth an aggressive plan of policy changes and infrastructure investments to tackle the issue of electricity access. There are three key milestones in the Generation Master Plan (GMP) for investment and capacity increases over the next decade. Specifically, by 2020, GoCI plans total investments to reach \$10 billion with four gigawatts of installed capacity. By 2025, GoCI plans an additional \$3.4 billion in investments to achieve five gigawatts of total installed capacity. Then by the end of 2030, \$3.1 billion in investments from the GoCI are expected to reach six gigawatts of total installed capacity. Infrastructure investments are also expected to include the construction of 47 new substations and more than 4,000 kilometers (km) of additional transmission lines.

Since 2012, GoCI has taken steps to increase the electrification rates and expand access to underserved communities. The current target is to achieve a nearly 100-percent electrification rate by 2025. So far, actual electrification rates have lagged the planned electrification rates. In 2018, the planned electrification rate was 73 percent, but the actual rate was only 64 percent. As shown in Figure 2, there is a substantial challenge for GoCI and CI-ENERGIES to reach the 2025 electricity access and electrification rate goals.

FIGURE 2. VILLAGE ELECTRIFICATION RATES IN CÔTE D’IVOIRE



Source: CI-ENERGIES. Rural Electrification Master Plan, July 2015

Policy objectives expand beyond just the issue of electricity access. Over the next decade, GoCI plans to reform policy to improve the reliability and security of the electricity supply, incorporate concerns about environmental impacts from increased energy use, and reinforce the nation’s position as a regional hub for electricity.

2.4.2 RURAL ELECTRIFICATION STRATEGY AND OFF-GRID SOLAR SUMMARY

CI-ENERGIES created the PDER to tackle the issue of rural electrification in Côte d’Ivoire.³⁷ The PDER is a strategic plan of national grid expansions to meet the rural electricity access targets and meet a growing demand for electricity, domestically and for export. Although extending the network connection is the option for electrification that is preferred by the national policy of electricity sector, the development of renewable energy potential is recommended because this will allow better penetration of renewable sources in the energy mix, while increasing electricity access beyond the grid.

³⁷ CI-ENERGIES, “Cote D’Ivoire Rural Electrification Masterplan.”

Investments to accomplish the goals of PDER are approximately 575 billion FCFA from 2015 through 2030. Investment activities include the following:

- › Extension of the medium-voltage grid to increase grid penetration (212 billion FCFA).
- › Reinforcement of the existing medium-voltage grid to meet the transmission and distribution demands for expected demand in 2030 (120 billion FCFA).
- › Extension of the low-voltage grid, including the medium-voltage and low-voltage transformers and cabinets (242 billion FCFA).
- › Distributed photovoltaic and diesel generation to electrify communities without grid access.

Table 5 summarizes the outcomes of PDER, the planned investments of the master plan, and key indicators of the plan's activities. By 2020, an additional 12,353 km of medium-voltage lines are expected to be installed, providing grid access to an additional 4,968 villages and access to electricity to an additional 5,385,325 residents. The first three years (the balancing, looping, and densification phase) of PDER focus on grid expansion and infrastructure investments, and the second three years (the other localities phase) aims to reach remote rural communities.

TABLE 5. SUMMARY OF THE PDER FROM 2015 THROUGH 2020

	YEAR						
	2015–2020	2015	2016	2017	2018	2019	2020
PHASE	PDER	BALANCING/LOOPING AND DESNSIFICATION			OTHER LOCALITIES		
Main outcomes							
Number of villages	4.968	495	727	987	985	992	782
Additional population with access	5,385,325	1,873,297	1,685,799	937,132	195,601	358,340	335,156
Medium-voltage grid expansion (km)	12.353	1.884	2.653	2.768	619	1.521	2.908
Investments (in millions FCFA)	574.9	137.8	140.7	114.3	29.1	59.3	93.7
Medium voltage lines	212.2	37.3	44.3	46.2	10.3	25.4	48.6
High-voltage transmission lines	120.1	21.1	25.1	26.2	5.9	14.4	27.5
Low-voltage lines	184.5	62.1	55.3	32.3	8.3	13.7	12.7
Transformers	34.2	9.4	9	5.3	3.5	3.9	3.2
Meters and connections	23.8	7.9	7	4.2	1.2	1.8	1.7
Indicators							
Distribution per Locality (M FCFA)	0	160.5	98.1	42.4	13.1	19.6	22.5
HTA per Locality (M FCFA)	0	118	95.5	73.4	16.5	40.1	97.3
Total Investment per Locality (M FCFA)	0	278.5	193.6	115.8	29.5	59.7	119.8
Total Investment per Capita (FCFA)	0	73,581	83,479	121,930	148,754	165,389	279,591
Average Cost to Connect a New Customer (FCFA)	0	1,105,593	1,341,885	1,894,091	1,753,955	2,249,162	3,859,577

Source: CI-ENERGIES Rural Electrification Master Plan, July 2015

The costs of implementing PDER vary from year to year, but the largest investments occurred early in PDER from 2015 to 2018. The most expensive PDER activity is the low-voltage grid expansion, followed by medium-voltage grid expansion. Investments are expected to substantially decrease between 2019 and 2024 until the 2025 increase in investment.³⁸

The National Program for Rural Electrification Program (Programme National d'Électrification Rurale [PRONER]), set forth by GoCI, is the plan for expanding access to electricity to rural areas. Starting

³⁸ CI-ENERGIES, "Développement Du Secteur de l'électricité de La CIV."

in 2015, PRONER aims to electrify all villages with more than 500 inhabitants that are within 10 km of the medium-voltage grid by 2020. According to GoCI, at the end of 2017, approximately 4,600 out of 8,000 villagers gained access to electricity.. The cost of connecting a new household to the grid is between 100,000 and 150,000 FCFA. Additionally, from the 2015 Programme Electricité Pour Tous report, the cost of interior installation is between 60,000 and 250,000 FCFA per household..

2.4.3 RENEWABLE ENERGY

In addition to the electrification targets set forth in PDER, there is a target of 42 percent of the total generation to originate from renewable sources. With recent and forecasted increases in electricity demand, and the finite natural gas reserves on which the country's current energy portfolio relies, there will inevitably be a need for renewables in Côte d'Ivoire's future energy portfolio. Fortunately, there is a large endowment of renewable energy potential.

In addition to the energy needs of a fast-growing economy, Côte d'Ivoire aims to meet its nationally determined contributions (NDC) goals for the Paris Climate Agreement. In the process of doing so, there is the potential for \$10 billion in investments, of which \$9 billion is linked to the 2030 PDER target of 42-percent generation from renewables. Most investments are expected to come from the private sector with some support from GoCI.³⁹ With the energy demands of a booming economy, the NDC goals of the Paris Climate Agreement, and the national targets for renewable energy, renewables will inevitably be a key part of Côte d'Ivoire's future energy portfolio.

2.4.4 RENEWABLE ENERGY POTENTIAL



Hydroelectric Power: With an estimated capacity of more than 879 MW, which can theoretically generate approximately 700 GWh per year. The Soubré development (275 MW) on the Sassandra River is the most recently commissioned project. Hydropower projects in the pipeline for the next 10 years include Singrobo (44 MW), Gribo Popoli (112 MW), Boutoubré (156 MW), and Louaga (283 MW). GoCI has identified 33 other hydroelectric power projects that have been financed, for a total capacity of 3,883 MW (including Tahibli, Daboitié, Tiboto, Tayaboui, and Gao). MPEER is planning the development of at least 81 MW of mini-hydropower projects before 2030.



Biomass: GoCI has announced plans to include biomass-fueled generation capacity in the energy mix by 2030 and has identified pilot projects to develop and build grid-connected facilities that can contribute to this target. GoCI has also issued recent tenders for cotton and cocoa biomass. Proposals are mainly for small- to medium-scale power from agriculture processors and private project developers. The biofuels sector is still in its early stages, but biogas pilot projects and bioethanol are being explored by using sugarcane, maize, and sweet sorghum.



Solar and Wind: Solar and wind resources are extensive throughout most of Côte d'Ivoire. As with other energy projects, an improved and simplified tender process can bring in new investors who are eager to enter the growing market in grid-tied, off-grid, and mini-grid distributed generation.⁴⁰

³⁹ International Finance Corporation, "Climate Investment Opportunities in Emerging Markets: An IFC Analysis."

⁴⁰ International Finance Corporation, "Unlocking Private Investment A Roadmap to Achieve Côte d'Ivoire's 42 Percent Renewable Energy Target."

2.5 DEMAND FOR ENERGY

A fast-growing economy—in conjunction with electricity access initiatives—has substantially increased the number of electricity customers over the past decade. In Table 6, the total number of low-voltage customers increased from 1,079,503 in 2010 to 1,892,711 in 2017. Most additional customers came from the “general” category, which includes residential customers.

TABLE 6. SUMMARY OF ELECTRICITY CUSTOMERS IN CÔTE D’IVOIRE

	YEARS							
	2017	2016	2015	2014	2013	2012	2011	2010
ELECTRICITY CUSTOMERS	LOW-VOLTAGE							
	1,892,711	1,626,653	1,428,317	1,311,742	1,219,727	1,150,528	1,108,218	1,079,503
Moderate	714,685	592,189	543,926	519,010	523,671	785,218	763,118	744,428
General	999,134	865,309	721,308	640,177	551,578	229,002	215,951	207,303
Business	161,897	152,777	147,500	138,083	130,866	123,451	116,982	115,638
Public lighting	9,807	9,446	8,822	8,104	7,597	7,215	6,830	6,818
Conventional	5,654	5,506	5,386	5,062	4,748	4,424	4,149	4,098
Free	1,534	1,426	1,375	1,306	1,267	1,218	1,188	1,218
ELECTRICITY CUSTOMERS	MEDIUM-VOLTAGE							
	5,115	4,790	4,462	4,096	3,868	3,539	3,316	3,255
Private	3,652	3,407	3,172	2,905	2,736	2,533	2,360	2,294
Administration	777	715	668	613	583	550	530	533
Autonomous	275	269	262	256	250	191	185	191
District	31	29	29	28	26	25	24	24
Group customer	326	300	261	222	206	175	154	149
Free of value-added tax	40	58	11	10	8	8	6	6
International organization	14	12	59	62	59	57	57	58
Grand Totals	1,897,826	1,631,443	1,432,779	1,315,837	1,223,595	1,154,067	1,111,534	1,082,758

Source: (CIE 2018)

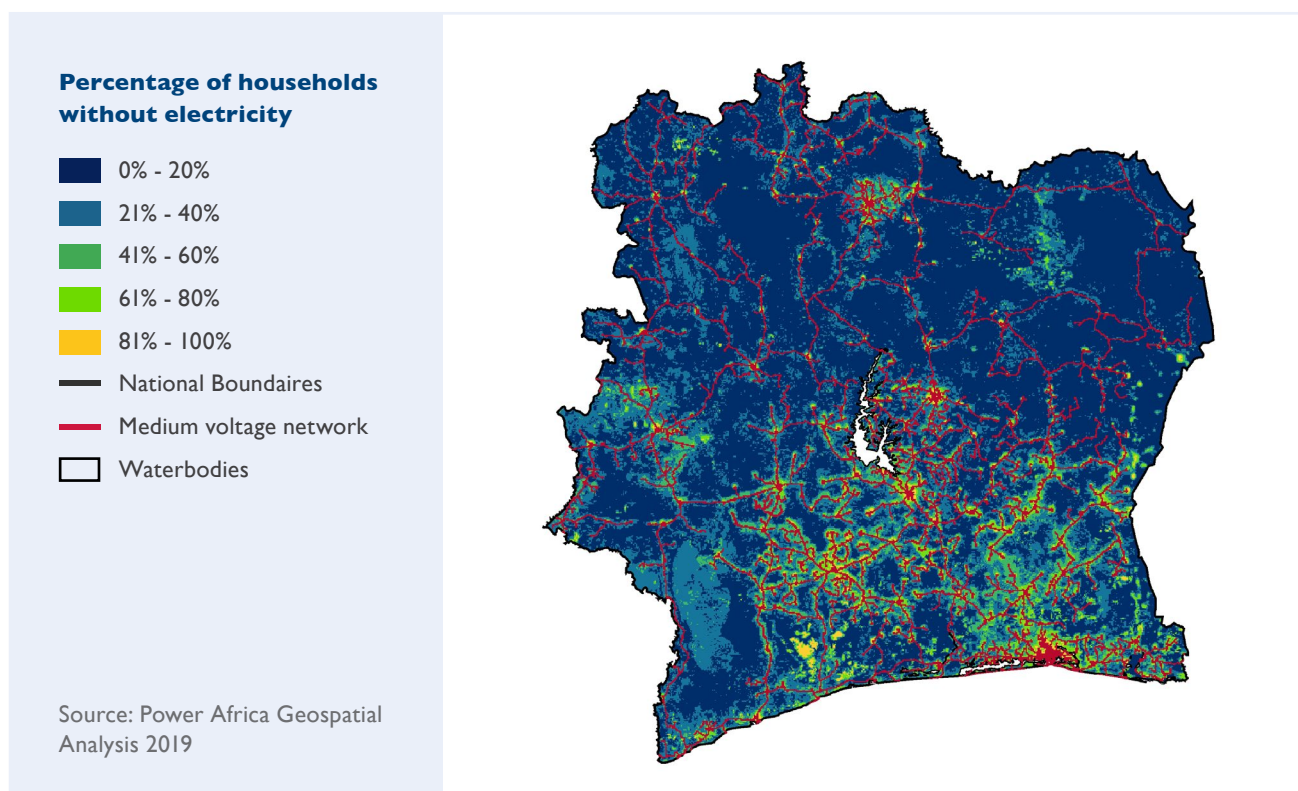
2.5.1 HOUSEHOLDS WITHOUT ELECTRICITY

To quantitatively and spatially understand the potential of off-grid solar power in Côte d’Ivoire requires sophisticated quantitative methods in conjunction with on-the-ground expertise. As such, Power Africa Off-grid Project’s geospatial analysis provides additional insights into the demand for electricity in Côte

⁴¹ CIE, “Rapport Annuel 2017.”

d'Ivoire and the potential for off-grid solar power. Figure 3 maps estimates of off-grid households from this analysis. As expected, large urban areas, such as Abidjan, Yamoussoukro, Gagnoa, Bouaké, Man, and Soubré have high electricity access rates. Additionally, small communities near main roadways have higher access rates than communities farther away from main roadways. Nationally, 38 percent of households are estimated to have no access to electricity, where approximately 90 percent of all households without electricity are in suburban and rural areas. An important factor in determining the electricity access of a household is its location relative to the medium-voltage grid. As part of the analysis, medium-voltage grid estimates are drawn from estimates performed by Facebook.⁴² As such, estimates of household access to electricity align closely with the predicted medium voltage network (MVN) across Côte d'Ivoire. In Figure 4, approximately 32 percent of households living within one km of MVN lines are estimated to have no access to electricity. However, electricity access rates vary from community to community. For example, in Abidjan, approximately three percent of households within one km of the MVN are estimated to have no access to electricity compared with 34 percent in Haut-Sassandra.

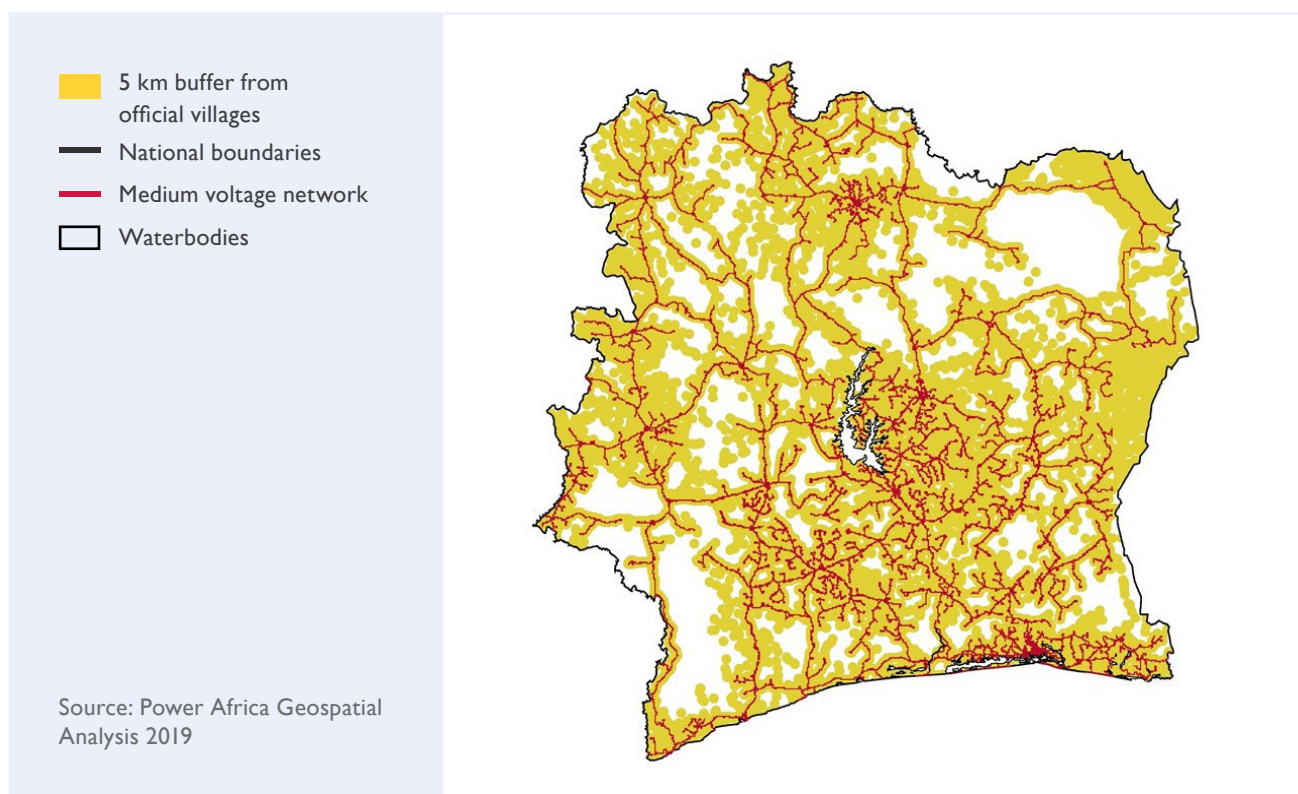
FIGURE 3. HOUSEHOLDS ESTIMATED TO NOT HAVE ELECTRICITY PER SQUARE KILOMETER



In addition to the predicted medium-voltage grid, the analysis incorporated information about “official villages,” which are defined as villages that already have access to electricity or villages to which GoCI plans to extend the grid by 2025. The predicted medium-voltage grid lines align closely with the location of official villages as shown in Figure 4.

⁴² MVN data predicted through models with 70% accuracy were prepared by Dmitry Gershenson, Brandon Rohrer, and Anna Lerner from Facebook.

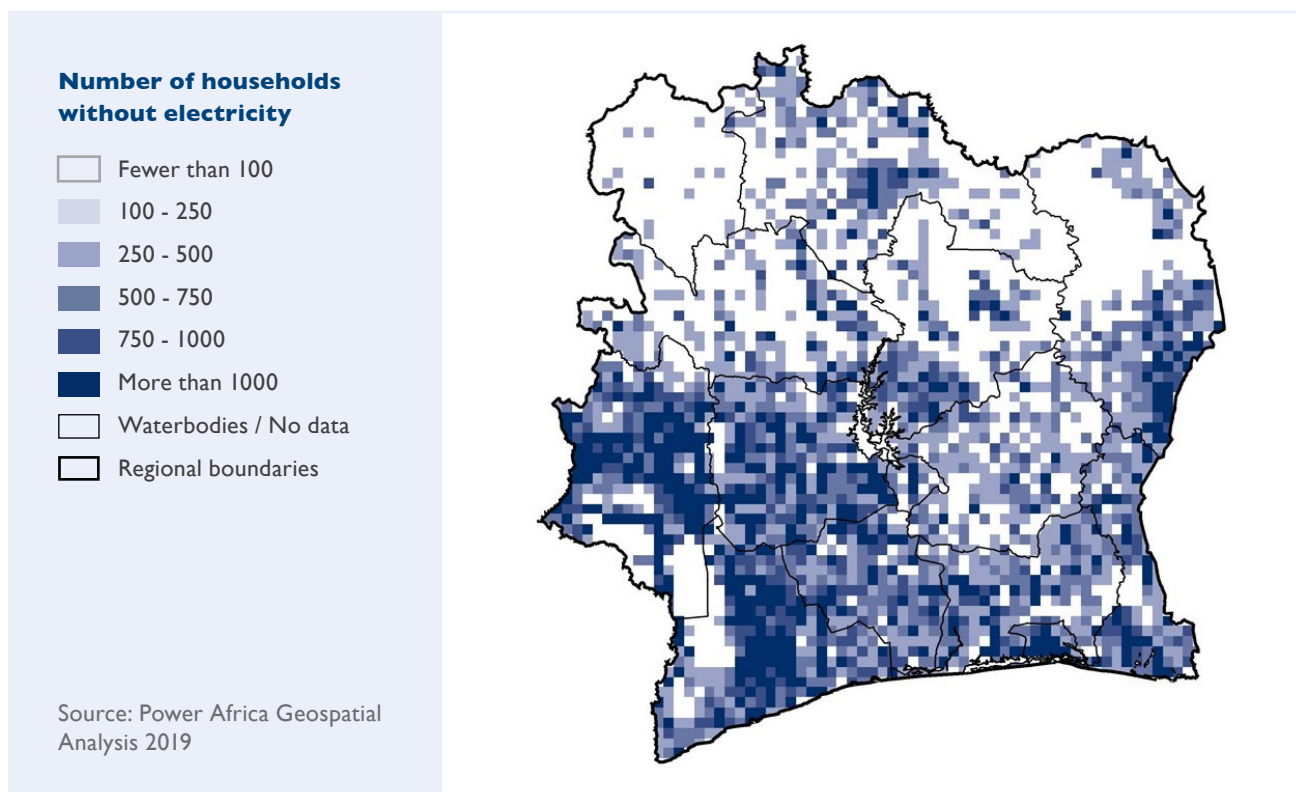
FIGURE 4. OVERLAY OF THE PREDICTED MEDIUM-VOLTAGE GRID AND A 5-KM BUFFER OF ALL OFFICIAL VILLAGES



Note: Official villages refers to the villages officially recognized by GoCI. The official villages do not include campements. The campements are settlements of varying size and development that traditionally have not been officially recognized by GoCI but are linked to villages. The current off-grid electrification targets campements when the Rural Electrification Program focusses on villages with more than 500 people.

Nationally, approximately 1.7 million households in Côte d'Ivoire are estimated to have no access to electricity. This group makes up approximately 38 percent of all households in the country, most of which are in rural areas. Additionally, ten percent of households in urban areas do not having access to electricity compared with 63 percent of households in rural areas that do not have access to electricity. Figure 5 maps the number households without electricity per 10 square km.

FIGURE 5. ESTIMATED NUMBER OF HOUSEHOLDS WITHOUT ELECTRICITY PER 10 SQUARE KILOMETERS



Note: Areas with fewer than five 250 households per 10 square kilometers or insufficient data are shown in grey, waterbodies are shown in white, and regional boundaries are shown in black.

Source: Power Africa Geospatial Analysis 2019

Additional estimates are as follows:

- › Approximately 1.5 million households with electricity (approximately 90 percent of all households without electricity) live within one km of the MVN lines or five km of an official village.
- › Approximately 99,000 households without electricity live one km to ten km from an MVN line and farther than five km from an official village.
- › The remaining 76,000 live more than ten km from an MVN line and more than five km from an official village.

2.5.2 SCHOOLS WITHOUT ELECTRICITY

In addition to households, a large portion of schools in Côte d'Ivoire lack access to electricity and/or water. As of 2018, there are 2,834 kindergartens in Côte d'Ivoire that serve more than 180,000 children. As shown in Table 7, 37 percent of all kindergartens are in rural areas, 46.4 percent are without access to electricity, and 38 percent are without access to clean water.⁴³ Compared with kindergartens, there are almost eight times more primary schools, with more than 3.9 million students. There is greater presence of primary schools in the rural areas; however, 61.8 percent of primary schools do not have electricity, and 50 percent are in areas without access to the national grid.

⁴³ Strategies, Planning, and Statistics Directorate, "Pocket School Statistics 2017-2018."

TABLE 7. SUMMARY OF SCHOOLS IN CÔTE D'IVOIRE

TYPES OF SCHOOLS	NUMBER OF SCHOOLS	NUMBER OF STUDENTS	RURAL (%)	NO ELECTRICITY (%)	NO WATER (%)
Kindergarten	2,834	180,000	37	46.4	38.0
Primary	16,957	3.9 million	66	61.8	57.4
High school	1,778	1.9 million	(Unavailable)	16.8	10.5

Note: These statistics are also available at a regional level.
Source: Ministry of education and professional training, 2018

2.6 INTERNATIONAL DONORS

Multiple donors have been, and continue to be, active in the Côte d'Ivoire energy sector. Table 8 highlights recent activities by donor agencies related to the energy sector but does not encompass all donor activities in Côte d'Ivoire.

TABLE 8. DONORS OPERATING WITHIN CÔTE D'IVOIRE

DONOR AGENCY OR ORGANIZATION	ACTIVITIES
German Society for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ])	<p>Renewable energy is promoted throughout the Economic Community of West African States (ECOWAS) region.</p> <p>Small and medium businesses receive support to adopt renewable energy technologies.</p> <p>Vocational training development for renewable energy.</p>
African Development Bank Group (AfDB)	<p>ZECI deploys pay-as-you-go (PAYGO) solar systems.</p> <p>Rural electrification is supported in the northern portion of Côte d'Ivoire.</p>
European Union (EU)	<p>The EU and Credit Institute for Reconstruction (Kreditanstalt für Wiederaufbau [KfW]), also known as the KfW Development Bank, provided €36.7 million of financing to build a 37.5 MW solar plant in Boundiali.</p> <p>Provide technical assistance on renewable energy development.</p>
World Bank	<p>The World Bank Electricity Transmission and Access Project allocated \$115.6 million for transmission line upgrades and \$95.4 million for distribution equipment.</p> <p>The Regional Off-Grid Electrification Project (ROGEP) will provide \$200 million of funding throughout sub-Saharan Africa.</p> <p>The Lighting Africa initiative has provided 28.8 million people across SSA with access to electricity via off-grid solar.</p>
French Development Agency (Agence Française de Développement [AFD])	<p>Support for the Biovea biomass plant along with Proparco.</p> <p>Hydroelectric powerplant rehabilitee projects.</p> <p>Rural electrification and connection programs.</p>
KfW Development Bank	<p>Guarantee mechanisms for renewable energy projects.</p> <p>Technical assistance on renewable energy development.</p>
USAID	<p>USAID funds the Power Africa Off-grid Project (PAOP).</p>
U.S. Trade and Development Agency (USTDA)	<p>USTDA has funded feasibility studies in biomass and other renewable energy products.</p> <p>USTDA will support investments in a cocoa biomass-fired power plant in Divo (awarded to Société des Energies Nouvelles [SODEN]).</p> <p>Smart grid feasibility study to develop a grid loss reduction strategy.</p>

Note: Information provided by the Power Africa technical advisory team.

2.7 SOLAR AND RENEWABLE ENERGY ASSOCIATIONS

At the national level, two organizations, namely the Ivorian Association of Renewable Energies (Association Ivoirienne des Energies Renouvelables [AIENR]) and the Association of Professionals of Renewable Energies (Association des Professionnels des Energies Renouvelables de Côte d'Ivoire (APERCI)) are promoting renewable energy and energy efficiency throughout Côte d'Ivoire. They aim to achieve three key goals by

2030: (i) to ensure universal access to modern energy services, (ii) double the share of renewable energy, and (iii) double the overall energy efficiency throughout the energy sector. Members of both associations include mini-grid companies and SHS companies composed of installers, retailers, and distributors of solar energy products and systems. Power Africa introduced the APERCI to GOGLA to allow discussions with the view to build a joint action plan to overcome the main barriers to the development of the off-grid solar energy in Côte d'Ivoire.

2.8 TRAINING INSTITUTIONS, INCUBATORS, AND ACCELERATORS

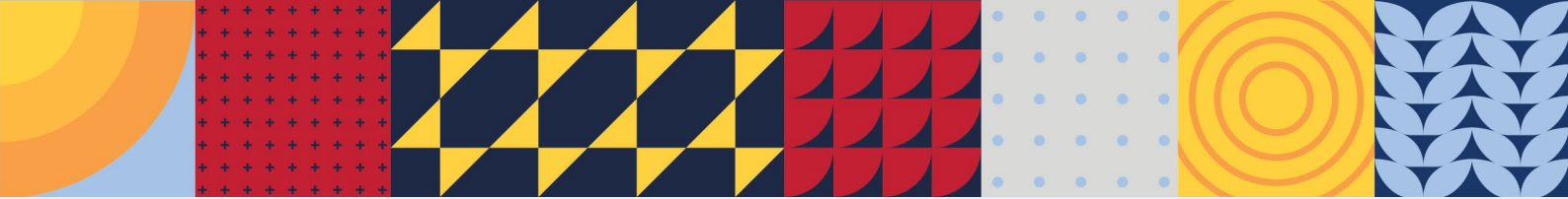
A database of skilled technicians does not exist, and only a few organizations and institutions provide training for the solar industry in Côte d'Ivoire. Table 9 lists the institutions and organizations that offer this training in the country. Training options vary in scope and length. For example, CIE runs the Center of Electricity Professions (Centre des Métiers de l'Electricité [CME]) training center east of Abidjan in Bingerville. The CME center offers training for skills needed throughout the electricity sector, including renewable energy (i.e. solar, biomass, and wind). As another option, LEDAK-CIV runs a six-month solar-specific training course about solar sales, SHS sizing, and installation.

TABLE 9. TRAINING INSTITUTIONS AND ORGANIZATIONS

INSTITUTION OR ORGANIZATION	LOCATION	DETAILS
CME Bingerville (CIE)	Bingerville (20 km east of Abidjan)	CIE's training center provides technical skills throughout the electricity sector.
LEDAK-CIV	Azito, Abidjan	LEDAK-CIV offers a six-month program focused on technical training for the solar industry.
International School of Vocational Training (Ecole Internationale de Formation Professionnelle [EIFP])	Abidjan	EIFP offers a nine-month program that focuses on general business skills and the solar industry.
Félix Houphouët-Boigny National Polytechnic Institute (Institut National Polytechnique Félix Houphouët-Boigny [INPHB])	Yamoussoukro	The university offers a degree in energy and a concentration in solar.

Note: Information provided by the Power Africa technical advisory team.

Unfortunately, most training centers are in and around Abidjan. The main exception is the Félix Houphouët-Boigny National Polytechnic Institute (Institut National Polytechnique Félix Houphouët-Boigny [INPHB]) in Yamoussoukro, which offers a degree course in energy with a concentration in solar. There is a need for training facilities outside of Abidjan, especially as SHS companies expand beyond their current service areas and into more remote areas of Côte d'Ivoire.



3 SHS COMPANIES

Many international off-grid solar companies, including most of the industry’s leading players (e.g., BBOXX, Greenlight Planet, Azuri, d.light, Off-Grid Electric, M-KOPA Solar, Fenix International, and French utilities EDF and Engie) have recently entered markets throughout West Africa. Two international pioneers in off-grid solar, PEG and Lumos have both expanded into Côte d’Ivoire and Togo, after originally launching in Ghana and Nigeria.⁴⁴ While the large international SHS companies are well capitalized, there is a lack of financing for smaller, early-stage companies that operate in nascent markets across West Africa and the Sahel. In fact, the top ten global off-grid solar companies have received nearly 90 percent of investment capital since 2012, while early-stage companies often struggle to raise the necessary capital to accelerate growth.⁴⁵

In Côte d’Ivoire, off-grid solar power is a nascent market. Historically, the focus from GoCI and donors has largely been on developing the national grid. However, since the adoption of a new electricity code in 2014, some SHS companies started offering services due to the off-grid solar sector’s potential for substantial growth. PAYGO is the most common business model and is enabling rapid scale up of the SHS market as it facilitates sales to households that cannot afford to pay for the system upfront.

3.1 SHS COMMERCIAL OVERVIEW

Currently, there are 14 solar SHS companies operating in Côte d’Ivoire that benefit from technical assistance provided by Power Africa. These companies are presented in Table 10.

⁴⁴ Bavier, “Off-Grid Power Pioneers Pour into West Africa - Reuters.”

⁴⁵ Acumen, “Accelerating Energy Access: The Role of Patient Capital.”

TABLE 10. SUMMARY OF SHS COMPANIES OPERATING IN CIV

LOGO	COMPANY NAME	OPERATING YEAR IN CÔTE D'IVOIRE
	S-Tel	2009
	Phaesun Ivory Coast	2009
	Aphelion Energy CIV	2013
	AD Solar	2014
	Schneider Electric: Access to Energy	2014
	Ivorian Energy Integration Company (Entreprise Ivoirienne d'Intégration Energétique [E2iE])	2014
	LIFI-LED	2014
	Yandalux CIV	2014
	Baobab+	2016
	PEG Côte d'Ivoire	2016
	ZECI	2016
	MTN/Lumos Cote d'Ivoire	2017
	Fenix International	2018
	Orange Énergie	2018

Note: Information provided by the Power Africa technical advisory team.

3.2 BARRIERS EXPERIENCED BY SHS COMPANIES

Key challenges facing SHS companies at the national level include the following:

- › **Limited Resources for Off-grid Electrification:** In its medium- and long-term rural electrification planning, GoCI has prioritized grid extension over the development of mini-grids, and ultimately seeks to extend the transmission grid to 100 percent of the population and subsidize household connections to the distribution network (as it is doing under the “Electricity for All” PEPT campaign). However, this approach to electrification limits public funds and resources available to provide support for stand-alone solar solutions that could accelerate electrification. Less than five percent of an estimated \$796 million in electrification costs through 2020 are slated to be spent on renewables and off-grid projects.⁴⁶ Moreover, the institutional market segment (i.e., schools and health clinics) faces budgetary and public finance constraints that limit investment in off-grid solar for these facilities.
- › **Off-Grid Regulatory Framework:** The off-grid sector has long been a neglected sector in Côte d’Ivoire without any specific policy and regulatory framework to support its development. Only a few companies were able to propose options for electrifying the unserved households using stand-alone solar solutions. Clarity is currently being sought on the enabling regulatory approach for the off-grid sector and the government’s vision for these technologies either as provisional measures or as long-term energy solutions for the country.⁴⁷ Market liberalization is expected to extend to electricity distribution after CIE’s concession agreement expires in 2020, which will allow private operators to enter the mini-grid market. Until then, an uncertain regulatory environment may impede private investment to the sector.
- › **Lack of Capacity and Interest of Local Financial Institutions:** Local financial institutions and MFIs lack enough internal capacity and are too risk averse to invest in the renewable energy and off-grid sectors. This challenge arises mainly from risk, limited knowledge of technologies, market characteristics, and historical data on portfolio credit performance. There is also an information gap about the potential size of these markets as well as doubts about the profitability of offering financial products in rural off-grid areas, where the creditworthiness of potential clients is unknown or perceived as too risky. The renewable energy and off-grid space is particularly complicated given relatively high transaction costs combined with an unfavorable regulatory environment that exists in the country.⁴⁸
- › **Uncertain Importation Duties and Processes:** According to in-person discussions with SHS companies currently operating in Côte d’Ivoire, there is confusion and a lack of transparency surrounding how the importation process is structured. Depending on the port-of-entry for goods, the customs officer on duty that day, and the bundling of solar products, duties and taxes can vary. This issue creates a source of uncertainty, which can also pose a barrier for SHS companies securing financing.
- › **Low Quality Products:** A lack of quality standards for solar equipment has led to a high presence of low-quality products in the market. Low quality products not only lead to reliability issues for SHS kits, but also reduce the consumer confidence for the technology. Improving quality standards and providing education and outreach to communities can change consumer skepticism surrounding the off-grid solar sector.

⁴⁶ Climatescope, “Climate Scope 2017 - The Clean Energy Country Competitiveness Index.”

⁴⁷ International Finance Corporation, “Climate Investment Opportunities in Emerging Markets: An IFC Analysis.”

⁴⁸ One notable exception to this is the commercial and industrial (C&I) market segment, where systems are larger, and off-takers are often companies with large enough balance sheets to borrow. This has been one of the stand-alone market segments where there has been some lending to date in Africa (e.g. AFD’s Sunref program).

- › **High Distribution Costs:** Operating in rural and remote areas poses logistical issues. In order to expand operations, investment is required by SHS companies to expand their field staff and provide the necessary equipment to service rural areas. However, due to the financial constraints that SHS companies face without the ability to invest in their field staff, SHS companies are limited to the areas where operations are the least expensive and easiest. Reaching the underserved regions will require more resources.
- › **Other challenges:** Successful development of the off-grid sector will require more than just a financial support mechanism. The government and its supporting agencies will also need to develop and implement a range of measures to reinforce growth of the off-grid electricity market, including a robust technical assistance program to support the policy objectives. These measures should be part of a national off-grid electrification action plan linked to renewable energy policy that inform decision-making of key stakeholders involved in the development and regulation of the country's SHS market.

3.3 SHS SALES SUMMARY

To start the market assessments, Power Africa engaged with GOGLA to obtain data and analysis, by country and region, across a multitude of dimensions of the off-grid solar sector. While not comprehensive for Côte d'Ivoire, the GOGLA sales and investment data provide insights into some of the general trends for the off-grid solar sector in the country. One such insight is that solar systems with less than 20 watt-peak (Wp) make up all sales prior to 2018. However, in 2018, sales shift towards larger systems and approximately double in volume. Additionally, in 2018, sales of solar systems in a strictly PAYGO model roughly match the sales where upfront cash is required alongside PAYGO.

In addition to data on sales and business models, GOGLA also provides an estimate of market penetration. Market penetration is calculated as follows:

$$\text{Market Penetration} = \frac{\text{People with improved energy access} - \text{currently}}{(1 - \% \text{ population with access to electricity}) * \text{population}}$$

For Côte d'Ivoire in 2017, the World Bank estimated an access rate of 65.64 percent with a total population without electricity access as 8,348,707 people. The resulting market penetration estimate is 9.55 percent. In other words, 90.45 percent of the potential market for off-grid solar power remained untapped as of 2017. As such, total sales of off-grid solar products grew 49 percent from the second half of 2017 to the second half of 2018.

From the GOGLA investment and funding data, activity in the off-grid solar sector started in earnest in 2014. Since then, investment and overall funding increased through 2018. Interestingly, 2018 proved to be an exceptionally positive year for fundraising for the West Africa off-grid solar sector, with significant amounts invested and fundraising continuing to increase. The year witnessed a growth primarily in equity, while debt transactions lagged substantially in comparison.

Another impressive shift was the increase in the number of off-grid transactions, which went up to 24 in 2018 from four reported in 2017. The median reported transaction size decreased dramatically as new players and smaller companies were able to close financing transactions in West Africa.

Geographic market expansion and the addition of new products was the primary use of funds for West African companies, accounting for 89 percent of funding. A smaller portion of funds (9 percent) was used

for bridging working capital needs. For-profit financial institutions dominated the sources of funding, with some notable capital coming from crowd-funders and unknown/unspecified sources.

3.4 ANALYSIS OF HOUSEHOLDS

To understand the potential market for different types of off-grid solutions, Power Africa’s analysis segments households without electricity based on key household characteristics and assets.⁴⁹ The goal of this effort is to understand different levels of consumption power within this group. For large consumption households, the analysis selects households without electricity that have at least one high cost asset out of the following: car, computer, television, or refrigerator. Medium consumption households are those that own a mobile telephone and live in a household with at least one type of high-quality housing material (i.e. metal roofing, vinyl or carpet flooring, etc.) for the roof, floor, or walls. Modest consumption households are those that own at least a radio or mobile telephone. Note that the groups are mutually exclusive, with each household being classified into the highest tier for which it is eligible.

The analysis further validates this segmentation by analyzing the corresponding distribution of wealth for each group, proxying for wealth by using an index that is based on asset ownership and other household characteristics. This analysis confirms that households with lower levels of wealth are classified as households with a modest consumption of power, and those with higher wealth are classified as households with a high consumption of power.^{50 51} All households in the modest-, medium-, and high-consumption groups report not having access to electricity, with the following estimates by consumer group:

- › Out of the 1,684,912 households without electricity in Côte d’Ivoire, 77 percent are classified as target consumer households; 20 percent of households without electricity fit the profile for the **modest consumption group**.
- › There are approximately 0.3 million households in Côte d’Ivoire without electricity in this group; 48 percent of households without electricity fit the profile for the **medium consumption group**.
- › There are approximately 1.1 million households in Côte d’Ivoire without electricity in this group; 9 percent of households without electricity fit the profile for the **large consumption group**.

The remaining 23 percent of households without electricity did not meet the requirements for the modest, medium, or large consumption groups. This group primarily comprises households that live in homes constructed from less durable materials and with lower levels of asset ownership and wealth.

Table II highlights key attributes of the different consumer profiles to provide solar companies with information about potential target customers. Broadly, large home system households tend to own more expensive assets, live in higher quality homes, and are more likely to access financial tools.

⁴⁹ Recent detailed household spending data, including spending on specific energy sources and discretionary items, are unavailable in Côte d’Ivoire.

⁵⁰ The DHS Program, “Wealth Index Construction.”

⁵¹ The DHS wealth index is a composite measure of a household’s living standards. For a full discussion of the methodology used to construct this index see DHS Wealth Index Construction.

TABLE II. SUMMARY OF HOUSEHOLD INDICATORS BY CONSUMPTION CATEGORY

INDICATOR	MODEST CONSUMPTION HOUSEHOLDS	MEDIUM CONSUMPTION HOUSEHOLDS	LARGE CONSUMPTION HOUSEHOLDS
Housing Quality and Characteristics			
Average household size	4.3	4.6	5.4
Advanced finished floor	9%	87%	88%
Advanced finished walls	5%	55%	62%
Advanced finished roof	12%	88%	88%
Advanced finished house	4%	50%	56%
Flush toilet	12%	11%	18%
Main cooking fuel is gas	>1%	2%	7%
Main cooking fuel is electricity	>1%	>1%	>1%
Asset Ownership			
Mobile telephone	85%	100%	97%
Radio	47%	38%	70%
Media Consumption⁵²			
Watches television at least once per week	14%	19%	55%
Listens to the radio at least once per week	28%	27%	36%
Involvement in Agriculture			
Rural	98%	86%	80%
Owns agricultural land	78%	69%	67%
Owns livestock	60%	46%	54%
Highest Level of Education Achieved by the Head of Household			
No education	67%	60%	62%
Primary	24%	24%	23%
Secondary	9%	16%	15%
Access to Financial Tools			
Bank account access	1%	5%	15%

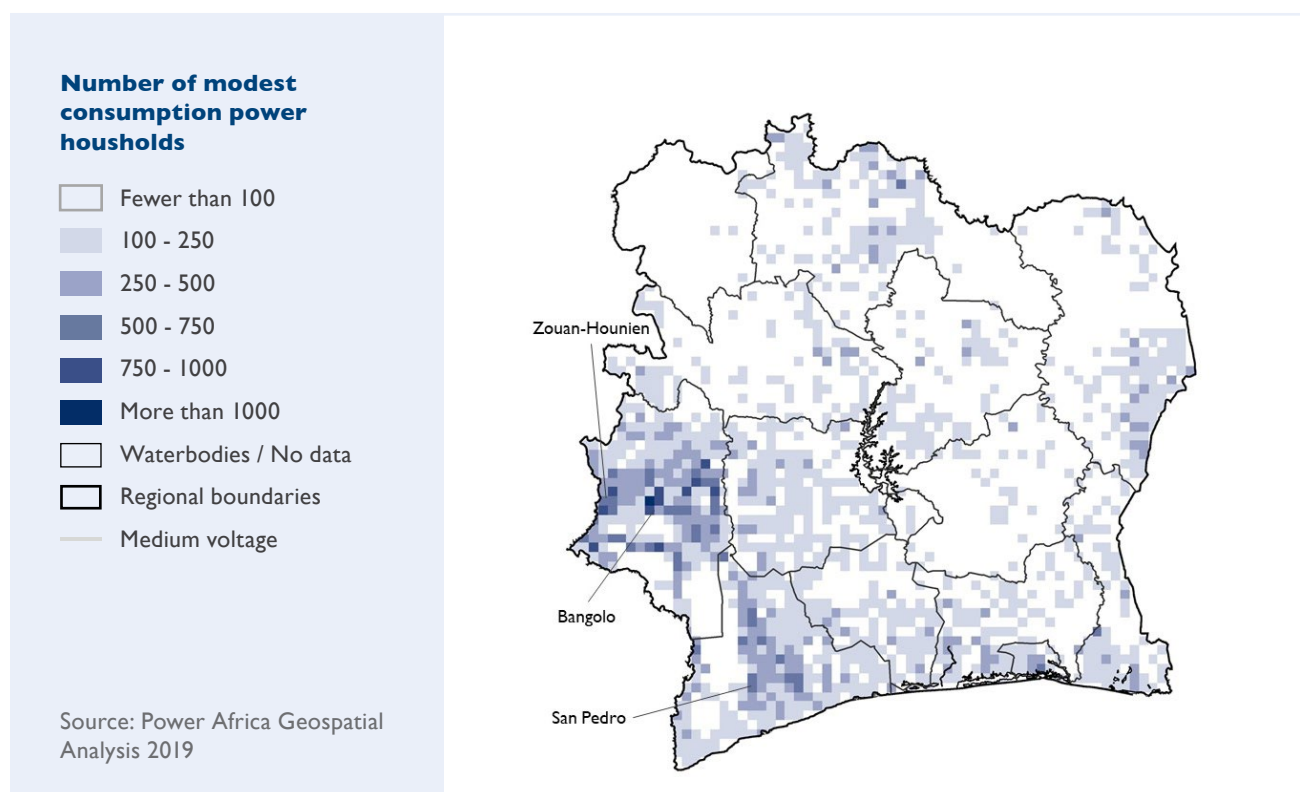
Source: Power Africa Geospatial Analysis 2019

⁵²Media consumption values were recorded for all people aged 15 to 49 years.

Financial inclusion among households without electricity is relatively low across Côte d'Ivoire, with approximately five percent of households having a bank account, compared with approximately 31 percent for households that have electricity. However, because 84 percent of households without electricity report owning a mobile telephone, there is significant opportunity for growth in mobile banking and mobile money, which could help facilitate payment plans for solar lights, home systems, and mini-grids.

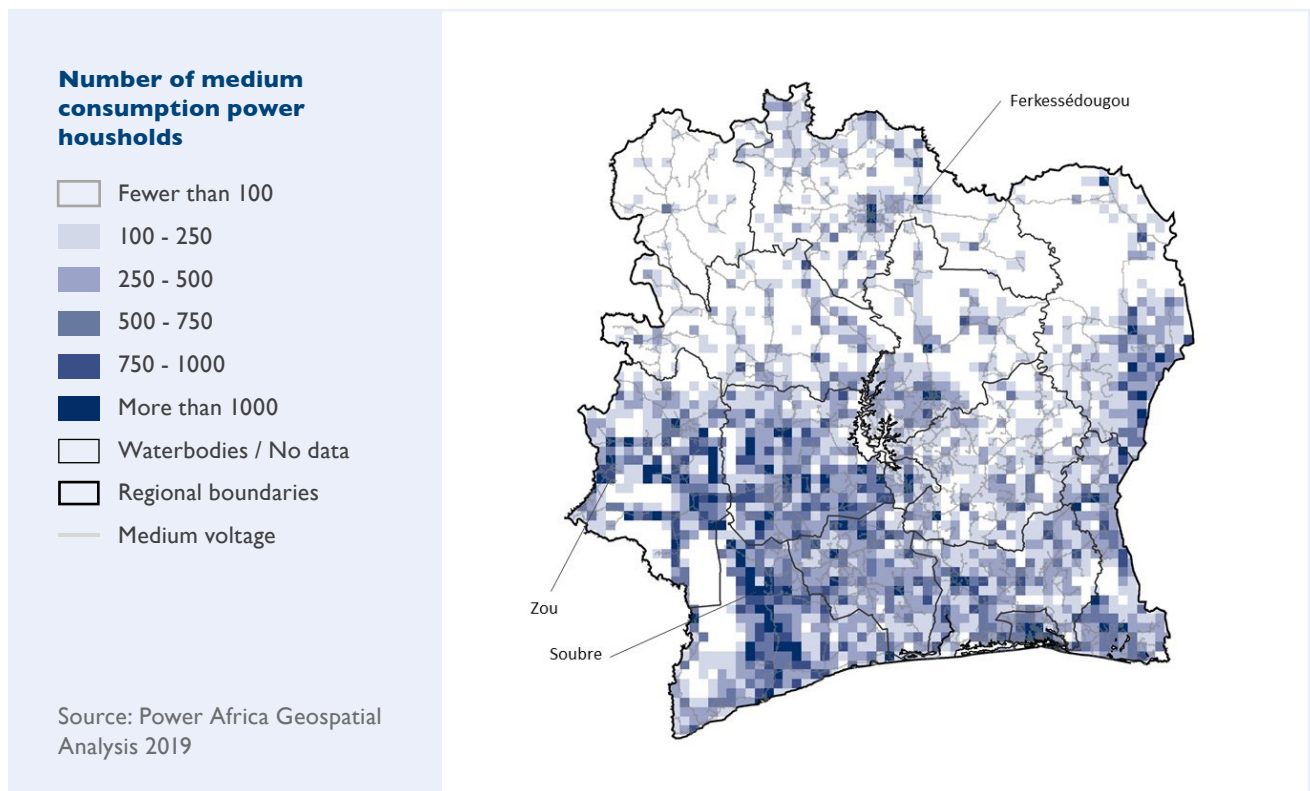
Distributions of these three consumer groups vary across the country. Figure 6, Figure 7, and Figure 8 each map the number of households by consumption group. In Figure 6, the modest-consumption group tends to be concentrated in more rural areas and has a stronger presence in the western and southern portions of Côte d'Ivoire. The Tonkpi and Guemon Districts have the largest total numbers of modest consumption households.

FIGURE 6. NUMBER OF MODEST CONSUMPTION POWER HOUSEHOLDS PER 10 SQUARE KILOMETERS



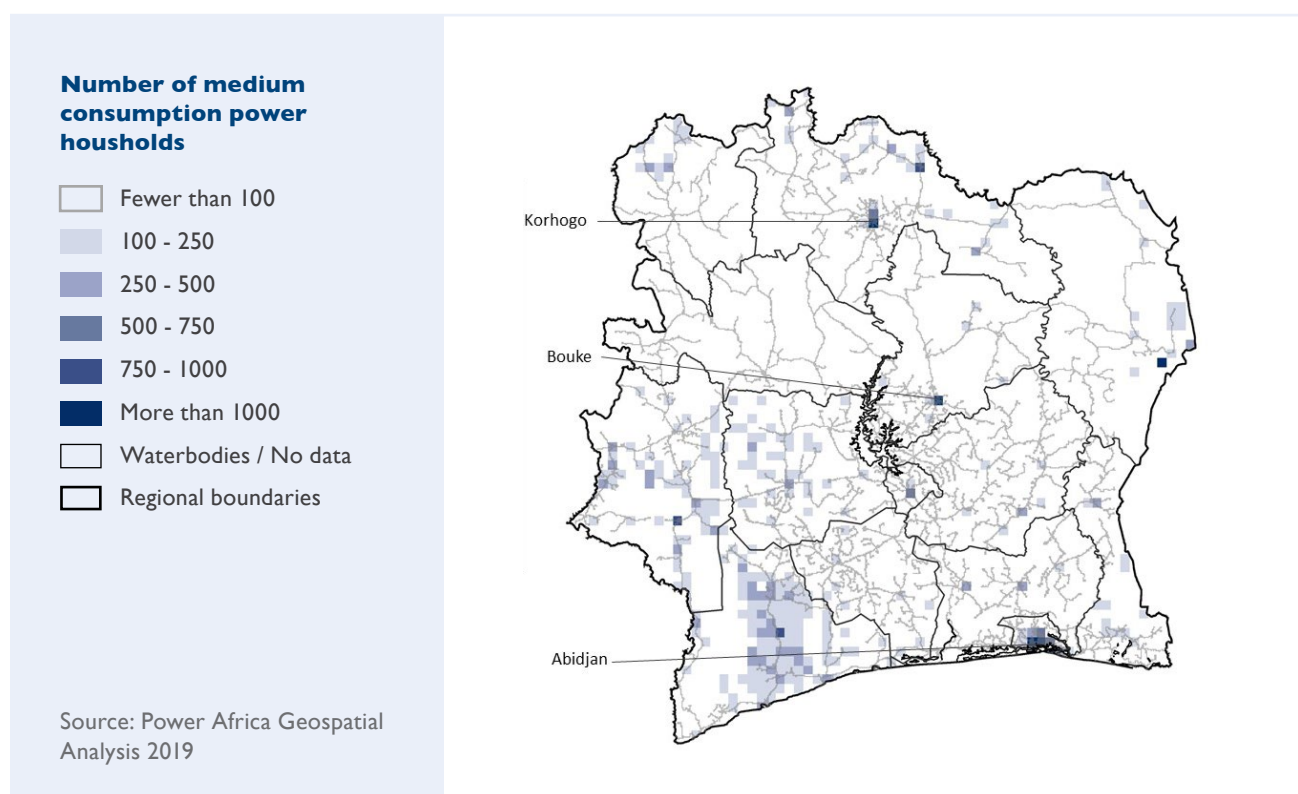
The medium-consumer group is by far the largest of the consumption categories. In Figure 8, households in the medium consumption group are mainly concentrated in the southern portion of Côte d'Ivoire, with small pockets in the northern area. The Haut-Sassandra, Nawa, and Gontougo Districts have the largest numbers of medium consumer households. The southern concentration of medium consumption households is indicative of the income inequality between Côte d'Ivoire's northern and southern regions.

FIGURE 7. NUMBER OF OFF-GRID MEDIUM CONSUMPTION POWER HOUSEHOLDS PER 10 SQUARE KILOMETERS



Of the three consumption categories, the large consumption households are also the fewest in terms of the number of households. The large consumption group is the smallest of the three consumer groups. This group tends to have higher concentrations in urban areas such as Korhogo, Abidjan, and Bouke.

FIGURE 8. NUMBER OF LARGE CONSUMPTION POWER HOUSEHOLDS PER 10 SQUARE KILOMETERS



3.4.I LATENT DEMAND FOR ELECTRIFICATION

To understand the potential latent demand for electrification, Power Africa analyzed the asset ownership and wealth of households without electricity in the large consumption households. Power Africa then compared this group with “similar” households with electricity that also have the same determining characteristics (must own at least one high-cost appliance, including a television, a refrigerator, a car, or a computer) with comparable wealth levels. The findings from the analysis illustrates the extent to which there is a potential to own high electronic assets requiring a higher energy demand once these large consumption households have access to reliable electricity.

The findings from the analysis reveal an urban–rural divide between both groups of households (i.e., households with or without electricity). Specifically, 41 percent of households with electricity are in urban areas compared with 15 percent of households with electricity. Within these comparison groups, the findings from the analysis show the following:

- › 71 percent of respondents from large consumption households without electricity say that they own agricultural land, compared with 61 percent of similar households with electricity. This finding is partly reflective of the urban–rural split between the groups with or without electricity access.
- › Ownership of high-end electronic assets is similar across both groups. Refrigerator ownership is low: 5 percent of respondents from households without electricity say that they own refrigerators compared with 4 percent of households with electricity. By comparison, television ownership is high. Specifically, 92 percent of respondents from households without electricity say that they own televisions compared with 98 percent of households with electricity.

- › Mid-range assets—mobile telephone and radio—have a slightly different pattern. Mobile telephones are ubiquitous across both groups. Specifically, 97 percent of respondents from households without electricity said that they own at least one mobile telephone compared with 98 percent of households with electricity. However, radio ownership is higher for the households without electricity access, possibly a reflection of the urban–rural divide. Specifically, 73 percent of respondents from households without electricity said that they own radios compared with 54 percent of households with electricity.
- › In terms of energy demand, use of advanced cooking fuel is relatively low. Specifically, 1 percent of respondents from households without electricity say that they use advanced cooking fuel compared with 4 percent of households with electricity.
- › There is a large disparity in television use, with regular viewership being significantly higher for households with access to electricity. Specifically, 50 percent of adults in households without electricity say that they watch television at least once per week compared with 81 percent in households with electricity.

Despite that households without electricity are generally located in more rural areas, the rates of electronic appliance ownership for items such as refrigerators, televisions, and mobile telephones are similar between the two groups (i.e., households with or without electricity). This finding indicates that adults in households without electricity also have the capacity and desire to purchase assets that require electricity.

3.4.2 AREAS FOR OFF-GRID POTENTIAL

Table 12 lists the estimated number of households without electricity, by district. The following four districts account for nearly or more than 50 percent of all households without electricity nationwide.

- › **Bas-Sassandra:** The 242,200 households without electricity access in this district comprise 14 percent of households without electricity access nationally. Of the total households in Bas-Sassandra, 54 percent of respondents reported lacking electricity access (Figure 10).
- › **Montagnes:** The 293,600 households without electricity access in this district comprise 17 percent of households without electricity access nationally. Of the total households in Montagnes, 59 percent of respondents reported lacking electricity access (Figure 11).
- › **Sassandra-Marahoué:** The 191,000 households without electricity access in this district comprise 11 percent of households without electricity access nationally. Of the total households in Sassandra-Marahoué, 48 percent of respondents reported lacking electricity access (Figure 12).
- › **Zanzan:** The 142,000 households without electricity access in this district comprise 8 percent of households without electricity access nationally. Of the total households in Zanzan, 69 percent of respondents reported lacking electricity access (Figure 13).

TABLE 12. HOUSEHOLDS WITHOUT ELECTRICITY BY DISTRICT

DISTRICT	TOTAL HOUSEHOLDS	HOUSEHOLDS ESTIMATED TO NOT HAVE ELECTRICITY	PROPORTION OF HOUSEHOLDS ESTIMATED TO NOT HAVE ELECTRICITY
Zanzan	205,800	142,000	69%
Woroba	143,400	94,600	66%
Denguéléa	34,200	21,600	63% ^a
Montagnes	495,700	293,600	59%
Bas-Sassandra	444,900	242,200	54%
Savanes	264,600	129,500	49%
Sassandra-Marahoue	394,800	191,000	48%
Lacs	213,900	97,000	45%
Lagunesa	294,500	122,500	42% ^a
Comoe	234,600	92,900	40%
Goh-Djiboua	293,100	109,600	37%
Valle Du Bandama	261,200	96,000	37%
Yamoussoukro	75,900	15,600	20%
Abidjan	1,085,700	37,000	3%
Owns agricultural land	78%	69%	67%
Owns livestock	60%	46%	54%
No education	67%	60%	62%
Primary	24%	24%	23%
Secondary	9%	16%	15%
Bank account access	1%	5%	15%

^a The number of households without electricity, and the corresponding percentages, in Denguélé and Lagunes are less precise than other districts.

Source: Power Africa Geospatial Analysis 2019

FIGURE 9. NUMBER OF HOUSEHOLDS WITHOUT ELECTRICITY PER SQUARE KILOMETER IN BAS-SASSANDRA

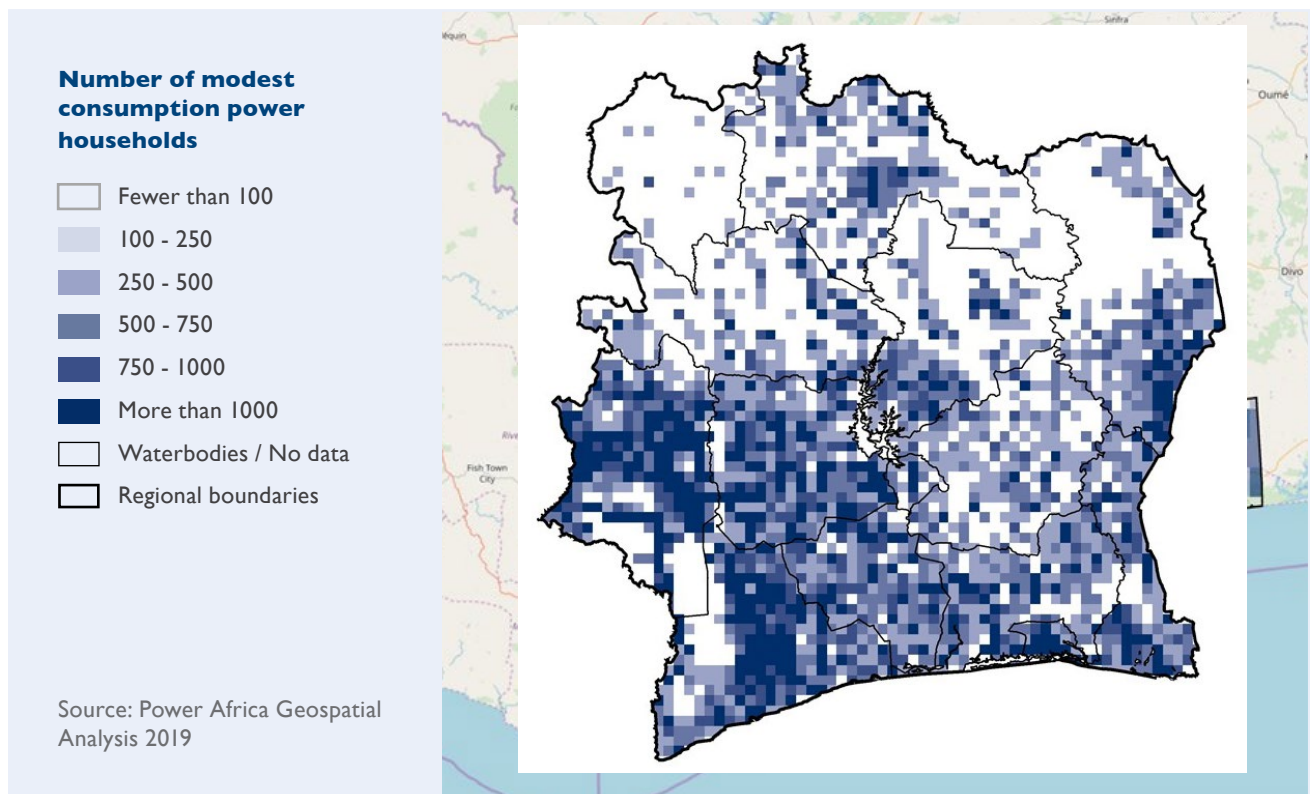


FIGURE 10. NUMBER OF HOUSEHOLDS WITHOUT ELECTRICITY PER SQUARE KILOMETER IN MONTAGNES

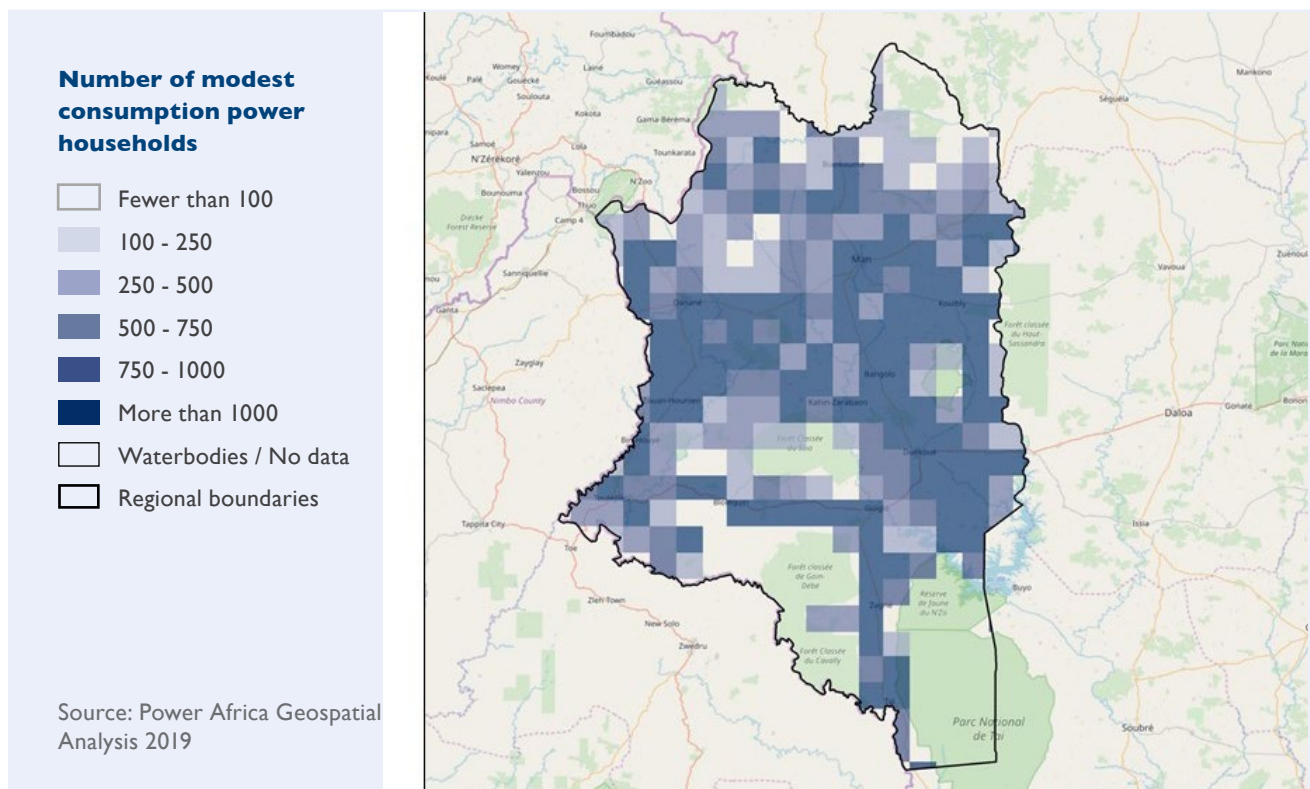


FIGURE 11. NUMBER OF HOUSEHOLDS WITHOUT ELECTRICITY PER SQUARE KILOMETER IN SASSANDRA-MARAHOUÉ

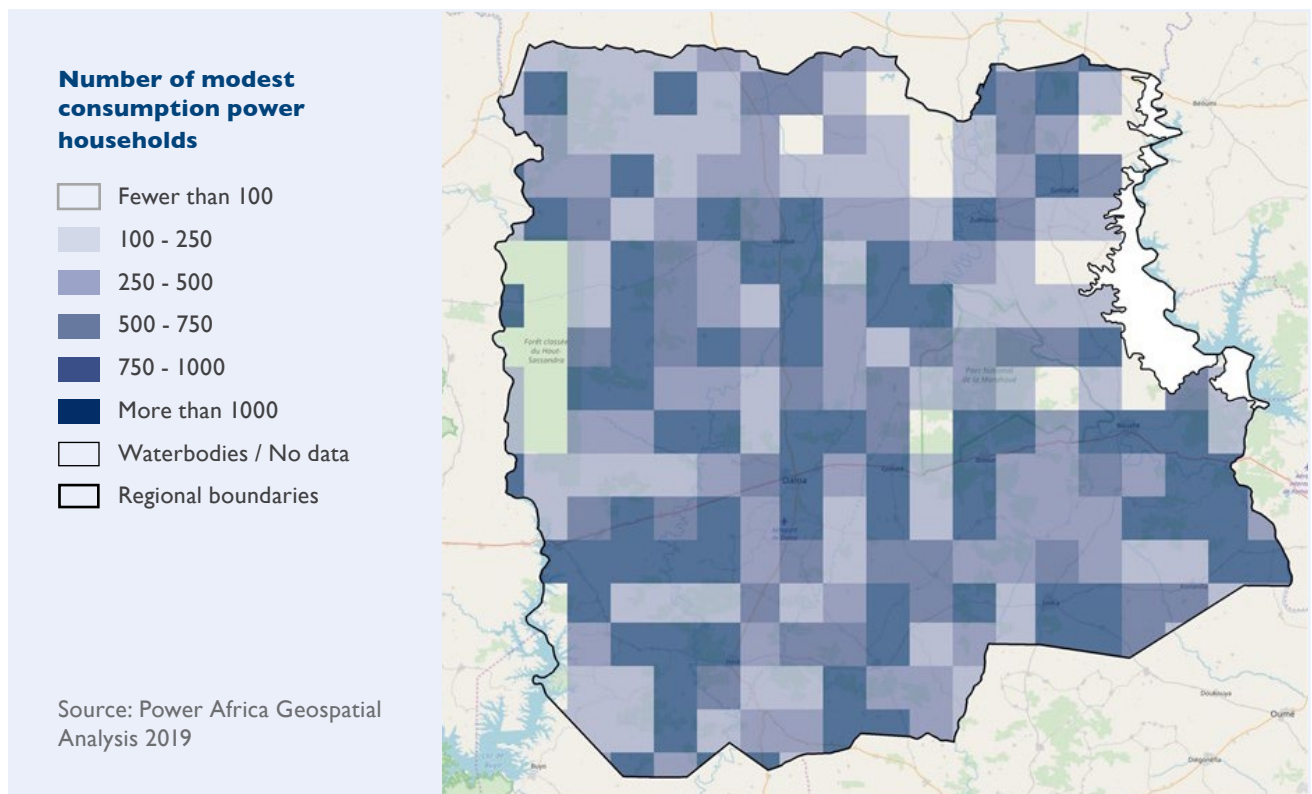
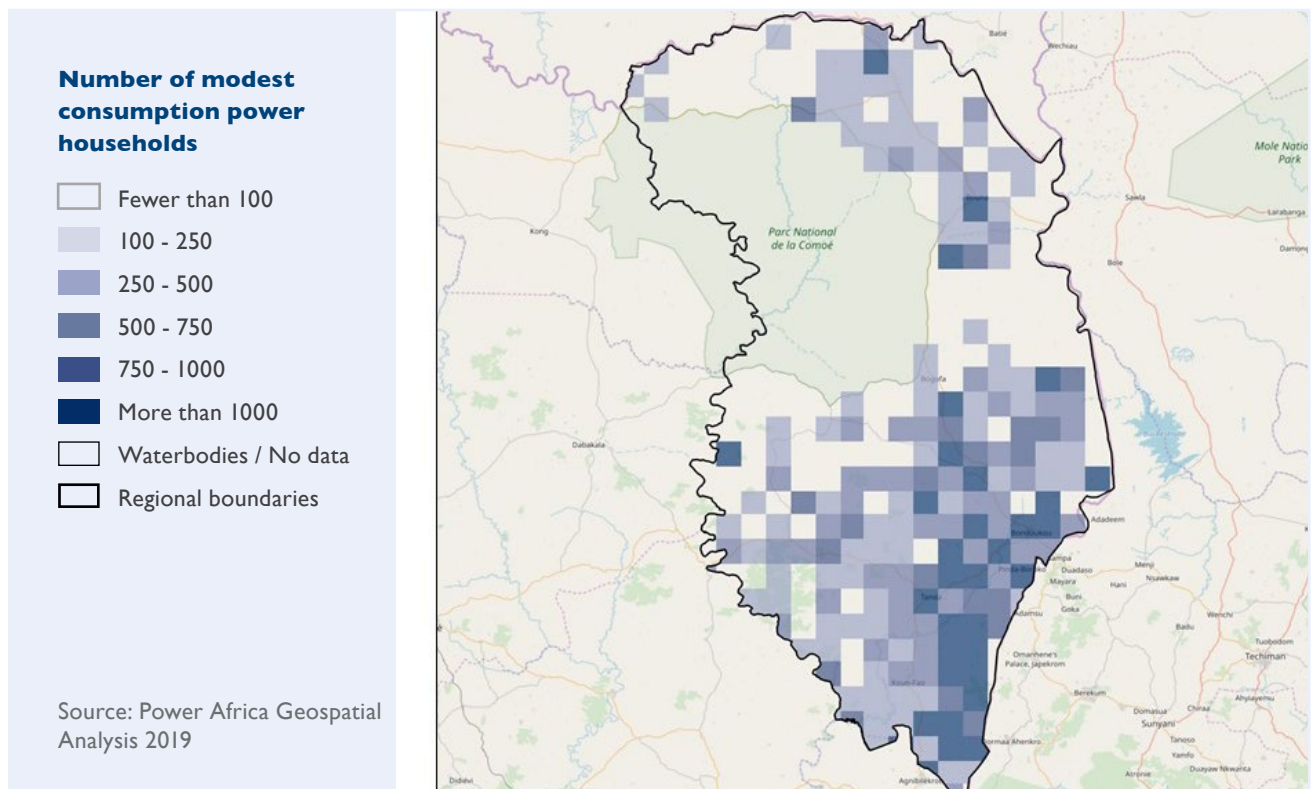


FIGURE 12. NUMBER OF HOUSEHOLDS WITHOUT ELECTRICITY PER SQUARE KILOMETER IN ZANZAN



Most modest, medium, and large consumption power households are within 1 km of MVN lines and within 5 km of official villages. Modest consumption power households comprise approximately 20 percent of all households without electricity. This percentage increases to 26 percent in areas farther than 10 km from MVN lines and farther than 5 km from official villages. Medium consumption power households comprise approximately 48 percent of all households without electricity. This percentage decreases to approximately 43 percent in areas farther than 10 km from MVN lines and farther than 5 km from official villages. Large consumption power households comprise approximately 9 percent of all households without electricity. This proportion does not drastically change, regardless of the distance from the MVN lines or official villages.

3.5 RELEVANT GOVERNMENT AND DONOR SHS SOLAR PROGRAMS

Although GoCI does not have specific policies to promote the off-grid solar sector, there are targets and support within the broader plan for rural electrification. As part of the PDER, combined systems of off-grid solar power and diesel back-up generators are intended to electrify areas where the grid will not extend. Similarly, PRONER does not have any specific plans for promoting the off-grid solar sector. However, GoCI is currently working toward adopting an off-grid solar power strategy. GoCI recognizes the following limitations of PRONER:

- › Budgetary constraints are causing long wait times for localities to be electrified.
- › It is estimated that 6,000 to 8,500 localities do not have access, and the electrification dates are either distant or are uncertain.
- › There has been a failure to account for the extension of the grid to remote localities (campements).
- › The high cost of connections poses a barrier for less affluent populations to gain access.



To this end, GoCI is updating PRONER to incorporate and promote the off-grid solar sector. This update is currently being drafted and expected to be promulgated by the end of 2019.

3.6 SHS RELEVANT REGULATIONS

Off-grid solar power is a nascent technology in Côte d'Ivoire, operating within a regulatory environment that has not been updated to meet the needs of the current market. For example, the processes for licensing and permitting are costly and unclear. Additionally, there is a lack of specific regulations for the sector, leading to uncertainty for SHS companies. Currently, GoCI is collaborating with USAID to create a clear regulatory framework to ease some of the barriers and inefficiencies that the off-grid solar industry is experiencing because of the current regulatory environment.

SHS companies also face an import duty on their products. While the standard value-added tax (VAT) is 18 percent, solar energy production equipment receives a reduced rate of 9 percent.⁵³ Even at the reduced rate, the VAT on solar energy production equipment serves as an additional hurdle for the nascent solar market in Côte d'Ivoire. GoCI is collaborating with USAID to reduce the VAT associated with solar energy production equipment.

⁵³ World Trade Organization, "WT/TPR/S/362 - Côte d'Ivoire."

3.7 PICO-SOLAR FINANCING OVERVIEW

A wide range of financial products can be utilized to support development of the solar sector in Côte d'Ivoire. These may include instruments such as:

- › Matching grants
- › Contingent loans
- › Results-based financing (grants reimbursing cost after completion of work)
- › Equity investment (seed capital and later stages)
- › Concessional debt (subsidized interest or forgiveness of a portion of principal repayment)
- › Short-term commercial credits for inventory purchases and working capital
- › Trade finance solutions (from export credit agencies or private trade funders)
- › Medium-term loans secured on assets or receivables from a portfolio of installed projects

3.7.1 COMPANY FINANCE

Investments into West Africa's off-grid solar industry have been booming since 2014. According to investment tracking by GOGLA, off-grid solar investments in West Africa totaled \$656,000 in 2014, \$107,385,000 in 2016, and \$67,659,000 in 2018.⁵⁴ As growth continues in West African economies, investors are turning to countries such as Côte d'Ivoire in search of new markets for growth and potential returns on investments.

As Côte d'Ivoire continues to grow both economically and demographically, the banking industry is bound to evolve as well. Where growth has traditionally been limited to the urban areas such as Abidjan, the banking industry has expanded its coverage in rural areas with the number of branches growing from 281 in 2008 to 631 in 2016.⁵⁵ Additionally, Côte d'Ivoire's banking sector is continuing along the path of privatization with the government recognizing the risk that publicly owned banks pose to that sector.

The banking sector is open to foreign banks. As of March 2019, 11 banks operating in Côte d'Ivoire also operate in the United States.⁵⁶ Table 13 lists the banks that are operating in Côte d'Ivoire and their corresponding U.S. bank (if different).

⁵⁴ GOGLA, "Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data."

⁵⁵ U.S. Embassies abroad, "Cote d'Ivoire - Banking Systems."

⁵⁶ U.S. Embassies abroad, "Cote d'Ivoire - U.S. Banks and Local Correspondent Banks."

TABLE 13. U.S. BANKS OPERATING IN CIV

BANKS IN CÔTE D'IVOIRE	CORRESPONDING BANKS
General Bank Corporation of Côte d'Ivoire (Société Générale de Banques en Côte d'Ivoire [SGBCI])	Société Générale de Cote d'Ivoire (SocGen)
BIAO Côte d'Ivoire (BIAO-CIV)	Commercial Credit of France (Crédit Commercial de France [CCF])
International Bank of Commerce and Industry of Côte d'Ivoire (Banque Internationale pour le Commerce et l'Industrie de la Côte d'Ivoire [BICICI])	National Bank of Paris (Banque Nationale de Paris [BNP Paribas])
Attijariwafa Bank	Agricultural Credit (Crédit Agricole), New York
Citibank	Citibank
Housing Bank of Ivory Coast (Banque de l'Habitat de Côte d'Ivoire [BHCI])	—
United Bank for Africa (UBA)	UBA, New York
Ecobank	Citibank, New York; and Bankers Trust
Bank of Africa Côte d'Ivoire	—
Atlantic Bank Ivory Coast (Banque Atlantique Côte d'Ivoire [BACI])	Bank of Tokyo–Mitsubishi, New York
Standard Chartered Bank	Standard Chartered USA, New York

Source: U.S. Department of Commerce 2019

3.7.2 COMMERCIAL FINANCE

In order to scale off-grid electrification, off-grid companies will need to access large volumes of commercial debt financing. In the longer term, partnerships between local commercial banks and MFIs will also be necessary to develop domestic, local-currency sources of financing and to reduce foreign exchange risk.⁵⁷ Partnerships with local financial institutions that have an understanding of the credit risk of local populations may also reduce financing costs more rapidly as compared to other methods (e.g., using debt from securitized receivables).⁵⁸ Although most financing currently comes from non-commercial sources (i.e., the international development community), global capital markets have the size and depth necessary to meet this investment challenge. Nevertheless, small investment sizes and other early-stage market investment risks are currently holding back abundant and low-cost private capital flows to the off-grid sector.⁵⁹

In order to mitigate risks and spur investment, the off-grid solar sector requires substantial policy and regulatory support. It is therefore important that governments send a clear signal to the private sector by integrating off-grid technologies into national development programs, electrification plans, and electricity access targets. Governments should also adopt favorable policies, laws, and regulations to boost private sector participation, including procurement and tax incentives, grants and subsidies, concession schemes,

⁵⁷ UNDP and ETH Zurich, “Derisking Renewable Energy Investment: Off-Grid Electrification.”

⁵⁸ Bloomberg, “How Can Pay-As-You-Go Solar Be Financed?”

⁵⁹ UNDP and ETH Zurich, “Derisking Renewable Energy Investment: Off-Grid Electrification.”

include public awareness raising, encouraging inclusive gender participation, and building local capacity at all levels (e.g. solar photovoltaic vocational training and technical certification programs, training for financial institutions to address the unfamiliarity of lenders with the off-grid solar sector, corporate and consumer financing needs, etc.).

Commercial lending to the off-grid sector has been limited because of the infancy of the off-grid solar market in Côte d'Ivoire and the lack of experience in lending to SHS companies within the country. To bridge this gap, donors must provide a guarantee to help secure loans for off-grid solar projects in Côte d'Ivoire and give commercial banks the necessary industry experience. Recent lending activities include the following:

- › ZECI has secured a 15.75 billion FCFA loan from SocGen, with one-third of the loan guaranteed by the AfDB. The purpose of this loan is to provide initial capital to finance SHS kits for 100,000 rural households by 2020.⁶⁰
- › The KfW Credit Institute for Reconstruction is lending \$32.9 million to Ecobank and the African Trade Insurance Agency to create a new financial instrument to support renewable energy projects of up to 50 MW throughout sub-Saharan Africa.⁶¹
- › Attijariwafa Bank recently became the first bank in Africa to be accredited by the United Nations' Green Climate Fund as an official financial intermediary for green financing in Africa.⁶²

As a follow up to the ZECI transaction with SOCGEN and AfDB, AfDB has launched a “Distributed Energy Service Companies (DESCOs)” financing program that aims to unlock local currency funding in the off-grid sector to scale up the deployment of PAYGO solar home systems in sub-Saharan Africa. The structure is being piloted in Côte d'Ivoire with ZECI.

The program demonstrates the use of securitization as an innovative financing mechanism for bringing private capital into the sector, notably through local bank participation. Its aim is to address the various barriers to access to finance, including the lack of familiarity with renewable energy technology, currency risk, and limited information about consumers' credit histories. After Côte d'Ivoire, the transaction program will look to diversify and expand into Kenya and Togo.

The European Investment Plan (EIP) Operational Board approved the DESCO Financing Program of the AfDB for (i) the second loss guarantee from the European Fund for Sustainable Development (EFSD) of up to €50 million to credit enhance transactions and lower the related all in cost for DESCOs, and (ii) €6 million grants for technical assistance to support African countries to create the enabling environment for the off-grid sector and to build the capacity of local banks and DESCOs to facilitate receivables-backed financing structures for the off-grid sector.

The AfDB, along with other co-investors, will provide partial credit guarantees for the senior tranche. Additionally, the EIP guarantee instrument, AfDB, and possibly other co-investors, will cover the mezzanine tranche.

The debt requirements of DESCOs could reach \$2–3 billion early in the 2020s. As the sector grows, expands, and thrives, the amount of debt needed to support it will as well. Securitization possesses the potential to open new, vital debt markets to DESCOs. The EFSD guarantee instrument explores the potential of securitization in the sector by providing attractive debt finance that mobilizes local banks investment in such structures.

⁶⁰ Ngounou, “IVORY COAST.”

⁶¹ Financial Afrik, “KfW and ACA Launch Africa Renewable Energy Facility.”

⁶² Kapital Afrik, “Attijariwafa bank obtains Green Climate Fund accreditation.”



In Côte d'Ivoire, 28 commercial banks operate mainly in urban areas, leaving many rural and low-income people and businesses with limited access to financial services. Although access to banking and financial services through formal institutions remains limited, Côte d'Ivoire is experiencing a sharp increase in the availability and usage of digital financial services and mobile banking, driven by widespread mobile phone ownership and rapidly growing mobile internet usage and network coverage.

This dynamic is driving greater financial inclusion. In 2017, 41 percent of the country's adult population had an account at a financial institution or with a mobile money service provider, up from 34 percent in 2014. In 2017, Côte d'Ivoire had among the highest rates of financial inclusion in West Africa and the Sahel: 8 percent above the regional average, though slightly below the average for sub-Saharan Africa. Despite this improvement, there is still a significant gender gap in rates of access to financial services, as women in Côte d'Ivoire are 11 percent less likely than men to have an account at a financial institution or with a mobile money service provider.⁶³

Commercial banks in Côte d'Ivoire will entertain the possibility of establishing a credit line for financing solar energy. However, the lack of experience in working with the solar industry and the nascency of the industry in Côte d'Ivoire presents a risk for lenders. As such, lenders require higher interest rates or guarantees by a donor. Unfortunately, national development credit lines are not available for lending directly to off-grid solar companies. Currently, SocGen, Ecobank, and Orabank-CIV are already providing loans for the purchase of solar lanterns and to a lesser extent SHS to small and medium enterprises (SMEs) with support from donor financial institutions.

Most off-grid business loans and all loans for purchasing SHSs by consumers will need to be denominated in local currency, which will limit the growth of the off-grid solar market. The use of credit lines denominated in foreign currencies presents substantial challenges for potential local lenders, given the need to manage the exchange rate risk. Nevertheless, when pricing collateral to hedge this risk, many foreign currency-denominated lines of credit become unattractive because the total cost of capital to the financial institution becomes too high for it to offer a competitive loan to borrowers. Thus, in the opinion of many of the financial institutions Power Africa approached, hard currency credit lines should therefore be offered at advantageous prices—ranging from 2 percent to 4 percent—to be widely accepted by financial institutions in the market.

The current guarantee requirements for commercial banks range from 40 percent to 100 percent. Lenders do not need first-level protection because they can overcome the risks associated with market perception. The use of *pari passu* guarantees from third parties in this case would theoretically replace the borrower's guarantees. A coverage of 50 percent would be normal, but a coverage of 70 percent to 80 percent would be better for the popularization of off-grid solar energy.

Representatives from financial institutions believe that the off-grid sector remains risky in the short term without any real prior knowledge of the market. To attract other lenders to this segment of the market, it is necessary to establish strong and reasonably priced credit enhancement mechanisms. To cover the market entry risks for lenders, guarantee instruments that cover initial losses are needed. However, first loss coverage—although necessary to attract new lenders in the off-grid sector—does not solve the key problem of collateral and is therefore likely to be insufficient on its own to stimulate the growth of financial institution commitment, unless it is associated with third-party guarantee coverage.

A well-designed technical assistance intervention is as crucial as reasonably priced credit lines and credit improvements are to enable the expansion of financial institutions' and MFIs' lending activities in the future.

⁶³ Demirgüç-Kunt et al., "The Global Findex Database 2017 Measuring Financial Inclusion and the Fintech Revolution."

The main areas of interest recommended are as follows:

- › Training of credit analysis staff and account managers to initiate transactions and appropriately assess the credit risk of companies and stand-alone solar projects.
- › In-depth due diligence support for eligible products and supplier approvals.
- › Support to new lenders for off-grid space in the construction transaction flow.

Attention should also be paid to providing advisory services to off-grid solar companies wanting to open in Côte d'Ivoire because these entrepreneurs often do not have adequate financial management and accounting systems in place, and are unable to present quality financial models because they often lack sufficient experience to structure their companies to meet loan obligations.

3.7.3 INVESTORS

There are a variety of investors that are currently participating in the solar sector in Côte d'Ivoire, as shown by Table 24. Investors range from donor institutions such as KfW, to impact investors such as Acumen, and to private equity firms such as Energy Access Venture. While there is a wide range of investors in the off-grid solar industry for Côte d'Ivoire, there remains a substantial need for financing.

TABLE 14. INVESTORS FOR THE CIV SOLAR INDUSTRY

TYPES OF INVESTOR	INVESTORS
Impact	Acumen, BlueHaven Initiative, Investisseurs & Partenaires, ElectriFI, and RePP
Private equity	Energy Access Venture, responsAbility
Foundations	Shell Foundation, Mastercard Foundation
Venture capital	Persistent Energy Capital and Total Energy Ventures
Loan and structure finance	SunFunder RePP, and Oikocredit
Donor financial institution	Canada Development Corporation and KfW Development Bank

Note: Information provided by the Power Africa technical advisory team

3.7.4 CONSUMER FINANCE

Microfinance Institutions. One of the fastest growing sectors in Côte d'Ivoire is the microfinance sector (Table 15). From 2012 to 2017, the sector grew 347 percent, from 72 billion FCFA to 250 billion.⁶⁴ Most MFI loans are for working capital requirements, investment credit (e.g., purchase of equipment, commercial development, purchase of goods), and consumer credit (e.g., personal loan, fast credit, school loan). No MFI currently provides loans for pico-solar purchase. However, Credit Access and First Microfinance Agency (Première Agence de Microfinance [PAMF]) Côte d'Ivoire are planning to develop loans for productive use appliances and equipment purchases. Mimoye Finance is an MFI dedicated to providing financing to women, but it does not currently provide loans for pico-solar.

MFIs are generally more appropriate sources of household finance. Households represent the majority of end-users in the country, and the level of cash flow this market segment has available for energy access depends heavily upon the formal or the informal economic activity in which they are engaged. In general,

⁶⁴ Grameen Credit Agricole Foundation, "Côte d'Ivoire."

the ability for households to pay from their own internal resources declines as their distance from urban centers increases and their opportunity to participate in the formal economy with regular cash income declines. Meanwhile, external funding is typically not available for rural households as they remain largely out of the coverage of financial institutions (except for households where members have regular sources of income from urban centers).

TABLE 15. SUMMARY OF MFIS IN CIV

INDICATORS	DECEMBER 2016	DECEMBER 2017	MARCH 2018
Number of approved institutions	54	51	50
Number of MFIs that reported their indicators	31	37	43
Number of service points	346	375	375
Number of members or clients (in thousands)	1,168	1,261	1,644
Outstanding deposits (in billions of FCFA)	210.1	278.2	262.2
Volume of credits set up during the quarter (in billions of FCFA)	83.1	99.4	79.1
Outstanding loans (in billions of FCFA)	189.9	270.4	266.1
Ratio of outstanding loans to outstanding deposits	90.4%	97.2%	101.5%
Percentages of MFIs meeting the regulatory standard associated with the portfolio at risk for more than 90 days, out of the sample of the 20 largest (standard: <3%)	30%	15%	15%

Source: ⁶⁵

The following three tables present market shares of MFIs in CIV (Table 16), outstanding savings from the main MFIs (Table 17), and the outstanding loans from the main MFIs (Table 18). The same 12 MFIs appear in all three tables.

⁶⁵ APSFD CI, “News - APSFD CI - L’association Professionnelle.”

TABLE 16. MARKET SHARES OF MFIS IN CIV

MFI	END JUNE 2018		END SEPTEMBER 2018	
	NUMBER OF CLIENTS	MARKET SHARE (%)	NUMBER OF CLIENTS	MARKET SHARE (%)
Advans Côte d'Ivoire	102,381	6.20	107,964	6.30
Atlantic Microfinance for Africa (AMIFA)	18,782	1.14	20,724	1.21
African Credit Company (Compagnie Africaine de Crédit [CAC])	42,952	2.60	36,654	2.14
African Fund Company for the Development of Active Retirement (Fonds International pour le Développement de la Retraite Active [FIDRA])	39,666	2.40	40,645	2.37
Savings and Support Group in Ivory Coast (Groupe d'Épargne et de Soutien en Côte d'Ivoire [GES-CI])	23,812	1.44	26,303	1.53
Mutual of Water and Electricity (Mutuelle de l'eau et de l'électricité [MA2E])	7,182	0.43	7,143	0.42
MicroCred Côte d'Ivoire	128,842	7.80	133,481	7.79
Mutual Credit and Savings for the Officials of Côte d'Ivoire (Mutuelle de Crédit et d'épargne pour les fonctionnaires de Côte D'Ivoire [MUCREF-CI])	20,192	1.22	22,417	1.31
PAMF Côte d'Ivoire	37,084	2.24	42,277	2.47
Network of Mutual Savings Banks and Credit (Réseau des Caisses Mutuelles d'Épargne et de Crédit Côte d'Ivoire [RCMEC-CI])	63,334	3.83	63,796	3.72
National Union of Savings and Credit Cooperatives of Ivory Coast (Union Nationale des Coopératives d'Épargne et de Crédit de Côte d'Ivoire [UNACOOPEC-CI])	980,630	59.34	990,478	57.80
Other MFIs	187,782	11.36	221,716	12.94
Total	1,652,639	100	1,713,598	100

Source: (Directorate-General for Treasury and Public Accounting 2018)

TABLE 17. OUTSTANDING SAVINGS FROM THE MAIN MFIS

MFI	END JUNE 2018		END SEPTEMBER 2018	
	SAVINGS OUTSTANDING (IN BILLIONS OF FCFA)	MARKET SHARE (%)	SAVINGS OUTSTANDING (IN BILLIONS OF FCFA)	MARKET SHARE (%)
Advans Côte d'Ivoire	36.10	13.16	31.70	10.83
AMIFA	3.20	1.17	4.40	1.50
CAC	32.00	11.67	41.80	14.28
FIDRA	23.10	8.42	24.70	8.44
GES-CI	9.90	3.61	10.20	3.48
MA2E	5.30	1.93	5.30	1.81
MicroCred Côte d'Ivoire	46.00	16.77	48.40	16.53
MUCREF-CIV	2.00	0.73	2.10	0.72
PAMF Côte d'Ivoire	2.20	0.80	2.30	0.79
RCMEC-CI	5.60	2.04	5.30	1.81
UNACOOPEC-CI	94.50	34.45	96.50	32.96
Other MFIs	14.40	5.25	20.10	6.86
Total	274.30	100	292.80	100

Source: (Directorate-General for Treasury and Public Accounting 2018)

TABLE 18. OUTSTANDING LOANS OF THE MAIN MFIS

MFI	END JUNE 2018		END SEPTEMBER 2018	
	OUTSTANDING (IN BILLIONS OF FCFA)	MARKET SHARE (%)	OUTSTANDING (IN BILLIONS OF FCFA)	MARKET SHARE (%)
Advans Côte d'Ivoire	60,90	23.14	52,10	18.29
AMIFA	7,70	2.93	9,90	3.48
CAC	26,40	10.03	32,20	11.31
FIDRA	11,60	4.41	13,60	4.78
GES-CI	11,00	4.18	12,90	4.53
MA2E	8,10	3.08	8,20	2.88
MicroCred Côte d'Ivoire	80,10	30.43	91,00	31.95
MUCREF-CI	2,90	1.10	3,30	1.16
PAMF Côte d'Ivoire	5,20	1.98	6,40	2.25
RCMEC-CIV	0,70	0.27	0,70	0.25
UNACOOPEC-CI	39,70	15.08	41,70	14.64
Other MFIs	8,90	3.38	12,80	4.49
Total	263,20	100	284,80	100

Source: (Directorate-General for Treasury and Public Accounting 2018)

Mobile Money. In recent years, Côte d'Ivoire has been a leader in West Africa with respect to mobile money. With the highest penetration rate of any West African country, mobile money has spread throughout various industries within the nation's economy.⁶⁶ With more than 19 million mobile subscribers and 9.8 million mobile money subscribers (the fifth highest in the world), mobile money subscriptions are expected to continue growing.⁶⁷ Mobile money is already playing a significant role in the country's economy and is likely to be equally important for the growth of the off-grid sector.

Expanding digital financial services, especially mobile money, can create new opportunities to better reach and serve women, lower-income populations, and other groups that are traditionally excluded from the formal financial system. Moreover, mobile money technology also plays a critical role in the application of off-grid solar solutions, particularly for PAYGO systems that rely on the inter-operability between digital financial services and stand-alone solar devices.

3.8 SHS INDUSTRY PARTNERS

Partnerships are forming within the solar industry in Côte d'Ivoire, and opportunities exist for new ones. One such partnership in development is between Orange Énergie, Baobab+, and Schneider Electric. Orange Énergie is the largest telecommunications company in Côte d'Ivoire and is currently partnering with other companies operating in the SHS market. Currently, Orange Énergie, Baobab+, and Schneider Electric are

⁶⁶ Lucini and Bahia, "Country Overview: Côte d'Ivoire: Driving Mobile-Enabled Digital Transformation."

⁶⁷ Youtap, "Market Opportunities in Mobile Money."

forming a cooperative to leverage each company's respective areas of expertise. forming a cooperative to leverage each company's respective areas of expertise.⁶⁸

One potential collaboration is with the National Federation of Cooperative Food Crops Societies of Côte d'Ivoire (Fédération Nationale de Sociétés Coopératives de Vivriers de Cote d'Ivoire [FENASCOVICI]). Operating since 2000, FENASCOVICI has more than 600 members and has expressed interest in agricultural uses of solar power.⁶⁹

3.9 GENDER MAINSTREAMING STRATEGY FOR SHS COMPANIES

Traditionally, in Côte d'Ivoire, the Ministry of Family, Women, and Children has handled gender issues. Broadly, GoCI has recently set forth initiatives to promote gender mainstreaming throughout the country's economy. In April 2019, a delegation from the United States joined GoCI in announcing the launching of a new Gender Unit within the Ministry of National Education and Technical Education. Staff in the Gender Unit are charged with empowering girls and women by providing the education and training necessary to participate in Côte d'Ivoire's growing economy.⁷⁰ Currently, no specific initiative exists in Côte d'Ivoire to support gender mainstreaming in the energy sector.

Women are not yet highly engaged in the nascent off-grid market. The overall lack of inclusion and participation of women in the sector is attributable to a wide range of factors. A 2018 survey conducted by IRENA found that nearly three-quarters of respondents cited cultural and social norms as the most common barrier to women's participation in expanding energy access, which reflects the need for gender mainstreaming. More than half of the women surveyed in Africa identified a lack of skills and training as the most critical barrier, compared to just one-third of respondents globally.⁷¹

The same survey found that access to necessary technical, business, or leadership skills development programs was the single most important measure that could be taken to improve women's engagement in energy access. Over half of survey respondents also highlighted the need to integrate gender perspectives into energy access programs, mainstream gender in energy policies, and enhance access to financing for women.

The main challenges that women face in the off-grid sector are:

- › Lack of access to skills development, technical capacity building, and education/training.
- › Lack of access to capital, asset ownership, collateral, and credit (e.g. to start a business).
- › Extensive household responsibilities reduce their ability to generate income and service credit.
- › Financial literacy among women remains low, and there is generally a lack of education and information available to women on access to financial resources.

⁶⁸ Orange Énergie has expertise in micro-finance and the PAYGO business model, Baobab+ has expertise in retailing SHS, and Schneider Electric is a global supply chain of power equipment.

⁶⁹ FENASCOVICI, "FENASCOVICI | NATIONAL FOOD COOPERATIVE FEDERATION OF COTE D'IVOIRE | OFFICIAL WEBSITE."

⁷⁰ Millenium Challenge Corporation, "MCC Vice President Joins W-GDP Trip in Côte d'Ivoire to Launch New Ivorian Gender Unit, Tour Future Compact Project Sites."

⁷¹ IRENA, "Renewable Energy: A Gender Perspective."

Despite the lack of explicit initiatives seeking to address these challenges and help improve gender inclusion in the country's energy and off-grid sectors, ECREEE partnered with AfDB in 2018 to launch a regional workshop to advance the participation of women in the renewable energy sector. The program intends to address the lack of female inclusion in the energy value chain, as women represent only two percent of energy sector entrepreneurs in West Africa. The joint initiative ultimately seeks to develop a pipeline of investment-ready, women-owned energy businesses across the region, including in Côte d'Ivoire.⁷² Additionally, there are gender mainstreaming initiatives within the mobile and IT sectors that overlap with various portions of the value chain for SHS companies. In 2014, mobile telephone operator Moov launched a program called "Weena" to promote women-led savings and community-based financing with the goal of using the community savings to finance community projects.⁷³ Another initiative is through the main telecommunications company for Côte d'Ivoire, Orange Énergie. In 2016, Orange Énergie launched the "She Is the Code" initiative to provide free training and IT equipment to unemployed women.⁷⁴ Additionally, Orange Énergie opened a network of centers to provide female entrepreneurs with access to IT equipment, a variety of training programs, and a free coworking space.⁷⁵

⁷² ESI Africa, "FEASIBILITY STUDY PROMOTES WOMEN'S PARTICIPATION IN ENERGY TRANSITION."

⁷³ GSMA, "Weena."

⁷⁴ Sheisthecode, "Sheisthecode Home Page."

⁷⁵ Orange Foundation, "The Women's Digital Centres Programme: Actively Supporting Women's Empowerment."

4 MINI-GRIDS IN CÔTE D'IVOIRE

The current regulatory environment in Côte d'Ivoire makes it infeasible for the private sector to provide mini-grid solutions to rural communities. This constraint is due to the CIE concession agreement that is in place until 2020.



Currently, the only mini-grids operating in Côte d'Ivoire are from development projects supported by donor agencies. With the expected decrease of mini-grid barriers, both incumbent and new entrant solar companies are preparing for a future market for mini-grids in Côte d'Ivoire.

Even though the number of mini grids in Côte d'Ivoire are limited, there are lessons to be learned. The most notable mini-grid project is the Akwaba project in the Zanzan district. The Akwaba project resulted in solar mini-grids for seven remote villages. They also included back-up diesel generators to resolve the storage requirements for 24-hour connectivity.⁷⁶ Funding partners include the EU, UNIDO, GEF, and the Non-governmental Organization Delegation Foundation Akwaba, with technical support provided by Azimut 360. The mini-grids are owned and managed by the individual villages via two groups within each village. One group manages the grid, collects fees, develops contracts for new customers, and provides overall decision making about the system. The other group monitors the grid's performance. The photovoltaic capacities range from 20 kilowatts (kW) to 40 kW with back-up diesel generators ranging from 30 kilovolt amperes (kVA) to 45 kVA.

TABLE 19: ZANZAN DISTRICT MINI GRID PROJECT TARIFFS

TARIFF CATEGORY	ENERGY (KWH MONTH)	COSTS (FCFA/MONTH)	COSTS (€/MONTH)	NOMINAL POWER (W)	TARIFF (€/KWH)
Economic	8	750	1.14	500	0.1425
Average	17	1,500	2.29	500	0.1347
Comfort	33	3,000	4.57	500	0.1385
Grand comfort	59	5,250	8	500	0.1356
Shops	59	5,250	8	500	0.1356
Religious	33	3,000	4.57	500	0.1385
Youth centers	67	6,000	9.15	1,000	0.1366
Social halls	100	9,000	13.72	2,000	0.1372
Gas station	67	6,000	9.15	2,000	0.1366

⁷⁶ Sørensen, "Flagship Project for the Development of Renewable Energies in Cote d'Ivoire."

5 AGRICULTURAL AND PRODUCTIVE USE SOLAR COMPANIES

Agricultural and productive use of off-grid solar systems is a market in its infancy in Côte d'Ivoire. In general, there is little formal data available on the potential for solar in the productive use sector in Côte d'Ivoire. Few companies are currently operating within this sector of the off-grid solar market, and sales have been limited. However, with the country's potential economic growth from agricultural processing, there is strong market potential for agricultural and productive use of off-grid solar.

TABLE 20. SOLAR COMPANIES OPERATING IN AG AND PRODUCTIVE USE SOLAR SECTOR

TECHNOLOGY	DETAILS	MATURITY LEVEL
Solar water pumping	ZECL is developing a water pumping solution for agriculture and access to drinking water PEG Côte d'Ivoire Baobab+	Introductory stage
Solar refrigeration	Aphelion STEL (Phaesun)	Introductory stage
Solar processing	Yandalux	Development stage
Others	STEL (Phaesun) has developed access to energy solutions for schools, health centers, petrol stations, and other rural businesses.	Growth stage

Note: Information provided by the Power Africa technical advisory team.

The Ivorian government has indicated that communities more than 80 km from the grid would be targets for productive use of energy interventions. The northern part of the country is generally considered an area that would greatly benefit from increased access to productive use of energy appliances, followed by the Western region and Vavoua, in the Daloa region, due to lack of infrastructure as a result of the political crises from 2002 to 2010.

Several donor-supported projects have tried to promote productive use appliances such as freezing of fish in Zanzan and a solar cassava grinding intervention carried out by the International Rescue Committee. Since services make up 41.58 percent of Côte d'Ivoire's GDP, a lack of reliable power has been shown to have substantial adverse effects on the profitability of firms.⁷⁷ Furthermore, business owners in areas with widespread grid connections have also been forced to deploy off-grid solutions, usually fossil fuel-powered generators, due to uncertainty and low availability of grid-connected power. There are also several productive use sub-sectors where solar power can immediately add value and build income. The impact of electricity use on SMEs depends on a variety of external and internal factors, especially access to markets, the location of the firm, supply of inputs, and financial capability. Therefore, the extent to which firms may be able to afford to invest in off-grid solar solutions is determined largely by increases in productivity, profitability, and employment/wages from the investment in off-grid appliances.

One of the most active solar companies offering products for agricultural and productive uses is STEL. As shown in Table 20, STEL is not only selling solar refrigeration, but also offering solar solutions to schools, health centers, petrol stations, and other rural businesses. Aside from STEL, only a handful of companies

⁷⁷ Statistica, "Share of Economic Sectors in the Gross Domestic Product (GDP) from 2007-2017, Côte d'Ivoire."

are in the introductory stage of offering agricultural and productive use solar systems. Given the economic potential for agricultural and productive use of solar in Côte d'Ivoire, there is a substantial potential market for agricultural and productive use solar systems that cannot be met by the current number of incumbent firms.

5.1 RELEVANT GOVERNMENT AND DONOR AGRICULTURE AND PRODUCTIVE USE PROGRAMS

The most recent policies, strategies, and acts related to agriculture and productive uses for off-grid solar power is the National Investment Program for Access to Energy Services in Côte d'Ivoire (Le Programme National d'Investissement pour l'Accès aux Services Énergétiques en Côte d'Ivoire [PNIASE-CI]). PNIASE-CI focused on identifying and measuring the level of energy access in the country by examining the proportion of electrified localities and households with access to electricity.

The PNIASE-CI is subdivided into three main components according to the three pillars of the Economic Community of West African States (ECOWAS) and West African Economic and Monetary Union (WAEMU) White Paper about access to energy services. The three main components are access to: (i) electricity, (ii) modern cooking energy, and (iii) applications of solar power to agriculture and productive uses (e.g. irrigation via solar pumping). These three components consist of subprograms that cover the following five sectors: agriculture, education, energy, health, and hydraulics.⁷⁸

Côte d'Ivoire is a predominantly agricultural country. Therefore, irrigation has remained one of the priorities of agricultural policies since the country's independence. These policies first focused on the development of large public perimeters, before progressively integrating support for smaller collective schemes and small private irrigation (at the producer level). The development of irrigation is considered a priority for increasing yields. Irrigation also provides a response to the risks regarding uncertain rainfall in West Africa, a phenomenon that could be aggravated by climate change effects. By increasing yields and reducing climate risks, irrigation policies can also help fight against farmers' poverty by allowing them higher and less uncertain incomes.

In 2014, GoCI launched PRONER to align public and private resources, coordinate the development efforts necessary to expand electricity coverage to all localities, and double the number of household connections. A key component of GoCI's electrification strategy is the "Electricity for All" (Programme Électricité Pour Tous [PEPT]) initiative, which aims to bring electricity access to approximately one million low-income households over the next five years. The PEPT initiative aims to bring electricity access through a combination of rehabilitation and extension of the transmission network, as well as a subsidy mechanism that eliminates the high cost for rural households to connect to the distribution grid.

Agriculture and productive use technologies are not included in the national electrification strategy. However, an off-grid electrification strategy and a renewable energy policy are in development and should be in 2019.

5.2 AGRICULTURE AND PRODUCTIVE USE RELEVANT REGULATIONS

There are no specific regulations regarding agriculture and productive use of solar technologies. There is no licensing and permitting differentiation from other uses of off-grid solar systems. There are some incentives for importers, but not for resellers. End users importing agriculture and productive use technologies can do so at the reduced 9 percent VAT provided the photovoltaic component is included.

⁷⁸ UNDP, "Rapport PNIASE-CI | Le PNUD En Côte D'Ivoire."

Côte d'Ivoire has an electricity regulator in charge of the following five different areas:

- › Supervising compliance with all energy laws and regulations by utility operators and IPPs.
- › Proposing electricity tariffs to the state as well as tariffs to access the national grid.
- › Settling disputes.
- › Protecting the collective interest of electricity consumers.
- › Providing advice and assistance to all electricity operators.

Additionally, agriculture and productive use solar technology companies must adhere to any electricity regulations, just as other SHS and pico-solar companies are required to do.

Agriculture and productive use solar technology companies must adhere to regulations involving importation duties for solar equipment. Regarding technologies such as solar pumps and refrigerators, no specific regulations exist. These technologies adhere to similar regulations applied to standard pumps and refrigerators. Furthermore, while the solar panels, batteries, and equipment are under the reduced 9 percent VAT, the importation challenges are the same as with SHS kits.

Creditinfo has been appointed by the Bank of West African States (La Banque Centrale des États de l'Afrique de l'Ouest [BCEAO]) as the regional Credit Bureau. Creditinfo is a service provider of credit information and credit risk management solutions, including tools for decision making, such as models and software.

The mobile payment regulations are not supportive because small payments made through the mobile system are still charged (contrary to what occurs in East Africa). Barriers include high rates of illiteracy and the cost of mobile payment transactions. BCEAO is leading the effort for making regulatory changes.

No organization is actively developing and implementing environmental regulations for agriculture and productive use solar products. However, the Ministry of Environment and Sustainable Development has developed a new regulation regarding e-waste. A framework for environmentally sound management is being reviewed by various stakeholders within both the public and private sectors. Support from Power Africa is underway for the regulation of environmentally sound disposal of renewable energy equipment.

5.3 PRODUCTIVE USE APPLICATIONS FOR OFF-GRID SOLAR SYSTEMS



Because households without electricity tend to be more rural than their counterparts, there is the potential to increase the agricultural productivity of those households. Approximately 88 percent of all modest, medium, and large consumption power households are in rural areas.

Nationally, approximately 50 percent of households without electricity own livestock and approximately 70 percent own agricultural land. Additional findings are as follows:

- › **Modest consumption households:** Approximately 65 percent of modest consumption households own livestock, and approximately 77 percent own agricultural land, making this consumption group the most rural.
- › **Medium consumption households:** Approximately 51 percent of medium consumption households own livestock, and 65 percent own agricultural land.
- › **Larger consumption households:** Approximately 52 percent of large consumption households own livestock, and 62 percent own agricultural land.

In these rural homes, electrification can help extend the time that families have to pursue domestic and leisure activities. Additionally, having electricity can help primarily agricultural households engage in other productive activities that might require electric devices. Having electricity can also increase the labor supply in rural communities.⁷⁹

Agricultural households that grow crops or produce animal products that could use some amount of processing, such as peanuts, palm oil, milk, and meat, could benefit from increased productivity through solar systems that provide electricity for mills or animal processing plants. In Côte d'Ivoire, a variety of irrigation models exist.⁸⁰

- › Full control irrigation: Sprinkler schemes for sugar, vegetable, rice and fruit production areas. The main surface irrigation techniques are pump irrigation and river diversion.
- › Equipped inland valley bottoms and swamps: Direct river diversions from small rivers to side canals in farming plots. Interventions in swamps are usually for controlling the level of the groundwater table through drainage.
- › Traditional irrigation: Inland valley bottoms and swamps. In such cases, there is no particular infrastructure. There may be some water management interventions.

Agricultural practices, especially for smallholder farmers, would benefit from a wide range of other off-grid solar technologies. Cold rooms, ice production, and solar dryers may also be profitable equipment investment for those working in aquaculture or fishing. Solar refrigeration appliances that address the perishability of milk would also enable livestock farmers to sell dairy products. Shelling, grinding, and drying are value addition activities that would be well suited for off-grid solar electrification in Côte d'Ivoire, as these appliances are currently powered by diesel generators in Ivorian off-grid villages.

5.4 FINANCIAL PRODUCTS FOR PRODUCTIVE USERS OF ENERGY

Financial instruments for SMEs and agriculture as end-users of sustainable energy represent a very important category of products in that they tend to be commercially viable and are thus important for the long-term sustainability of energy systems. While households and community facilities use energy primarily for consumption, often resulting in main sources of income or budget being allocated to cover the cost of service, SMEs and agriculture use energy for income-generating activities and can therefore cover electricity costs through the income generated by their activity. A rural business or farm with positive cash flows gives financiers more comfort as well as an opportunity to design financial instruments that are commercial in nature. A loan product with parameters that match the business ability to service the debt would be a strong and commercially viable option. MFIs often provide short-term loans to off-grid farms and microenterprises on this basis while financial institutions often limit their lending to SMEs with strong balance sheets and available collateral.

⁷⁹ Van de Walle, "Long Term Impacts of Household Electrification in Rural India."

⁸⁰ FAO, "Irrigation Technologies | Adapting Irrigation to Climate Change (AICCA) | Food and Agriculture Organization of the United Nations."

ANNEX A DEFINITIONS FOR GEOSPATIAL ANALYSIS

TABLE A 1. DEFINITIONS FOR GEOSPATIAL ANALYSIS

VARIABLE	DESCRIPTION
Households without access to electricity	Households that responded “no” to the survey question: “Does your household have access to electricity?”
Consumption groups—Note that the groups listed below are mutually exclusive, with each household being classified into the highest tier for which it was eligible.	
Large consumption households	Households without electricity that had at least one high-cost asset out of the following: car, computer, television, or refrigerator.
Medium consumption households	Households without electricity that owned a mobile telephone and used at least one type of high-quality housing material for the roof, floor, or walls.
Modest consumption households	Households without electricity that owned at least a radio or mobile telephone, and that did not fall into the large or medium consumption household categories.
Household asset ownership	
Computer	Household reported owning a computer.
Television	Household reported owning a television..
Refrigerator	Household reported owning a refrigerator
Mobile telephone	Household reported owning a mobile telephone.
Car	Household reported owning a car.
Radio	Household reported owning a radio.
Agricultural land	Household reported owning land used for agriculture.
Livestock	Household reported owning at least one livestock animal (i.e., sheep, goats, cows, horses, pigs, or chickens).
Bank account	Household reported having at least one bank account, without specifying how they used it.
Household characteristics	
Household size	Number of people living in the household.
Advanced finished floor	Household floors made out of cement, vinyl, tile, or carpet.
Advanced finished walls	Household walls made out of cement, brick, cinderblocks, tiles, covered adobe, or limestone.
Advanced finished roof	Household roof made out of cement or metal.
Advanced finished house	Housing floor, walls, and roof all made of advanced finished materials.
Advanced cooking fuel	Household used electricity or gas.
Flush toilet	Household reported having any type of flush toilet.
Media consumption	
Regular television watcher	Individual aged 15–49 years who reported watching television at least once per week.

Regular radio listener	Individual aged 15–49 who reported listening to the radio at least once per week.
Head of household education	
Did not finish primary school	Head of household received no schooling or did not finish primary school.
Finished primary	Head of household completed primary school, and may have attended, but not completed, secondary school.
Finished secondary	Head of household completed secondary and may have had some higher education.

Source: Power Africa Geospatial Analysis 2019

ANNEX B METHODOLOGY FOR GEOSPATIAL ANALYSIS

The Fraym database on African populations is composed of existing household surveys that are harmonized and re-weighted based on population data from third-party sources such as the United Nations and the World Bank, ensuring that indicators are comparable across countries and over time.

For this study, indicators at the individual and household levels were sourced from the 2016 Côte d'Ivoire Multiple Indicator Cluster Survey (MICS), which was initiated by a collaboration between the Government of Côte d'Ivoire and the United Nations Children's Fund (UNICEF), and executed by the National Statistics Institute.⁸¹ ⁸² The MICS data had a total sample size of 12,800 households. This analysis also used information from the 2012 Demographic and Health Survey (DHS), which was prepared by the Ministry of Health, Fight Against AIDS, and the National Statistics Institute.⁸³ Geotagged data from the 2012 DHS were used to supplement non-geotagged data from the 2016 MICS concerning indicators on household access to electricity.

After data collection, post-hoc sampling weights were created to account for any oversampling and to ensure survey representativeness. The weights and resulting population proportions were triangulated with data from independent, third-party sources, such as the United Nations Population Division and the World Bank's World Development Indicators.

Because publicly available data on energy transmission networks are often low resolution, the Medium-Voltage Distribution predictive model prepared by Dimitry Gershenson, Brandon Rohrer, and Anna Lerner at Facebook was leveraged. Creation of this model involved collaboration with the Energy Sector Management Assistance Program at the World Bank, KTH Royal Institute of Technology in Stockholm, World Resources Institute, and the University of Massachusetts at Amherst. The resulting product "generates grid paths within one kilometer of known grid locations approximately 70 percent of the time based only on publicly available data."⁸⁴

SPATIAL PREDICTION

To create spatial layers of off-grid households, machine learning was used to combine survey coverage data at the cluster level with satellite imagery to identify spatial relationships and predict patterns at a hyper-local scale. Power Africa relied on a survey question that asked "Does your household have electricity? (referring to materials and equipment that work)."

Eight of the 40-plus spatial covariates (satellite images) for this process were used. These covariates are selected because of their availability across time and space and their high predictive power. A combination of raw and modeled satellite data layers are provided by respected organizations including LandScan, the U.S. Geological Survey, the European Space Agency, the Socioeconomic and Applications Center, and the Center for International Earth Science Information Network.

⁸¹ USAID Demographic and Health Surveys Program, "Available Datasets: Cote d'Ivoire."

⁸² Central Statistical Agency of Ethiopia, "Ethiopia Socioeconomic Survey, Wave 3 (ESS3) 2015-2016."

⁸³ National Institute of Statistics (INS) and ICF International, "Demographic and Health Survey and Multiple Indicators 2011-2012."

⁸⁴ EnergyData.Info, "Off-Grid Market Opportunities."

European Space Agency, the Socioeconomic and Applications Center, and the Center for International Earth Science Information Network.

Although the particular process for creating spatial layers is proprietary, related approaches are detailed in the academic literature, including:

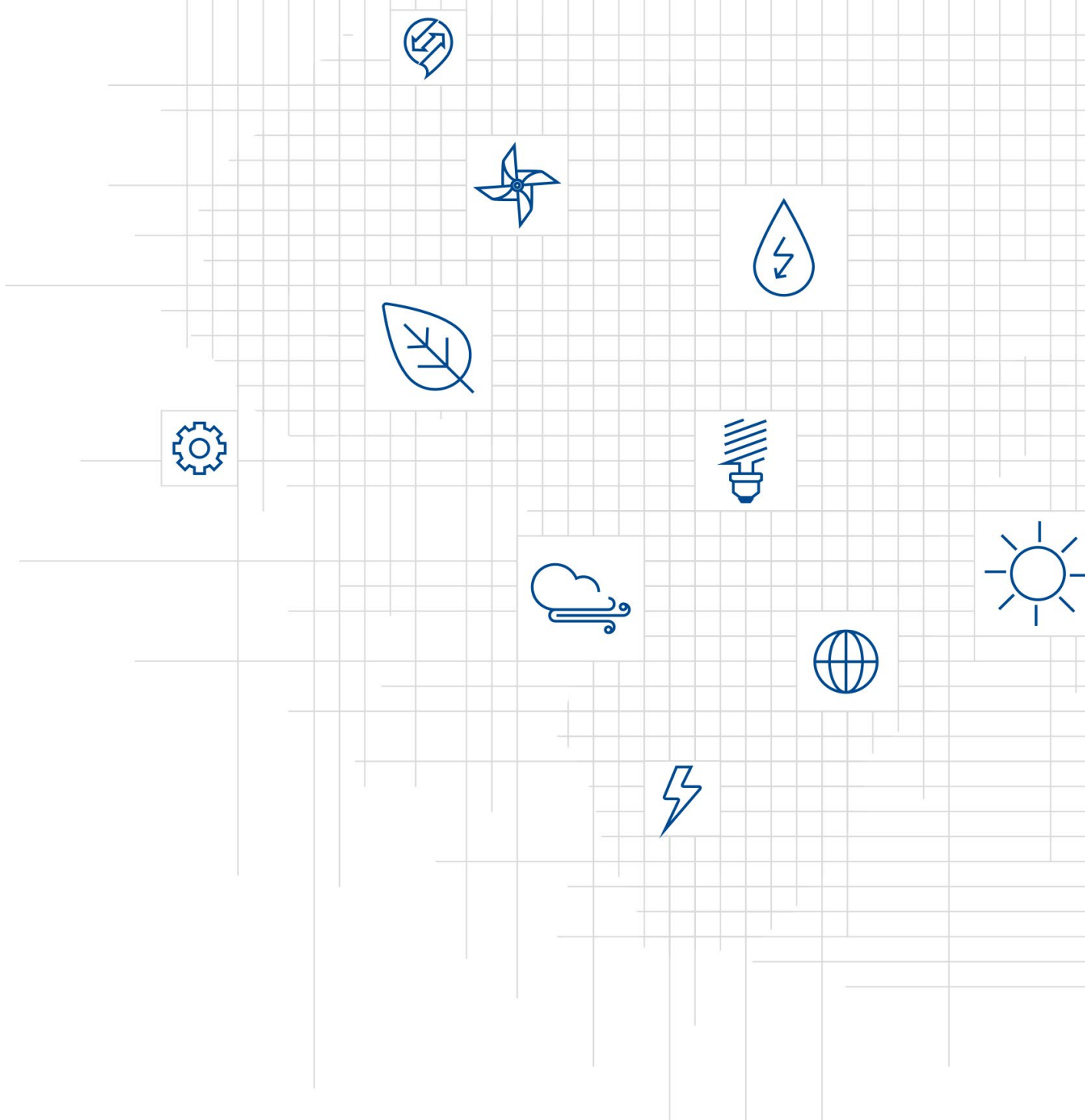
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- › Engstrom, Ryan, Jonathan Samuel Hersh, and David Locke Newhouse. 2017. Poverty from Space: Using High-Resolution Satellite Imagery for Estimating Economic Well-Being. World Bank Policy Research Working Paper No. WPS 8284. Washington, DC: World Bank. <http://documents.worldbank.org/curated/en/610771513691888412/Poverty-from-space-using-high-resolution-satellite-imagery-for-estimating-economic-well-being>

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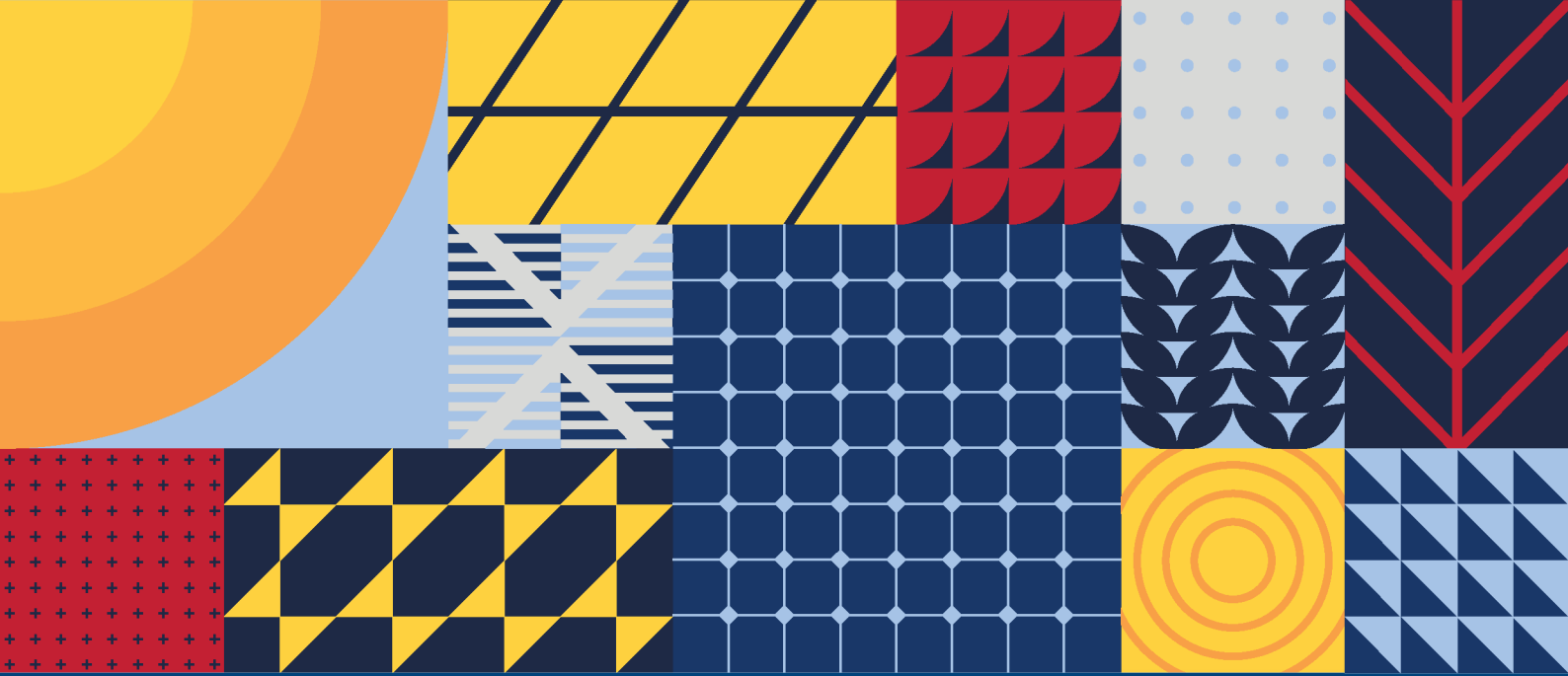
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Power Africa aims to achieve 30,000 megawatts of new generated power, create 60 million new connections, and reach 300 million Africans by 2030.