WORLD BANK GROUP

ECREEE

TOWARDS SUSTAINABLE ENERGY

REGIONAL OFF-GRID ELECTRIFICATION PROJECT

Off-Grid Solar Market Assessment & Private Sector Support Facility Design

BENIN REPORT

JULY 2019

GreenMax Capital Advisors

Energio Verda
Renewable Energy for Development

ASD

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ABBREVIATIONS & ACRONYMS

ABERME	Agence Béninoise d'Electrification Rurale et de Maitrise d'Energie (Beninese Agency of Rural Electricity and Energy Management)
AFD	Agence Française de Développement (French Development Agency)
AfDB	African Development Bank
ARE	Autorité de Régulation de l'Électricité (Electricity Regulatory Authority)
ASD	African Solar Designs
BCEAO	Banque Centrale des États de l'Afrique de l'Ouest (Central Bank of West African States)
BIC	Bureaux d'Information sur le Crédit (Credit Information Bureaus)
BOAD	Banque Ouest Africaine de Développement (West African Development Bank)
BPC	Benin Power Compact
C&I	Commercial and Industrial
CAPEX	Capital Expenditure
CAR	Capital Adequacy Ratio
CEB	Communauté Electrique du Bénin (Electricity Company of Benin)
CEMAC	Communauté Economique et Monétaire de l'Afrique Centrale (Economic and Monetary Community of Central Africa)
CFA	Communauté Financière Africaine (African Financial Community)
COD	Cash-on-Delivery
DFI	Development Finance Institution
DGE	Direction Générale de l'Énergie (General Directorate of Energy)
EBID	ECOWAS Bank for Investment and Development
ECA	Export Credit Agency
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
ECOWREX	ECOWAS Observatory for Renewable Energy and Energy Efficiency
ECREEE	ECOWAS Center for Renewable Energy and Energy Efficiency
EHR	L'Électrification Hors-Réseau (Off-Grid Electrification Framework)
EIB	European Investment Bank
ENDEV	Energizing Development Program
ERF	Fonds d'Électrification Rurale (Rural Electrification Fund)
ESMAP	Energy Sector Management Assistance Program
EU	European Union
EUR	Euro
EVA	Energio Verda Africa
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FECECAM	Fédération des Caisses d'Épargne et de Crédit Agricole Mutuel (Federation of Savings and Rural Loan Cooperatives)
FEI	Facility for Energy Inclusion
FGD	Focus Group Discussion
FI	Financial Institution
FX	Foreign Exchange
GDP	Gross Domestic Product
GIIN	Global Impact Investing Network
GIS	Geographic Information System
GNI	Gross National Income
GoB	Government of Benin
GOGLA	Global Off-Grid Lighting Association
GSMA	Groupe Spéciale Mobile Association (Global System for Mobile Communications)

HC	Health Center
HDI	Human Development Index
HH	Household
ICT	Information and Communication Technology
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IMF	International Monetary Fund
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
JVE	Jeunes Volontaires pour l'Environnement (Young Volunteers for the Environment)
kW	Kilowatt
kWh	Kilowatt-hour
LTO	Lease-to-Own
MCC	Millennium Challenge Corporation
MFI	Microfinance Institution
MTF	Multi-Tier Energy Access Framework
MW	Megawatt
NDC	Nationally Determined Contribution
NDP	National Development Plan
NGO	Non-Governmental Organization
NPL	Non-Performing Loan
O&M	Operation and Maintenance
OCEF	Off-Grid Clean Energy Facility
OGS	Off-Grid Solar
OHADA	L'Organisation pour l'Harmonisation en Afrique du Droit des Affaires (Organization for the Harmonization of Business Law in Africa)
PANER	Plan d'Action National pour les Énergies Renouvelables (National Renewable Energy Action Plan)
PARMEC	Programme d'Appui à la Réglementation des Mutuelles d'Epargne et de Credit (Regulatory Program for Mutual Support)
PAYG	Pay-As-You-Go
PPA	Power Purchase Agreement
PPP	Public-Private-Partnership
PUE	Productive Use of Energy
PV	Photovoltaic
RE	Renewable Energy
REB	Bureau d'Électrification Rurale (Concessions for Rural Electrification)
REF	Rural Electrification Fund
RISE	Regulatory Indicators for Sustainable Energy
ROA	Return on Assets
ROE	Return on Equity
ROGEP	Regional Off-Grid Electrification Project
SBEE	Société Beninoise d'Electricité et d'Eau (Beninese Electric Power Company)
SEFA	Sustainable Energy Fund for Africa
SEforALL	Sustainable Energy for All
SELF	Solar Electric Light Fund
SHS	Solar Home System
SME	Small and Medium Enterprise
SPV	Special Purpose Vehicle

SSA	Sub-Saharan Africa
SUNREF	Sustainable Use of Natural Resources and Energy Finance
TA	Technical Assistance
UEMOA/WAEMU	Union Économique et Monétaire Ouest Africaine / West African Economic and Monetary Union
UN	United Nations
UNDP	United Nations Development Programme
USD	United States Dollar
VAT	Value Added Tax
WAPP	West African Power Pool
WB	World Bank
Wh	Watt-hour
Wp	Watt peak

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KEY DEFINITIONS

ELECTRICITY ACCESS

For the purpose of this analysis, figures on national, urban and rural electrification rates are from the International Energy Agency (IEA) Energy Access Outlook Report, 2017.[1] Although local government authorities (energy ministries, rural electrification agencies, utilities etc.) may have different or more up-to-date electrification data, one single, uniformly-accepted source was necessary as a baseline to assess electricity access figures across all 19 of the countries analyzed under this regional market assessment.

There is no single internationally-accepted and internationally-adopted definition of modern energy access. The IEA defines energy access as "a household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average."[2] A "basic bundle of energy services" means, at a minimum, several lightbulbs, task lighting (such as a flashlight or lantern), phone charging and a radio. This definition of energy access serves as a benchmark to measure progress towards UN Sustainable Development Goal 7.[3] The IEA electricity access statistics presented in this report include household connections, either from a grid connection or from a renewable energy-based off-grid source; the approach excludes illegal connections. The data is sourced wherever possible from governments, supplemented by data from multilateral development banks, various international organizations and other publicly available statistics.

The Multi-Tier Energy Access Framework (MTF) is also used as a key reference throughout this report. Rather than measuring electricity access as a household connection to an electricity grid, the MTF views electricity access along a continuum of service levels (tiers) and according to a series of indicators, including capacity, availability/duration of supply, reliability, quality, affordability, legality and health/safety.[4]

OFF-GRID / STAND-ALONE SOLAR

The term "off-grid" as it is widely used throughout this report (e.g. "off-grid sector") refers to both mini-grids and stand-alone systems. When "off-grid solar" or its acronym "OGS" are used, this refers *only* to stand-alone solar systems and does not include mini-grids. The main focus of this market assessment is the stand-alone solar sector. While micro/mini-grids typically provide a small community with electricity, stand-alone solar systems are not connected to an electricity distribution system and typically include a battery, but may also be used in conjunction with a diesel generator, wind turbine etc. Stand-alone solar technology broadly includes the following:

- Pico solar/solar lanterns[5]
- Single module solar systems (DC)[6]
- Multiple module solar systems (AC)[7]
- Large solar systems (AC)[8]

In addition to providing electricity access, stand-alone solar products/systems also support a wide range of productive applications (e.g. solar water pumping, agricultural processing, milling equipment, refrigeration etc.).

[1] https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
[2] https://www.iea.org/energyaccess/methodology/
[3] https://sustainabledevelopment.un.org/sdg7
[4] "Multi-Tier Framework for Measuring Energy Access," World Bank ESMAP: https://www.esmap.org/node/55526
[5] Typically less than 10 Wp; all-in-one lighting and/or phone charging; enables partial or full Tier 1 electricity access
[6] Typically 11-100 Wp; capable of powering a few appliances (lights, mobile phone charging, TV, radio, fan etc.); often referred to as a "plug-and-play" solar home system when components are sold as a set; enables full Tier 1 or higher electricity access
[7] Typically 101-500 Wp; capable of powering multiple appliances; requires small inverter
[8] Typically greater than 500 Wp; most often used to power a large home; requires large inverter

Multi-tier Matrix for Measuring Access to Household Electricity Supply

			TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
ATTRIBUTES	1. Peak Capacity	Power capacity ratings[28] (in W or daily Wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
				Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
		OR Services		Lighting of 1,000 lmhr/ day	Electrical lighting, air circulation, television, and phone charging are possible			
	2. Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2 hrs
	4. Quality						Voltage problems do not affect the use of desired appliances	
	5. Afford-ability					Cost of a standard consumption package of 365 kWh/year < 5% of household income		
	6. Legality						Bill is paid to the utility, pre-paid card seller, or authorized representative	
	7. Health & Safety						Absence of past accidents and perception of high risk in the future	

Source: World Bank Energy Sector Management Assistance Program (ESMAP)

WEST AFRICA AND THE SAHEL

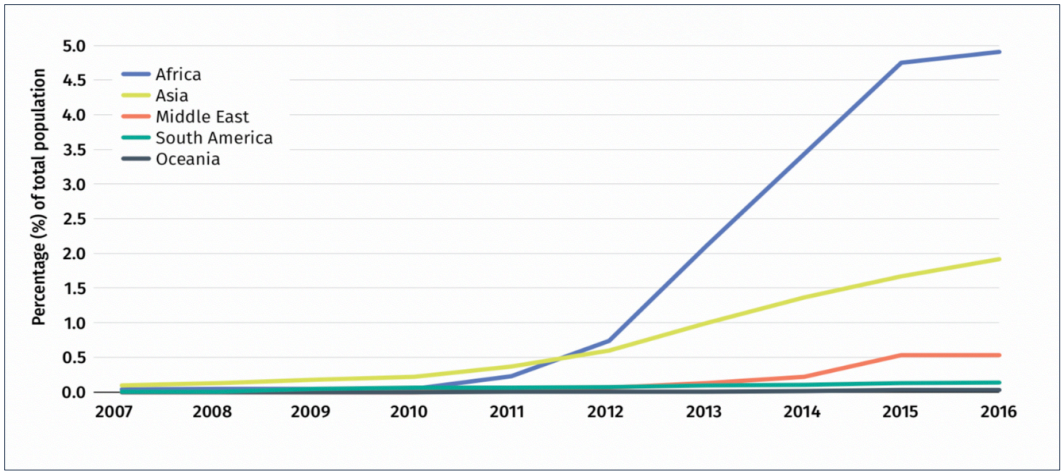
The term "West Africa and the Sahel" as it is used to throughout this report refers to the 19 countries covered by the first phase of the Regional Off-Grid Electrification Project (ROGEP). The countries include the 15 member states of the Economic Community of West African States (ECOWAS) – Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Sierra Leone, Senegal and Togo – plus Cameroon, Central African Republic, Chad and Mauritania.

EXECUTIVE SUMMARY

I. INTRODUCTION

Access to electricity in Sub-Saharan Africa has improved significantly over the past decade. The number of people without access to electricity in the region stopped increasing for the first time in 2013 and has since declined.[9] Although grid connections continue to be the primary method of electrification, access to electricity through off-grid renewable energy systems has grown considerably. The use of off-grid solar (OGS) power is notably on the rise, with African countries accounting for most of the sector's growth over the last decade (**Figure ES-1**). The pace of solar electrification has accelerated more rapidly in Sub-Saharan Africa than anywhere in the world.[10] In order to achieve universal electrification by 2030, the International Energy Agency (IEA) estimates that Sub-Saharan Africa will need more than half of new electricity access connections between 2017 and 2030 to be made through decentralized systems (mini-grids and stand-alone systems), with solar technologies representing nearly 60% of these connections.[11]

Figure ES-1: Off-Grid Solar Access Rate by Region



Tier 1 access and above

Source: International Renewable Energy Agency

Despite this progress, government efforts to increase electricity access in Africa have struggled to keep pace with rapid population growth and increasing demand. Many countries across the region must navigate the interrelated challenges of energy poverty, energy security and climate change (among other sociopolitical, economic and development challenges), which collectively slow the adoption of renewable energy and the pace of off-grid market growth. Rates of energy access remain particularly low in rural areas, where the electrification rate is less than 25% across Sub-Saharan Africa.[12] In part, this is due to the gap between the power sector's infrastructure needs and the availability of necessary resources to expand grid electrification. Extending the grid to rural areas can be challenging due to significant transmission distances and low population densities.

[9] "Energy Access Outlook, 2017: From Poverty to Prosperity," International Energy Agency, (2017): https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
[10] "Tracking SDG7 – The Energy Access Report 2018," The World Bank, IEA, IRENA, UN Statistics Division and the WHO, (2018): https://openknowledge.worldbank.org/handle/10986/29812
[11] Tracking SDG7 – The Energy Access Report, 2018.
[12] IEA Energy Access Outlook, 2017.

As of 2016, over 200 million people in West Africa and the Sahel – more than half of the region's population – lacked access to electricity. This figure represents nearly one-third of Africa's total unelectrified population. Rates of urban and rural electrification vary widely across the region, with the average rate of access nearly three times higher in urban areas.[13]

Despite these access deficits, the region is generously endowed with renewable energy resources – including hydropower, solar, wind and bioenergy. These resources are largely untapped, however, as investments in the power sector remain high-risk due to market instability, as well as a variety of political and regulatory risks. Other energy sector challenges include *inter alia* limited institutional capacity, poor utility financial performance, a shortage of local technical expertise and a lack of support from local financial institutions (FIs).

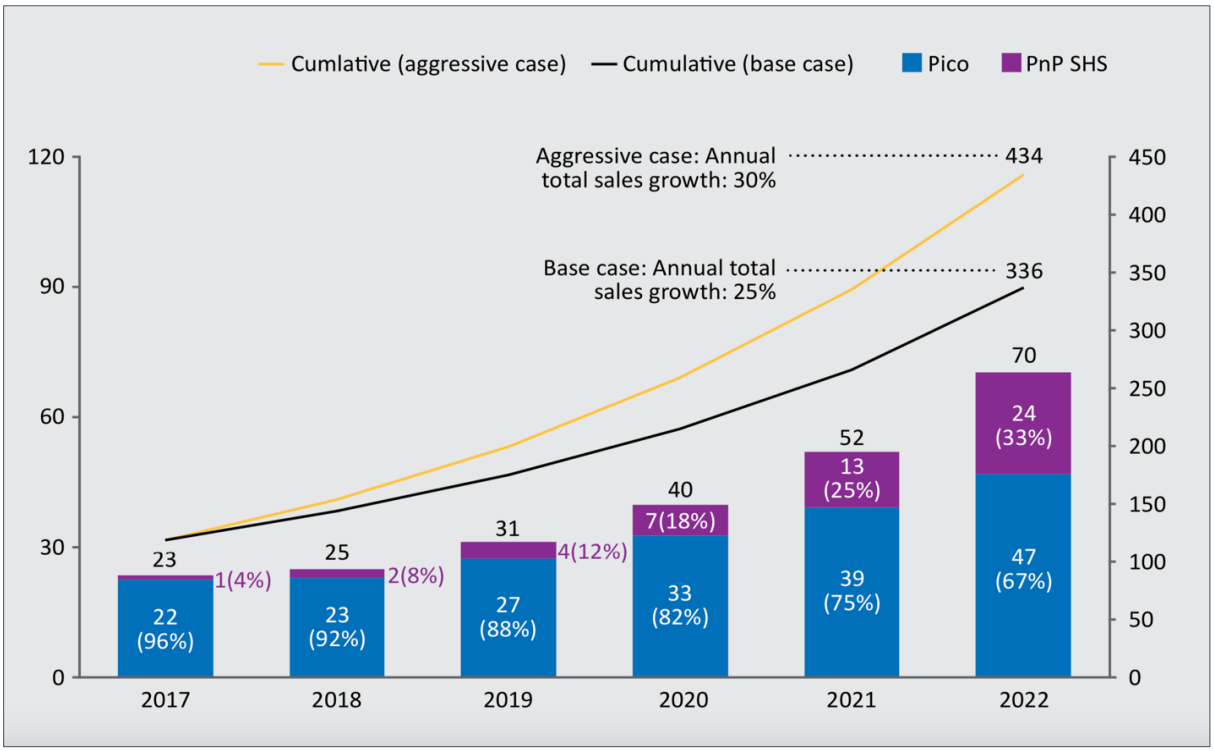
Until recently, diesel generators largely served as the expensive alternative both for rural electrification and for urban and peri-urban "bad grid" areas, where electricity was unreliable or only available for part of the day. However, the advent of decentralized renewable energy technologies, particularly stand-alone solar and mini-grid systems, offers opportunities to deliver clean and cost-effective off-grid solutions. Accordingly, policymakers are increasingly utilizing these options in electrification planning as they offer a reliable, flexible and relatively affordable complement to grid extension initiatives.

Solar energy is the most promising technology in the off-grid space, with three key trends converging to drive the industry's growth: first, continued reductions in hardware and balance of system costs (solar modules, batteries, inverters, appliances etc.); second, a digital revolution, with mobile communication technology facilitating payments and monitoring; and third, innovation in private sector business models, such as pay-as-you go (PAYG) and third-party ownership of solar home systems (SHS), which offer energy as a service and remove previously prohibitive up-front costs for households.[14] As a result of these developments, the off-grid solar market is rapidly evolving and expanding.

In 2016, the OGS market reported global revenues of approximately USD 1 billion. This figure is expected to increase to USD 8 billion by 2022, with SHS representing the majority of this revenue growth and an increasing share of unit sales **(Figure ES-2)**. Investments in the off-grid solar sector doubled annually between 2012 and 2016, increasing by 98% over this period. Between 2013 and 2017, East Africa represented 86% of the global PAYG market in terms of cumulative unit sales, followed by West Africa at 12% and Asia at 2%.[15] As the East African market becomes more crowded and solar companies expand their operations into West Africa, the region will account for a larger geographic share of the burgeoning global OGS market. Although the sector's investment trends remain volatile, there is some preliminary evidence to suggest that this transition is already underway: in 2016, West Africa accounted for 34% of total funds raised, up from 9% in 2015, while East Africa's share of funding decreased from 77% to 47% over the same period.[16]

[13] IEA Energy Access Outlook, 2017.
[14] "Derisking Renewable Energy Investment: Off-Grid Electrification," United Nations Development Programme (UNDP) and ETH Zurich, (December 2018): https://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Climate%20Strategies/DREI%20Off-Grid%20Electrification%20-%20Full%20Report%20(20181210).pdf
[15] "Off-Grid Solar Market Trends Report 2018," Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf
[16] Ibid.

Figure ES-2: Global Off-Grid Solar Market Forecast (million units sold)



NOTE: Left axis = annual sales volume; Right axis = cumulative sales volume; PnP SHS = Plug-and-Play Solar Home System

Source: Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP

Many international off-grid solar companies, including most of the industry's leading players – BBOXX, Greenlight Planet, Azuri, d.light, Off-Grid Electric, M-KOPA Solar, Fenix International, and French utilities EDF and Engie among others – have recently entered markets in West Africa, joining international pioneers such as PEG and Lumos, which launched originally in Ghana and Nigeria, respectively, and both expanded into Côte d'Ivoire and Togo.[17] While these large international companies are well capitalized, there is a dearth of financing for smaller, early-stage companies that operate in nascent markets across West Africa and the Sahel. In fact, the top 10 global off-grid solar companies have received nearly 90% of investment capital since 2012, while early-stage companies often struggle to raise the necessary capital to accelerate growth.[18]

In order to scale off-grid electrification, OGS companies will need to access large volumes of commercial debt financing. In the longer term, partnerships with local commercial banks and microfinance institutions (MFIs) will also be necessary in order to develop domestic, local-currency sources of financing and reduce foreign exchange risk.[19] Partnerships with local FIs, whose understanding of the credit risk of local populations, may also reduce financing costs more rapidly compared to other methods (e.g. using debt from securitized receivables).[20] Although most financing currently comes from non-commercial sources (i.e. the

[17] Bavier, J., "Off-grid power pioneers pour into West Africa," Reuters, (February 20, 2018): https://www.reuters.com/article/us-africa-power-insight/off-grid-power-pioneers-pour-into-west-africa-idUSKCN1G41PE

[18] "Accelerating Energy Access: The Role of Patient Capital," Acumen, (2018): https://acumen.org/wp-content/uploads/Accelerating-Access-Role-of-Patient-Capital-Report.pdf

[19] UNDP and ETH Zurich, 2018.

[20] "How can Pay-As-You-Go Solar Be Financed?" Bloomberg New Energy Finance, (7 October 2016): https://www.bbhub.io/bnef/sites/4/2016/10/BNEF_WP_2016_10_07-Pay-as-you-go-solar.pdf

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.[21]

In order to mitigate risks and spur investment, the OGS 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, streamlined licensing and permitting procedures, and quality standards for equipment. Additional measures include public awareness raising, encouraging inclusive gender participation, and building local capacity at all levels (e.g. solar PV vocational training and technical certification programs, training for FIs to address unfamiliarity of lenders with off-grid solar sector, corporate and consumer financing needs etc.).

In addition, solar companies increasingly rely on mobile money platforms to scale their business, as mobile payments allow them to offer low-income customers new ways to access and pay for electricity through innovative business models such as PAYG. Mobile money services, however, are only just beginning to be deployed in West Africa and the Sahel. Solar companies are therefore limited by low levels of penetration and in some cases by country-specific regulatory restrictions.[22] Governments can take action to foster linkages between the off-grid solar, telecommunications and mobile money sectors to expedite the uptake of market-transforming technology platforms and business models.

Governments across West Africa and the Sahel have implemented a range of policies and approaches to support off-grid market development, including private concessions, Public Private Partnerships (PPPs), Rural Electrification Agencies (REAs) and Rural Electrification Funds (REFs), among other measures. Some countries like Senegal and Mali have adopted private concessions to scale up mini-grids in rural areas, while others, such as Nigeria and Ghana, have improved rural electrification largely through public investment.

To support these initiatives, the Economic Community of West African States (ECOWAS) adopted the ECOWAS Renewable Energy Policy (EREP) in 2013, which intends to achieve universal electricity access in the region by 2030. The EREP also aims to increase the share of the region's rural population served by decentralized renewable energy services (mini-grids and stand-alone systems) to 25% by 2030. The ECOWAS Center for Renewable Energy and Energy Efficiency (ECREEE) is working with member states to develop and implement national policies and strategies with electrification targets through 2030 in line with the EREP, including Sustainable Energy for All (SEforALL) Action Agendas and National Renewable Energy Action Plans (NREAP), among other programs in support of renewable energy and off-grid market development.[23]

[21] UNDP and ETH Zurich, 2018.
[22] "Scaling Access to Energy in Africa: 20 Million Off-Grid Connections by 2030," Scaling Off-Grid Energy: A Grand Challenge for Development, USAID, UK DFID, Shell Foundation, (2018): https://static.globalinnovationexchange.org/s3fs-public/asset/document/SOGE%20YIR_FINAL.pdf?uwUDTyB3ghxOrV2gqvsO_r0L5OhWPZZb
[23] ECOWAS Renewable Energy Policy, 2013: http://www.ecreee.org/sites/default/files/documents/ecowas_renewable_energy_policy.pdf

II. BACKGROUND AND CONTEXT OF THE ASSIGNMENT

In this context, with funding from the World Bank, ECREEE launched the Regional Off-Grid Electrification Project (ROGEP) in 19 countries in West Africa and the Sahel. The project aims to enhance shared capacity, institutions and knowledge in order to increase electricity access of households, businesses and public institutions using modern stand-alone solar systems through a harmonized regional approach. ROGEP has two main components/objectives:

- ✓ **Component 1: Accelerate development of a regional off-grid solar market:**

  (1A) Foster regional collaboration and promote a supportive enabling environment for the OGS sector;
  (1B) Provide entrepreneurship technical support to OGS companies at various stages of development (training to accelerate business growth and/or facilitate market entry);
  (1C) Provide entrepreneurship financial support to OGS companies at various stages of development (matching grants);
  (1D) Provide financing to remove barriers in challenging markets (market entry grants and performance grants to OGS companies operating in challenging markets)

- ✓ **Component 2: Facilitate access to financing for off-grid solar businesses:**

  (2A) Provide line of credit for OGS businesses via the West African Development Bank (Banque Ouest Africaine de Développement, BOAD) to be extended to local FIs for on-lending to local entrepreneurs (working capital for companies to finance equipment imports, receivables from PAYG schemes etc.)
  (**2B**) Implement contingent grant facility via BOAD to share risks with local FIs and encourage lending to OGS businesses.

In addition, the project intends to support a range of capacity building activities targeting public and private sector stakeholders to address existing policy, regulatory, institutional, financial, economic, business, technology and capacity related barriers. ECREEE will also assist each country with development and implementation of national programs and initiatives in the areas of renewable energy, rural electrification and energy access in line with the regional focus of the assignment.

Under the first phase of the project, an initial assessment of the off-grid solar market was undertaken in each of the 19 countries. The study focused exclusively on the stand-alone solar PV market and did not assess mini-grids (see **Key Definitions**). The scope of work was broadly divided into the following tasks:

(1) Review the current enabling policy and market environment for the off-grid solar sector
(2) Analyze the market for off-grid solar products and systems, including an estimate of demand from the household, institutional and productive use market segments and analysis of the supply chain;
(3) Assess the willingness and capacity of national and regional financial institutions to provide commercial and/or consumer financing to the off-grid solar sector; and
(4) Propose models to incentivize the private sector and financial institutions to support off-grid solar market development and to harmonize a regional market to achieve universal access.

Available geographic information system (GIS) data for each country supported the Task 1 and Task 2 analyses. A least-cost electrification analysis was undertaken utilizing geospatial mapping to assess the potential development of electricity access and grid coverage in each country through 2023 and 2030. The study estimated the total number of potential settlements, people and households electrified by on-grid, mini-grid or off-grid stand-alone solutions under each timeframe based on a series of indicators, including national electricity grid proximity, population density and nodes of economic growth. The assessment was also performed for health facilities and education centers (although the analysis was limited by the

availability and/or quality of GIS data for these market segments). The results of the analysis were used to estimate the share of the population suitable for off-grid stand-alone solar solutions over the analyzed periods and to assess corresponding potential demand from the household sector under the Task 2 market sizing.

Within the context of this assignment, a gender-focused analysis was also implemented in order to assess the level of female participation in each country's off-grid energy sector. Each stage of the market study therefore analyzed inclusive participation and gender implications. A comprehensive gender profile is presented in **Annex 4**, including a summary of findings, as well as recommendations to improve gender equality and enhance women's engagement in development of the off-grid sector.

To carry out these tasks, the project team utilized a combination of desk research, input from local country experts and feedback from engagement with a wide range of stakeholders at the country and regional levels. Interviews were conducted with policymakers, industry experts, and representatives from solar companies and financial institutions. Focus group discussions were also held in each country with key stakeholders from the four market segments analyzed under Task 2 (household, institutional, productive use and supplier). Focus group participants included representatives from government, the donor community, NGOs, solar companies, business and industry associations, academia, community groups, and women's groups. In addition to the focus group meetings, surveys were administered in order to collect additional Task 2 market data, including (i) a survey of international solar companies to gauge their level of interest in the region; (ii) a survey of local solar companies and retail suppliers in each country to inform the supply chain analysis; and (iii) an assessment of an off-grid village in each country to better understand how solar is being utilized for productive uses. Under Task 3, a survey was administered to local and regional FIs to determine their level of capacity and interest in lending to the off-grid solar sector. A detailed description of the methodology used to carry out these tasks is presented in **Annexes 1-3**.

This report is organized into three sections that correspond to Tasks 1-3 described in the scope of work above (Task 4 was prepared in a separate report). **Section 1** covers the enabling policy and market environment for the OGS sector. This includes an overview of the status of the on-grid and off-grid markets, an analysis of off-grid energy policy and regulation and gaps in the existing framework, and a summary of off-grid development initiatives. The results of the least-cost electrification analysis are also included in this section.

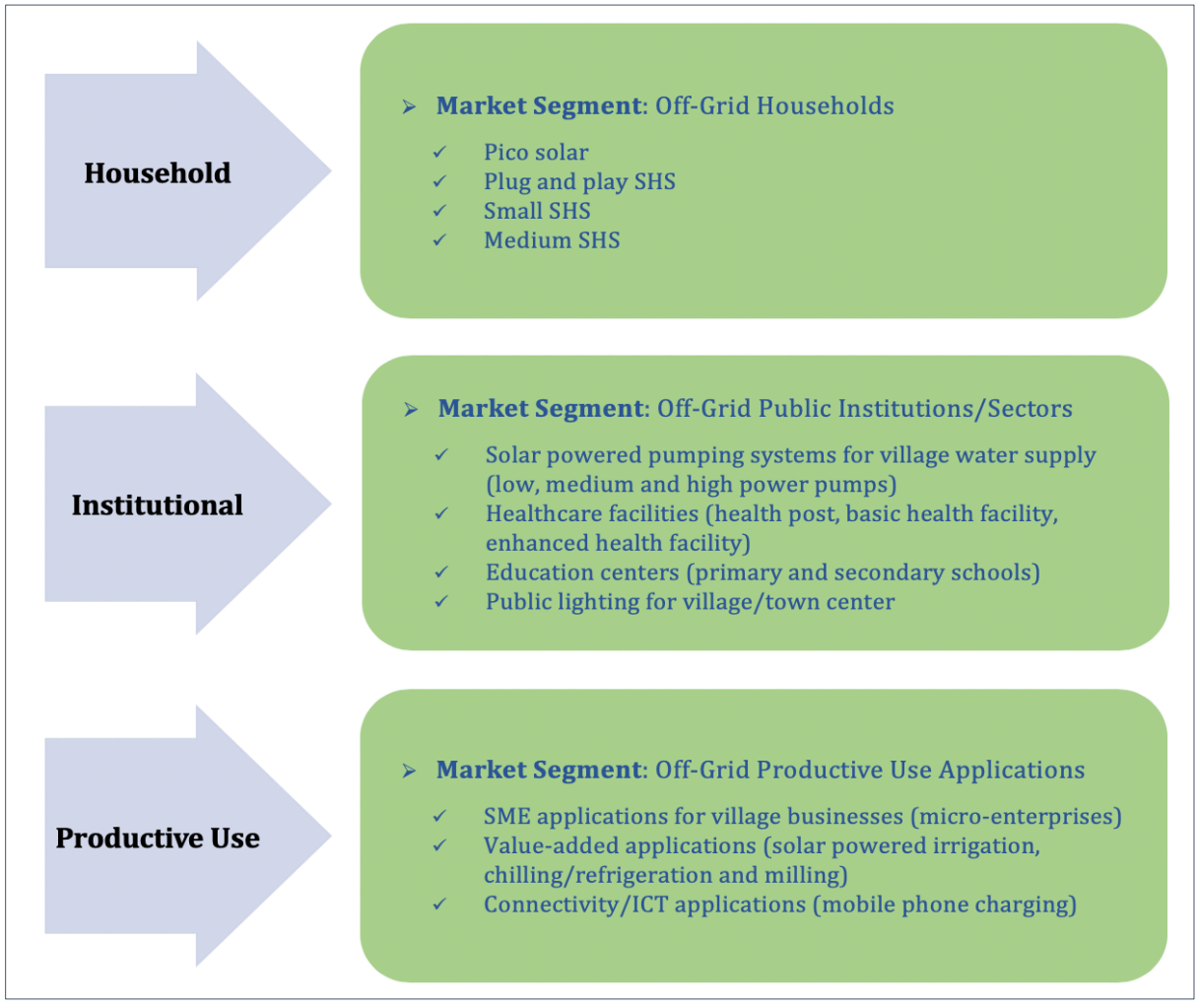
Section 2 estimates the potential market for off-grid solar products and systems by assessing potential demand from the household, institutional and productive use market segments (**Figure ES-3**), followed by an analysis of the supply chain. The household market sizing utilizes results from the least-cost electrification analysis, along with data on household income and energy expenditure, in order to estimate potential demand based on the number of households able to afford various OGS systems. Both the cash and financed market potential were estimated for 2018, 2023 and 2030.

The institutional sector analysis combines available GIS data with secondary research to estimate potential demand based on assumptions about the electricity needs, usage patterns and associated costs of solar electrification of four public/institutional markets – water supply for off-grid communities, healthcare facilities, education centers (primary and secondary schools) and public lighting. Where GIS data was unavailable, per capita comparisons were made using data from similar countries to estimate off-grid solar demand by market segment (see **Annex 2** for country categorization). The productive use of energy (PUE) market sizing estimates potential off-grid solar demand for SME, value-added and connectivity applications. Feedback from stakeholder interviews and focus group discussions informed the analysis and helped characterize each market segment's consumer perceptions, interest, awareness, ability to pay and access to finance.

The Task 2 supply chain analysis presents an overview of key market actors, solar products and services, sales figures and business models, and includes a discussion of the role of informal market players and the impact of uncertified products. The analysis also addresses the capacity needs of the supply chain and describes specific areas of support where technical assistance is needed to accelerate market growth.

Section 3 assesses the willingness and capability of national and regional financial institutions (FIs) to provide commercial and/or consumer financing to the off-grid solar sector in each country. This section includes a summary of financial products for the off-grid sector, a comprehensive overview of each country's financial market and commercial lending environment (including analysis of commercial banks, microfinance institutions and other non-bank financial institutions) and any programs supporting off-grid solar lending. This section also examines the scope of financial inclusion in each country and the impact of digital financial services and mobile money on access to finance. It concludes with the results of surveys that were administered to financial institutions in each country across the region.

Figure ES-3: Analyzed Off-Grid Market Segments



NOTE: SHS = Solar Home System; ICT = Information Communication Technology

III. EXECUTIVE SUMMARY

Benin is a small West African country with a relatively stable and democratic government and promising rates of economic growth. The country's economy is highly dependent on trade with Nigeria, which accounts for approximately 20% of GDP.[24] Cotton is a key export commodity, as the agriculture sector contributes to 25% of GDP and employs nearly half of the labor force.[25] The majority of the population remains outside of the formal economy and faces high rates of poverty, particularly in rural areas.

Access to electricity remains an ongoing challenge. In 2016, approximately two-thirds of the overall population in Benin – an estimated 7.6 million people – lacked access to electricity, with a significant disparity between rates of access in urban (56%) and rural (11%) areas.[26] Even where grid connections exist, power supply is often unreliable, with fewer than one-fifth of firms and one-third of households reporting reliable access to electricity when surveyed.[27] Off-grid electrification is a policy priority for the Government of Benin (GoB), which is committed to achieving universal access by 2030. Currently, the Government's efforts to establish a supportive policy and regulatory framework for the off-grid sector are progressing well, as evidenced by the country's 14-point improvement in its World Bank Regulatory Indicators for Sustainable Energy (RISE) energy access score between 2015 and 2017.[28]

Several off-grid programs are in various stages of implementation by the GoB, with funding and support from development partners. With support from ECREEE, the Government has outlined its commitments and initiatives to develop renewable energy and meet its electrification targets in its SEforALL National Renewable Energy Action Plan (Plan d'Action National pour les Énergies Renouvelables, PANER). The GoB is also developing an off-grid regulatory framework (Électrification Hors-Réseau, EHR) with support from the U.S. Government's Millennium Challenge Corporation (MCC). The EHR calls for legal reforms to the electricity code to prioritize renewable energy consumption over conventional electricity, promotes the integration of mobile money services in the off-grid sector and includes specific measures to incentivize private sector participation and investment in off-grid project development.[29] The MCC is also supporting implementation of the Off-Grid Clean Energy Facility (OCEF), which provides a platform for organizations and companies in Benin to search for potential partners to finance and develop off-grid clean energy projects.[30] The OCEF includes three distinct grant funding windows and corresponding technical assistance to support proven and sustainable off-grid clean energy businesses and projects, with the third funding window dedicated to the stand-alone solar market segment.

This report assesses the market opportunity for off-grid solar products and systems by estimating demand from the household, institutional, and productive use sectors in Benin (**Figure ES-4**). According to the assessment, there is a significant OGS market opportunity, with the annualized cash market potential in 2018 estimated to be USD 66.6M. The productive use sector (USD 41.1M) makes up the majority of estimated demand, followed by the household (USD 24.2M) and institutional (USD 1.3M) sectors.

[24] "Benin Economic Outlook," African Development Bank, (2018): https://www.afdb.org/en/countries/west-africa/benin/
[25] "World Bank Open Data: Benin," World Bank, (2017): https://data.worldbank.org/country/benin
[26] IEA Energy Access Outlook, 2017.
[27] Blimpo, M., and Cosgrove-Davies, M., "Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact," AFD and World Bank, Africa Development Forum, (2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf?sequence=6&isAllowed=y
[28] "Policy Matters: Regulatory Indicators for Sustainable Energy," World Bank ESMAP, (2018): http://documents.worldbank.org/curated/en/553071544206394642/pdf/132782-replacement-PUBLIC-RiseReport-HighRes.pdf
[29] "Regulatory Framework for Off-Network Electrification, Cadre Réglementaire de L'électrification Hors-Réseau (EHR)," Benin Energie & Electrification Hors Reseau, (2018): https://www.benin-energie.org/bilan-energetique.html
[30] "Launch of the Off-Grid Clean Energy Facility in Benin," Energy Access Practitioner Network, (2018): http://energyaccess.org/news/recent-news/launch-of-the-off-grid-clean-energy-facility-in-benin/

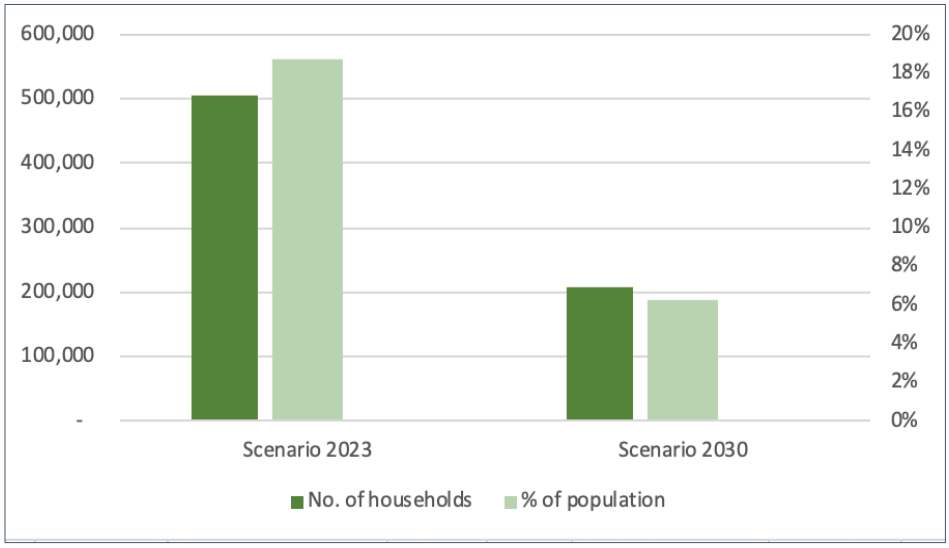
Figure ES-4: Indicative Total Cash Market Potential for Off-Grid Solar Products in Benin, 2018

Source: African Solar Designs analysis

The least-cost electrification analysis found that by 2023, 3,924 settlements across Benin (2,018,362 households) will be connected to the main grid, representing 74.7% of the population. By 2030, this figure will increase to 6,850 settlements (3,055,464 households), equivalent to 93.2% of the population. These estimates are based on the assumption that all planned grid extensions will be completed by 2030.

In the off-grid sector, the analysis identified 3,081 settlements (505,506 households), representing 18.7% of the population in 2023, as suitable for stand-alone systems, decreasing to 970 settlements (207,535 households) and 6.3% of the population in 2030 (**Figure ES-5**). While the total size of the OGS market for households will decrease over time, it will also become more concentrated in the remote northern region of the country, with the largest share of off-grid households located in the districts of Atakora, Alibori and Borgou in 2030. This trend has implications for long-term business models of the solar product market, which will need to consider broader distribution areas as the total number of off-grid households declines and becomes concentrated in areas far from urban centers in the southern part of the country.

Figure ES-5:
Estimated Number of Households and Share of Population Suitable for OGS Systems in Benin, 2023 and 2030

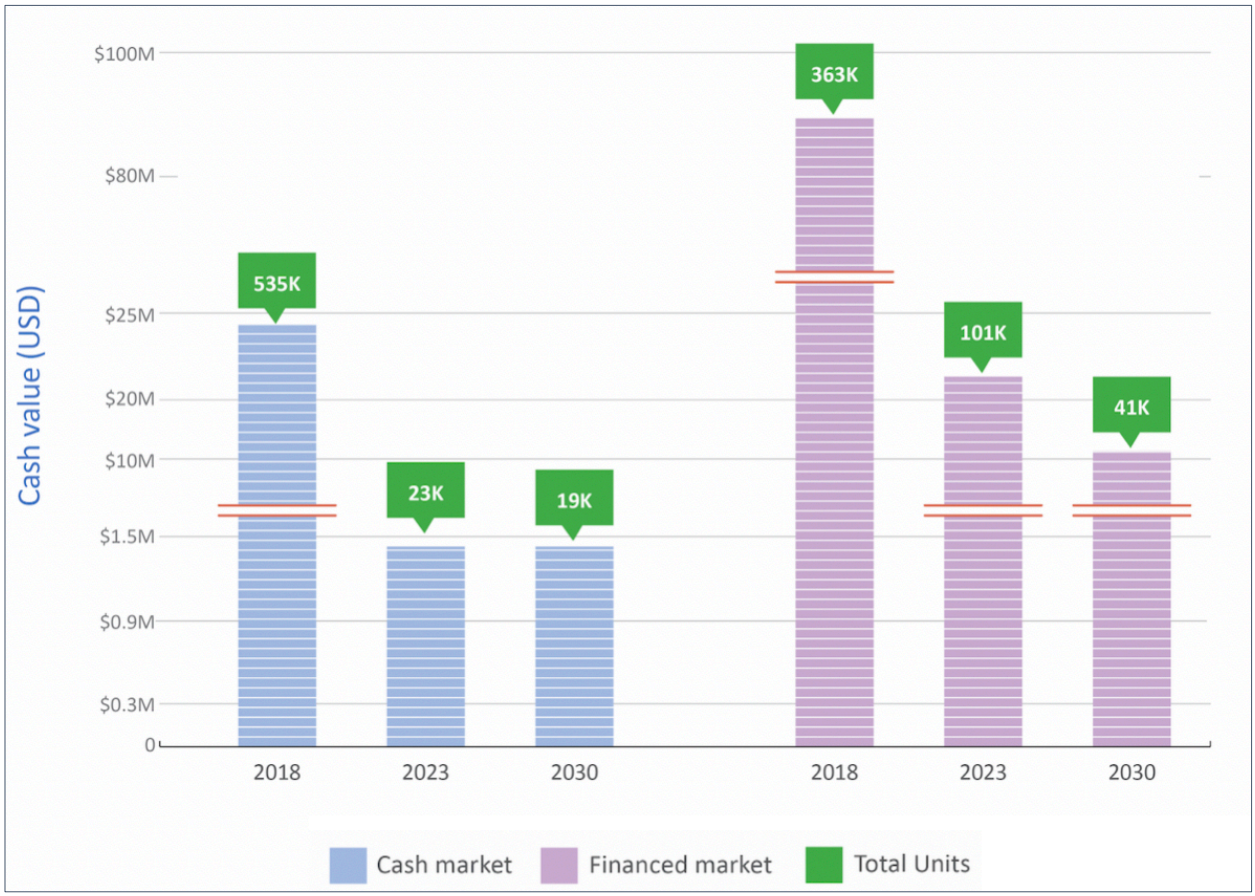


Source: Energio Verda Africa GIS analysis

According to the analysis, the annualized off-grid solar cash market potential for the household sector in 2018 is USD 24.2 million, with the estimated market value more than tripling in size to USD 89.4 million with the addition of consumer financing (**Figure ES-6**). Consumer financing allows the poorest households to enter the market and those already in the market to afford larger systems.

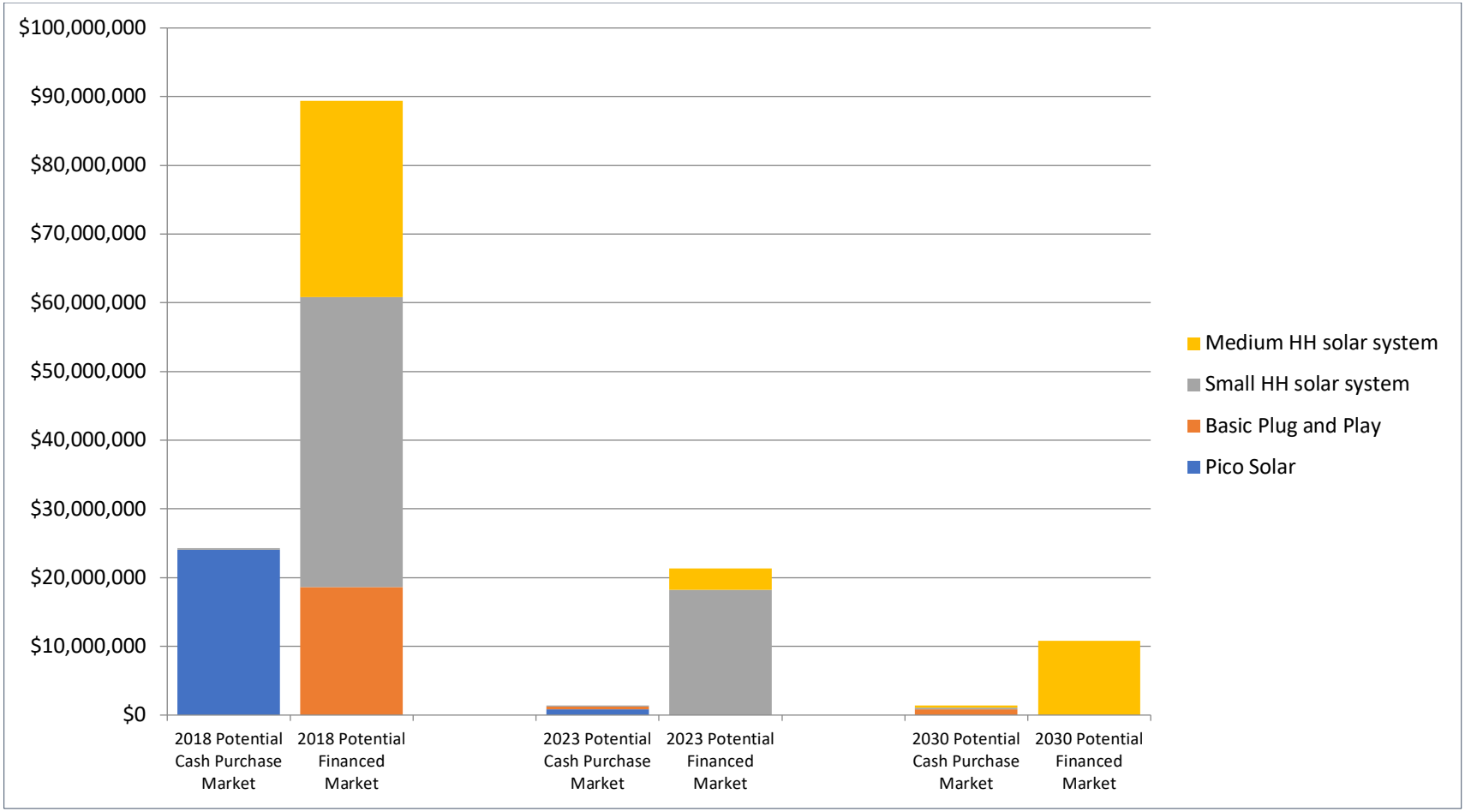
According to the assessment, the most common types of systems the market can afford on a cash basis are pico solar and small plug and play systems; however, this changes significantly with the introduction of financing (**Figure ES-7**). While affordability improves over time, households in the lowest income quintiles cannot afford any off-grid solar products without financing. Consumer financing will therefore prove critical for accelerating off-grid solar market growth and meeting electrification targets through 2030.

Figure ES-6: Estimated Off-Grid Solar Cash and Financed Market Potential for Household Sector



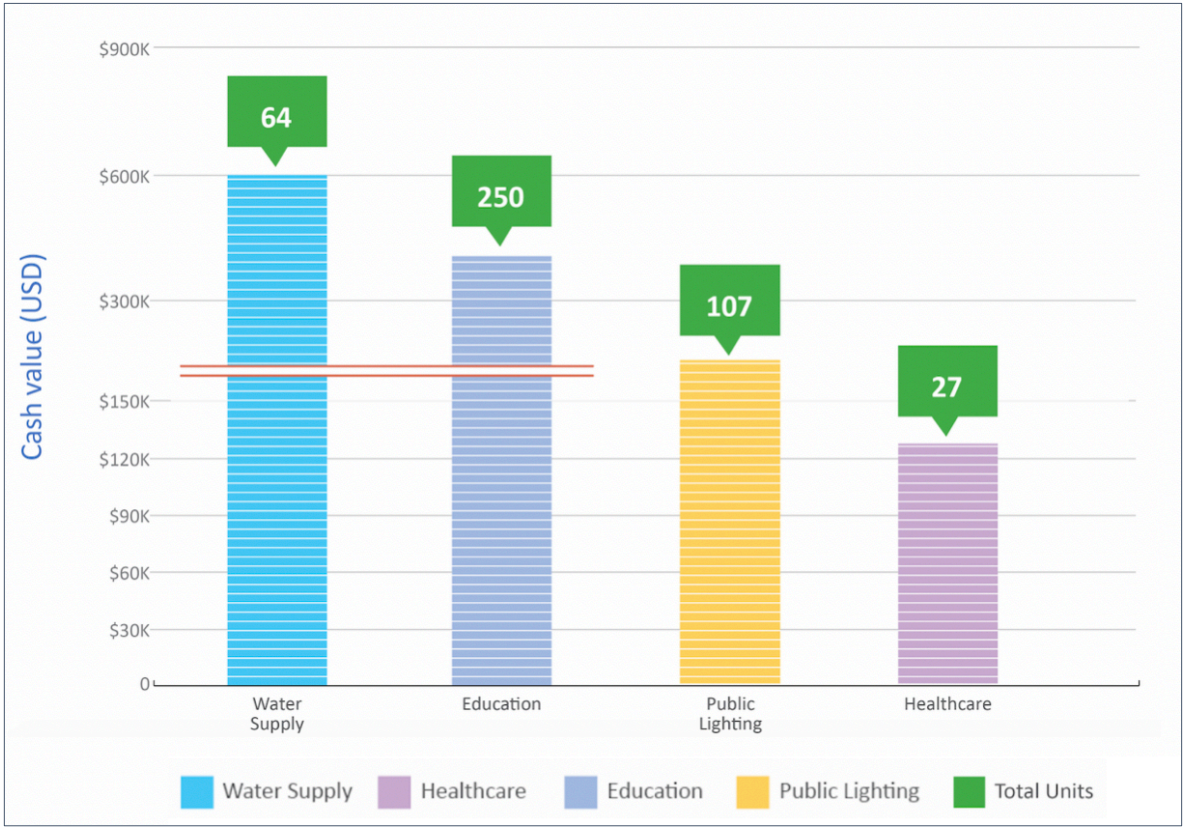
Source: African Solar Designs analysis

Figure ES-7: Estimated Off-Grid Solar Cash and Financed Market Potential for Household Sector by System Type



Source: African Solar Designs analysis

Figure ES-8: Estimated Off-Grid Solar Cash Market Potential for Institutional Sector

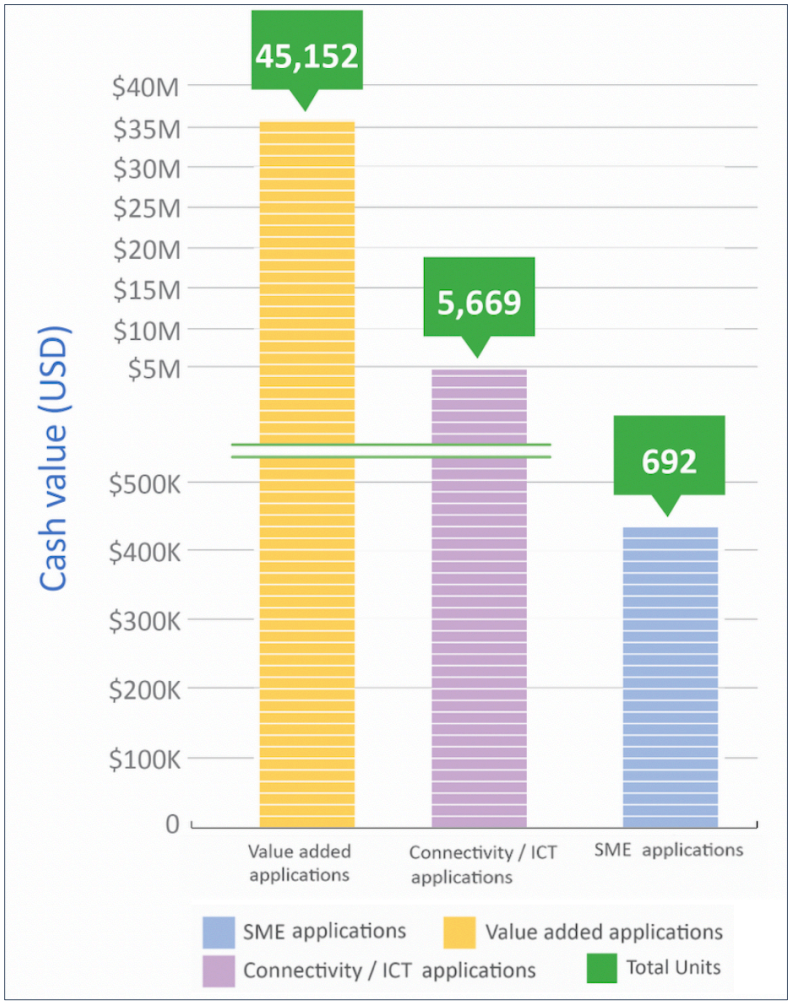


Source: African Solar Designs analysis

The estimated annualized cash market potential for Benin's public/institutional sector in 2018 is USD 1.3 million (**Figure ES-8**). The institutional market segments with the largest potential are water supply (USD 601K), followed by education (USD 404K), public lighting (USD 160K) and healthcare (USD 127K). The water supply sector analysis identified off-grid water points such as boreholes and wells that could benefit from solar technology for water pumping. The healthcare sector analysis identified off-grid health facilities categorized by their size (from basic clinics to enhanced health facilities) that could be electrified by stand-alone systems. The education sector analysis identified primary and secondary schools that could be electrified by stand-alone systems. The public lighting analysis assessed the lighting needs for off-grid villages and market centers (excluding street lighting).

According to the analysis, the annualized off-grid solar cash market potential for the productive use sector in 2018 is USD 41.1 million (**Figure ES-9**). The estimated demand from value-added applications represents most of the PUE market potential (USD 35.7M), followed by applications for connectivity (USD 4.9M) and SMEs (USD 432K).

Figure ES-9: Estimated Off-Grid Solar Cash Market Potential for Productive Use Sector



Source: African Solar Designs analysis

The value-added applications that were analyzed include solar pumping for agricultural irrigation, solar powered milling and solar powered refrigeration. The assessment utilized a series of inputs, including data from the UN's Food and Agriculture Organization on national agricultural production, as well as applicable solar technologies to support income generation for small shareholder farmers (i.e. solar pumps, mills, and refrigeration systems). Access to energy for agriculture is critical for the country's economic development, particularly given the sector's importance to GDP.

Off-grid solar power supports a wide range of connectivity applications, including mobile phone charging, wi-fi servers, banks, mobile money kiosks, and telecommunications towers. Mobile phone and internet connectivity are also necessary pre-cursors to mobile money and PAYG solutions in the off-grid solar sector. The market sizing examined mobile phone network coverage as well as rates of mobile phone

ownership and mobile internet penetration to estimate the market potential for mobile phone charging enterprises (stations/kiosks).

The calculation of the estimated off-grid solar market for SMEs focused only on barbering and tailoring appliances, which comprises a small portion of overall SME sector demand. These two microenterprises are indicative of the service-based SME off-grid solar market, as they benefit significantly from extended working hours and the use of modern appliances/machinery. The estimated demand for this market segment is therefore intended to provide a baseline for future research, as a more robust analysis would be necessary to assess realistic demand from all SMEs.

It should be noted that the Task 2 market sizing assesses the total *potential* demand for off-grid solar, as well as variables that affect demand, such as changes in population density, household income, expansion of national grids and access to finance, among other factors. This data will support policymakers and practitioners as they assess market potential over time. However, the quantitative demand estimate has not been revised to reflect *realistic* market potential. Many other factors and market failures will prevent the full realization of this total market potential, and these will vary by market segment.

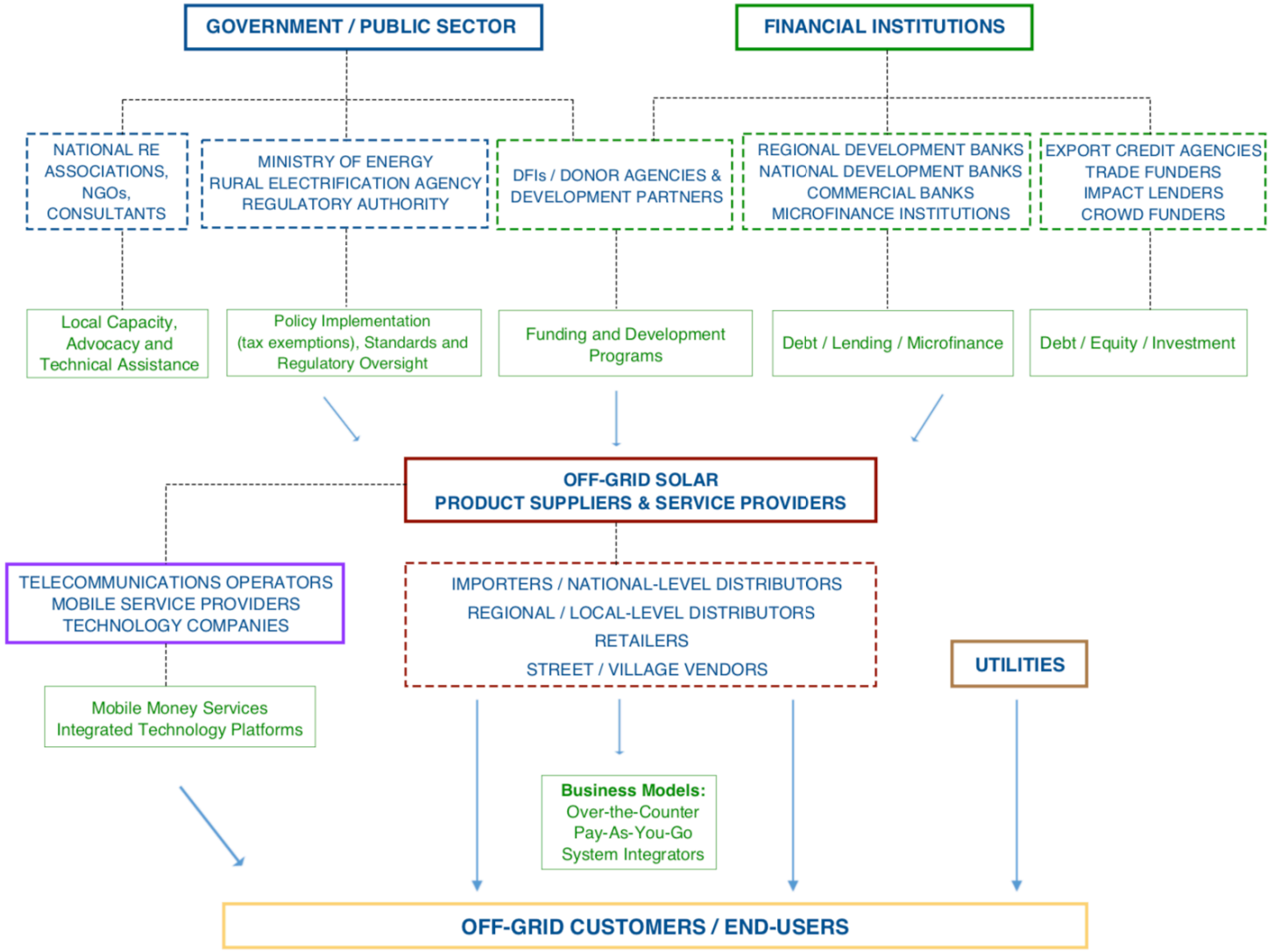
For household demand, the off-grid solar market is already tangible. Still, many factors will affect household demand for solar products, such as distribution realties, consumer education, competing economic priorities for households, financial shocks, etc. The institutional market will be affected largely by government and donor budget allocations along with the potential for community-based finance. The productive use market is perhaps the least concrete. Considered a relatively new market segment for the off-grid solar industry, productive use market dynamics are not yet well understood. The ability to realize potential productive use market demand will also be affected by many of the factors that commonly determine enterprise prospects in the country, including infrastructure, rural distribution, marketing, access to finance, insecurity, regulation, etc. The data presented in this report is intended to provide a baseline for future research.

Following the estimates of market demand, this report analyzes the supply chain for off-grid solar products and services in Benin, which includes a wide range of stakeholders, including importers, distributors, wholesalers, retailers and end-users (**Figure ES-10**). The country has a small but quickly growing solar supply chain, which is made up of both formal and informal companies that offer a variety of solar products and systems and deploy several business models. Rural households make up the main market for OGS products in the country, as the demand for lighting products and household electrical appliances is growing. Nevertheless, urban households, both electrified and non-electrified, are also a key consumer market, as they may have greater ability to afford solar products and systems.

The off-grid solar supply chain faces several barriers, including competition from the informal market. The widespread sale of low-quality, uncertified products undermines consumer confidence in solar equipment, undercuts the prices of sellers of quality-verified products and hinders overall OGS market growth. There are also a number of interrelated challenges and capacity building needs of the supply chain, including financial, capacity, awareness and regulatory challenges.

Benin's nascent solar market is poised to grow if requisite technical assistance is provided to the supply chain. To operate effectively, companies need a significant amount of both local and international technical and financial expertise, as well as an ability to make practical decisions about their operations. Companies face a number of technical competency requirements, including the selection of approaches and solar PV technologies, the design of their associated marketing instruments and the implementation of related initiatives.

Figure ES-10: Off-Grid Solar Market and Supply Chain Overview



Source: GreenMax Capital Advisors

Local industry and supply-chain stakeholders who participated in the Task 2 focus group discussions and surveys identified the following key barriers to and drivers of OGS market growth in Benin:

Key Barriers to Off-Grid Solar Market Growth
• Low consumer purchasing power and lack of consumer financing options
• Low levels of consumer awareness of solar solutions, particularly in rural areas
• Lack of financing for solar companies
• Informal sector competition and market spoilage
• Lack of local capacity/qualified technicians to maintain systems
• High transaction costs associated with equipment inventory, distribution, importation, taxation etc.
• Insufficient or fragmented market data on consumer electricity needs, usage or experience
Key Drivers of Off-Grid Solar Market Growth
• Strong off-grid electricity demand
• Government policy and action is supportive of the industry, which helps attract substantial/sustained investment to the market
• Growing penetration of mobile money services allows OGS companies to increasingly utilize integrated technology platforms and innovative business models to offer PAYG consumer financing solutions to the market
• Extensive private sector engagement in development of the off-grid sector, with companies adopting new business models and strategies to attract external investment and expand their operations
• Strong donor presence and support from the international development community provides confidence that the market will continue to receive financial, policy and technical support necessary to develop (e.g. Millennium Challenge Corporation – EHR and OCEF)

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

Access to financing is critical for off-grid solar market growth. Solar companies need financing for working capital needs, while off-grid solar consumers need financing for the purchase of systems. This report analyzes the willingness and capacity of national and regional financial institutions to provide financing to businesses and consumers in Benin and throughout the region to support development of the OGS sector. In addition to commercial banks and microfinance institutions, impact investors and crowd funders are also active in several markets across the region.

With 15 commercial banks in Benin, the number of institutions relative to the population is extremely low. Moreover, commercial banks operate mainly in urban areas, leaving many rural and low-income people and businesses with limited access to financial services. Microfinance institutions have helped fill this void, as about 700 of these institutions serve roughly one-third of the country's adult population.

Although access to banking and financial services through formal institutions remains limited, Benin is experiencing a sharp increase in the availability and usage of digital financial services and mobile banking, driven by widespread mobile phone ownership, rapidly growing mobile internet usage and network coverage. This dynamic is driving greater financial inclusion; in 2017, 38% of the country's adult population had an account at a financial institution or with a mobile money service provider, up from 10% in 2011 and slightly above the regional average in West Africa and the Sahel. Despite the country's overall improvement with regard to financial inclusion, there is still a significant gender gap in rates of access to financial services, as women in Benin are 20% less likely than men to have an account at a financial institution or with a mobile money service provider.[31]

Expanding digital financial services, especially mobile money, can create new opportunities to better serve women, the lower-income population, 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-

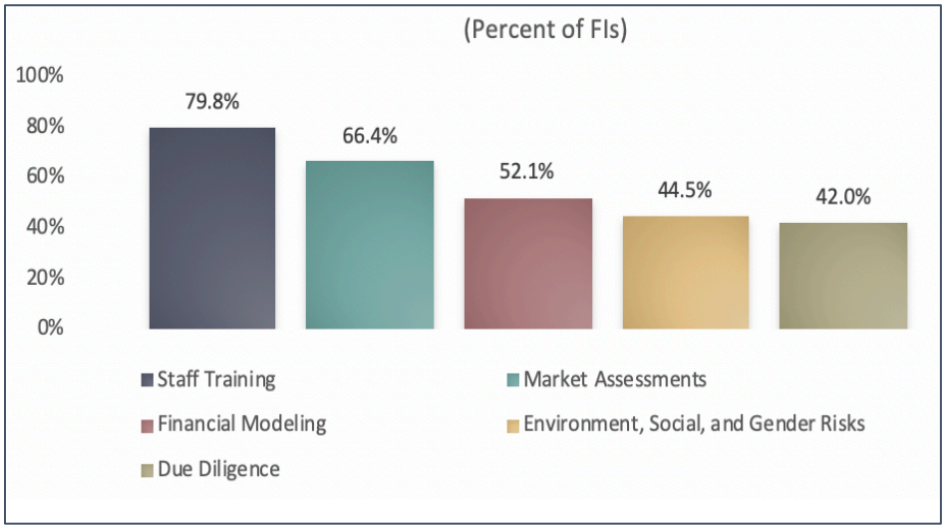
[31] Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., and Hess, J., "The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution," World Bank, (2017): http://documents.worldbank.org/curated/en/332881525873182837/pdf/126033-PUB-PUBLIC-pubdate-4-19-2018.pdf

grid solar solutions, particularly for PAYG systems that rely on the interoperability between digital financial services and stand-alone solar devices.

While there are several donor and DFI-funded programs and initiatives that provide financing to support development of Benin's off-grid solar market (e.g. OCEF), these funds have not been channeled through local commercial banks or MFIs. ROGEP is therefore a pioneering initiative in the country, as it endeavors to boost OGS lending via engagement with local financial partners. Local FIs are increasingly becoming more aware of off-grid sector opportunities thanks to initiatives such as AFD's Sustainable Use of Natural Resources and Energy Finance (SUNREF) West Africa program. In 2014, Orabank, Société Générale and AFD signed a partnership agreement to launch SUNREF's West Africa program, which makes a EUR 30 million credit line available to banks in the West African Economic and Monetary Union. Several clean energy projects in Benin have already benefitted from financing under the SUNREF West Africa program.

According to the Task 3 survey of financial institutions in Benin and across the region,[32] there is strong interest to provide financing to the off-grid solar sector. Respondents identified loan guarantees and credit lines as the most important measures to reduce market entry risks for lenders and stimulate FI engagement in the sector. Surveyed FIs also identified several areas of internal capacity that require improvement in order to lend (or increase lending) to the OGS sector (**Figure ES-11**). The most common need among FIs was training for bank staff, which includes *inter alia* assistance to originate deals and appropriately assess the credit risk of off-grid solar firms and projects, due diligence support to qualify products and approve vendors, and targeted support for new lenders to the sector with product structuring and development as well as building deal-flow. Technical assistance for solar enterprises (as is envisioned under Component 1B of ROGEP) will also be necessary, as entrepreneurs often do not have proper financial management and accounting systems in place, are unable to present quality financial models and lack the expertise required to structure their companies to take on debt obligations.

Figure ES-11: Financial Institution Needs to Increase Off-Grid Solar Lending



Source: Financial Institution survey; Stakeholder interviews; GreenMax Capital Advisors analysis

[32] The results are based on feedback from a total of 121 FIs (including commercial banks, microfinance institutions and other non-bank FIs) that were interviewed across the 19 countries.

Gender inclusiveness is also a key component of this market assessment, and the key findings of the gender analysis are presented throughout this report. Given that the off-grid market is only beginning to emerge in Benin, women are not yet highly engaged in the sector. The overall lack of inclusive participation in the off-grid space 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 (**Figure ES-12**). 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.[33]

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 in energy access programs, mainstream gender in energy policies and to enhance access to financing for women (**Figure ES-13**).[34]

[33] "Renewable Energy: A Gender Perspective," International Renewable Energy Agency, (2019): https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf
[34] Ibid.

Figure ES-12: Key Barriers to Women's Participation in Energy Access

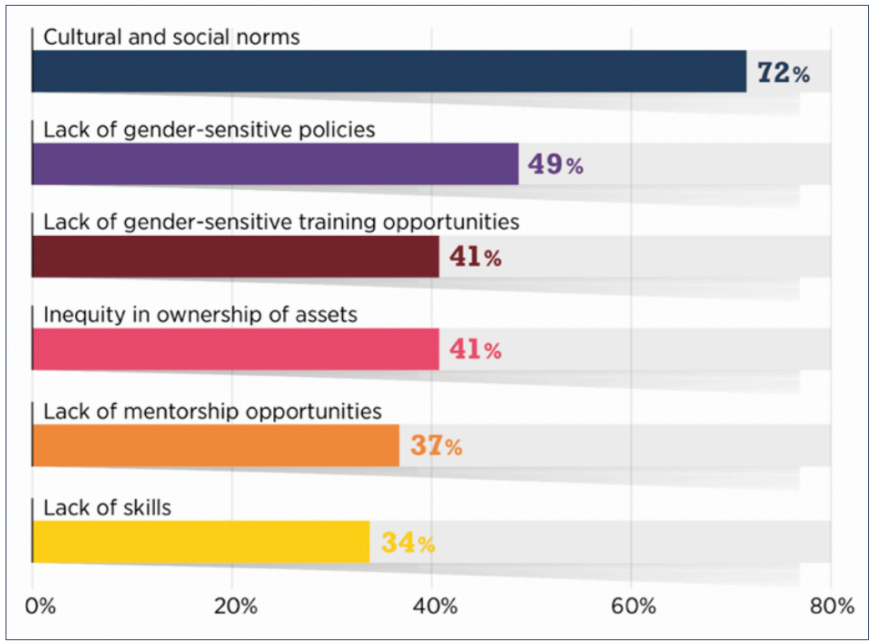
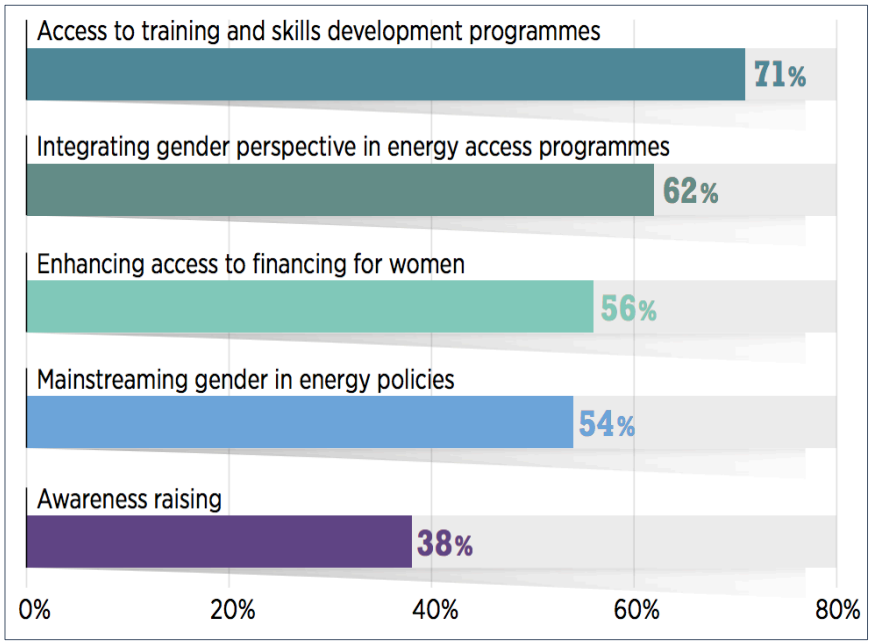


Figure ES-13: Measures to Improve Women's Engagement in Energy Access



Source: International Renewable Energy Agency

The gender analysis undertaken in Benin corroborated many of these findings and revealed several interrelated challenges that women face in the off-grid sector, including 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); and low rates of financial literacy due to a lack of education and information available to women on access to financial resources.

A number of initiatives exist that seek to address some of these challenges and help improve gender inclusion in the country's energy and off-grid sectors. For example, in 2018, ECREEE partnered with AfDB 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 2% 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 Benin.[35]

[35] "Feasibility study promotes women's participation in energy transition," ESI Africa, (7 May 2018): https://www.esi-africa.com/feasibility-study-promotes-womens-participation-in-energy-transition/

I. STATE OF ENERGY ACCESS AND ENABLING MARKET ENVIRONMENT

This section begins with a brief introduction of key macroeconomic and social indicators in Benin (**Section 1.1**). This is followed by an overview of the country's existing energy sector (**Section 1.2**), with a focus on the status of energy access, including an assessment of both the on-grid and off-grid markets, a least-cost electrification analysis and a review of gender policies. **Section 1.3** examines national energy policy and regulation vis-à-vis the off-grid solar market, including detailed analysis of the existing framework for off-grid stand-alone systems[36] in Benin as well as gaps in the framework. **Section 1.4** is a summary of all relevant national and donor-funded development initiatives in the off-grid sector. **Annex 1** provides an overview of the Task 1 methodology.

1.1 Country Overview

Benin is a small West African country bordered by Togo, Niger, Nigeria, and Burkina Faso. It has a relatively stable and democratic government that experienced economic growth at a rate of 5.5% in 2017, with a similarly promising outlook projected for 2018-2019.[37] Cotton is a key export commodity, while the country's economy is highly dependent on trade with Nigeria, which accounts for approximately 20% of national GDP. Benin's agriculture sector contributes to 25% of GDP and employs nearly half of the labor force.[38] Private foreign direct investment in the country is relatively small, while foreign aid accounts for a large proportion of investment in infrastructure and development. The majority of Benin's population remains outside of the formal economy and faces high rates of poverty and inadequate access to basic social services.

Table 1: Macroeconomic and Social Indicators

Population	11.2 million[39]
Urban Population	44% of total
GDP	USD 9.2 billion
GDP growth rate	5.5%
GNI per capita*	USD 800
Unemployment rate	2.5%
Poverty rate	36.2% (2015)
Urban	31.4%
Rural	39.7%
Currency	West African CFA franc (CFA)
Official language	French
Natural resources	Cotton, cashews, peanuts, palm products, textiles

* World Bank Atlas method (current USD)

All figures from 2017 unless otherwise indicated
Source: AfDB and World Bank

[36] NOTE: The term "off-grid" as it is widely used throughout this report (e.g. "off-grid sector") refers to both mini-grids and stand-alone systems. When "off-grid solar" or its acronym "OGS" are used, this refers *only* to stand-alone systems and does not include mini-grids
[37] "Benin Economic Outlook," African Development Bank, (2018): https://www.afdb.org/en/countries/west-africa/benin/
[38] "World Bank Open Data: Benin," World Bank, (2017): https://data.worldbank.org/country/benin
[39] 50.12% female/49.88 % male

1.2 Energy Market

1.2.1 Energy Sector Overview

The Electricity Community of Benin (Communauté Electrique du Bénin, CEB) is the state-owned electricity company of Benin (50%) and Togo (50%), with a monopoly over generation and transmission of electricity in both countries. Benin's national power utility, Beninese Electric Power Company (Société Beninoise d'Electricité et d'Eau, SBEE) is concerned with electricity distribution within Benin as well as grid improvement and maintenance in northern Benin and neighboring Togo.[40] Following the amendment in 2017 of the Beninese-Togolese electricity code, CEB no longer had a monopoly over the production and sale of electricity. Independent power producers (IPPs) can now directly produce and sell their energy to the SBEE or any other major consumer of electricity. Electricity distribution within Benin remains the monopoly of SBEE. A specialized agency, the Beninese Agency of Rural Electricity and Energy Management (Agence Béninoise d'Électricité Rurale et de Maîtrise d'Énergie, ABERME), was established in 2004 to promote rural electrification and off-grid development.

Table 2: Institutional and Market Actors in the Energy Sector

Institution / Company	Role in the Energy Sector
Ministry of Energy (Ministère de l'Énergie)	The Ministry of Energy oversees all energy sector activities and is responsible for developing and implementing energy policy
Direction Générale de l'Énergie (DGE)	Implements state policy in the energy sector and ensures its implementation, monitoring and evaluation
Communauté Électrique du Benin (CEB)	CEB is a bipartite utility supplying electricity to national distribution utilities in Benin and Togo (around 85% of generation capacity)
Société Béninoise d'Énergie Électrique (SBEE)	National utility responsible for electricity distribution and local generation through diesel generators (around 13% of generation capacity)
Agence Béninoise d'Électrification Rurale et de Maitrise d'Énergie (ABERME)	Benin's Agency for Rural Electrification and Energy Conservation established to oversee the country's rural electrification programs and development initiatives
Autorité de Régulation de l'Électricité (ARE)	Regulatory authority responsible for ensuring compliance with the laws and regulations governing the electricity sector, protecting the public interest and guaranteeing the continuity and quality of service

Source: ECOWAS Center for Renewable Energy and Energy Efficiency

1.2.2 Electricity Access: *Grid and Off-Grid*

In 2016, approximately two-thirds of the overall population in Benin – an estimated 7.6 million people – did not have access to electricity, with a significant disparity in rates of access between urban (56%) and rural (11%) areas.[41] Off-grid electrification is therefore a policy priority for the Government of Benin (GoB), which is committed to achieving universal access to electricity by 2030 (**Table 3**). It is estimated that to meet this target, the GoB will need to make a minimum of 5 million new connections in rural Benin over the next decade.[42]

[40] "Benin Energy Service Improvement Project," GTAI, (2017): https://www.gtai.de/GTAI/Content/DE/Trade/Fachdaten/PRO/2017/07/Anlagen/PRO201707035003.pdf?v=1
[41] "Energy Access Outlook, 2017: From Poverty to Prosperity," International Energy Agency, (2017): https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
[42] "Benin SEforALL Country Action Agenda," ECREEE / SEforALL, (2015): http://se4all.ecreee.org/sites/default/files/se4all_aa.pdf

1.2.2.1 Off-Grid Market Overview

In 2017, the World Bank approved a USD 60 million credit line to help Benin improve energy services through increasing the operational performance of SBEE and the expansion of electricity access to the rural areas. The funding will mainly go towards reducing commercial and technical losses and strengthening the capacity of key stakeholders.[43]

Table 3: Electricity Access Targets[44]

Indicator	2016	2025 target	2030 target
National electricity access rate	32%	36%	100%
Urban access rate	56%	95%	100%
Rural access rate	11%	65%	100%

Source: DGE, IEA and SEforALL Country Action Agenda

The Millennium Challenge Corporation (MCC) has also been supporting the Government for several years to develop a policy and regulatory framework to support clean energy development and off-grid electrification.[45] The MCC has assisted Benin through the capacity building of the Electricity Regulatory Authority (AER) and in the development of a performance plan with measurable targets for the national utility, SBEE. In 2017, Benin passed legislation to attract IPPs to the power sector and is actively developing policies to increase private investment in off-grid development.[46]

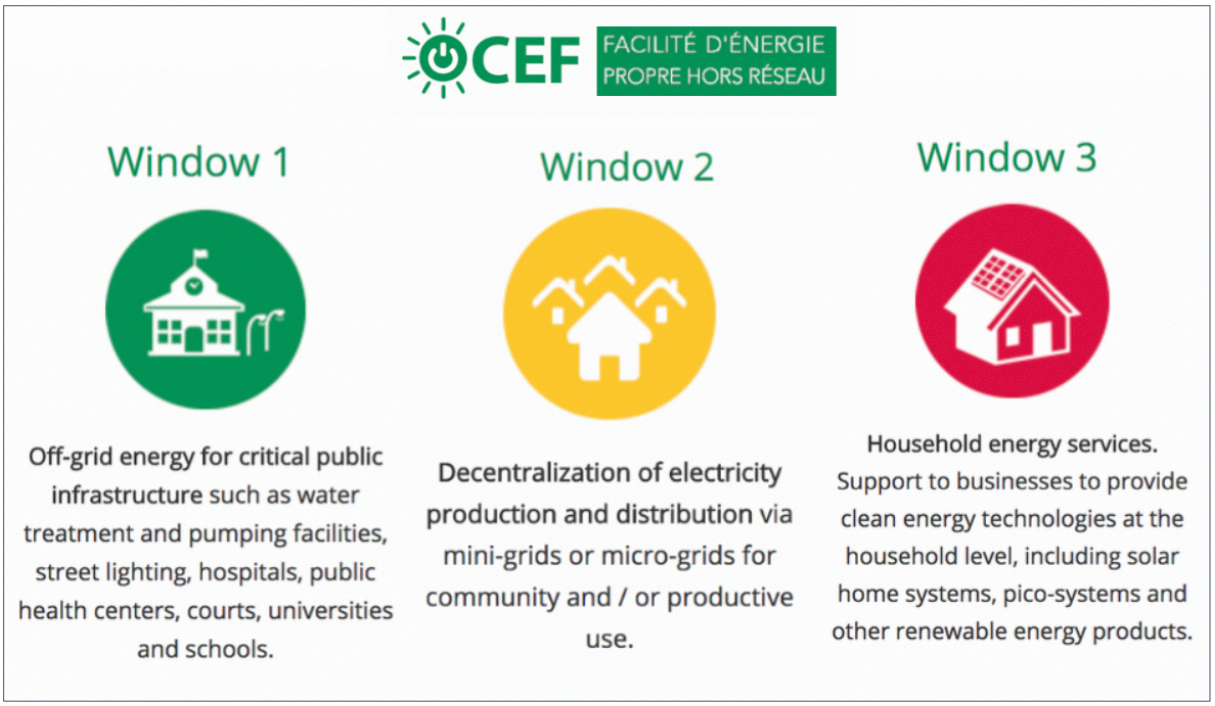
Though the policy has yet to be implemented, the Government has divided the country's rural areas into 15 zones, known as Concessions for Rural Electrification (Bureau d'Électrification Rurale, REB), which allows localities within a zone to develop their own initiatives for electrification. The GoB has also established a Rural Electrification Fund (Fonds d'Électrification Rurale, ERF) to ensure financing is available for off-grid projects. An off-grid regulatory framework that is currently under development (Électrification Hors-Réseau, EHR), includes a regime for contracts with the private sector for the sale of quality-verified pico solar products receiving a subsidy in an off-grid area.

The EHR framework, which is being developed by the Government with support from MCC, is intended to serve as the country's electrification master plan. The EHR calls for legal reforms to the electricity code to prioritize renewable energy consumption over conventional electricity, promotes the integration of mobile money services in the off-grid sector and includes specific measures to incentivize private sector participation and investment in off-grid project development.[47] The MCC is also supporting implementation of the Off-Grid Clean Energy Facility (OCEF), which provides a platform for organizations and companies in Benin to search for potential partners to finance and develop off-grid clean energy projects (**Figure 1**).[48] The OCEF includes three distinct grant funding windows and corresponding TA to support proven and

[43] "Benin Gets World Bank's Support to Improve Energy Services," World Bank, (2017): http://www.worldbank.org/en/news/press-release/2017/06/23/benin-gets-world-banks-support-to-improve-energy-services
[44] "Energy Access Outlook, 2017: From Poverty to Prosperity," International Energy Agency, (2017): https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf; and "ROGEP National Workshop, PPT Presentation from the "Direction Générale des Énergies Renouvelables," ECREEE, Ministry of Energy, (22 November 2017); and "Benin SEforALL Country Action Agenda," ECREEE / SEforALL, (2015): http://se4all.ecreee.org/sites/default/files/se4all_aa.pdf
[45] "Benin Power Africa Sheet," USAID, (2018): https://www.usaid.gov/powerafrica/benin
[46] Ibid.
[47] "Regulatory Framework for Off-Network Electrification, Cadre Réglementaire de L'électrification Hors-Réseau (EHR)," Benin Energie & Electrification Hors Reseau, (2018): https://www.benin-energie.org/bilan-energetique.html
[48] "Launch of the Off-Grid Clean Energy Facility in Benin," Energy Access Practitioner Network, (2018): http://energyaccess.org/news/recent-news/launch-of-the-off-grid-clean-energy-facility-in-benin/

sustainable off-grid clean energy businesses and projects, with the first round complete and the second funding window scheduled to open in 2019. The third window includes funding for the stand-alone solar market segment. Project developers are encouraged to take gender, social impact and environmental aspects into account in their project design.[49]

Figure 1: Benin Off-Grid Clean Energy Facility



Source: Millennium Challenge Corporation

Outside of public sector initiatives, Greenlight Planet is a leading private company operating in Benin's off-grid solar market, providing solar lighting and solar home system solutions through a pay-as-you-go (PAYG) business model. In 2016, Greenlight Planet partnered with SNV and MTN to launch the "Bright Lights for Benin" project, funded by GSMA's Mobile for Development Utilities Innovation Fund. The project had a goal of catalyzing PAYG solar sales in Benin by connecting Greenlight's PAYG products with the pre-existing solar supply chain. This project was the first PAYG solar project in Benin and facilitated the sale of 9,000 solar products and systems over 18 months in mostly rural areas of the country. The project benefitted from import tax exemptions from the GoB.[50]

[49] "OCEF - Access to Electricity and Promotion of Renewable Energy in Benin," La Facilité d'Énergie Propre Hors Réseau: https://ocef.bj/
[50] "Introducing Solar Pay As You Go Products in Benin," SNV, (2016): http://www.snv.org/update/introducing-pay-you-go-solar-products-benin

1.2.2.2 Demand and Supply/Generation Mix

Table 4: Electricity Sector Indicators, 2017[51]

Installed Capacity	220.5 MW
Thermal	220 MW
Hydropower	0.5 MW[52]
Renewable (non-hydro)	-
National electrification rate (2016) Urban electrification rate Rural electrification rate	32% 56% 11%
Population without access	7.6 million
Households without access	1.5 million
Electrification target	Universal access by 2030

Source: DGE, IEA and World Bank

Thermal power generation accounts for 85% of existing installed capacity in Benin, while hydropower accounts for the remaining 15% (**Table 4**). Security of electricity supply is a major challenge for the country and one that will only be exacerbated as energy demand is expected to double by 2024.[53] The country relies on imported electricity from Ghana, Côte d'Ivoire, Nigeria and Togo for most of its needs, with about one-third of total supply produced domestically. Benin has significant renewable energy potential that remains largely untapped due to limited local technical and financial capacity and an unfavorable pricing environment. The country possesses significant solar resource potential, as the technology is expected to contribute to nearly half of the installed capacity by 2030 (**Table 5**).

Solar energy potential of Benin lies between 3.7kWh/m2 and 6.2 kWh/m2, which signifies high levels of solar generation potential. Wind speeds in Benin vary between 3m/s ad 6m/s, indicating that there is potential for small wind turbine generation in Benin. Large wind turbine generation would require a minimum wind speed of between 6m/s and 8m/s[54], which Benin is currently not experiencing. There is also potential of about 5 million tons of annual biomass power generation in Benin. The country has extremely low volcanic activity, indicating low potential for geothermal generation.

Table 5: Current and Planned Installed Capacity[55]

Installed Capacity (MW)	2017	2020 (planned)	2030 (planned)
Thermal	220	365	-
Hydro	0.5	33	338
Solar	-	95	95
Bioenergy	-	21	21
Total Installed Capacity (MW)	**220.5**	**506**	**934**
Total Thermal	220	356.5	480
Total Renewable Energy	0.5	149.5	454

Source: DGE and SEforALL National Renewable Energy Action Plan (PANER)

Electricity tariffs in Benin are not cost-reflective as supply costs per kWh exceed the retail price. The average electricity tariff set by the independent electricity regulator, ARE, is USD 0.22/kWh for all end

[51] See **Section 2.1** for more details on households/population without access to electricity.
[52] While Benin produces 0.5 MW of hydroelectricity domestically via the Yeripao hydropower plant, the country utilizes another 32.5 MW of hydropower generated from the Nangbeto Dam in neighboring Togo.
[53] "New Opportunities for Benin: A Call for Proposals," Millennium Challenge Corporation, (27 February 2018): https://www.mcc.gov/blog/entry/blog-022718-benin-call-for-proposals
[54] "Wind Turbine Systems," Level, (2017): http://www.level.org.nz/energy/renewable-electricity-generation/wind-turbine-systems/
[55] "Benin National Renewable Energy Action Plan," ECREEE / SEforALL, (2015): http://se4all.ecreee.org/sites/default/files/paner_editing_final_.pdf

users.[56] The rate is slightly lower for low-income customers who receive a social tariff subsidy. With support from the World Bank, SBEE instituted a series of reforms to improve its commercial viability, including revisions to its tariff policy.[57]

1.2.2.3 Transmission and Distribution Network

Benin's electricity system (**Figure 2**) is managed by CEB, the public utility company that supplies electricity to national distribution utilities, the SBEE, responsible for electricity distribution, and ABERME, the agency that oversees rural energy supply. Benin's receives more than 80% of its electricity from Ghana, Côte d'Ivoire, Nigeria and Togo.

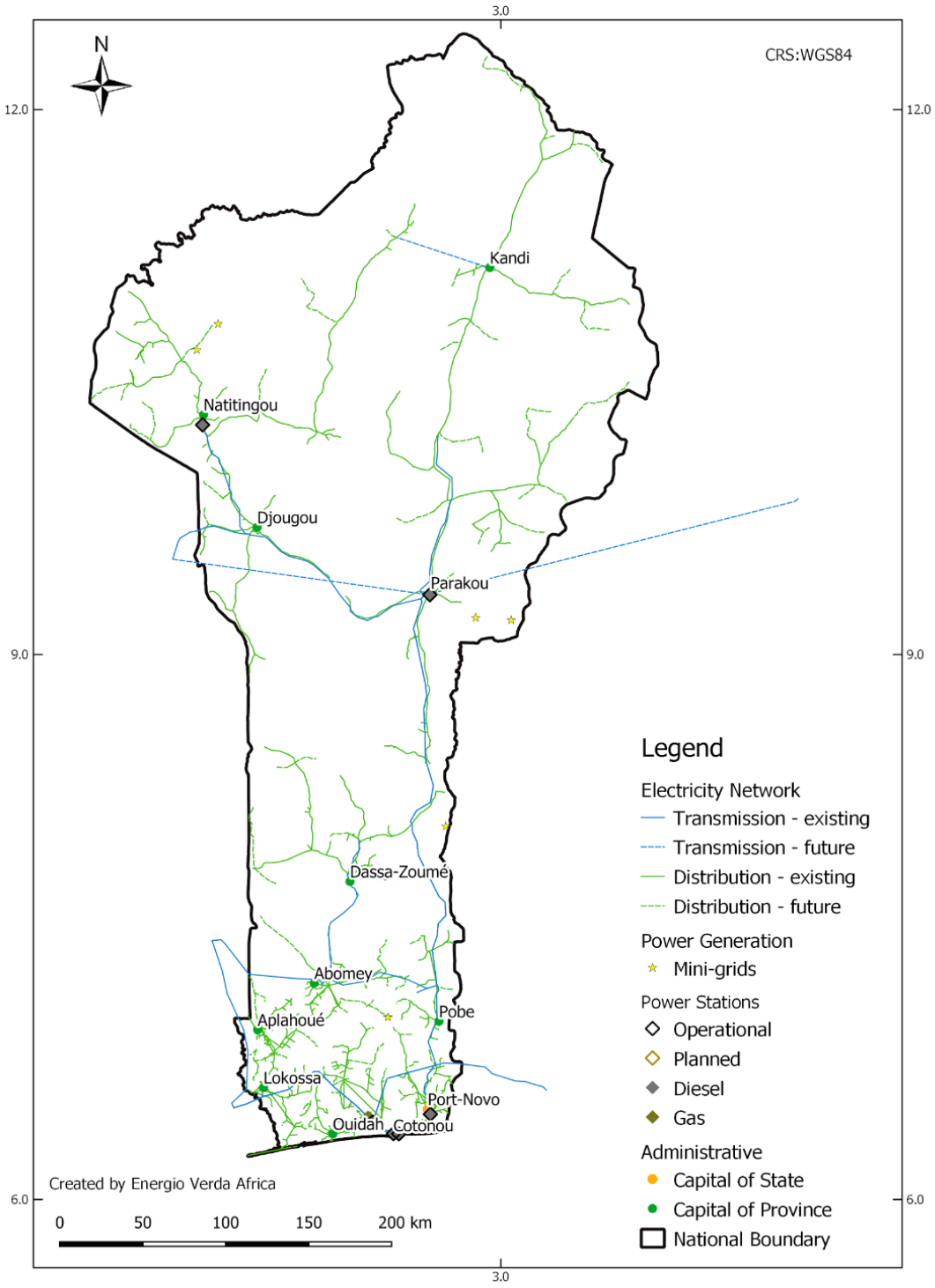
Overall, a significant gap exists between the infrastructure needs of the country's power sector and the availability of resources to invest in grid maintenance and extension to rural areas; as a result, the country's electricity network is overloaded and often unreliable (**Figure 3**).

To address these challenges, the MCC has partnered with the GoB to implement the Benin Power Compact (BPC) from 2017 to 2022. This compact will expand Benin's electricity network, support SBEE, increase access to electricity, and improve the quality and reliability of the electricity sector.[58] Benin is also a member of the West African Power Pool (WAPP) and is currently in partnership with the Transmission Company of Nigeria to support a project designed to build a second 330 kV transmission line to increase electricity supply to the country by 2021.[59]

In the medium term, the Government has formulated the Policy and Strategy Document for the Development of the Electricity Sector. This policy aims to ensure reliable electricity supply, achieve national energy security and develop an efficient energy distribution system with an optimal energy resource through new power generation plants, regional interconnection and rural electrification. AFD is also developing a framework to support the restoration and extension of the grid in the region of Abomey-Calavi as well as the Atlantique Department, with additional funding from the European Union (EU) and the European Investment Bank (EIB).

[56] "Regulatory Indicators for Sustainable Energy: Benin," World Bank, (2018): http://rise.worldbank.org/country/benin
[57] "Benin Energy Sector Budget Support Programme," African Development Fund, https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Benin-_AR-Energy_Sector_Budget_Support_Programme_-_Phase_I__PASEBE_I_.pdf
[58] "Evaluation Design Report for the Benin Power Compact's Electricity Generation Project and Electricity Distribution Project," Mathematica Policy Research, (2018)
[59] "WAPP to build a 330kV transmission line to connect Benin," ESI, (2017): https://www.esi-africa.com/wapp-project-erect-transmission-line-benin/

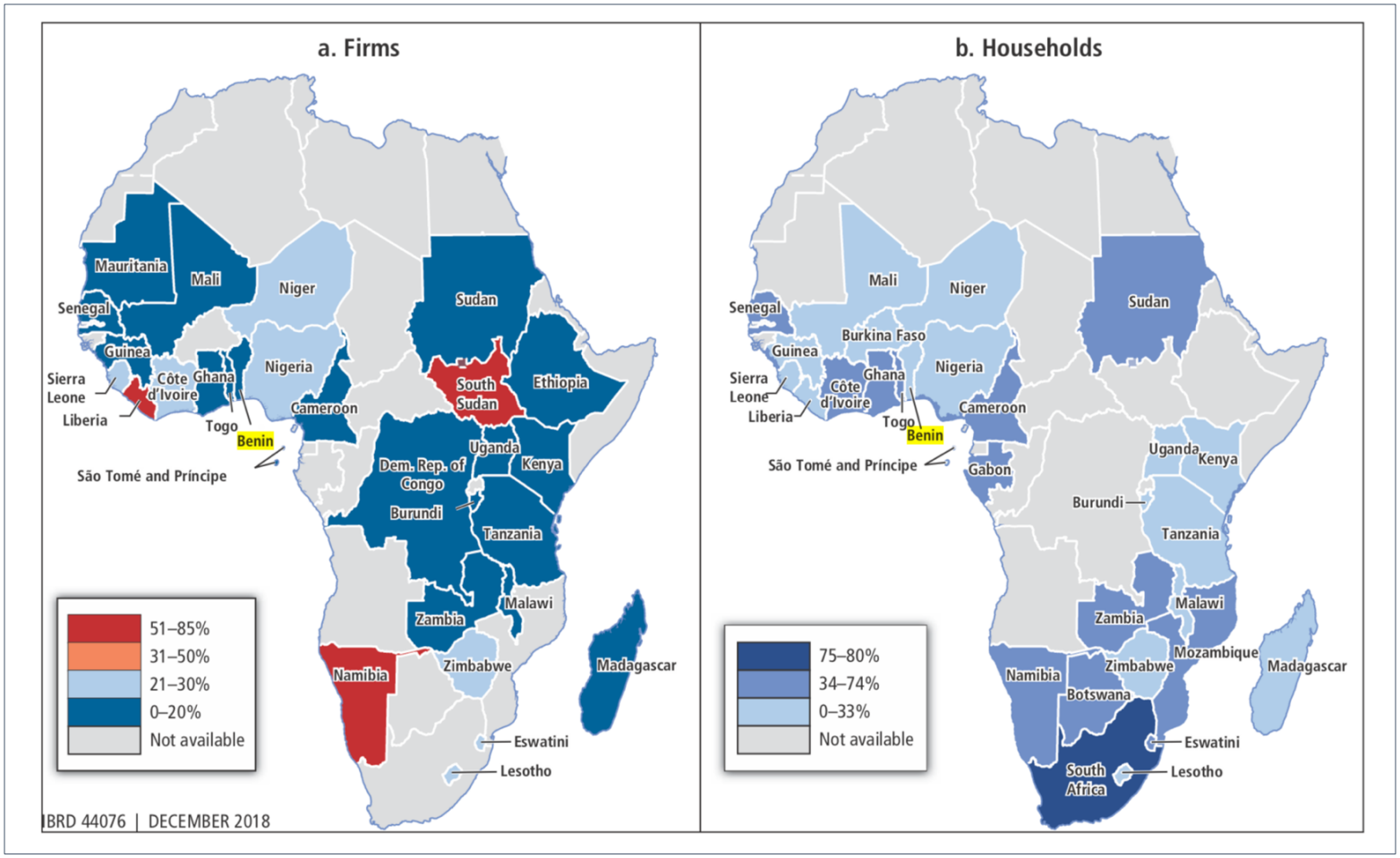
Figure 2: Electricity Transmission and Distribution Network[60]



Source: Energio Verda Africa GIS analysis

[60] See **Annex 1** for more details, including data sources.

Figure 3: Access to Reliable Electricity by Firms and Households in Africa[61]



Source: World Bank Enterprise Surveys, 2013-2017 and Afrobarometer Household Surveys, 2014-2015

The maps in **Figure 3** illustrate the share of firms (Panel a) and households (Panel b) reporting access to a reliable supply of electricity. In Benin, fewer than one-fifth of surveyed firms and less than one-third of surveyed households reported having reliable access to electricity.

[61] Blimpo, M., and Cosgrove-Davies, M., "Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact," AFD and World Bank, Africa Development Forum, (2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf?sequence=6&isAllowed=y

1.2.2.4 Least-Cost Electrification Analysis

A least-cost electrification analysis was undertaken to assess the potential development of electricity access in Benin through 2023 and through 2030 (referred to below as "Scenario 2023" and "Scenario 2030").[62] The analysis identifies the scale of potential market opportunities for off-grid electrification in the country. A brief summary of the approach and methods used, main assumptions and key results of the analysis in Benin are outlined below. Additional geographic information system (GIS) information, including categorizations, key definitions, and datasets are included in **Annex 1**.

- **Methodology**

This analysis used geospatial techniques to determine the least-cost electrification options for settlements across Benin based on their proximity to electrical infrastructure, population density or nodes of economic growth.

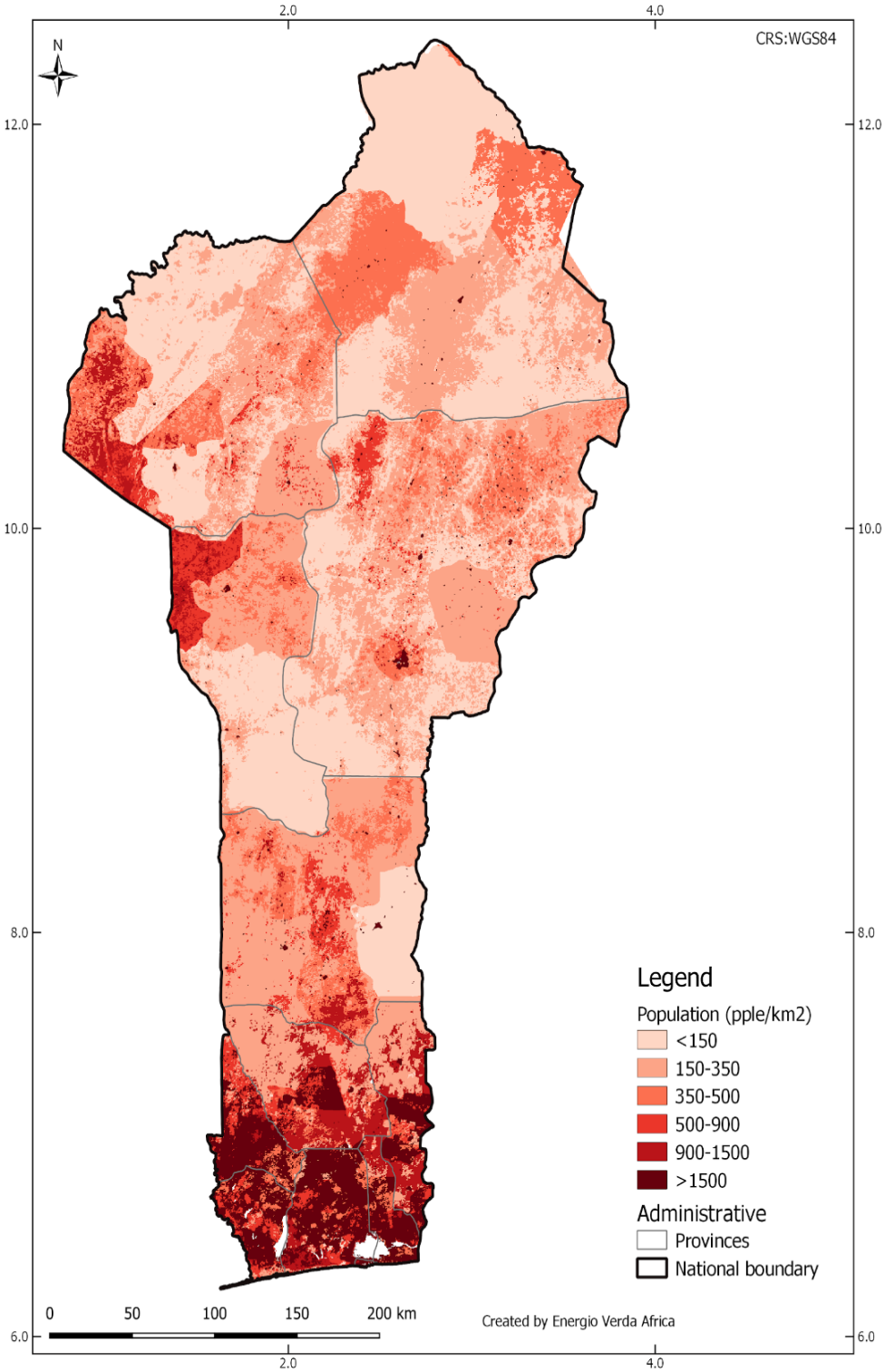
For the Scenario 2023 analysis, it is assumed that widespread densification of the existing electrical grid will enable settlements within 5 km of existing grid lines to connect to the grid (according to WAPP densification plans).[63] Beyond this area, the likely candidates for electrification by mini-grid systems are settlements that are relatively dense (above 350 people/km^2) and have active local economies, evidenced by the presence of social facilities and by their proximity to other settlements already with electricity access (i.e. within 15 km of night-lights areas). All remaining settlements – those in areas of lower population density (below 350 people/km^2) or far from the national grid – are considered candidates for off-grid stand-alone systems.

For the Scenario 2030 analysis, it is assumed that the grid and the reach of grid densification efforts will extend far beyond the existing network. Hence, settlements that are within 15 km of current lines (average densification distance for West African utilities over a 10-year timeline) and within 5 km of future planned line extensions are assumed to be connected. For mini-grids, future economic development – which will allow new settlements to grow sufficiently to become candidates for mini-grids – is assumed to occur in settlements within 1 km of mini-grid settlements (average distance of mini-grid coverage of different developers) identified in the Scenario 2023 analysis, as well as within 15 km of economic growth centers – airports, mines and urban areas. All other settlements are considered candidates for off-grid stand-alone systems.

Given the lack of low voltage distribution line data, it was necessary to approximate areas where un-electrified settlements in close proximity to the grid exist. The analysis therefore focuses on settlements that are within 5 km of the high and medium voltage network, but that are located beyond 15 km of areas with night-time light emissions (indicative of electrification). Settlements in areas of low population density (below 350 people per km^2) that met the above criteria are identified as both being currently un-electrified and unlikely to be electrified under Scenario 2030.[64] Additional analysis was undertaken to estimate the population within each settlement. The current annual national population growth rate of 2.8%[65] was applied to the geospatial analysis to project population figures for the Scenario 2023 and Scenario 2030 analyses.[66] **Figure 4** shows population density across the country, which served as the basis for this analysis.

[62] NOTE: Rather than presenting a 10-year projection through 2028, the analysis conforms to GoB electrification targets for 2030
[63] NOTE: Low-voltage distribution lines were not considered in this analysis (data was unavailable)
[64] Note that this analysis was performed for Scenario 2023 but not for Scenario 2030 due to uncertainties regarding population densities being too high over such a long timeframe
[65] https://data.worldbank.org/indicator/SP.POP.GROW?locations=BJ
[66] See **Annex 1** for the results of this analysis as well as more details on the approach and methods used

Figure 4: Population Density, 2014[67]



Source: Energio Verda Africa GIS analysis

[67] See **Annex 1** for more details, including data sources.

- **Results**

Table 6 summarizes the results of the least cost electrification analysis. **Figure 5** and **Figure 6** illustrate the distribution of settlements according to least-cost electrification options under scenarios 2023 and 2030, respectively. The number of households was estimated by using the average household size for the country (5 persons/household).[68]

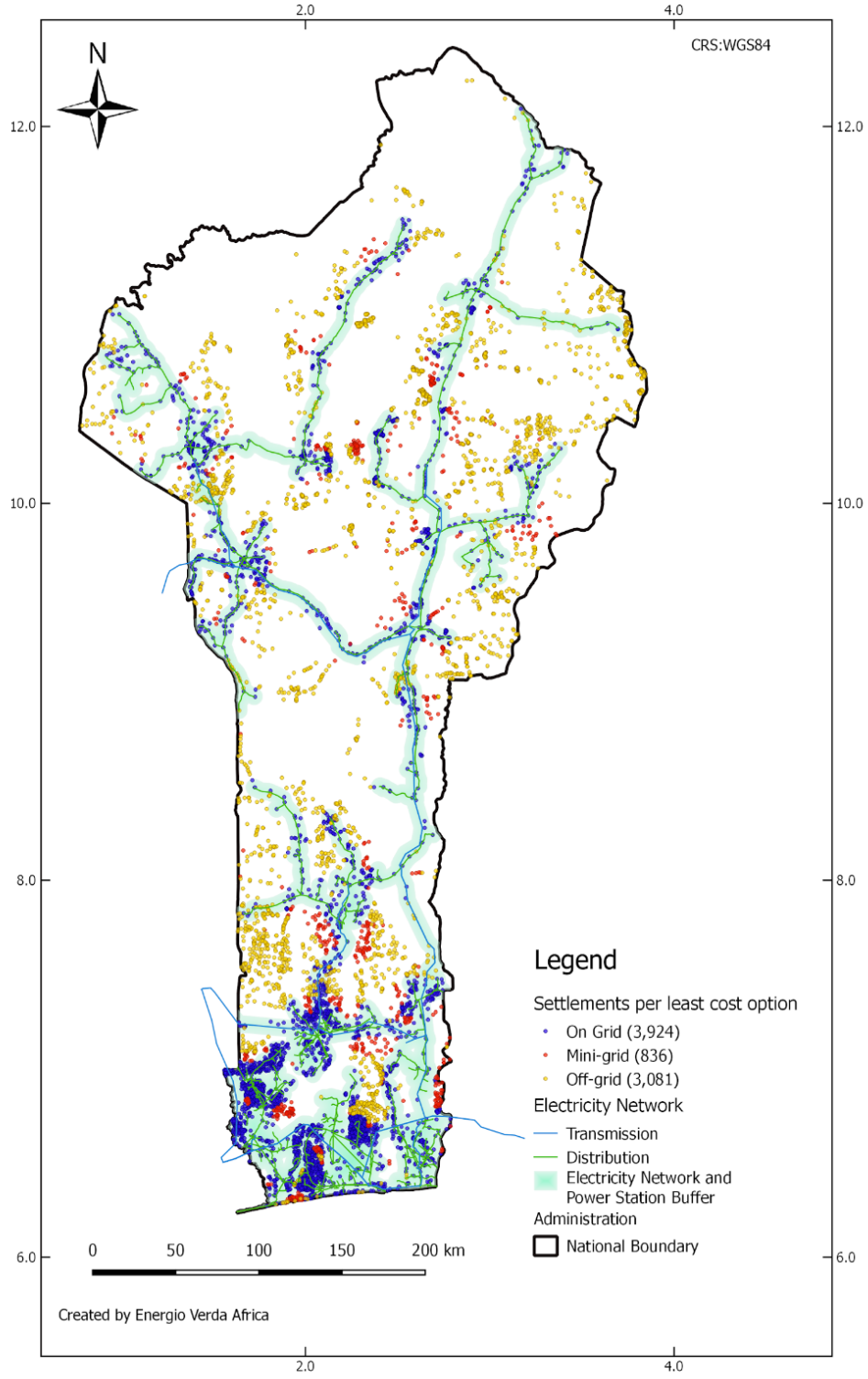
Table 6: Results of Least-Cost Electrification Analysis

Scenario	Indicator	Least-Cost Electrification Option			Grid Vicinity		
		Grid extension	Mini-grid	Off-grid stand-alone systems	Under-grid un-served	Total under-grid	Total outside grid vicinity
Scenario 2023	Number of settlements	3,924	836	3,081	360	4,284	3,554
	% of settlements	50.1%	10.7%	39.3%	8.4%	54.7%	45.3%
	Total population	10,091,810	896,148	2,527,532	230,330	10,322,140	3,193,350
	% of population	74.7%	6.6%	18.7%	2.2%	76.4%	23.6%
	Number of households	2,018,362	179,230	505,506	46,066	2,064,428	638,670
Scenario 2030	Number of settlements	6,850	21	970	Not calculated	6,850	988
	% of settlements	87.4%	0.3%	12.4%	Not calculated	87.4%	12.6%
	Total population	15,277,321	82,730	1,037,674	Not calculated	15,277,321	1,120,404
	% of population	93.2%	0.5%	6.3%	Not calculated	93.2%	6.8%
	Number of households	3,055,464	16,546	207,535	Not calculated	3,055,464	224,081

Source: Energio Verda Africa GIS analysis

[68] "Household Size and Composition Around the World," United Nations, (2017): http://www.un.org/en/development/desa/population/publications/pdf/ageing/household_size_and_composition_around_the_world_2017_data_booklet.pdf

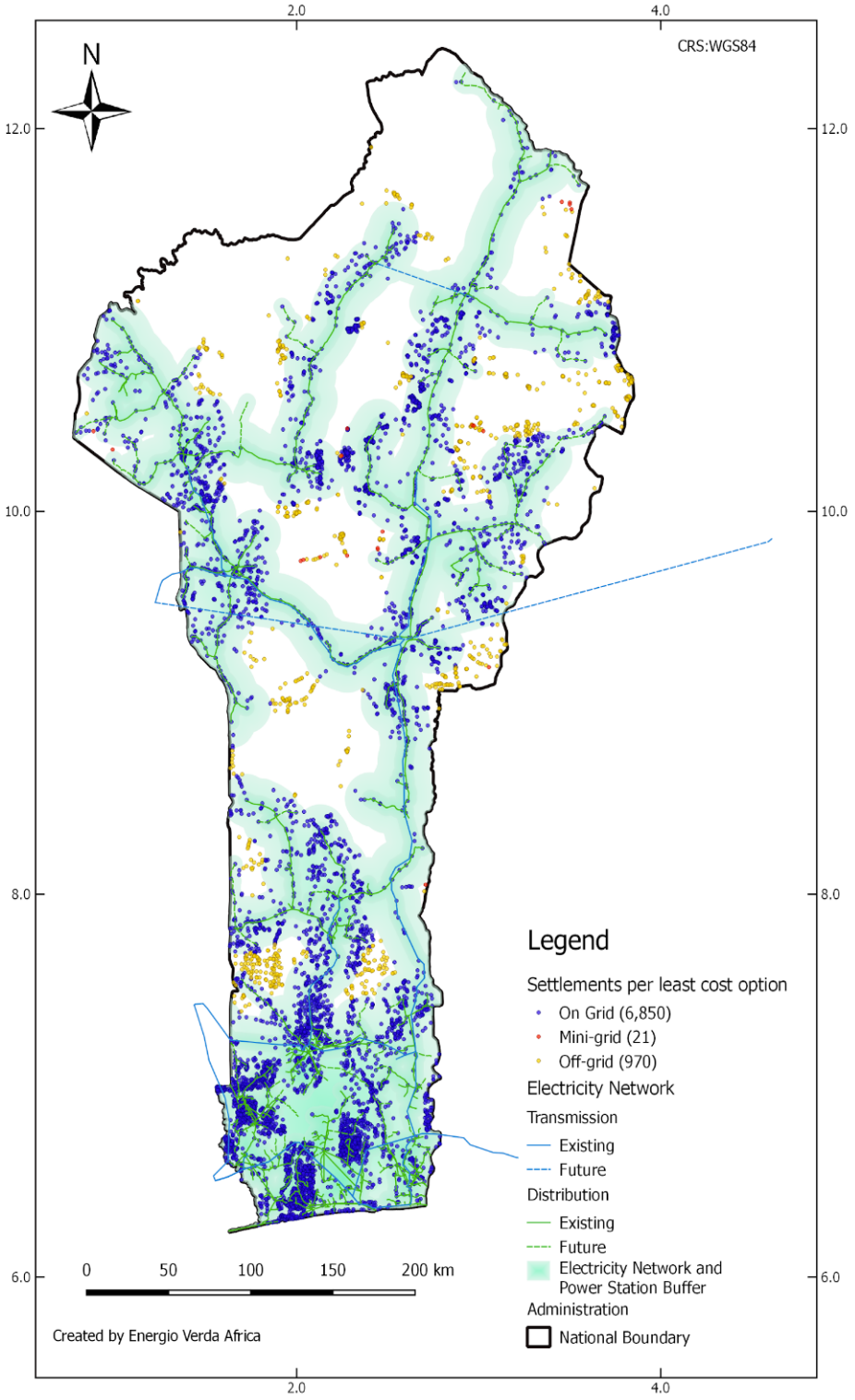
Figure 5: Distribution of Settlements by Least-Cost Electrification Option, 2023[69]



Source: Energio Verda Africa GIS analysis

[69] Displaying identified settlements with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

Figure 6: Distribution of Settlements by Least-Cost Electrification Option, 2030[70]



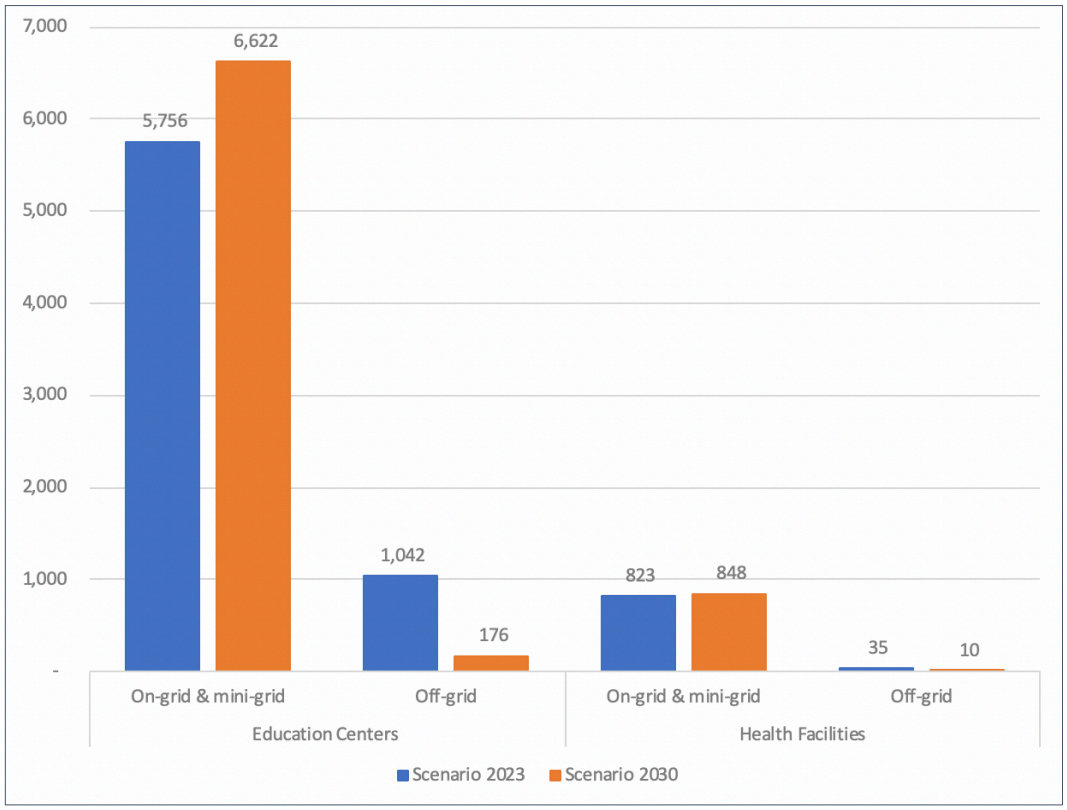
Source: Energio Verda Africa GIS analysis

[70] Displaying identified settlements with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

The analysis also covered education centers and health facilities that could remain off-grid during the analyzed timeframes. The data on education centers and health facilities used in the analysis was collected during the 2013 census; a total of 6,798 education centers and 858 health facilities were analyzed.

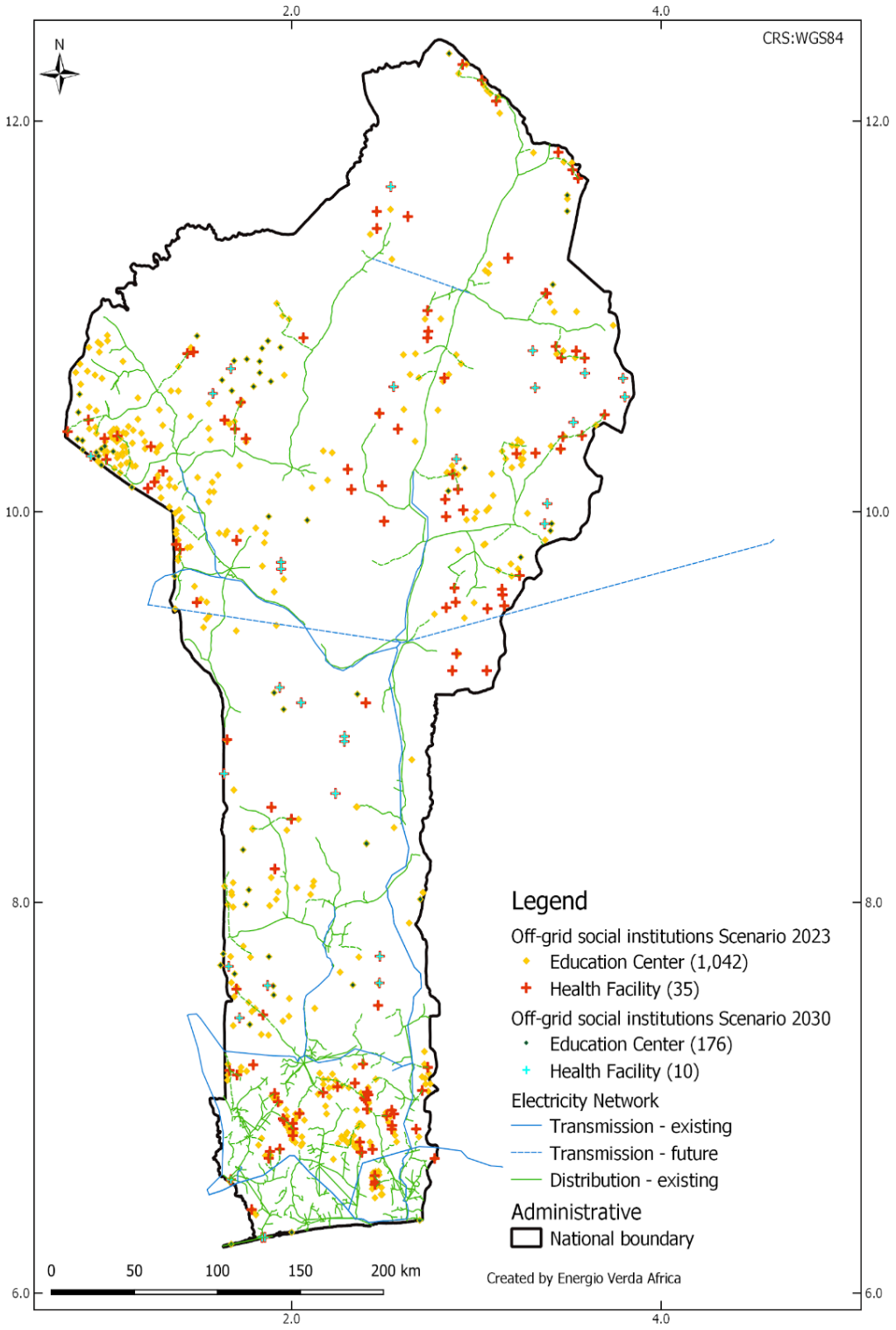
Figure 7 summarizes the number of education centers and health facilities that may be electrified by on-grid or mini-grid solutions or that are suitable for off-grid stand-alone solutions in scenarios 2023 and 2030. **Figure 8** illustrates the distribution of potential off-grid facilities across the country under the two scenarios.

Figure 7: Identified Social Facilities Suitable for On-Grid, Mini-Grid and Stand-alone Solutions, 2023 and 2030



Source: Energio Verda Africa GIS analysis

Figure 8: Distribution of Potential Off-Grid Social Facilities, 2023 and 2030[71]



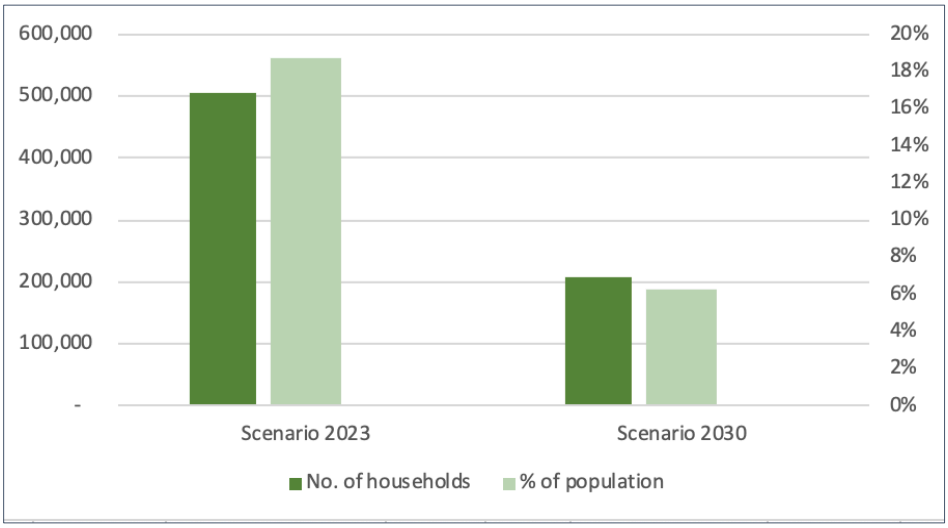
Source: Energio Verda Africa GIS analysis

[71] Displaying identified facilities with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

According to the geospatial analysis (**Table 6**), by 2023, 3,924 settlements across Benin (2,018,362 households) will be connected to the main grid, representing 74.7% of the population. By 2030, this figure will increase to 6,850 settlements (3,055,464 households), equivalent to 93.2% of the population. These estimates are based on the assumption that all planned grid extensions will be completed by 2030. Not all settlements in close proximity to electricity lines will connect to the main grid, largely due to the low density of these areas (dispersed settlements with a density below 350 people/km^2). By 2023, an estimated 360 settlements located under the grid will meet these criteria (or 8.4% of the settlements located within 5 km of the grid).

Outside of the main grid areas, settlements with higher economic growth potential and higher population density can optimally be electrified by mini-grids. By 2023, this represents an estimated 836 settlements (179,230 households), or 6.6% of the population, decreasing to 21 settlements (16,546 households), or 0.5% of the population by 2030. The remaining more dispersed settlements (further from centers of economic activity) can optimally be served by off-grid stand-alone systems. This comprises 3,081 settlements (505,506 households) and 18.7% of the population in 2023, decreasing to 970 settlements (207,535 households) and 6.3% of the population in 2030 (**Figure 9**).

Figure 9: Estimated Number of Households and Share of Population Suitable for OGS Systems, 2023 and 2030



Source: Energio Verda Africa GIS analysis

The analysis indicates that the off-grid stand-alone market has the potential to grow significantly. According to figures published by the Global Off-Grid Lighting Association (GOGLA),[72] as of the end of 2017, an estimated 191,383 off-grid stand-alone solar PV products (pico solar and SHS) had been sold in Benin (see **Section 2.4.3**). The least-cost analysis estimates that more than 2.5 million people and 500,000 households are suitable for these solutions through 2023.

[72] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth2-2017_def20180424_web_opt.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth12017_def.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2016): https://www.gogla.org/sites/default/files/recource_docs/final_sales-and-impact-report_h22016_full_public.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2016): https://www.gogla.org/sites/default/files/recource_docs/global_off-grid_solar_market_report_jan-june_2016_public.pdf

In its SEforALL National Renewable Energy Action Plan (Plan d'Action National pour les Énergies Renouvelables, PANER), the GoB envisioned a relatively limited share of the population would gain electricity access through off-grid systems (**Table 7**). The findings of the least-cost analysis suggest that the Government may need to consider increasing the utilization of off-grid solutions (a combination of mini-grids and stand-alone systems) in its electrification planning in order to achieve its energy access targets, particularly in the near-term until planned grid extensions are realized. It is worth noting that since publication of the PANER in 2015, the Government has taken steps to move the country in this direction (i.e. through the OCEF initiative).

Table 7: Estimated Share of Population Served by Off-Grid Systems[73]

Share of population with access to off-grid systems powered by renewable energy (%) *	2020 (target)	2030 (target)
	2%	5%

* Estimate includes both mini-grids and stand-alone systems

Source: SEforALL National Renewable Energy Action Plan

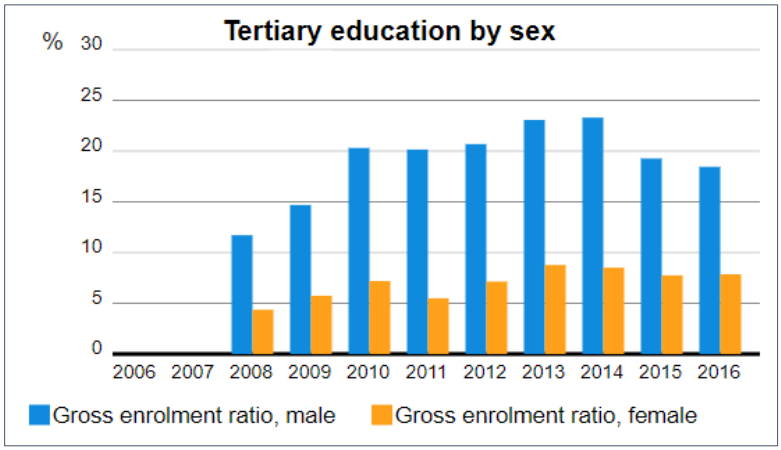
1.2.2.5 Inclusive Participation[74]

Inclusive participation in Benin remains an ongoing challenge. Gender inequality persists, as women are under-educated and generally have a lower socio-economic status, with inadequate access to basic social services and reduced economic opportunities compared to men. Women are also vastly underrepresented in high-level decision-making positions.[75] Benin performs poorly in the United Nations Development Programme (UNDP) Gender Inequality Index, which measures several indicators to assess levels of gender inequality in the areas of health, access to education, economic status and empowerment.[76] Female participation in education, particularly higher education, remains disproportionately low (**Figure 10**).[77] While gender discrimination is widespread, these issues tend to be more pronounced in rural areas.

Benin has adopted several policies and action plans to promote gender equality and has signed on to key international and regional framework agreements protecting women's rights. In 2007, the GoB adopted the National Gender Policy promoting gender equality, women's empowerment and improved social protection, including improvements to gender inequality in education and training. The National Policy for the Advancement of Women and Gender Equality (2009–2016) included specific targets for gender equality by 2025. Like many countries in the region, Benin has two parallel and overlapping judicial codes – one based on Western, mainly French, systems and one based on traditional systems. Under the Western system, women's rights are reasonably protected, and Benin is a signatory to most of the major international conventions on women's rights. Under the traditional code, however, while there is variation among ethnic groups, women often do not share the same freedoms as men.

[73] "Benin National Renewable Energy Action Plan," ECREEE / SEforALL, (2015): http://se4all.ecreee.org/sites/default/files/paner_editing_final_.pdf
[74] See **Annex 4** for more details
[75] "Benin Country Overview," The World Bank: https://www.worldbank.org/en/country/benin/overview
[76] "Gender Inequality Index," UNDP, (2015): http://hdr.undp.org/en/composite/GII
[77] "Benin Participation in Education," UNESCO Institute for Statistics, (2018): http://uis.unesco.org/en/country/bf?theme=education-and-literacy

Figure 10: Rates of Enrollment in Tertiary Education



Source: UNESCO Institute for Statistics

In the energy sector, efforts have been made to implement measures under the regional framework, ECOWAS Policy for Gender Mainstreaming in Energy Access, as well as at the national level. As part of this process, the Government has established a gender focal point at the Ministry of Energy to promote inclusive participation for women in the energy sector. Under its newly developed off-grid regulatory framework (EHR), Benin has emphasized gender mainstreaming and social inclusion, encouraging project developers eligible to receive funding under the OCEF facility to take gender and social impact aspects into account in their project design. This includes an analysis of the project's implications for each target population group (men, women, youth, disadvantaged) at each stage of the project life cycle along with corresponding corrective measures that will be implemented if the project does not benefit all groups fairly. Developers receiving assistance from OCEF are required to (i) commit to implement certain gender and social measures; (ii) assess these issues in the project's area; and (iii) include indicators in the system operation monitoring plan.[78]

Despite these initiatives, gender mainstreaming in the country's energy sector requires additional capacity building of staff and the implementation of management systems at the institutional level to guide gender responsive leadership and decision-making.

1.2.3 Key Challenges

Some of the key energy sector challenges facing Benin include (but are not limited to) the following:

- **Investment in Grid Extension and Maintenance**: Economic growth and corresponding increases in electricity demand are putting pressure on power supply – a mismatch that will continue to burden the electricity transmission and distribution network that needs maintenance and investment to reduce losses and expand access.

- **Electricity Tariffs**: Average electricity tariffs in Benin (USD 0.22/kWh) are slightly above the ECOWAS region's average tariff of USD 0.20/kWh.[79] Benin subsidizes electricity tariffs for low-income consumers, providing electricity to poorer households below the cost of supply with funds from

[78] "Regulatory Framework for Off-Network Electrification, Cadre Réglementaire de L'électrification Hors-Réseau (EHR)," Benin Energie & Electrification Hors Reseau: https://www.benin-energie.org/bilan-energetique.html

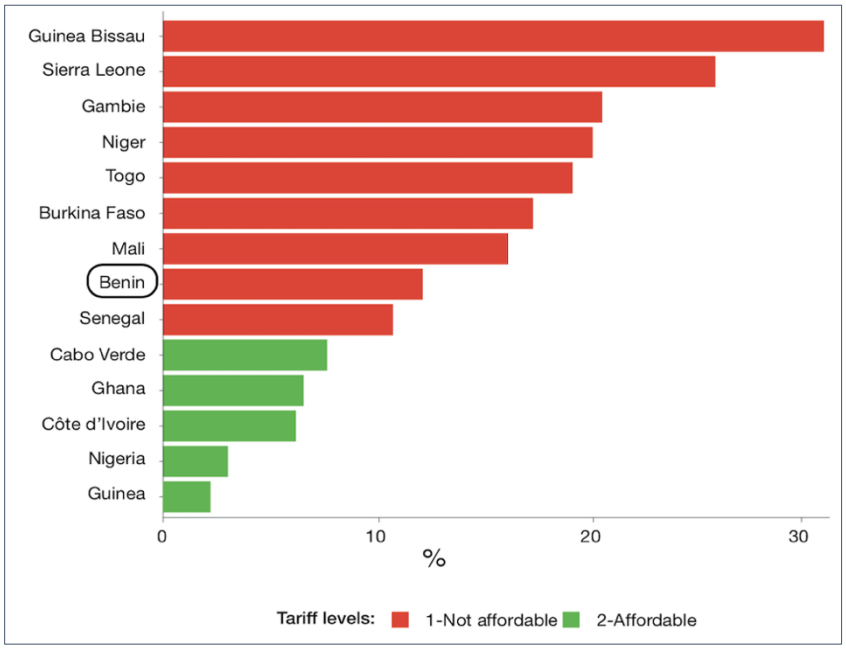
[79] "Electricity Tariffs in ECOWAS Region," African Development Bank Group, Energy Policy, Regulation and Statistics Division, (September 2018): http://www.ecowrex.org/sites/default/files/pesr1_-_energy_statistics_bulletin_september_2018.pdf

the GoB and the country's utilities (CEB and SBEE) through residential and commercial consumers who pay higher electricity rates. Despite this cross-subsidization scheme, average households in the country still spend a disproportionate amount of their income on electricity (**Figure 11**).

- **Utility Financial Performance**: Without cost-reflective tariffs in place, both CEB and SBEE are not financially viable, as they routinely run annual losses and lack the ability to invest sufficiently in grid extensions and maintenance. As a result, Benin's power sector remains largely dependent upon foreign assistance.

- **Imbalanced Energy Mix and Lack of Energy Security**: The country's power sector is overly reliant upon thermal and large hydropower – technologies that are susceptible to price volatility and climatic conditions – and on power imported from neighboring states, which accounts for more than 80% of its supply. There is also little investment in non-hydro renewable energy, which cannot complete with cheaper baseload power without significant policy and financial support.

Figure 11: Share of Income Spent on Household Electricity in ECOWAS Countries, 2018



NOTE: Liberia is excluded from the analysis; the threshold for what is considered an affordable tariff is 10% of income spent on electricity – a household is considered energy poor if more than 10% of income is spent on energy/fuel to maintain adequate level of comfort; On average, households in the ECOWAS region spend 17% of their income on electricity.

Source: ECOWAS Regional Electricity Regulatory Authority

- **Rural Electrification:** Energy access is a huge challenge for Benin. With a rural electrification rate of 11% and more than half of the population still living in rural areas, the IEA estimates that some 8 million people are without access.[80] While SBEE is pursuing a number of planned extensions to the

[80] "Energy Access Outlook, 2017: From Poverty to Prosperity," International Energy Agency, (2017): https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf

network, the GoB is implementing a framework to engage the private sector in development of off-grid areas through stand-alone solar and mini-grid solutions.

- **Local Financial Institutions:**[81] Local financial institutions (FIs) and microfinance institutions (MFIs) lack sufficient internal capacity and credit appetite to invest in the renewable energy/off-grid sectors. This challenge is complicated as it arises mainly from the risk perceptions of FIs, which influence whether efforts should be made to develop strategies and customize financial products to target a nascent market, where there is often limited knowledge of technologies, market characteristics and historical data on portfolio credit performance. There are also likely misperceptions 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 may be an issue. The renewable energy/off-grid space is particularly complicated given relatively high transaction costs and a comparatively unfavorable regulatory environment that exists in the country.[82]

- **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 expedite growth of the market, including a robust technical assistance (TA) platform to supplement ROGEP's objectives. This platform should address *inter alia* (i) awareness raising, education and training for consumers, including organization of appropriate community management structures; (ii) solar PV system supply chain and operations and maintenance (O&M) services, including training of local technicians to ensure that the cost of maintenance is affordable and sustainable; and (iii) standards for equipment and service providers (i.e. installers, technicians) to guide customers to companies providing the best value for their money. These measures should be part of a national rural electrification sector strategy to inform decision-making of key stakeholders surrounding development and regulation of the country's stand-alone solar PV market.

[81] The role of FIs is examined in further detail in **Section 3**.

[82] 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).

1.3 National Policy and Regulation

1.3.1 National Electricity/Electrification Policy

The 2009 Strategic Plan to Develop the Power Sector in Benin confirms the following long-term strategic objectives in the energy sector through 2025:[83]

- Improvement of the legal and institutional framework
- Strengthening of national energy security by diversifying the energy mix and improving electricity supply reliability
- Increasing energy access by building new power plants, setting rural electrification targets, and improving regional interconnection
- Promoting energy sector investments and improving the business environment
- Promoting energy efficiency nationally
- Provide 150 villages annually with electricity access.

In 2016, the Government adopted the Emergency Action Plan (Programme Énergétique d'Urgence Nationale du Bénin, 2015-2030), and considered this to be the country's de facto 'Master Plan' for the electricity sector.[84] This plan aims to increase domestic generation capacity and improving the financial viability of the distribution segment. It also includes an investment program with four major components: (i) upgrade thermal generation capacity and add new capacity (420 MW in total), (ii) develop renewable energy capacity (147 MW), (iii) restructure SBEE, (iv) develop an energy efficiency program (public buildings and residential sectors). The plan notably lacks measures promoting IPPs, provisions for a tariff increase, an investment expansion plan and a framework to support renewable energy. There are also no specific provisions in the policy that pertain to development of the off-grid sector.

1.3.2 Integrated National Electrification Plan

A fully integrated national electrification plan currently does not exist in Benin. While the Policy on Rural Electrification (2016) and Policy and Strategy Document to Develop the Power Sector (2008) are considered national electrification plans, they are outdated and neither includes specific off-grid provisions. Rural electrification falls under the purview of the EHR framework that has yet to be implemented.

1.3.3 Energy and Electricity Law

Benin has two fundamental electricity laws:

- Benin-Togo Electricity Code: The 2005 law is based on an energy agreement concluded between the two countries in 1968 and later revised in 2005 in order to add provisions to allow IPPs in the electricity generation segment, which was until then under CEB's monopoly. In 2006, the Code was reviewed to liberalize the production and distribution segments. CEB remains the single buyer of commercial electricity in Benin; for private operators to enter the electricity markets of either Benin or Togo, they must sign a concession contract with CEB or a Power Purchase Agreement (PPA) with SBEE.[85]

[83] "Benin-Europa, Fiche-Pays Bénin," Facilité d'Assistance Technique Énergie Durable pour Tous/Afrique de l'Ouest et Centrale, EU, 2016.
[84] "Benin Gets World Bank Support to Improve Energy Services," World Bank, (2017): http://www.worldbank.org/en/news/press-release/2017/06/23/benin-gets-world-banks-support-to-improve-energy-services
[85] "Prospectus d'Investissement, État des lieux et perspectives: Bénin," ECREEE, (2016) : http://www.ecreee.org/sites/default/files/presentation_of_action_agendas_and_ip_advancements_by_national_directors_for_energy_-_benin_-_sakariyou_mahman_director_for_energy.pdf

- Benin Electricity Code: The 2006 code governs the electricity sector in Benin only and completes the Benin-Togo Electricity Code. The code organizes the liberalization of the production and distribution segments and allows concession contracts to be signed with IPPs. However, power sector reform has had little success, with distribution still operated by SBEE and transmission by CEB.

Neither code provides any legal context for the off-grid sector; however, the EHR framework that is under development intends to change this through several key reforms to each law that would establish a framework to mobilize off-grid renewable energy development.

1.3.4 Framework for Stand-alone Systems

Figure 12 is an overview of the key national policies, programs, laws, and regulations pertaining to Benin's framework for stand-alone systems. The gaps in this framework are addressed in **Section 1.3.5**.

To date, the Government's efforts to establish a supportive policy and regulatory framework for the off-grid sector are progressing well, as evidenced by the country's 14-point improvement in its World Bank Regulatory Indicators for Sustainable Energy (RISE) energy access score between 2015 and 2017. In the 2017 RISE evaluation, Benin ranked fifth in West Africa and the Sahel and was among the highest scoring countries in Africa (**Figure 13**).

Figure 12: Policy and Regulatory Framework for Stand-alone Systems

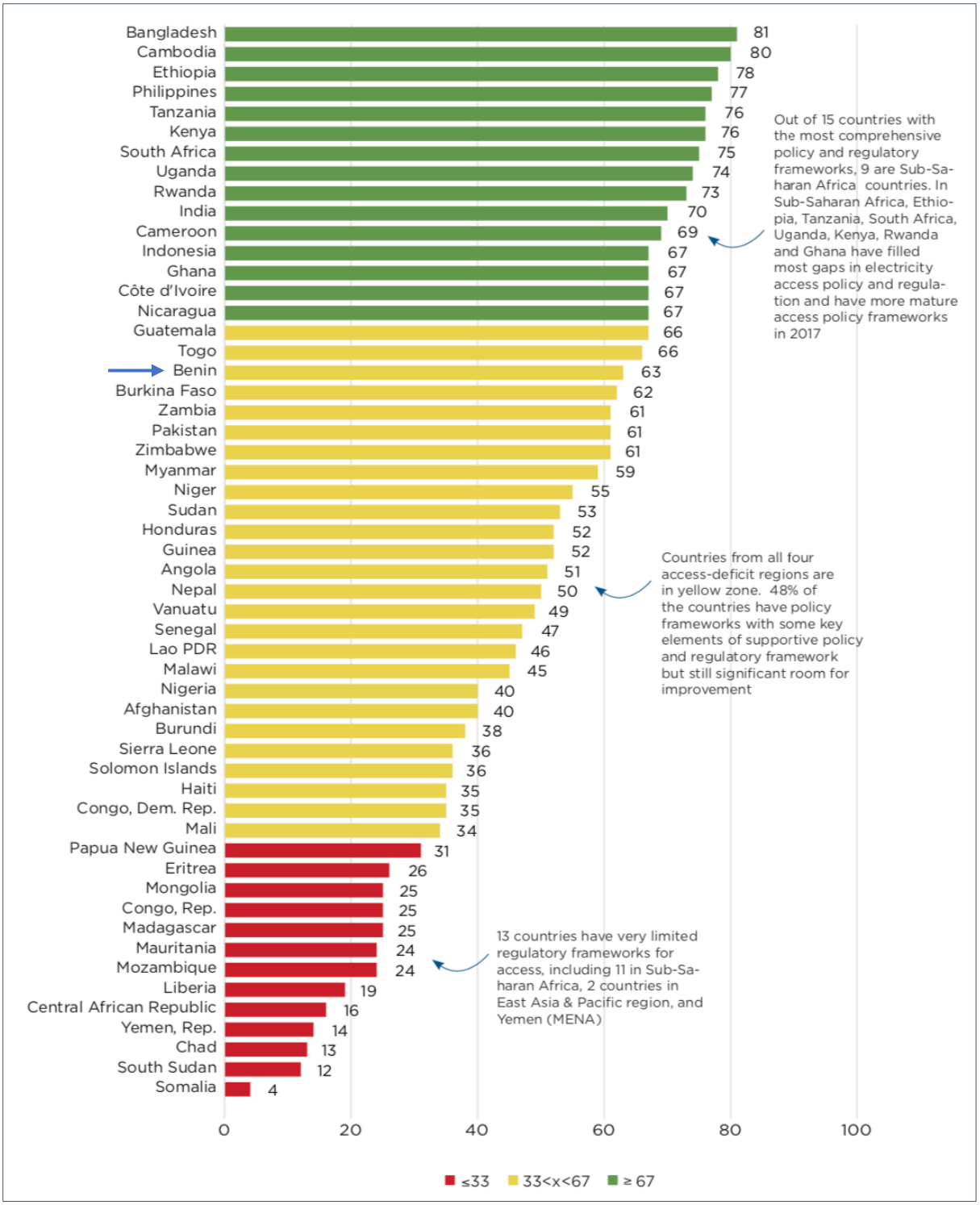
BENIN			
	World Bank RISE 2017 Energy Access Score: 63 World Bank RISE 2015 Energy Access Score: 49	2017 ranking among West Africa and the Sahel (ROGEP) countries: 5th	
Policy/Regulatory Support and Financial Incentives	**Specific national policies, laws and programs**[86]		
	National electrification policy with off-grid provisions	x	
	Integrated national electrification plan	[ ]	EHR
	Energy/electricity law with off-grid provisions	x	
	National programs promoting off-grid market development	√	OCEF
	Specific target for rural electrification	√	Universal access by 2030
	Financial incentives		
	Subsidies, tax exemptions or related incentives for solar equipment/stand-alone systems	√	VAT reduction on solar equipment
	Standards and quality		
	Government-adopted international quality standards for stand-alone systems	√	ISO & IEC equipment standards
	Government-certified program for solar equipment installers	x	
	Consumer awareness/education programs	x	
	Concession Contracts and Schemes	[ ]	Concessions for rural electrification will come into effect when EHR is implemented
	Business Model Regulation	√	EHR / OCEF

√ = existing/implemented provisions in the current regulatory framework
X = no existing provisions
[ ] = planned/under development

Source: World Bank RISE, Stakeholder interviews and GreenMax Capital Advisors analysis

[86] The EHR framework remains under development as of late 2018, while the OCEF financing facility launched in early 2018, with the second financing window due to open in 2019.

Figure 13: Distribution of RISE Electricity Access Scores in Access-Deficit Countries, 2017[87]



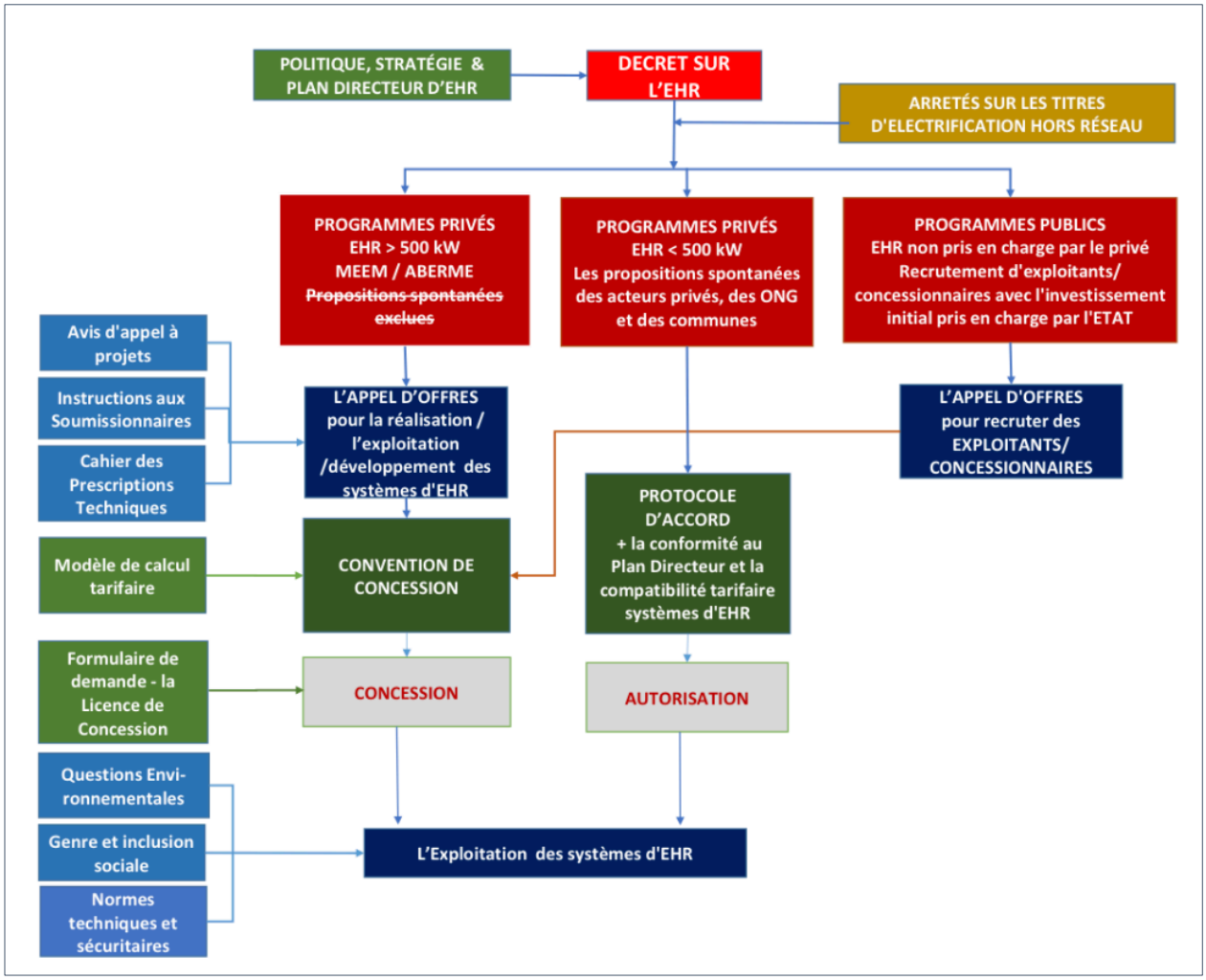
Source: World Bank Regulatory Indicators for Sustainable Energy

[87] "Policy Matters: Regulatory Indicators for Sustainable Energy," World Bank ESMAP, (2018): http://documents.worldbank.org/curated/en/553071544206394642/pdf/132782-replacement-PUBLIC-RiseReport-HighRes.pdf

1.3.4.1 Existence of Specific National Programs

Benin's EHR framework includes financial incentives for the private sector, concession schemes, technical regulation, quality standards, and gender and social inclusion components (**Figure 14**). The plan falls under the broader OCEF initiative, which provides a platform for organizations and companies in Benin to search for potential partners to finance and develop off-grid clean energy projects. The GoB has partnered with SNV, GSMA, and other private sector partners to pursue a range of policy measures to ensure a supportive framework is in place to catalyze OGS market growth. The EHR framework is expected to cost about 200 billion FCFA, with approximately half of the implementation funds raised as of the end of 2017.[88]

Figure 14: Off-Grid Electrification Policy and Strategy (EHR Framework)



Source: ABERME

[88] "Regulatory Framework for Off-Network Electrification, Cadre Réglementaire de L'électrification Hors-Réseau (EHR)," Benin Energie & Electrification Hors Reseau: https://www.benin-energie.org/politique-et-strategie.html

1.3.4.2 Financial Incentives

The EHR plan includes a contractual framework and regulatory regime for the Government/ABERME to provide financial incentives to the private sector in the form of a tariff that reflects the full range of capital and operating costs of developing an off-grid system and ensures an acceptable return on the private sector capital investment required. The framework uses a Cost-Plus pricing methodology consistent with Benin's electricity code tariffs. These tariffs are included in the framework to ensure coverage of all costs incurred by the concessionaire in the design, construction, acceptance of works, commissioning and operation of the project. ABERME will be the entity responsible for managing the private sector engagement process and approving these costs, with regulatory oversight from ARE.[89]

The Government of Benin also has the Rural Electrification Fund (ERF) in place as a means to ensure availability of adequate financial resources for rural electrification. The ERF draws from various sources, including grants, donor funds, and taxes applied to power generation. Although the ERF is under-funded and thus has had limited impact, it is a strong incentive towards catalyzing off-grid development in Benin. Going forward, it will be crucial for the GoB to increase public investment in the ERF through various mechanisms. This can be achieved through a variety of methods including the unpopular political decisions to increase electricity tariffs and/or power production taxes.

1.3.4.3 Standards and Quality

The GoB has adopted IEC and ISO standards for stand-alone systems but has yet to implement certification standards for solar equipment installers. The EHR program recommends IEC technical and safety standards for off-grid electrification in Benin. The National Agency for Standardization, Metrology and Quality Control (ANM) will consider these standards when its Technical Committee develops Benin's long-term national quality standards for off-grid electrification. The EHR program also includes specific provisions covering environmental regulation as well as a monitoring and evaluation framework for EHR projects administered by ABERME.[90]

1.3.4.4 Concession Contracts and Schemes

Under the new proposed policy, Benin's land mass has been split into 15 zones as part of the country's Concessions for Rural Electrification (REB) program. Under this scheme, which is yet to be implemented, localities within these different zones have the opportunity to adopt their own electrification programs as well as issue calls for concession bids. Within the REB framework, priority programs for rural electrification are identified within the various localities. These initiatives will be largely funded through the ERF, which draws from several funding sources, including national government grants, donor funds and power production taxes. Although the impact of the ERF has been minimal to date, this is expected to change following implementation of the EHR regulatory regime.

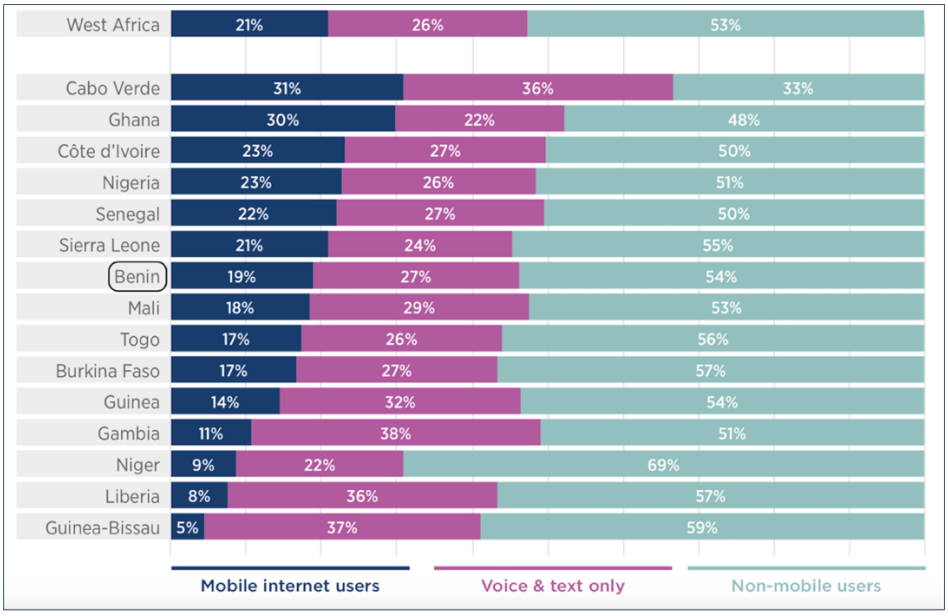
Under the proposed EHR framework, off-grid operators will be selected from a pool of applicants who respond to a request for applications launched by ABERME. Applicants will submit proposals for the construction and operation of an off-grid power system and successful applicants will enter into a concession agreement. The EHR operating framework provides procedures for off-grid operators to obtain a license, a proposed application format for licenses and concession agreements, and additional guidelines addressing agreement timelines, partner responsibilities, and procedures for establishing a connection to the national network or that of another concessionaire.

[89] "Regulatory Framework for Off-Network Electrification, Cadre Réglementaire de L'électrification Hors-Réseau (EHR)," Benin Energie & Electrification Hors Reseau: https://www.benin-energie.org/bilan-energetique.html
[90] Ibid.

1.3.4.5 Specific Business Model Regulation

The EHR regulatory regime, combined with the OCEF, provide a supportive framework for off-grid business models to develop in Benin. The Government can take additional measures to support PAYG business models that have already been deployed by private solar companies engaged in the market. As was demonstrated in East Africa in recent years, the proliferation of mobile money platforms can rapidly facilitate energy access. Recent data suggests that there is an opportunity for the GoB to bring together key stakeholders in the off-grid sector (solar providers, telecommunications companies etc.) to take advantage of the country's rapidly growing mobile internet usage and expand PAYG options (**Figure 15**).

Figure 15: West Africa Mobile Internet Penetration Rates, 2017[91]



Source: GSMA Intelligence

1.3.5 Capacity Building and Technical Assistance

To overcome the challenges surrounding rural electrification, a range of technical and financial resources from both the public and private sector must come together. At the institutional level, the ABERME and the electricity market regulator, ARE, among others, will play key roles in establishing a supportive policy and regulatory framework. Additional reforms to the power sector may be required to provide the incentives necessary to increase private sector participation. Local FIs and MFIs will need incentives and support to develop and implement new financial products and administrative procedures to lend to the off-grid sector. International and local solar companies will need policy and financial support. Local technical capacity of the solar sector will need to be developed to ensure long-term O&M services are available and sustainable. Above all, financing and TA will be critical for all market actors – government, financial institutions, end-users, suppliers and service providers – in order to accelerate growth.

Table 8 identifies some of the policy/regulatory challenges facing off-grid market development in Benin and the proposed mitigation measures/TA interventions to overcome these gaps.

[91] "The Mobile Economy: West Africa 2018," GSMA Intelligence, (2018): https://www.gsmaintelligence.com/research/?file=e568fe9e710ec776d82c04e9f6760adb&download

Table 8: Gaps in the Off-Grid Policy and Regulatory Framework[92]

Indicator	Policy/Regulatory/Market Gaps	Recommended TA Intervention
1. Specific National Policies, Laws and Programs	**A. Lack of National Electricity / Electrification Policy**	
	a. Main focus of policy is on national grid extension only	a. Help Government develop a comprehensive, fully integrated electrification plan with least cost planning to consider where extension is the most efficient and sustainable approach to increasing energy access vs. development of the off-grid sector – mini-grids and stand-alone systems powered by local renewable resources.[93]
	b. Government is subsidizing fossil fuel electricity production	b. Help Government analyze where fossil fuel subsidies serve as an impediment to development of safe, clean energy access alternatives
	B. Lack of Integrated National Electrification Plan	
	a. Insufficient focus on or understanding of framework to support private sector participation	a. Help Government improve the existing EHR planning framework to encourage private participation in mini-grid and stand-alone solar system options, including *inter alia* preparation of guidelines to enhance collaboration between Government and private companies, industry associations, and other relevant stakeholders to coordinate development of effective policy that is flexible and responsive to the needs of the market
	C. Lack of Energy and Electricity Law	
	a. No specific Energy or Electricity Law with off-grid provisions exists	a. Help Government develop new legal framework that is flexible and helps create appropriate incentives for private sector participation in off-grid market development (e.g. to initiate process of unbundling and SBEE and CEB and support general electricity market liberalization)[94]
	D. Insufficient national policies, laws, programs and/or action plans targeting off-grid market development	
	a. No specific Off-Grid Policy, Law, or Action Plan in place	a. Help Government establish the medium-long term rural electrification strategy in the country through development and implementation of a rural electrification Master Plan
	b. Insufficient focus on or understanding of framework to support private sector participation	b. Help Government improve policy and regulatory guidelines under EHR framework to augment the 2016 Policy on Rural Electrification and create appropriate incentives for private sector participation to expedite off-grid solar market growth, including *inter alia* preparation of procurement schemes and financing mechanisms designed to encourage PPP engagement in the off-grid sector

[92] "Government" as it is used throughout this table refers to the main public institutions, officials and policymakers responsible for planning, management and regulation of the energy sector in Benin (**Table 2**), including the Ministry of Energy, the Director General of Energy (DGE), the Rural Electrification Agency (ABERME), the Regulatory Authority (ARE), and the national utility (SBEE) among other national and local authorities

[93] The EHR regulations currently under development will provide a framework for off-grid RE development when fully implemented

[94] The Government is currently developing a renewable energy law with support from GIZ

2. Financial Incentives (import duties, taxes, etc.)	**A. Insufficiently supportive financial incentives/tax regime**	a. Help Government expand existing financial incentives[95] to cover the entire off-grid stand-alone solar product supply chain, including batteries, inverters or other system components to provide necessary support to the industry b. Help Government establish a Special Task Force to (i) mitigate potential difficulties in customs clearance and import logistics, and (ii) oversee implementation of tax exemptions by coordinating with all agencies and regulatory bodies involved c. Help Government introduce appropriate grant and subsidy schemes which require private funding matches and are predictable and not overly bureaucratic d. Help Government utilize the Rural Electrification Fund to create PPP schemes to share high project development and market entry costs particularly with developers in remote areas e. Help Government analyze where subsidies or exemptions for non-renewable energy sources provide unfair advantage for fossil-fuels and impede development of clean energy solutions
3. Standards and Quality	**A. Insufficient Market Data**	a. Help Government establish a Special Task Force (within DGE or ABERME) responsible for collaborating with the private sector to compile and regularly update a database of critical off-grid market data (solar product imports, costs, sales volumes, resource potential etc., GIS data and other key indicators) that can be (i) utilized by policymakers to make informed electrification planning decisions based on accurate market information, and (ii) made accessible to interested off-grid developers, investors and industry stakeholders
	b. Lack of capacity of local technical sector (solar PV technicians, installers, services providers etc.)	a. Support establishment of technical certification and vocational training programs through government, private sector, and/or academia for installation and maintenance of stand-alone solar systems (e.g. through ABERME) b. Support development of database of best practices / information sharing services to ensure skills transfer from international, local and regional initiatives
	c. Insufficient attention of private companies to environmental/social standards and community engagement	a. Assist private sector and/or civil society organizations to ensure environmental/social standards are in place b. Assist in development of strategies encouraging inclusive gender participation c. Support with the implementation of a repair and recycling framework for off-grid solar systems and equipment
	d. Insufficient public awareness	a. Support Government, trade associations, and civic society organizations to expand existing consumer awareness programs and to develop and implement new consumer awareness, marketing, and education programs on the benefits of off-grid solar products and the existence of related national programs b. Support development and implementation of programs to educate consumers, retailers and distributors on the benefits of quality certified (vs. counterfeit) solar products

[95] The GoB has implemented a reduction in VAT for solar equipment

4. Concession Contracts and Schemes	**A. Lack of clear licensing and permitting procedures**	
	a. Unclear procedures	a. Help Government develop clear licensing and permitting procedures under EHR framework via the forthcoming Concessions for Rural Electrification (REB) plan. Clarify role of the Rural Electrification Fund, and assist implementation of the Priority Programs for Rural Electrification
	b. Insufficient communication and streamlining	b. Help Government develop improved systems for sharing and disseminating information to project developers and key stakeholders, including establishment of a "one-stop-shop" to expedite approval of permits
	B. Lack of understanding of emerging concession and energy services schemes for off-grid providers	
	a. Need for understanding of different SHS concession schemes	a. Help Government understand all options and models for possibilities of granting geographic concessions to private operators of SHS[96]
	b. Need for understanding of emerging 'Integrated Private Utilities' models	b. Help Government understand and develop approaches to facilitate pilots of 'Integrated Private Utility' or 'Energy Company of the Future' schemes.[97]
	c. Public finance laws that hamper deployment of energy services models for public facilities	c. Help Government develop procurement and public finance laws that will facilitate stand-alone solar system investment for public facilities (schools, health care facilities, etc.)
	d. Lack of standardized contracts for energy services provided by private system operators to public facilities	d. Help Government, trade associations or civic society organizations develop model bilateral PPA and Energy Services Contracts for small scale IPPs and ESCOs to sell power or deliver energy services to public facilities (i.e. schools, health care facilities) or deliver solar street lighting services to municipalities
	e. Insufficient protection for stranded investments	e. Help Government develop proper procedures and guidelines to protect against stranded investments from competition among all on-grid and off-grid rural electrification approaches[98]

[96] Different models used to grant geographic concessions to SHS providers can yield wide-ranging results. Some observers have lauded the approaches being used in Rwanda, Nigeria, Togo and DRC as highly successful while, there has been criticism of the approach deployed in Senegal.

[97] Innovative models are emerging for entire geographic areas to be concessioned to integrated private energy services operators who may offer an appropriate mix of solutions within their franchised area (i.e. a mix of SHS, rooftop solar, specialized systems for productive use, mini-grids and micro-grids). This is being piloted by the Shell Foundation in several countries.

[98] As the off-grid sector becomes populated by a variety of different approaches, all private operators are subject to potential stranded investments "when the grid arrives" and even SHS providers can have their assets and revenues threatened when the mini-grid arrives.

5.	**Business Model Regulation**	**A. Lack of understanding about different pricing schemes and business models offered by stand-alone solar system developers**	a. Support capacity building of regulators, Government, and all stakeholders about different pricing schemes offered by stand-alone solar system providers to improve understanding and help avoid unnecessary interventions to regulate.[99] b. Support regulators and off-grid enterprises to collaborate specifically on developing pricing schemes for productive use market segment[100] c. Support capacity building of and foster linkages between off-grid solar companies and telecommunications companies/mobile money providers to help roll out technology platforms and PAYG business models

Source: Focus Group Discussions; Stakeholder interviews; GreenMax Capital Advisors analysis

[99] The term "pricing schemes" used in this context refers to pricing options offered by standalone solar system providers for SHS, productive use, rooftop solar for public facilities, solar street lighting, etc. that are new, innovative and may be difficult for stakeholders to initially well understand. Whether these are PAYG, Lease to Own, electricity sales, commodity-based pricing, time of use or block pricing, the lack of understanding can often cause stakeholders to ask Government to intervene to "protect consumers" where such regulation of the market could in fact be misguided and unwarranted.

[100] The productive use segment is brand new with SHS providers, mini-grid operators and vendors specialized on a single type of SME or agricultural productive use (i.e. grain mills, water pumps, cocoa processing etc.) all grappling to arrive at attractive approaches to billing for energy services. This is a particular area where TA support is much needed to help all stakeholders sort out practical approaches.

1.4 Development Initiatives

1.4.1 National Government Initiatives

To date, there have been relatively few initiatives led by the Government of Benin to address the country's massive off-grid energy challenges. ABERME has had limited success due in large part to a lack of funding. Instead, most ongoing government initiatives are focused on upgrading existing power plants, developing new installed capacity, and making improvements to the distribution network. To manage demand, the Ministry of Energy has also implemented various energy saving projects to manage electricity usage and associated costs in public buildings. Meanwhile, the Government has set an ambitious target for increasing the national electrification rate to achieve universal access by 2030.

1.4.2 DFI and Donor Programs

The U.S. government has been an active partner for the Government of Benin, supporting a range of initiatives to support the country, mainly through Power Africa's Millennium Challenge Corporation, which has a USD 375 million fund in Benin designated to improvement of the power sector. The GoB has invested USD 28 million alongside the MCC as part of the program. The flagship program for development of the off-grid stand-alone solar market segment is the MCC-funded OCEF along with the corresponding EHR regulatory framework. Development Finance Institution (DFI) and donor programs and initiatives supporting development of the off-grid sector are summarized in **Table 9**.

Table 9: DFI and Donor-Funded Off-Grid Development Programs

Project/Program	Sponsor / Funding Source	Timeline	Market Segment(s)	Description
Power Africa "Millennium Challenge Corporation" Program	US Government	2015-Present	Technical assistance, rural electrification, mini-grids, solar home systems, energy efficiency	• The MCC Benin compact enables much needed tariff reform, an improved business environment for private sector IPPs, as well as operational restructuring to ensure the financial viability of the SBEE. • MCC is also supporting the Government with preparation of its first master plan for off-grid electrification (EHR) as well as implementation of the Off-Grid Clean Energy Facility in 2018. The USD 32 million grant fund will finance the following types of off-grid projects: (i) off-grid public infrastructure, (ii) mini-grids, (iii) stand-alone solar systems (pico solar and solar home systems) and (iv) energy efficiency • Projects are recruited by calls for proposals. MCC issued the first call in the first half of 2018 and are currently selecting projects. The second funding window is expected to open at the end of 2018.
Sustainable Use of Natural Resources and Energy Finance (SUNREF) initiative	AFD	2017 - present	Off-grid project financing and TA	• €30 million program provides concessional financing to encourage FIs to fund clean energy projects • Includes TA to validate projects and their eligibility for the program and then present them to partner banks for financing • The facility has been deployed to partner banks in **Benin**, Côte d'Ivoire, and Senegal • The SUNREF initiative has been largely successful in East Africa, where it has focused

Project/Program	Sponsor / Funding Source	Timeline	Market Segment(s)	Description
				on the commercial and industrial (C&I) market segment, where systems are larger, off-takers are often companies with large enough balance sheets to borrow. As a result, this has been one of the stand-alone market segments where there has been some lending to date. The program is now just launching in West Africa and could be a potential partner for ROGEP.
Increased Access to Modern Energy Program	World Bank	2009-Present	Grid extension, mini-grid, pico solar, SHS	• The "Increased Access to Modern Energy" project is being implemented by the World Bank with support from KfW. The project consists of four main support components: - Component A: Electrical network upgrading, - Component B: Electrification and modern energy services in rural areas, - Component C: Sustainable energy services, and - Component D: Project preparation.
Energy Service Improvement Project	World Bank	Ongoing	Technical assistance, Rural electrification, Biomass	• The World Bank's Energy Service Improvement Project will improve the utility's performance as well as expand electricity access in targeted off-grid areas. • The project also promotes best practices for community forest management.
EnDEV (Energizing Development Program)	GIZ	2011-Present	Grid extension, pico-solar, clean cookstoves	• The EnDev program executed by GIZ and financed by various donors is supporting grid extension and densification, as well as pico-solar PV system and distribution of efficient cook stoves in Benin. • Benin, EnDev supports the marketing of photovoltaic products by financially supporting importers and distributors in the field through a result-based finance mechanism: up to 50% of the product FOB cost is paid or given to partner companies which import quality photovoltaic products on every sale they make. In partnership with rural electrification agency ABERME, EnDev also provides financial support to households, productive units and social institutions for the installation of stand-alone systems: SHS, pico PV (for some the price has been reduced up to 50%).
"Bright Lights Benin"	SNV, GSMA, MTN, Greenlight Planet, Angaza, ARESSS.	2016	Distributed energy, rural electrification, stand-alone systems, solar kits.	• The Bright Lights for Benin project which was funded by GSMA's Mobile for Development Utilities Innovation Fund and implemented by SNV, was designed in partnership with the GoB to catalyze the PAYG solar market in Benin. • The project collaborated with various private sector partners including Greenlight Planet (Sunking), ARESSS, Angaza, and MTN to leverage their experiences and expertise on rural distribution networks.

Project/Program	Sponsor / Funding Source	Timeline	Market Segment(s)	Description
RECASEB	EU	2017-2021	Rural electrification	• The EU is providing Benin's Ministry of Energy with institutional support and capacity building as part of the RECASEB program. • The goal of RECASEB is to improve Benin's institutional framework in preparation of the implementation of key reforms. • The program's main components include: - Capacity building within the energy sector - Development of management, supervisory, and other decision-making tools for sector strategies - Improved information sharing and documentation within the sector.

1.4.3 Other Initiatives

Outside of the Government and DFI/donor initiatives mentioned above, there are also several non-governmental organization (NGO) programs and other related initiatives in Benin's off-grid sector.

Solar Electric Light Fund (SELF)[101] and NOVI are two US-based NGO's that are working to advance off-grid electrification in Benin. After beginning work in the country in 2006, SELF helped initiate a solar electrification project for a variety of uses in schools and health clinics in the Kalalé district. This project has helped provide 44 villages with solar powered drip irrigation, solar lighting, and electricity provision in public spaces. Novi has similarly focused its efforts on providing solar lighting and electricity to rural off-grid communities in Benin. The organization sees the great potential of off-grid solar solutions to reduce polluting and expensive kerosene. Novi has set a target to power 10,000 Beninese households by 2020.

JVE (Jeunes Volontaires pour l'Environnement)-Benin and Eco-Benin are two additional NGOs that are working in Benin's off-grid energy sector. JVE Benin is a non-profit that is primarily concerned with climate, energy, water, and both rural and urban development. In Benin, JVE is developing young leaders and encouraging their participation in the sustainable development of their communities. Eco-Benin is working with ten rural communities in Benin to promote various sustainable development projects in the areas of eco-tourism, conservation, and energy. As part of this project, Eco-Benin is promoting solar powered efficient cook stoves in the pilot area of Pendjari National Part, in the Northern region of Benin.

[101] "Ongoing projects," Solar Electric Light Fund, (2018): https://www.self.org/current-projects/

II. OFF-GRID SOLAR PV MARKET ASSESSMENT

This section presents the overall market assessment for stand-alone off-grid solar (OGS) energy systems in Benin. **Section 2.1** provides an overview of the current household off-grid energy situation and estimates potential household market demand for solar energy systems. **Section 2.2** introduces institutional off-grid energy demand and the potential of solar to supply this market. **Section 2.3** evaluates the demand for off-grid solar to serve productive use applications. **Section 2.4** examines the existing off-grid solar product supply chain in the country. **Table 10** summarizes the overall total cash market potential for OGS systems from each of the analyzed market segments. **Annex 2** provides an overview of the Task 2 methodology.

It should be noted that the Task 2 market sizing assesses the total *potential* demand for off-grid solar, as well as variables that affect demand, such as changes in population density, household income, expansion of national grids and access to finance, among other factors. This data will support policymakers and practitioners as they assess market potential over time. However, the quantitative demand estimate has not been revised to reflect *realistic* market potential. Many other factors and market failures will prevent the full realization of this total market potential, and these will vary by market segment.

For household demand, the off-grid solar market is already tangible. Still, many factors will affect household demand for solar products, such as distribution realties, consumer education, competing economic priorities for households, financial shocks, etc. The institutional market will be affected largely by government and donor budget allocations along with the potential for community-based finance. The productive use market is perhaps the least concrete. Considered a relatively new market segment for the off-grid solar industry, productive use market dynamics are not yet well understood. The ability to realize potential productive use market demand will also be affected by many of the factors that commonly determine enterprise prospects in the country, including infrastructure, rural distribution, marketing, access to finance, insecurity, regulation, etc. The data presented in this report is intended to provide a baseline for future research.

Table 10: Indicative Total Cash Market Potential for Off-Grid Solar PV Products in Benin, 2018

Off-Grid Market Segment	Annualized Cash Demand (Units)	Annualized Cash Demand (kW)	Annualized Cash Market Value (USD)	Financed Market Value (USD)
Household				
Pico solar	534,198	1,603	$24,038,913	$0.00
Plug and play	0	0	$0.00	$18,626,153
Small SHS	894	45	$223,514	$42,244,116
Medium and Large SHS	0	0	$0.00	$28,498,015
Household Subtotal	**535,092**	**1,648**	**$24,262,427**	**$89,368,284**
Institutional				
Water supply	64	241	$601,688	-
Healthcare facilities	27	52	$127,425	-
Primary and secondary schools	250	138	$404,145	-
Public lighting	107	53	$160,125	-
Institutional Subtotal	**448**	**484**	**$1,293,383**	**-**
Productive Use				
SME applications for microenterprises	692	173	$432,375	-
Value-added applications	45,152	8,054	$35,787,356	-
Connectivity / ICT (phone charging)	5,669	2,268	$4,886,476	-
Productive Use Subtotal	**51,513**	**10,495**	**$41,106,207**	**-**
TOTAL	**587,053**	**12,627**	**66,662,017**	

Source: African Solar Designs analysis

2.1 Demand – Households

This section analyzes the main characteristics of the household (HH) OGS demand in Benin. Section 2.1.1 provides an overview of the household market segment, including its geographic components. Section 2.1.2 analyzes current household ability and willingness to pay for electricity services to estimate the total potential household sector demand. From this data, the potential household market for off-grid solar products is then calculated for both cash purchases (Section 2.1.3) and financed (2.1.4) purchases. Section 2.1.5 assesses consumer perceptions, interest, and awareness on OGS.

2.1.1 Overview of Household Market Segment

According to the International Energy Agency (IEA), in 2016 there were 1.5 million households (7.6 million people) in Benin without access to electricity.[102] In that year, an estimated 32% of the population had access to electricity, with the rate of access at 56% in urban areas and 11% in rural areas. As shown in **Table 11**, the large majority of the population does not have access to electricity, and households without access are spread across the lowest three income quintiles, between rural, peri-urban and urban areas.

This section gives an introduction to household consumer market segments, their characteristics and size (**Table 11**). It then discusses household sources of income and geographic distribution of off-grid households, both presently and projected over time. This provides context for the next section, 2.1.2, which sizes household segment potential market demand through a series of detailed analyses.

[102] See **Annex 2** for more details.

Table 11: Household Consumer Market Segments[103]

Income Quintile	% w/o Access	# of HH w/o Access	Avg. GDP per HH per year	Energy Tier	% w/o Access	# of HH w/o Access	Avg. GDP per HH per year	Energy Tier	% w/o Access	# of HH w/o Access	Avg. GDP per HH per year	Energy Tier	Geographic segments	Description
	2018 Scenario				2023 Scenario				2030 Scenario					
Highest 20%	1%	4,470	$10,900	Tier 3	1%	5,406	$12,427	Tier 3	1%	6,559	$14,900	Tier 3	High income rural	• Small portion of rural households using a petrol generator set • Has a demonstrated ability to pay for solar off-grid systems
													Mid to high income urban	• Professionals, business owners and salaried people are likely to be connected to the grid. • Small portion without grid access desire replacement to generator power[104]
Fourth 20%	50%	223,514	$4,343	Tier 3	2%	10,812	$4,951	Tier 3	2%	13,118	$5,937	Tier 3	Low income peri-urban / urban "under-grid"	• Low income urban population engaged in SME work or casual labor • Lives near grid but cannot afford or does not have access to connection
Third 20%	90%	402,325	$2,881	Tier 2	3%	16,219	$3,285	Tier 2	3%	19,677	$3,938	Tier 2		
Second 20%	99%	442,557	$2,064	Tier 1.5	4%	21,625	$2,353	Tier 1.5	4%	26,236	$2,821	Tier 1.5	Low income rural	• Engaged in farming, SME or mining support activities • Lives more than 15km from the nearest grid connection.
Lowest 20%	100%	447,028	$1,311	Tiers 1, 1.5	84%	451,444	$1,495	Tiers 1, 1.5	22%	141,944	$1,793	Tiers 1, 1.5		
Total Households without Access to Electricity		**1,519,894**			**Total**	**505,506**			**Total**	**207,535**				

Source: IEA and World Bank; African Solar Designs analysis

[103] See **Annex 1** and **Annex 2** for more details.

[104] This model does not consider connected on-grid households that would purchase OGS systems as a back-up power system due to poor grid quality and reliability. The "households without electricity access" estimates shown here include households without electricity connections, either from a grid connection or from a renewable energy-based off-grid source. This does include "under-grid" households, largely in the lower income quintiles, that live within grid vicinity but are currently not connected. 2023 and 2030 projections assume that under-grid households will become connected in those years.

- **Off-grid household characteristics**

Benin has a high level of extreme poverty (households living below USD 1.90 a day) compared to other countries in the region. The vast majority of the country's households have a low income (**Table 12**).

Table 12: Poverty Headcount in Benin, 2015

Poverty headcount ratio*	% of population
Lives at or below $1.90 a day	49.6%
Lives at or below $3.20 a day	76.2%
Lives at or below $5.50 a day	90.6%

*2011 PPP

Source: World Bank

Local stakeholder interviews found that the National Institute of Statistics has not identified any studies that have decided on the categories of income in the country. A thorough audit would be required to verify such an investigation**.** However, a socio-economic study conducted as part of the PRODERE I VOLET I project in 2013 reveals a segmentation of households into three groups:

- Household the least well off with an average monthly expenditure of CFA 3,450
- Intermediate households with an average monthly expenditure of CFA 7,500
- Well-off households with an average monthly expenditure of CFA 12,250

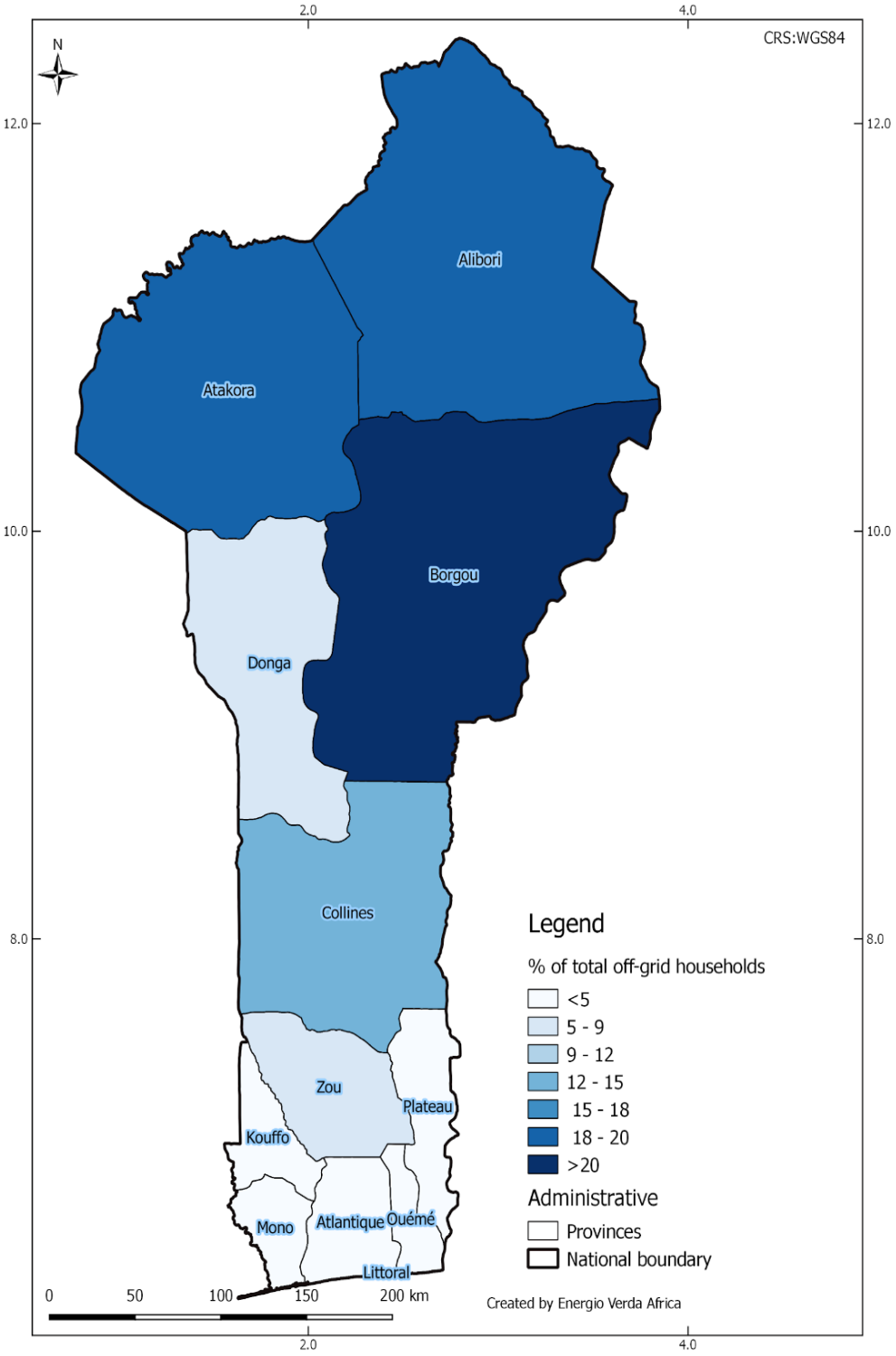
In addition, the willingness to pay of the population, according to the report of the study, is evaluated on a weighted average of CFA 5,104 for energy services; which corresponds to approximately 415 CFA/kWh. A 2015 survey assessed willingness and ability to pay for quality energy. Off-grid households willing to connect to the grid would be willing to pay between 135 and 202 CFA/kWh. There is no other study examining the geographic distribution of households according to their ability to pay as well as their number.

- **Geographic components of the solar market**

This study looks at how the total number of off-grid households and their geographic distribution will change significantly over time. To analyze the potential OGS market over time, GIS maps were prepared from demographic information to present potential market areas for OGS. GIS calculations consider drivers of off-grid household market change including grid extension around current urban and peri-urban centers, mini-grid development for more densely populated rural areas, and population growth. Sources of information for the maps presented below (**Figures 16-19)** can be found in **Annex 1**.

GIS maps shown here are for 2023 and 2030. Data shown for 2023 includes information on existing grid lines only. The data of planned "future lines" is not broken down in enough detail to show in which year future lines will be built, so an assumption was made that all future lines would be built after 2023, but prior to 2030. As shown in **Figures 16-19**, the total size of the OGS market will decrease over time, while also becoming more concentrated in remote regions. This has implications for long-term business models of the solar product market, which will need to consider broader distribution areas as the total number of off-grid households declines and becomes concentrated in areas far from urban centers in the southern part of the country. For example, by 2030 the large majority of off-grid households will be concentrated in the more remote northern region of Benin. Serving this region from an urban base in the south of the country in Cotonou will be logistically challenging and expensive in terms of developing long-distance distribution networks. However, the concentration of off-grid households in the north could also allow suppliers to establish distribution bases there to more effectively serve all three districts of Atakora, Alibori and Borgou.

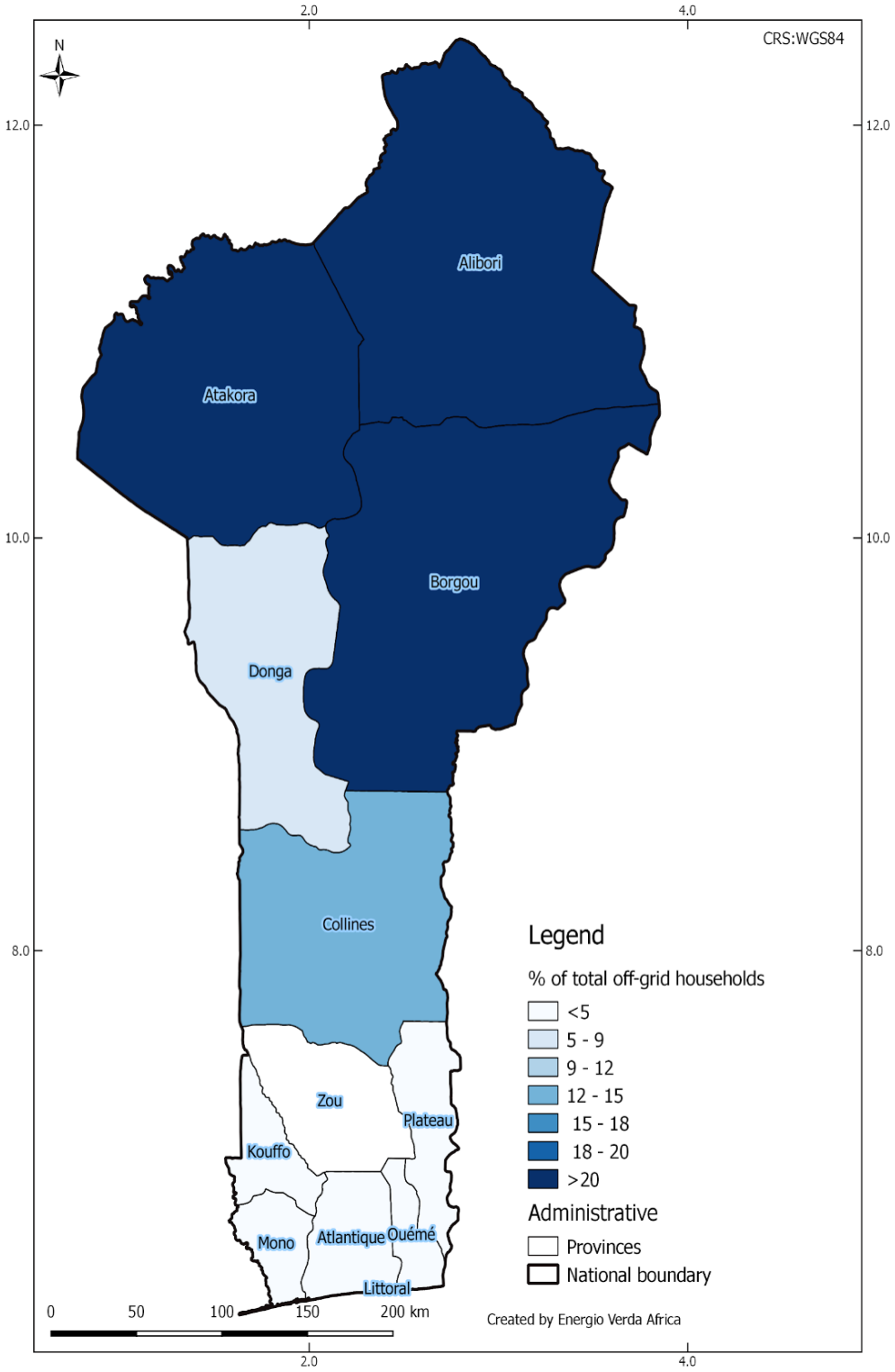
Figure 16: Distribution of Potential Off-Grid Households by Region, 2023[105]



Source: Energio Verda Africa GIS analysis

[105] See **Annex 1** for more details, including data sources.

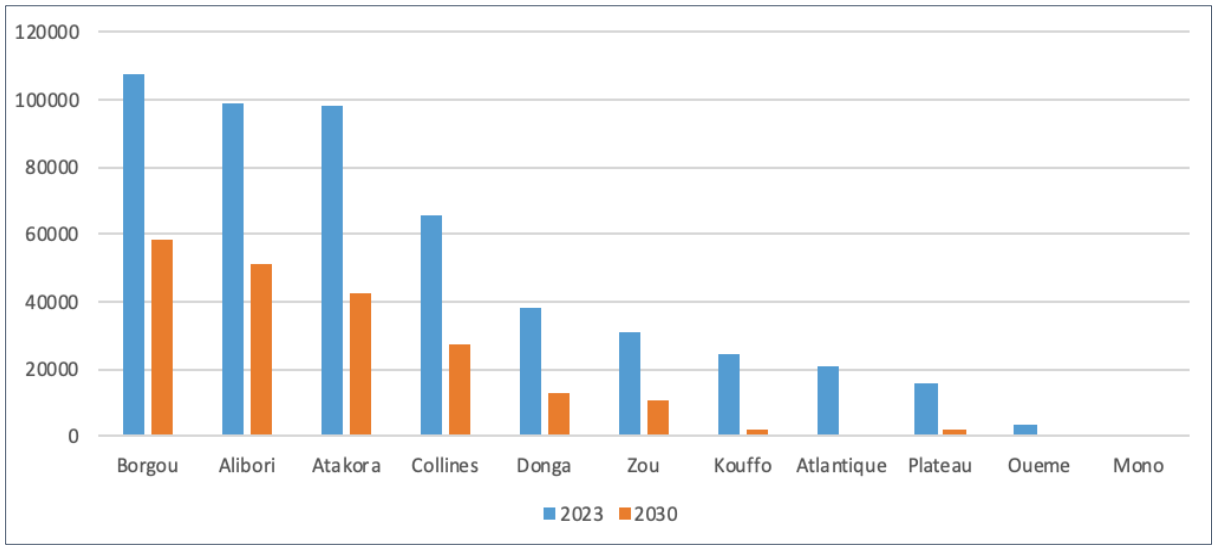
Figure 17: Distribution of Potential Off-Grid Households by Region, 2030[106]



Source: Energio Verda Africa GIS analysis

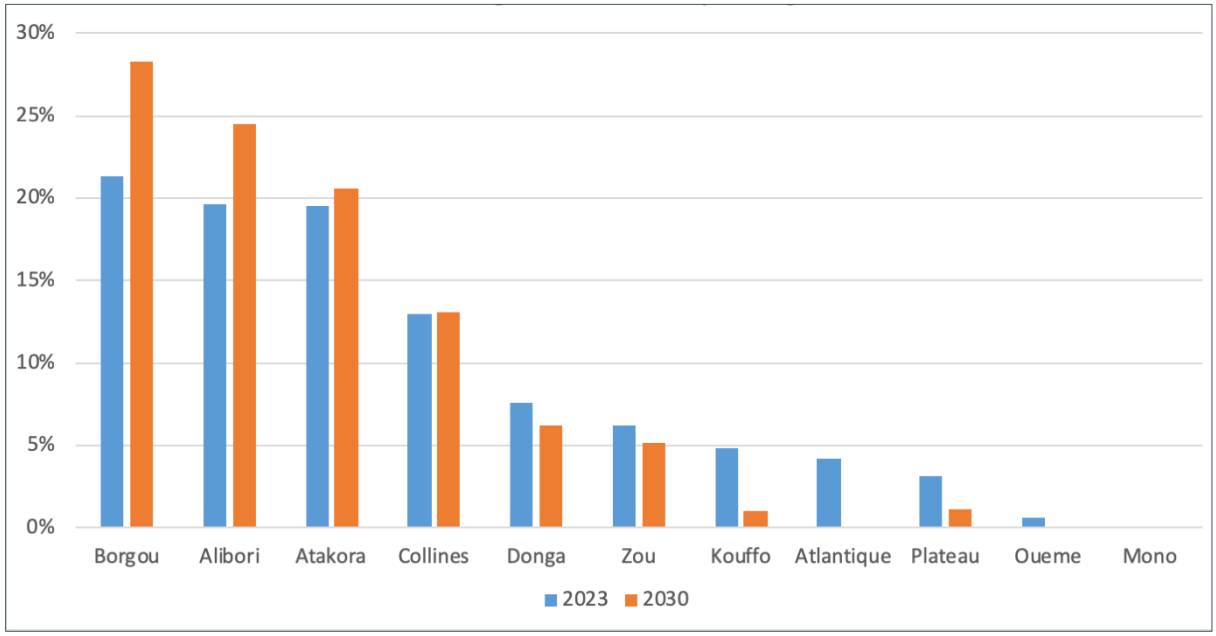
[106] See **Annex 1** for more details, including data sources.

Figure 18: Estimated Number of Off-Grid Households by Region, 2023 and 2030



Source: Energio Verda Africa GIS analysis

Figure 19: Estimated Percentage of Off-Grid Households by Region, 2023 and 2030



Source: Energio Verda Africa GIS analysis

2.1.2 Analysis of Household Market Segment Demand

In order to calculate total potential household demand for off-grid solar products for the national market, this section examines several indicators:

- Household usage and costs of typical rural energy fuels and devices (non-solar)
- How these rural energy technologies align with typical access to "energy tiers"
- Cost of off-grid solar products alternatives, by energy tier
- Household uptake of solar products thus far
- Potential household demand based on household income quintiles

From this data, the potential household market for off-grid solar products is then calculated for both cash purchases and financed purchases.

➢ **Consumption and expenditures on typical rural energy fuels and devices (non-solar)**

According to feedback from focus group discussion (FGD) participants, the most common off-grid electricity sources used by households in rural areas are batteries, accumulator batteries, generators; solar pico kits, and solar home systems. The main household appliances used are lamps, radios, televisions, fans, mobile phones.

Table 13 shows the typical monthly cost of using common rural energy technologies. Household use of different types and amounts of energy technologies is associated with different energy access tiers, as defined in the Multi-Tier Energy Access Framework. For example, a household using one battery powered lantern and one charged cell phone would fall under the Tier 1 level of energy access. A household using two lanterns, one cell phone and a radio would be in Tier 1.5.

These tiers are defined in **Table 14**. Establishing an average monthly household expenditure for each energy tier using common rural technologies shows how household income level aligns with energy tiers. Secondly, it provides a basis to compare these costs to solar products that can offer an equivalent level of service by energy tier. This in turn reveals potential household savings by switching to solar products, as shown in **Figure 20** and **Table 15**.

It should be emphasized that even where households can be categorized into energy tiers by their income, few households actually pay full typical monthly costs because they do not have the available income. In reality, household income is highly variable throughout the year, and they simply do without service for portions of the month and year when cash is not available. This accounts for the difference between "typical monthly costs" (which are real) and "equivalent service costs" (which would be required to maintain the tier-level service). For example, very few households could actually run generators for the number of hours that would enable full tier 3 level services.

Table 13: Rural Energy Technology and Costs[107]

Technology	Description	Average Life (Years)	# of Units/ Month	Unit Operating Cost (USD)	Unit Capital Cost (USD)	Typical Monthly Cost (USD)	Unit Capital Cost (USD)	Typical Monthly Cost (USD)	Unit Capital Cost (USD)	Typical Monthly Cost (USD)
					2018 Scenario		2023 Scenario		2030 Scenario	
Torch lights/Electric Lanterns	Torch lights/electric lanterns powered by D-type, AA-type or AAA-type batteries	0.5	16	$0.22	$2.00	$3.52	$2.17	$3.81	$2.61	$4.59
Cell Phone Charging	Done at a charging station	-	8	$0.17	$0.00	$1.36	$0.00	$1.47	$0.00	$1.78
Smart Phone Charging	Done at a charging station	-	16	$0.17	$0.00	$2.72	$0.00	$2.95	$0.00	$3.55
Battery-powered DC Radio	Radio powered by dry cells replaced two times per month	-	8	$0.22	$0.00	$1.76	$0.00	$1.91	$0.00	$2.30
Small Petrol Generator	The most popular rural generator for basic use is 0.9kW generator (for phone charging, lighting, TV, fan and music system)	2	30	$1.05	$100.00	$31.50	$108.30	$34.12	$130.53	$41.12

Source: African Solar Designs analysis

[107] Data from FGDs, field surveys and various published data sources

Table 14: Typical Tier-Based Energy Costs

Device category and indicative energy supplied	Appliances and level of service	Non-solar devices used to power tier requirement	Typical Monthly Cost (USD) 2018	Typical Monthly Cost (USD) 2023	Typical Monthly Cost (USD) 2030
Tier 0 No electricity	• Characterized by complete lack of electricity services • Many cash-poor consumers are in this situation part of each month when they don't have money to buy dry cells or charge phones	• Rely solely on kerosene, wood and other fuel sources for cooking and lighting	• Subsistence level of energy • Absolute energy poverty	• Subsistence level of energy • Absolute energy poverty	• Subsistence level of energy • Absolute energy poverty
Tier 1 Range: 1 to 20 Wh/day	• Access to one torch powered by dry cell batteries • One cell phone powered by charging service	• One battery-powered light requires dry cell replacement on weekly basis • One cell phone charged 8 times per month	$4.88	$5.29	$6.37
Tier 1.5 Range: 20 to 100 Wh/day	• Access to one torch and one lantern each powered by dry cells • One cell phone powered by charging service • Radio powered by dry cells	• Two battery-powered light points require dry cell replacement on weekly basis • One cell phone charged 8 times per month • Radio dry cells replaced two times per month	$10.16	$11.01	$13.26
Tier 2 Range: 55 to 500 Wh/day	• One torch and two lanterns powered by dry cells • One cell phone and one smart phone powered by charge service • Radio • DC TV	• Three battery light points require dry cell replacement on weekly basis • One cell phone charged 8 times per month and one smart phone charged 16 times per month • TV/Radio powered by lead acid battery recharged once per week	$18.16	$19.67	$23.70
Tier 3 Range: 500 to 2500 Wh/day	• Five lighting points • Multiple cell/smart phones • AC radio and music system • AC TV	• Generator powers a set of appliances	$31.50	$34.12	$41.12

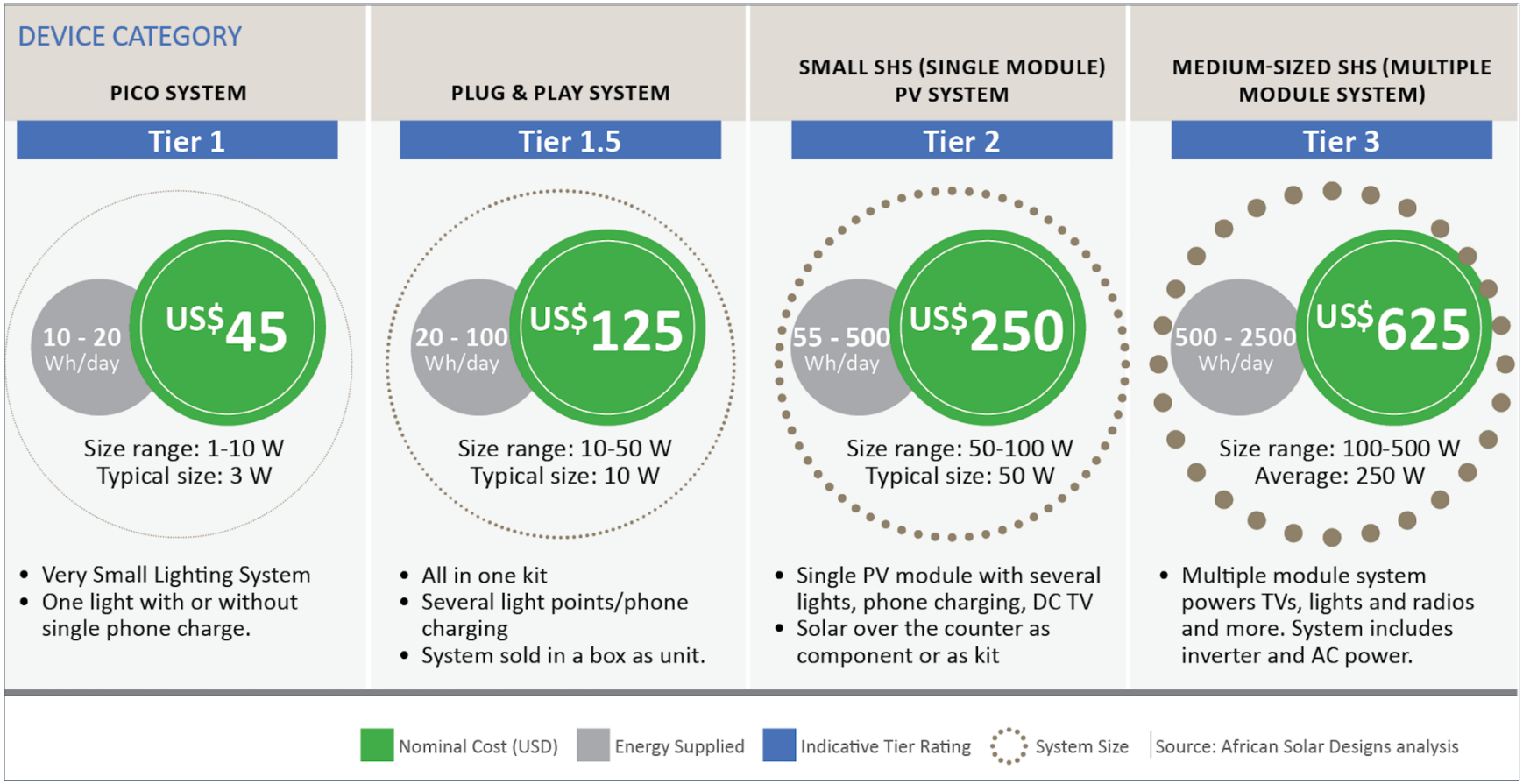
Source: African Solar Designs analysis

Per **Table 14**, it can be seen that, given the purchase price of dry cells and the cost of phone charging, the "ideal" electricity availability is extremely difficult to sustain. This is especially true where there is a high incidence of poverty in rural areas and lack of regular incomes. In reality, households often must reduce their energy consumption when cash is not available. This means that even a Tier 2 level family might drop to Tier 1 for a week each month when cash is not available to pay for phone charging or dry cell purchase.

- **Household solar PV system types**

Solar PV systems can provide lower cost and higher levels of service than existing dry cell, phone charging and generator options. In order to model how solar systems can meet existing energy use categories, levels of service and ability to pay, four types of household solar systems are configured to match the tier-based demands of off-grid communities. The system descriptions, energy outputs, prices, tier ratings and target consumer groups are presented in **Figure 20**.

Figure 20: Household PV System Descriptions and Market Segments



Source: African Solar Designs analysis

- **Current usage and procurement process for household solar products**

According to the FGDs, solar is important for off-grid electrification in Benin. Solar is one of the main sources of energy that can be exploited and OGS solutions are widely utilized. The implementation of various government and donor-funded energy access projects have contributed enormously to this awareness.

The northern part of the country has benefited the most from off-grid solar projects for two reasons: (i) this part of the country has a lower access to electricity and (ii) benefits from better sunshine. Off-grid solar projects in Benin are mainly aimed at electrifying households and socio-community infrastructure in off-grid localities. However, when the share of households with access to electricity from solar energy are considered, this role is still marginal.

- **Potential household demand for off-grid solar products**

Looking beyond current use of off-grid solar products by households, this study analyzes potential for OGS market development by estimating potential household demand based on household income. Household income shown in **Table 15** is sourced from World Bank demographic data based on household surveys, which reports income by population quintiles. From household income, potential for energy spending is estimated as 10% of monthly income.[108] Future scenarios project higher energy budgets as household incomes rise with economic development over time. In all scenarios, the large majority of off-grid households will fall under the lowest income quintile.

Table 15: Energy Expenditure of Different Income Groups

Population Income Quintiles	Per Capita Income (USD per month)	Household Income (USD per month)	Energy as % of Income	Monthly Energy Budget (USD)
2018 Scenario				
Lowest Quintile of Population	$21.86	$109.29	10%	$10.93
2nd Quintile of Population	$34.40	$171.99	10%	$17.20
3rd Quintile of Population	$48.01	$240.07	10%	$24.01
4th Quintile of Population	$72.38	$361.90	10%	$36.19
Highest Quintile of Population	$181.67	$908.33	10%	$90.83
2023 Scenario				
Lowest Quintile of Population	$24.92	$124.60	10%	$12.46
2nd Quintile of Population	$39.22	$196.09	10%	$19.61
3rd Quintile of Population	$54.74	$273.71	10%	$27.37
4th Quintile of Population	$82.52	$412.61	10%	$41.26
Highest Quintile of Population	$207.12	$1,035.62	10%	$103.56
2030 Scenario				
Lowest Quintile of Population	$29.88	$149.39	10%	$14.94
2nd Quintile of Population	$47.02	$235.11	10%	$23.51
3rd Quintile of Population	$65.64	$328.18	10%	$32.82
4th Quintile of Population	$98.94	$494.72	10%	$49.47
Highest Quintile of Population	$248.34	$1,241.69	10%	$124.17

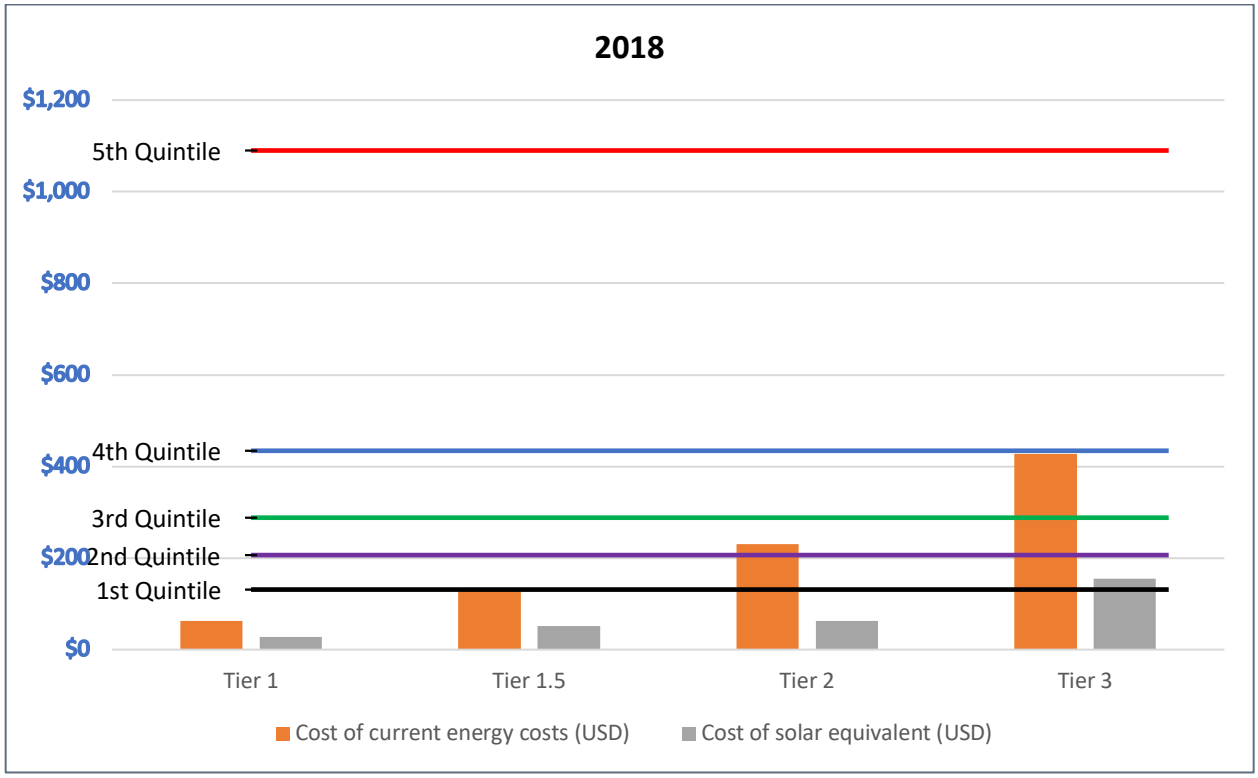
Source: African Solar Designs analysis

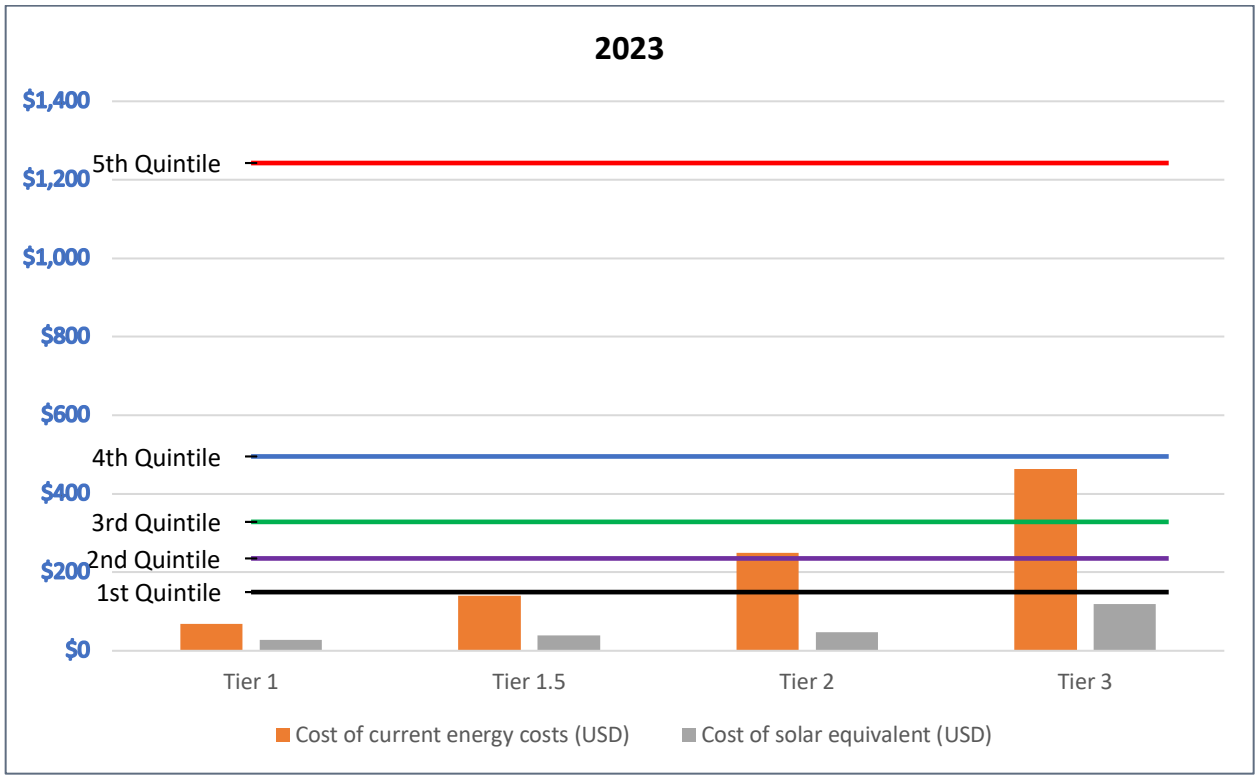
[108] See **Annex 2** for more details.

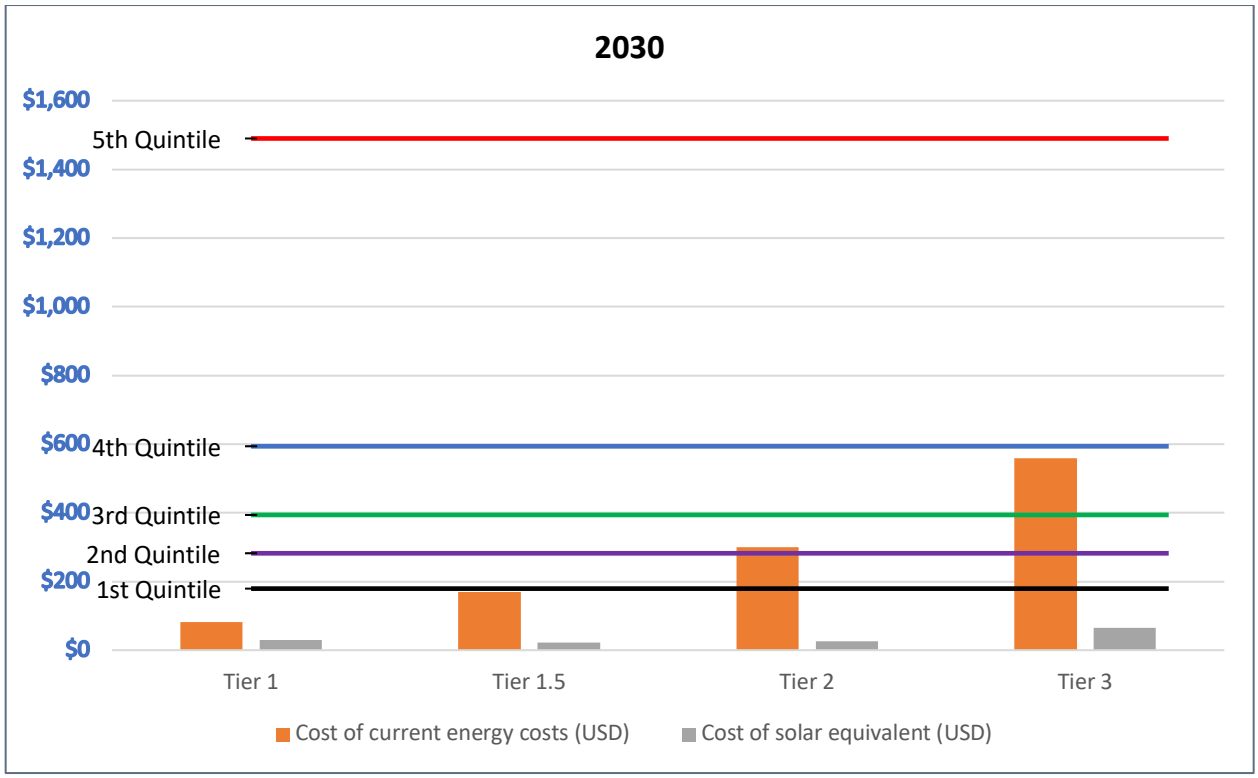
Figure 21 summarizes the preceding data in this section by comparing household energy spending with typical rural energy costs and their solar equivalents. This analysis presents annualized costs (not including financing cost) of current energy technologies for each energy tier, compared with the annual cost of an equivalent solar product. Both the annual costs of current energy technologies and equivalent solar solutions consider the capital costs of the units, and the operating costs considered over the average unit life times.

The data clearly shows strong potential savings for households to switch to solar products. Affordability also increases over time, as the cost of solar technology reduces, while the cost of traditional energy sources increases with inflation, and household income increases. Affordability here is shown by comparing annual income and energy costs over the life of a product. This indicates the need for short term financing, as many households still struggle to pay up front unit capital costs to achieve subsequent savings.

Figure 21: Annual Household Energy Budget by Quintile, Annual Energy Costs and Cost of Solar Equivalents







Source: African Solar Designs analysis

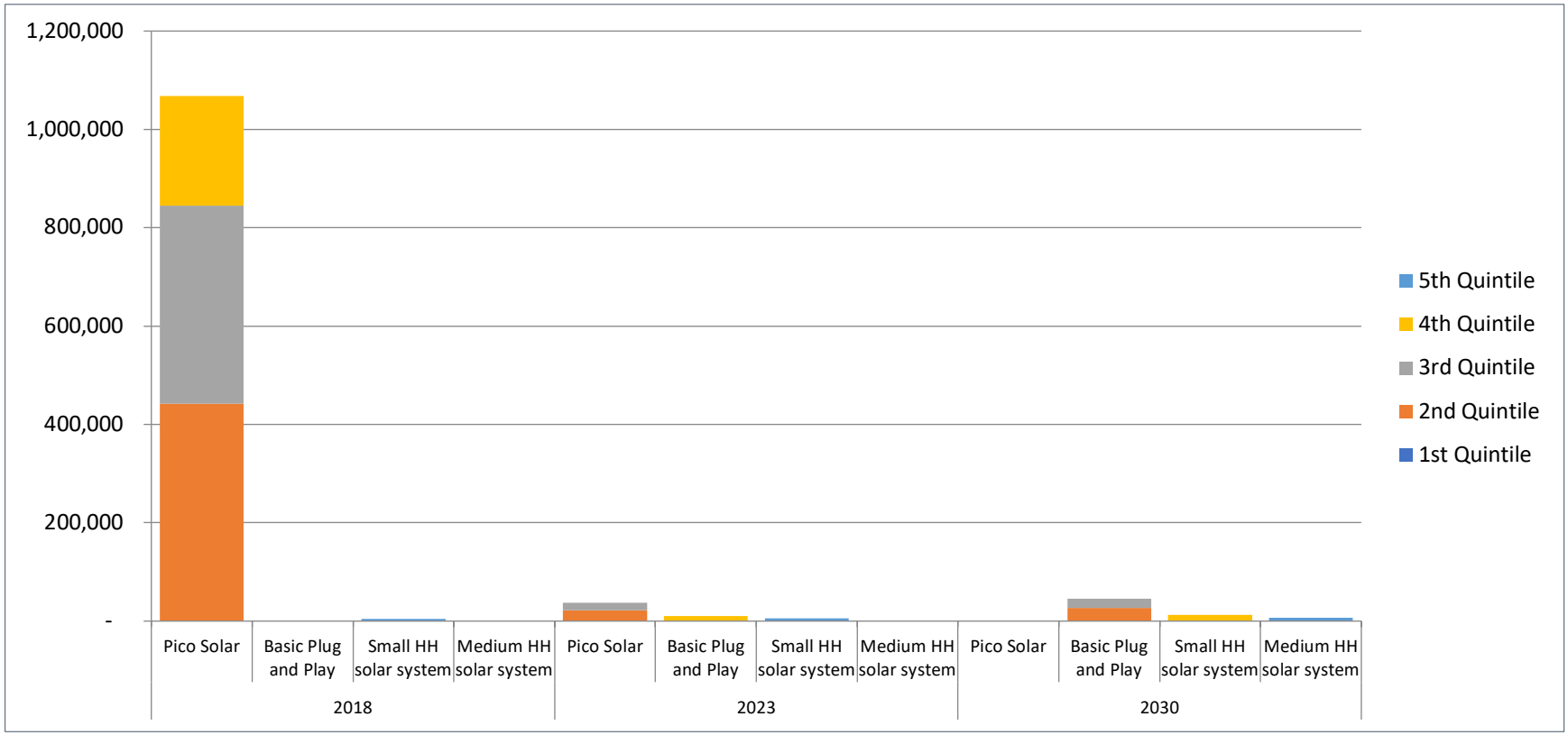
2.1.3 The Market for Household Devices without Consumer Finance

This section analyzes the cash market for various income levels and the corresponding energy services powered by OGS systems they can afford. Modelling of the viable market was based on income quintiles associated with data from the World Bank. The calculations and assumptions made are presented in **Table 16**. It was assumed that for a cash purchase a household is willing to save three months of their current energy expenditure to purchase the OGS system.

Based on the income quintiles and corresponding estimated current energy expenditure, in the 2018 scenario, households without access in the higher income quintiles – 2, 3 and 4 – can only afford a pico solar product unfinanced while households in the highest income quintile can afford small SHS unfinanced. Households in the lowest quintiles cannot afford any OGS product without finance. While affordability .

The model assumes that each household purchases only one system. It also does not consider on-grid households that would purchase OGS systems as a back-up power system due to poor grid quality and reliability. This market has become a key segment of the more mature OGS markets (e.g. in East Africa), but is not the focus of this study, which is based on sizing the current markets in West Africa, alongside a least cost analysis for future access to energy that prioritizes reliable grid connections where possible.

Figure 22: Estimated Number of Households Able to Afford Cash Purchase of OGS Systems by Income Group



Source: African Solar Designs analysis

Table 16 presents the estimated annualized cash market potential for off-grid solar product sales in the country's household sector.

Table 16: Estimated Cash Market Potential for Household Sector

Solar System	Annualized Demand (Units)	Annualized Demand (kW)	Annualized Market Value (USD)
2018 Scenario			
Pico Solar	534,198	1,603	$24,038,913
Basic Plug and Play	0	0	$0.00
Small HH solar system	894	45	$223,514
Medium HH solar system	0	0	$0.00
Total	**535,092**	**1,648**	**$24,262,427**
2023 Scenario			
Pico Solar	18,922	57	$858,553
Basic Plug and Play	3,604	36	$346,817
Small HH solar system	1,081	54	$208,090
Medium HH solar system	0	0	$0.00
Total	**23,607**	**147**	**$1,413,460**
2030 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	15,305	153	$799,890
Small HH solar system	2,624	131	$274,248
Medium HH solar system	1,312	328	$342,810
Total	**19,241**	**612**	**$1,416,948**

Source: African Solar Designs analysis

The following observations should be considered when analyzing this data:

- The most common type of systems which the market can afford on a cash basis are pico and small plug and play systems. Based on available income figures Tier 2 and Tier 3 solutions are less viable for the vast majority of the population in the near term. However, this picture changes significantly with the introduction of finance, and as incomes increase over time.
- The model does not adequately address highest quintile and actual sales in the market. Note that the analysis does not predict purchases of Tier 3 equipment and it does not reflect what is happening at the extreme high end of the market. Because the analysis divides the population into relatively wide quintiles, it does not adequately address the very small portion of apex rural (and peri-urban) customers that now use generators.

2.1.4 The Financed Market for Off-Grid Solutions

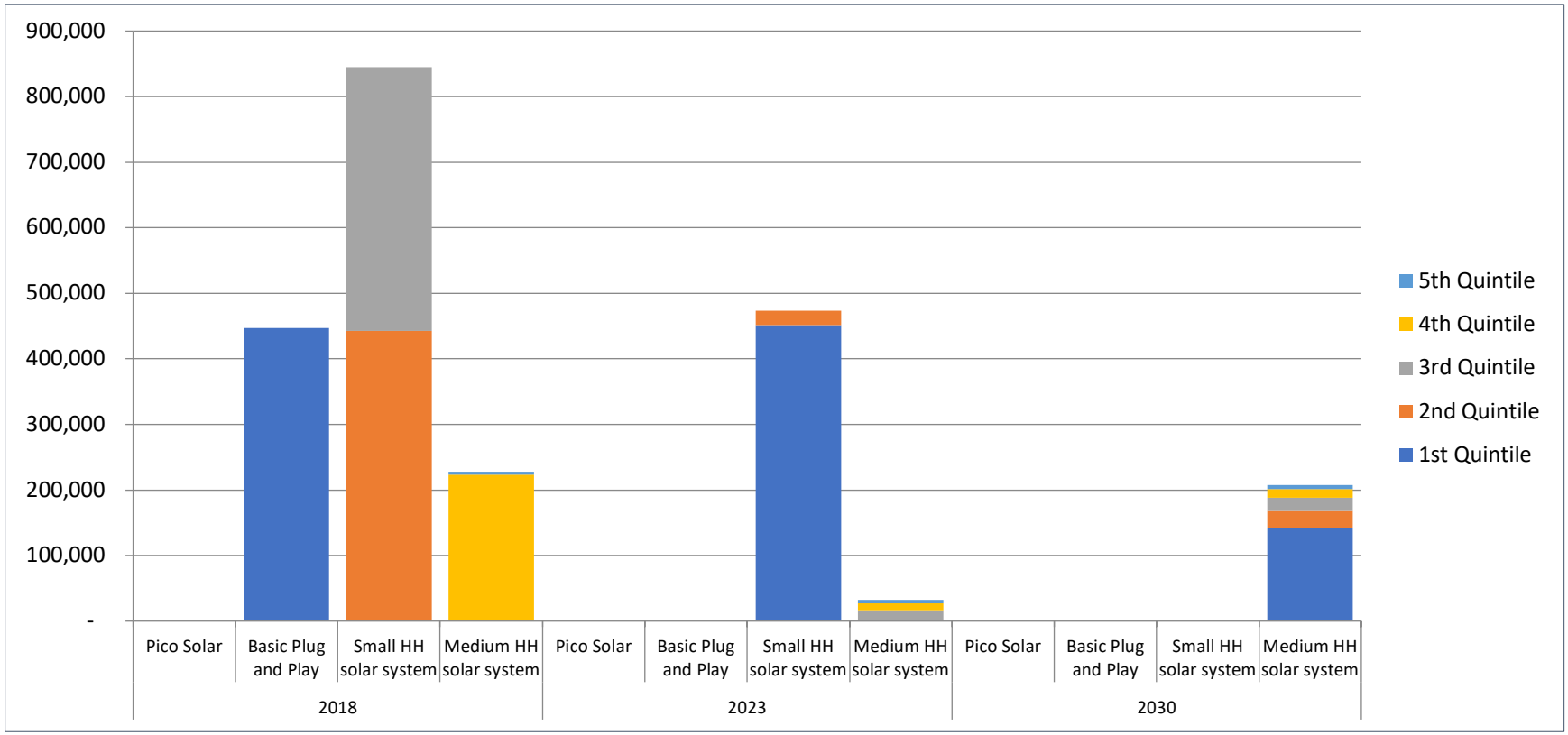
- **Financial Model**

In order to portray the effects of finance, a simple model was prepared that provides OGS system finance with a 24% p.a. interest rate[109] and a 24-month term. The financial model assumes that the households would be willing to save for three months of their current energy expenditure to cover a small upfront deposit of 10% of the system and their current energy expenditure would be used to pay the monthly installments.

This model assumes that each household will purchase the system that offers the highest energy serve level they can afford. As with the cash market model, it assumes that each household purchases one unit each. However, this finance model greatly over-estimates the potential market for credit as both MFIs and PAYG companies would likely be extremely cautious in approving customers. Without concrete data on the loans given to consumers in each income quintile in the country, it is difficult to estimate what the more realistic figures are. Nevertheless, this model does give a clear indication that long loan tenors combined with a low upfront payment would result in significant market transformation. The results of this analysis are presented below.

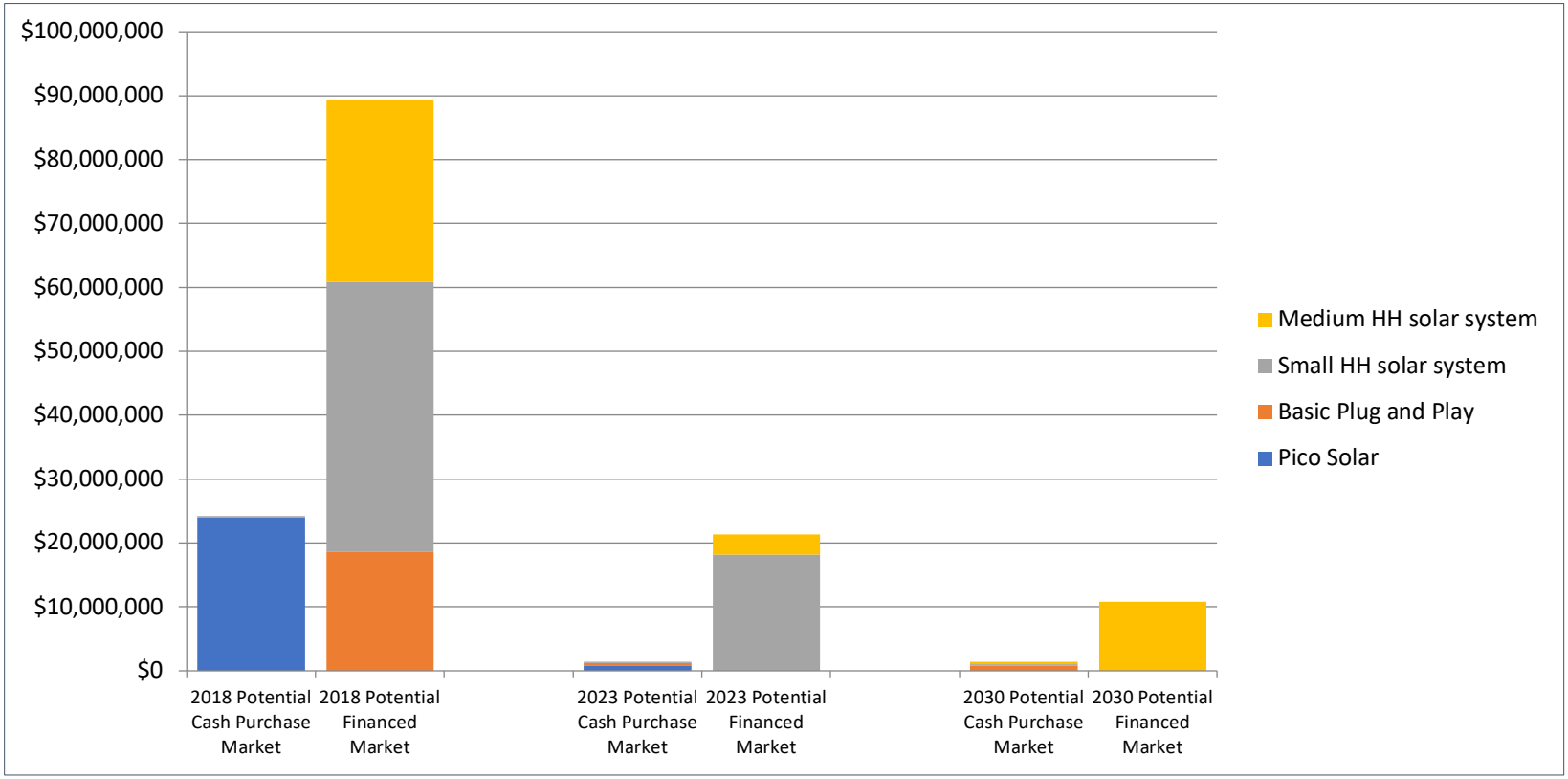
[109] Ferrari, A., Masetti, O., Ren, J., "Interest Rate Caps: The Theory and the Practice," World Bank Policy Research Working Paper, (April 2018): http://documents.worldbank.org/curated/en/244551522770775674/pdf/WPS8398.pdf

Figure 23: Estimated Number of Households Able to Afford Financed OGS Systems by Income Group



Source: African Solar Designs analysis

Figure 24: Estimated Off-Grid Solar Cash and Financed Market Potential for Household Sector by System Type



Source: African Solar Designs analysis

In 2018, without financing, only 1,072,866 households (70.6% of households without access) in the country could afford an OGS system. However, with financing, 1,519,894 households (100% of households without access) could afford an OGS system as the 447,028 off-grid HH in the lowest income quintile are enabled to acquire at least one OGS system. Consequently, the annualized potential market size increases from USD 24,262,427 to USD 89,368,284 mainly due to the fact that the households are enabled to purchase larger systems (**Figure 24**).

The least-cost electrification 2023 scenario calculates that 505,506 households could be electrified by stand-alone systems. Under this scenario, with financing, the number of households with the ability to acquire at least one OGS system increases from 54,062 (10.7% of off-grid households) to 505,506 (100% of all off-grid households) as the 451,444 off-grid HH in the lowest income quintile are enabled to acquire at least one OGS system. The annualized potential market size increases from USD 1,413,460 to USD 21,330,295 (**Figure 24**).

The least-cost electrification 2030 scenario calculates that the total number of households that could be electrified by stand-alone systems would drop further to 207,535. Under this scenario, with financing, the number of households with the ability to acquire at least one OGS system increases from 65,591 (31.6% of households without access) to 207,535 (100% of households without access) as the 141,944 households without access in the lowest income quintile are enabled to acquire at least one OGS system. The annualized potential market size increases from USD 1,416,949 to USD 10,846,787 (**Figure 24**).

Table 17 presents the estimated annualized financed market potential for off-grid solar product sales in the country's household sector.

Table 17: Estimated Financed Market Potential for Household Sector

Solar System	Annualized Demand (Units)	Annualized Demand (kW)	Annualized Market Value (USD)
2018 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	149,009	1,490	$18,626,153
Small HH solar system	168,976	8,449	$42,244,116
Medium HH solar system	45,597	11,399	$28,498,015
Total	**363,583**	**21,338**	**$89,368,284**
2023 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	0	0	$0.00
Small HH solar system	94,614	4,731	$18,208,941
Medium HH solar system	6,487	1,622	$3,121,354
Total	**101,101**	**6,353**	**$21,330,295**
2030 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	0	0	$0.00
Small HH solar system	0	0	$0.00
Medium HH solar system	41,507	10,377	$10,846,787
Total	**41,507**	**10,377**	**$10,846,787**

Source: African Solar Designs analysis

2.1.5 Consumer Perceptions, Interest and Awareness

- **Purchasers of solar are "early adopters" who tend to buy from system integrators as well as hardware traders**

  - **Retail purchasers**: Most purchases are made over-the-counter sales in capital and major cities as cash purchases. As with the consumer migration from kerosene to electric lights, there is a gradual migration from low cost dry-cell electric lamps to solar PV systems. Consumers make purchases in the same shops, and sellers are adapting to changes in demand by offering solar equipment.
  - **High-end consumers**: As elaborated in **Section 2.4**, a small number of early adopting consumers buy from specialized solar integrators who offer quality services and components. A large portion of buyers in this segment opt for systems above 200Wp for residential and small business demand.
  - **PAYG**: As the PAYG market segment is still in its nascent stages, detailed data of PAYG customers is still largely unavailable, although recent experience from East Africa suggests that these customers include both rural and peri-urban inhabitants. The PAYG business model / method is still not widely understood; moreover, there are still questions about how to account for the seasonality of incomes as opposed to regular monthly payment plans.

- **Consumers have a general awareness that solar can economically replace generators and batteries, but they are still largely uninformed about solar electric specifics**[110]

  - While knowledge is gradually improving (particularly for small/pico solar lighting systems) most consumers are not yet educated enough to make informed decisions about solar systems.
  - There are often geographic disparities in awareness levels of OGS products, as households in urban or peri-urban areas tend to have better understanding of solar vis-à-vis rural villages.
  - Consumers are hearing "general messages" (i.e. "solar is good," "solar can be cheap," "solar can be more economical"). These messages need to be translated into more specific understanding of the technology (i.e. what are the options, what products are better than others, where to buy solar, what is a best way to pay for solar, what suppliers are more reliable, how to manage O&M, etc.).
  - Consumers often do not get fair information on the product they are buying. Marketing messages are quite mixed and much 'overpromising' occurs for systems. Consumers are largely unaware of standards and quality assurance for solar.

- **Perceptions of households vary according to experience they have had with solar**

  - Although many households recognize the benefits of solar, there is a general perception that solar equipment is very expensive and that products are considered largely un-affordable.
  - Many customers are disappointed with solar technology or mistrust it because:
    - They have bought a substandard/not certified product that broke down quickly;
    - There was no adequate maintenance, aftersales service when the system broke down;
    - There was lack of understanding/experience on how to use the system and it broke down due to over usage or incorrect usage.
    - There is no warranty or fault management system (long-term O&M)
  - Households that have a fuel-powered generator, consider them as a 'sunk cost' and treat solar only as an addition to that cost.
  - Solar is seen as risky by many. Since there are so many options and little information as to what the best solution is, many people think that it is easy to make a costly mistake in choosing what is

[110] Focus group participants indicated that off-grid solar solutions are widely understood by the population in Benin. This is thanks largely to the implementation of awareness-raising campaigns such as the solar electricity access projects of GIZ as well as promotional actions undertaken by ABERME among others.

best for them. Generators are much better understood.
- Some consumers have 'investment fatigue' from buying multiple solar products of low or unknown quality and are unwilling to make further investments.

➢ **Willingness to Pay is strongly associated with consumer understanding and perceptions of OGS**

Although there is demonstrated ability to pay for households in higher income demographics on cash purchase, and for many households through a financed scenario, willingness to pay is strongly associated with consumer understanding and perceptions of OGS. Component-based Plug-and-Play SHS are much more expensive than battery-powered alternatives and are more than what households expect to pay for access to lighting. Consumers who purchase low-priced inferior lighting products for which they have low expectations are less likely to be willing to purchase a relatively high priced OGS system without fully understanding the difference between the products.

Since most of the retail-shop dry-cell battery-powered lighting products are extremely low cost (and short-lived), conservative rural consumers are wary of expensive new products if they are unable to assess product quality and durability. For this reason, willingness to pay presents a much larger barrier for the development of sales than actual *ability* to pay. East African experience with Global Lighting-certified products has demonstrated that consumer awareness campaigns can grow the demand for quality products.

2.2 Demand – Institutional

2.2.1 Overview of Institutional Market Segment

This section estimates the market potential for off-grid solar products for institutional users in Benin. This market includes the following segments: (i) rural water supply, (ii) healthcare facilities, (iii) primary and secondary schools, and (iv) public town center lighting. The following sub-sections provide an overview of the assumptions used for each market segment along with corresponding analysis. The section concludes with an assessment of institutional ability to pay, looking at funding sources and highest potential market segments. **Annex 2** provides an overview of the methodology, including all calculations.

2.2.2 Analysis of Institutional Market Segment Demand

Table 18 shows the estimated annualized cash market potential for institutional users in Benin. This estimation is calculated using available GIS data, secondary research, and primary source field data. The analysis is based on available information from planned expansion of the sectors and typical usage patterns and costs of existing systems in the country.

Table 18: Indicative Total Cash Market Potential for Institutional Sector[111]

Institutional Sector		Units	kW Equivalent	Cash Value (USD)
Water supply	Low power pumping system	32	48	$120,188
	Medium power pumping system	21	86	$214,000
	High power pumping system	11	107	$267,500
	Subtotal	64	241	$601,688
Healthcare	Health post (HC1)	14	4	$9,000
	Basic healthcare facility (HC2)	2	3	$7,125
	Enhanced healthcare facility (HC3)	11	45	$111,300
	Subtotal	27	52	$127,425
Education	Primary schools	242	121	$362,625
	Secondary schools	8	17	$41,520
	Subtotal	250	138	$404,145
Public lighting	Public lighting (excluding street lighting)	107	53	$160,125
TOTAL		**448**	**484**	**$1,293,383**

Source: African Solar Designs analysis

[111] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

- **Water Supply**

Table 19: Key Assumptions for Water Supply Sector Analysis

Sector	System Sizes	Key Assumptions
Water supply	• Low Power (1,500 W) • Medium Power (4,000 W) • High Power (10,000 W)	The type of pump selected is dependent on depth, yield, community need and other factors. System sizes depend on the common pump sizes used for rural applications: • Low power pumps are used for low/medium head applications. They replace hand pumps for shallow wells • Medium power pumps have high volume low head and medium volume medium head applications • High power pumps are used for high volume or high head applications such as deep wells and boreholes

The water supply sector analysis considered the electricity needs for water supply for communities in off-grid areas. Energy is only one component of this sector – a variety of factors (water quality, number of users, yields of well, delivery system etc.) need to be considered when planning for off-grid water supply. The supply of solar powered pumping systems for village water supply requires additional planning and study to identify the most viable sites.

Available GIS data identified off-grid water points such as boreholes and wells that could be electrified by stand-alone systems. Based on the analysis, the estimated annualized cash market potential for the water supply sector is presented in **Table 20**; the distribution of off-grid water points is illustrated in **Figures 25-26**.

Table 20: Estimated Cash Market Potential for Water Supply[112]

Pump Type	Units	kW Equivalent	Cash Value (USD)
Low power	32	48	$120,188
Medium power	21	86	$214,000
High power	11	107	$267,500
Total	**64**	**241**	**$601,688**

Source: African Solar Designs analysis

[112] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

Figure 25: Distribution of Off-Grid Water Points

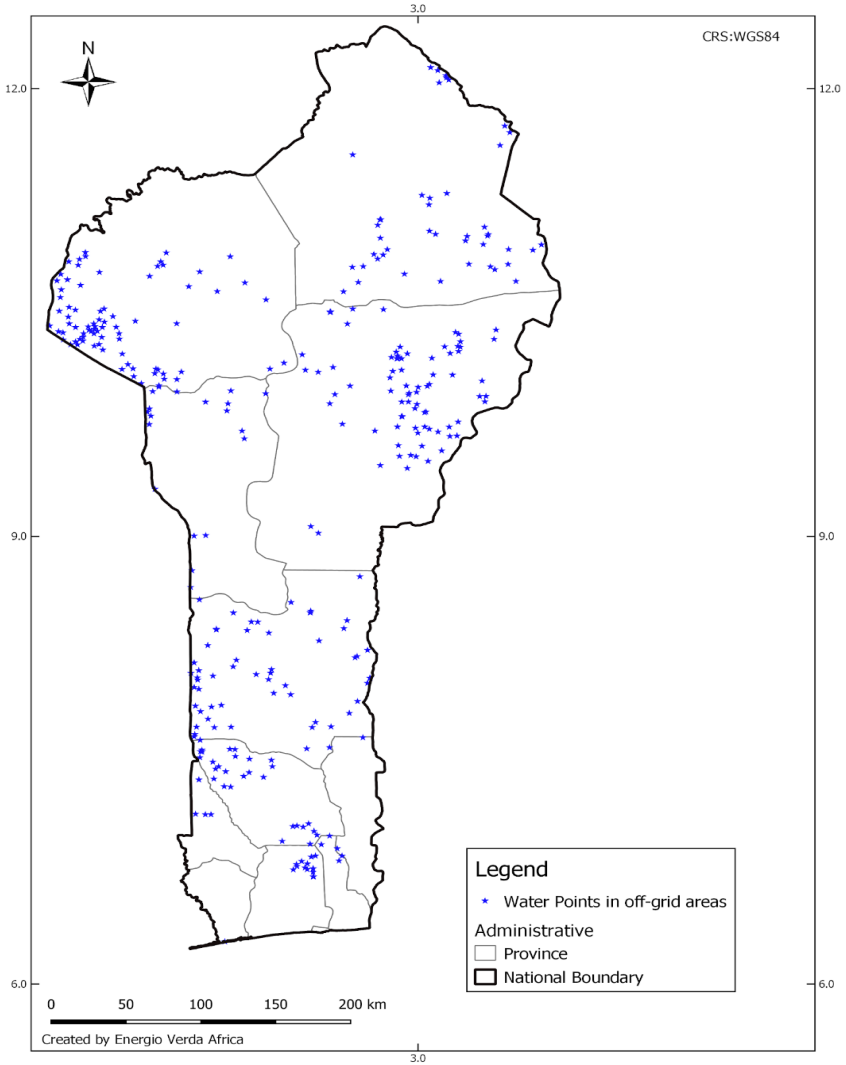
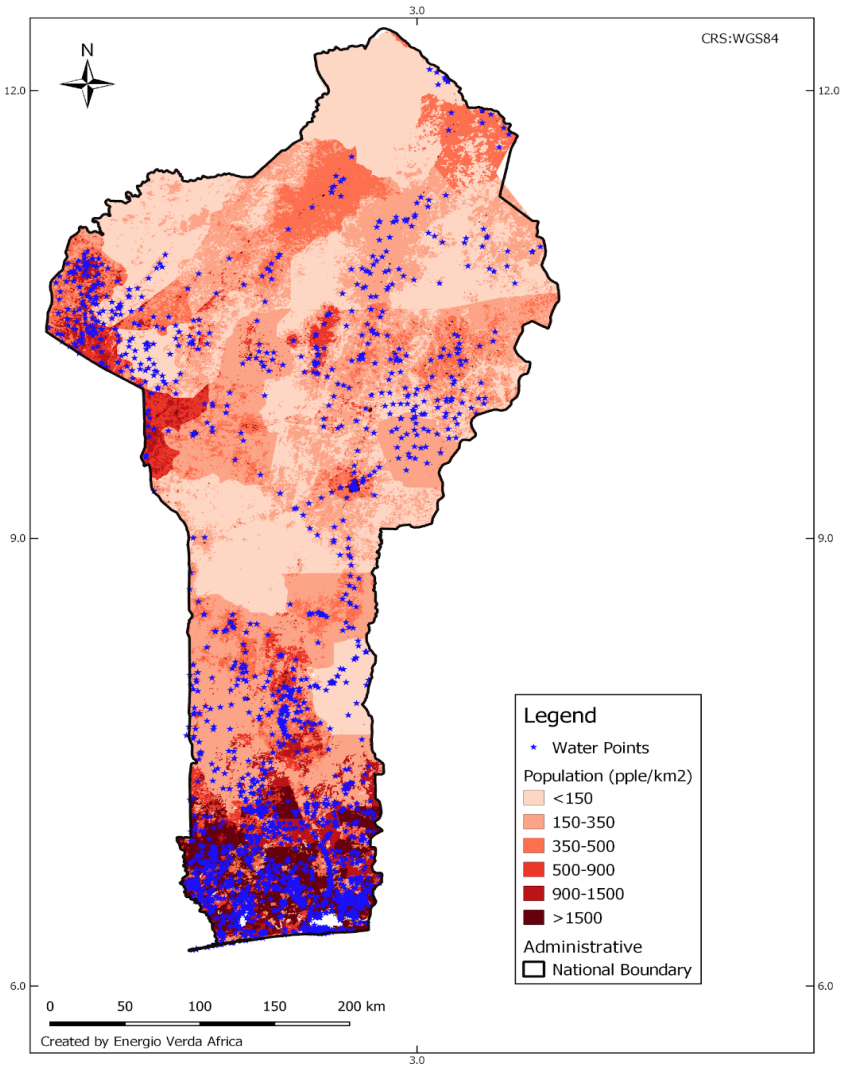


Figure 26: Distribution of Water Points and Population Density



Source: Benin Energie; Energio Verda Africa GIS analysis

- **Healthcare**

Table 21: Key Assumptions for Healthcare Sector Analysis

Sector	System Sizes	Key Assumptions
Healthcare	• HC1: Dispensary health post (300 W) • HC2: Basic health facility (1,500 W) • HC3: Enhanced health facility (4,200 W)	322 off-grid healthcare facilities were identified that could be electrified by stand-alone systems

The healthcare sector analysis considered the electricity needs for off-grid health facilities in the country. Off-grid clinics require power for lighting and various Information and Communications Technology (ICT) needs, including phone charging, maternity, medical examinations, vaccine refrigeration, laboratory, sterilization and staff housing. The size of a facility and number of patients served determines the amount of energy it requires.

Available GIS data identified off-grid health facilities categorized according to their size (HC1, HC2, and HC3) that could be electrified by stand-alone systems.[113] To establish electricity demand, an assessment of equipment found within each category of healthcare facility was undertaken, with the daily demand of each used to calculate the system size required to cater to the load of the facility (**Table 22**). The assumptions of system size below are based on the services offered at each of these facilities.

Table 22: Healthcare Facility Categorization and Electricity Demand[114]

Type of Facility	Load Category	Wh/day	Total Load (Wh/day)	System Size (W)
Health post (HC1)	Lighting	240		
	Communication	160		
	ICT	800		
			1,200	**250**
Basic healthcare facility (HC2)	Lighting	1,600		
	Maternity	800		
	Vaccine refrigeration	800		
	Communication	400		
	Examination room	400		
	ICT	1,600		
	Staff housing	400		
			6,000	**1,500**
Enhanced healthcare facility (HC3)	Lighting	3,200		
	Communication	1,600		
	Examination room	1,200		
	ICT	2,400		
	Maternity	2,400		
	Laboratory	2,000		
	Sterilization	1,200		
	Vaccine refrigeration	1,200		
	Staff housing	1,600		
			16,800	**4,200**

Source: GIZ; African Solar Designs analysis

[113] NOTE: This represents a small sub-set of the overall health infrastructure in the country; see **Annex 1** for more details.
[114] "Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances," GIZ, (2016): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/GIZ__2016__Catalogue_PV_Appliances_for_Micro_Enterprises_low.pdf

Based on these assumptions, the estimated annualized cash market potential for the healthcare sector is presented in **Table 23.** The distribution of potential off-grid health facilities is shown in **Figures 27-28**.

Table 23: Estimated Cash Market Potential for Healthcare Facilities[115]

Type of Facility	Units	kW Equivalent	Cash value (USD)
HC1 Health post	14	4	$9,000
HC2 Basic healthcare facility	2	3	$7,125
HC3 Enhanced healthcare facility	11	45	$111,300
Total	**27**	**52**	**$127,425**

Source: African Solar Designs analysis

[115] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

Figure 27: Distribution of Potential Off-Grid Healthcare Facilities, 2023

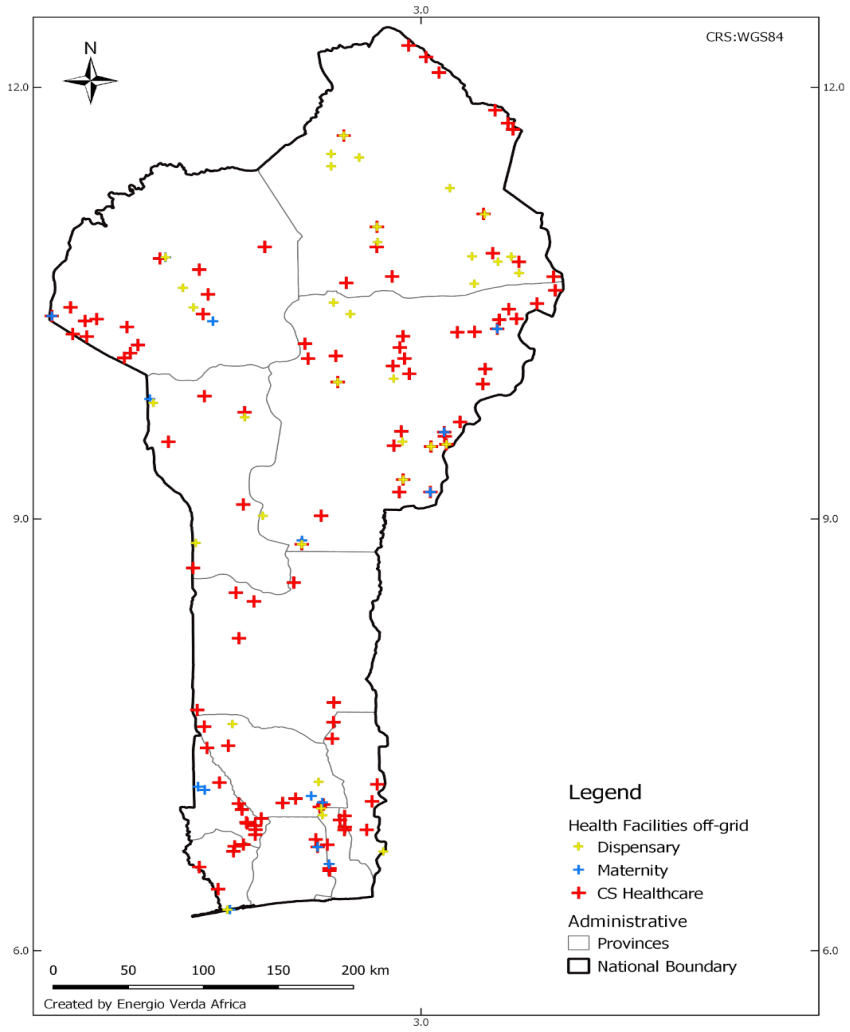
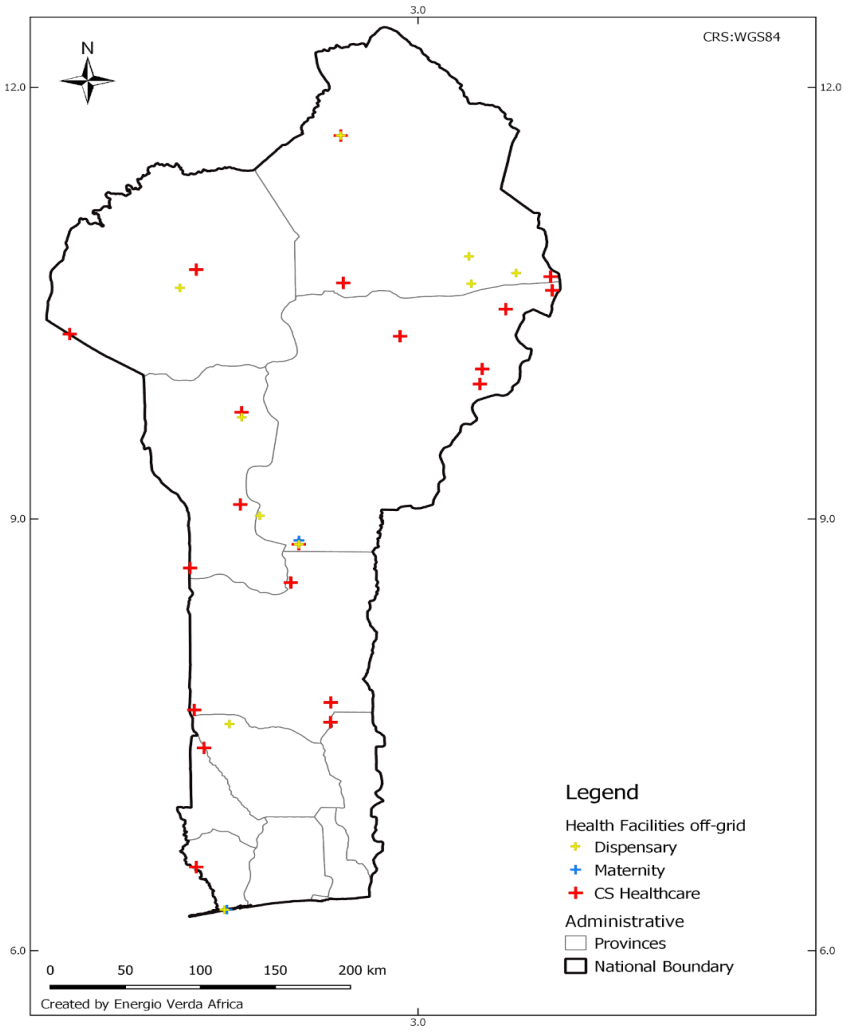


Figure 28: Distribution of Potential Off-Grid Healthcare Facilities, 2030



Source: Benin Energie; Energio Verda Africa GIS analysis[116]

[116] Displaying identified facilities with known location (given coordinates) only; see **Annex 1** for more details.

- **Education**

Table 24: Key Assumptions for Education Sector Analysis[117]

Sector	System Sizes	Key Assumptions
Education	• Elementary schools (500 W) • Secondary schools (1,920 W)	4,835 off-grid primary schools and 173 off-grid secondary schools were identified that could be electrified by stand-alone systems

The education sector analysis considered the electricity needs of off-grid primary and secondary schools.[118] These include lighting, ICT (computers, tablets etc.), communication (phone charging), laboratories and staff housing. The size of a school and number of students determines the amount of energy it requires.

Available GIS data identified off-grid primary and secondary schools that could be electrified by stand-alone systems. To establish electricity demand, an assessment of equipment found within each type of school was undertaken, with the daily demand of each used to calculate the system size required to cater to the load of the school (**Table 25**).

Table 25: Education Center Categorization and Electricity Demand[119]

Type of Facility	Load Category	Wh/day	Total Load (Wh/day)	System Size (W)
Primary School	Communication	160		
	Lighting	640		
	ICT	800		
	Staff house	400		
			2,000	**500**
Secondary School	Communication	160		
	Lighting	1,920		
	ICT	3,200		
	Laboratory use	800		
	Staff house	1,600		
			7,680	**1,920**

Source: GIZ; African Solar Designs analysis

Based on these assumptions, the estimated annualized cash market potential for primary and secondary schools is presented in **Table 26.** The distribution of potential off-grid primary and secondary schools is shown in **Figures 29-30**.

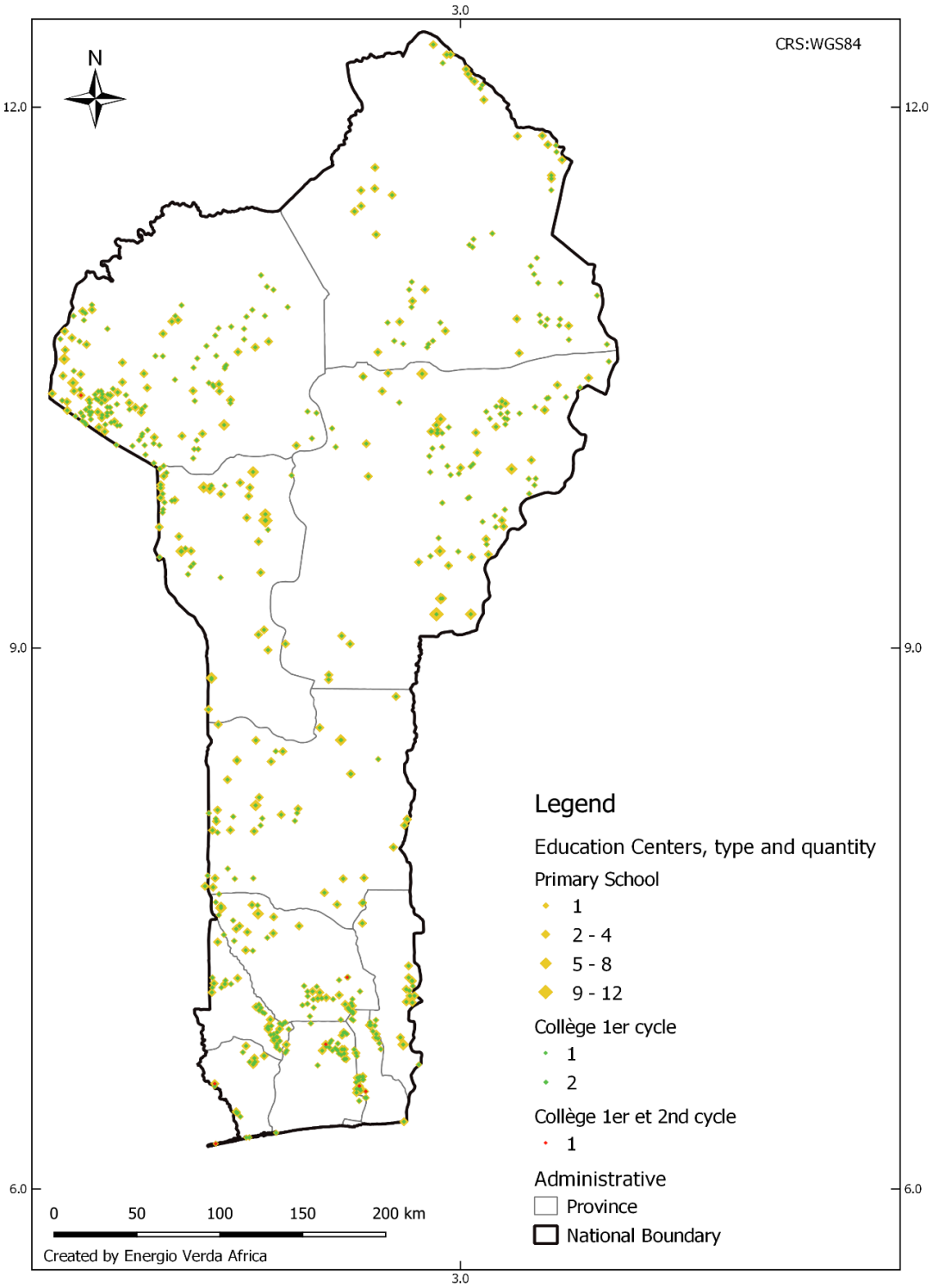
Table 26: Estimated Cash Market Potential for Primary and Secondary Schools[120]

Type of Facility	Units	kW Equivalent	Cash value (USD)
Primary school	242	121	$362,625
Secondary school	8	17	$41,520
Total	**250**	**138**	**$404,145**

Source: African Solar Designs analysis

[117] NOTE: While the GIS analysis in **Section 1.2.2.4** covers all education centers (including nursery, pre-primary, primary, secondary, technical-vocational, universities etc.), this analysis only examines primary and secondary schools (see **Annex 1** and **Annex 2**).
[118] Primary schools encompass both primary and nursery schools. Vocational schools and universities were not considered because they tend to be in cities, which are often grid electrified.
[119] "Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances," GIZ, (2016): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/GIZ__2016__Catalogue_PV_Appliances_for_Micro_Enterprises_low.pdf
[120] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

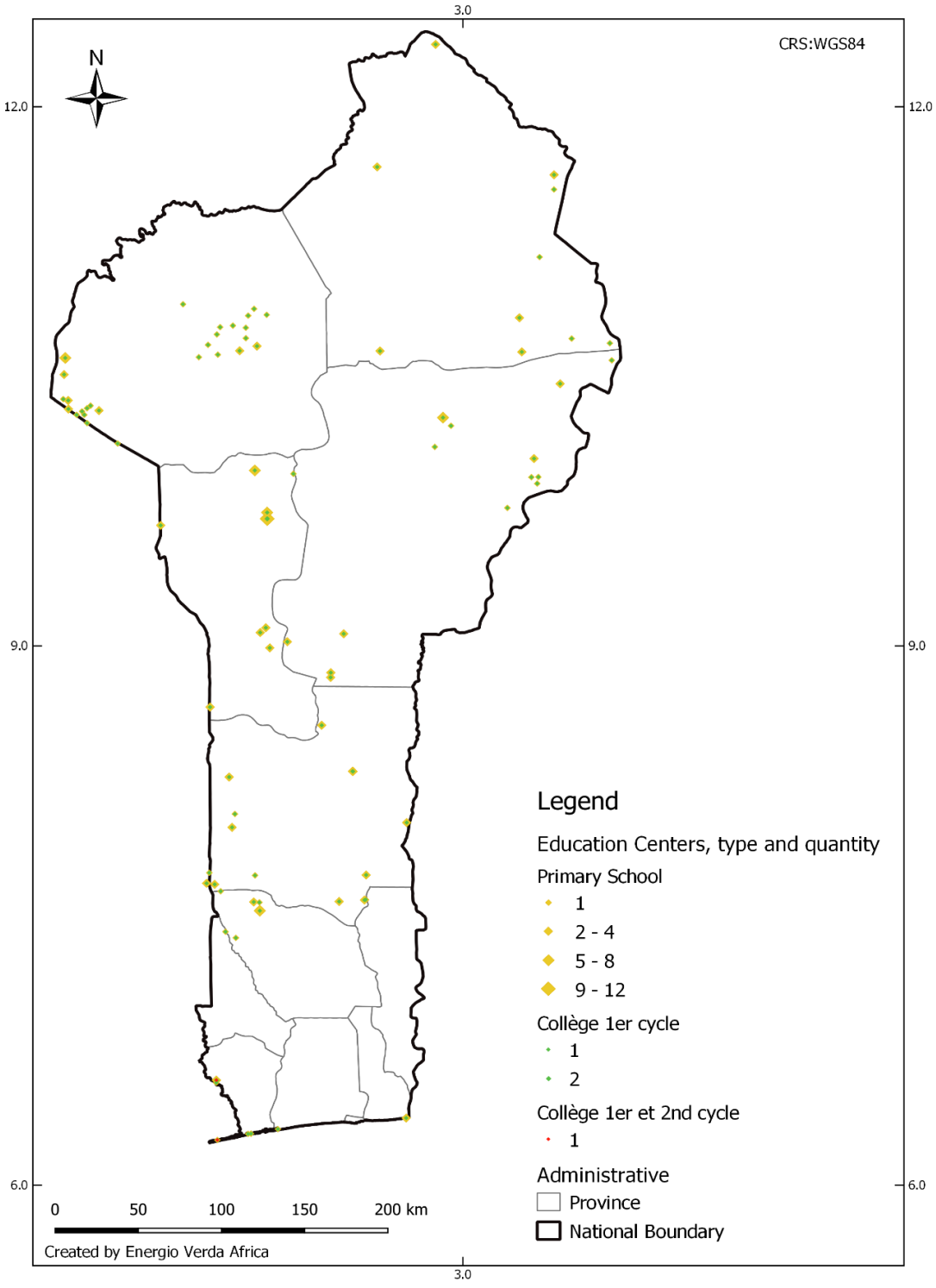
Figure 29: Distribution of Potential Off-Grid Primary and Secondary Schools, 2023[121]



Source: Energio Verda Africa GIS analysis

[121] Displaying identified facilities with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

Figure 30: Distribution of Potential Off-Grid Primary and Secondary Schools, 2030[122]



Source: Energio Verda Africa GIS analysis

[122] Displaying identified facilities with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

- **Public Lighting**

Table 27: Key Assumptions for Public Lighting Sector Analysis[123]

Sector	System Sizes	Key Assumptions
Public lighting	Standard system (200 W)	• District population figures were used to determine the number of market centers per district, assuming 5,000 people per market center • Each market center was assumed to have two public lighting points

Analysis of the public lighting sector considered the public lighting needs for off-grid villages and market centers. It did not assess public street lighting, which would generally be included in road infrastructure projects. Based on these assumptions, the estimated annualized cash market potential for the public lighting sector is presented in **Table 28**.

Table 28: Estimated Cash Market Potential for Public Lighting[124]

Public Lighting Network	Units	kW Equivalent	Cash value (USD)
Village lighting (excluding street lighting)	107	53	$160,125

Source: African Solar Designs analysis

2.2.3 Ability to Pay and Access to Finance

Financing for institutional off-grid systems in Benin typically comes from budget allocations made directly by relevant ministries or, more commonly, by donor-funded projects. In recent years, virtually all institutional solar projects in the country have been financed with tender-based procurements and cash-based contracts. Government allocations are typically made ad-hoc, depending on the needs and priorities of the ministry, and whether funds are available. Operation, maintenance and replacement of parts in energy systems (e.g. solar system batteries and inverters) is typically the responsibility of the institution and community. Schools, clinics and other institutions with generators must buy fuel on a regular basis. With the development of the renewable energy sector, NGO/donor funds increasingly design projects that ensure that maintenance of the system is factored into its implementation. However, when there are no funds to maintain the system any further, usage is typically discontinued, and the system falls into disrepair.

Institutional users that rely on government or donor funds for the purchase and O&M of solar systems may be constrained by limited funds and/or competing budget priorities. Thus, local communities benefiting from solar electrification would also have to bear some long-term costs for the maintenance of systems and replacement of parts. In the event that public or donor funding is made available to cover the initial capital expenditure, funds can be raised by local communities through a minimal tariff to customers of the health facilities, water pumping stations etc. for long-term O&M. A market standard of 5-10% of the capital expenditure is accepted as a rate for annual maintenance of systems.[125]

Given budgetary constraints, some institutional sectors may be prioritized for solar electrification over others. Advanced health centers for example, could be prioritized by governments and communities given that electricity is essential to run advanced healthcare equipment. It may be easier in this case to extract maintenance fees from community members receiving health services or budget allocations from local government. In contrast, off-grid schools can be run more easily without access to electricity and may therefore present a lower priority institutional market.

[123] Population figures used in this analysis were obtained from: https://www.citypopulation.de/Benin.html
[124] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[125] Grundfos: https://www.grundfos.com/service-support/encyclopedia-search/maintenance-and-repaircostscm.html

2.3 Demand – Productive Use

2.3.1 Overview of Productive Use Market Segment

The section provides an overview of the main characteristics of productive use of energy (PUE) and how off-grid solar applications have the potential to generate economic activity, increase productivity and transform rural livelihoods in Benin. Focus group participants noted that productive use applications in the agricultural, food processing and informal sectors already exist in the country, including solar powered lighting, mobile phone charging, refrigeration and chilling, water pumping, irrigation and agricultural processing. The PUE market sizing analyzed demand for SME applications for village microenterprises, value-added applications for solar powered irrigation, milling and refrigeration, and connectivity applications for mobile phone charging enterprises.

The calculation of the estimated off-grid solar market for SMEs focused only on barbering and tailoring appliances, which comprises a small portion of overall SME sector demand. These two microenterprises are indicative of the service-based SME off-grid solar market, as they benefit significantly from extended working hours and the use of modern appliances/machinery. The estimated demand for this market segment is therefore intended to provide a baseline for future research, as a more robust analysis would be necessary to assess realistic demand from all SMEs.

The value-added applications that were analyzed include solar pumping for smallholder agricultural irrigation, solar powered milling and solar refrigeration. Access to energy for agriculture is critical to economic development, particularly given the sector's importance to GDP in the country.

Off-grid solar power supports a wide range of connectivity applications, including mobile phone charging, wi-fi servers, banks, mobile money kiosks, and telecommunications towers. Mobile phone and internet connectivity are also necessary precursors for mobile money and PAYG solutions in the off-grid solar sector. The market sizing examined rates of mobile phone ownership and mobile internet penetration to estimate the market potential for mobile phone charging enterprises (stations/kiosks) in the country.

A number of productive uses have emerged in Benin with support from various institutions such as the ECOWAS Renewable Energy Facility Project and the ASEMI group's Renewable Energy Services Supply and Promotion Project. The project installed a mini hybrid power plant in Igbodja to support the energy needs of local welders, craftsmen and carpenters. A similar initiative, 'Power out of Poverty,' was undertaken by SNV to support village micro-entrepreneurs by equipping them with skills and tools to run profitable businesses selling phone charging services and solar power systems. The FGDs also identified pumping for agriculture production and irrigation, milling, dryers for agro-processing, entertainment centers, and refrigerators to sell fresh produce and drinks as applications with the highest potential for solar use in Benin.

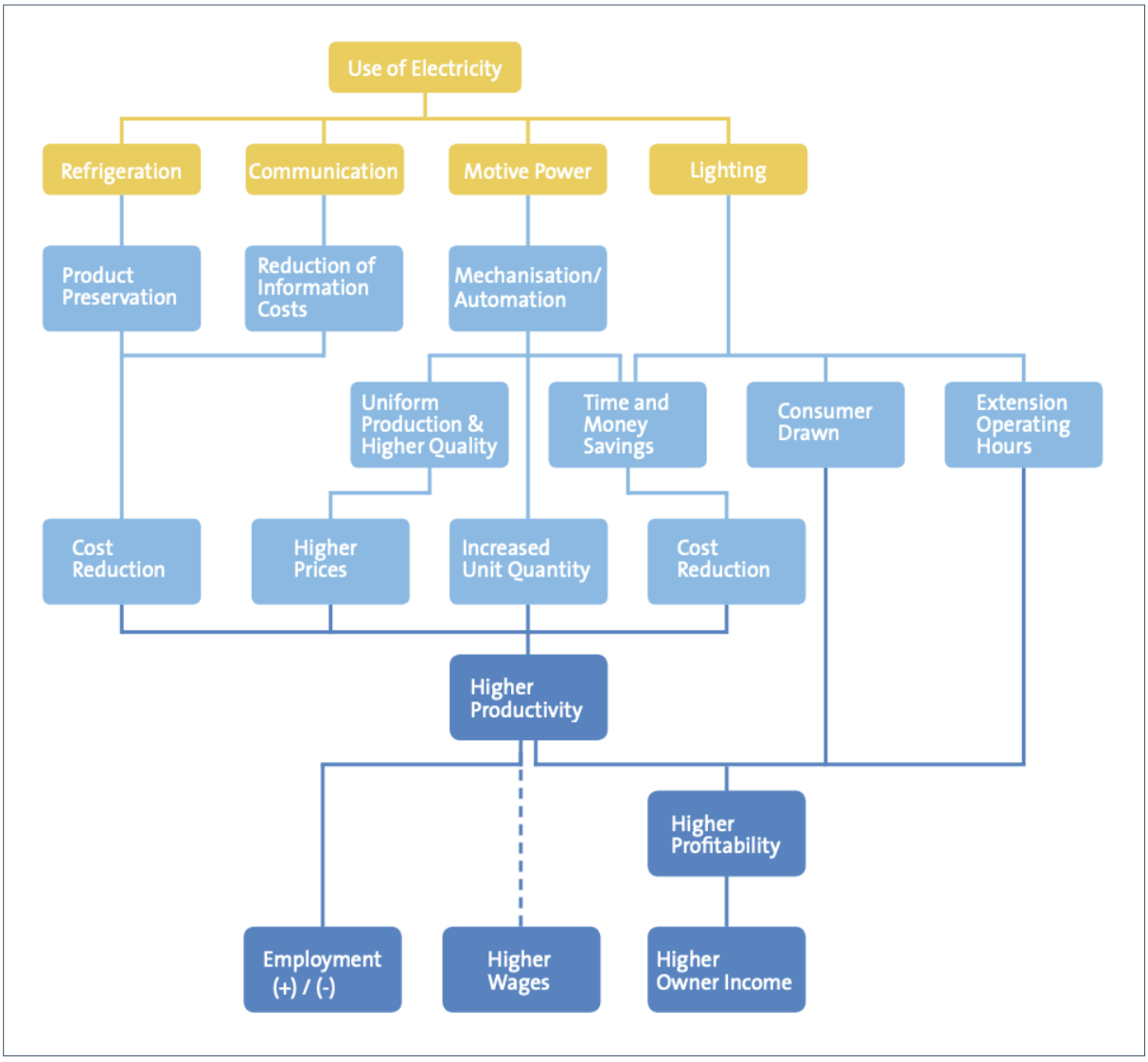
Given that agriculture contributes nearly 40% to Benin's GDP, the Government is aiming to improve productivity of the sector to transform the country into a major exporter of agricultural products by 2025.[126] Nearly 70% of Benin's population practices subsistence farming and is dependent on the agriculture sector for employment. Thus, diversifying economic activities with the help of solar applications would be beneficial to Benin's poverty reduction goals.

Another key industry in Benin's economy is the services sector, which contributes to more than 50% of GDP. Under its 'Revealing Benin' Action program, the GoB is committed to addressing increased load

[126] Benin Agricultural Situation, Global Agricultural Information Network (GAIN), USAID: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Agricultural%20Situation_Lagos_Benin_3-20-2014.pdf

shedding in the power sector by prioritizing modernized electricity production via thermal and renewable energies.[127] It is important to note that 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 can afford to invest in off-grid solar solutions is determined largely by increases in productivity, profitability, and employment/wages from the investment in the off-grid appliance (**Figure 31**).

Figure 31: Pathways from Electricity to Income Generation[128]

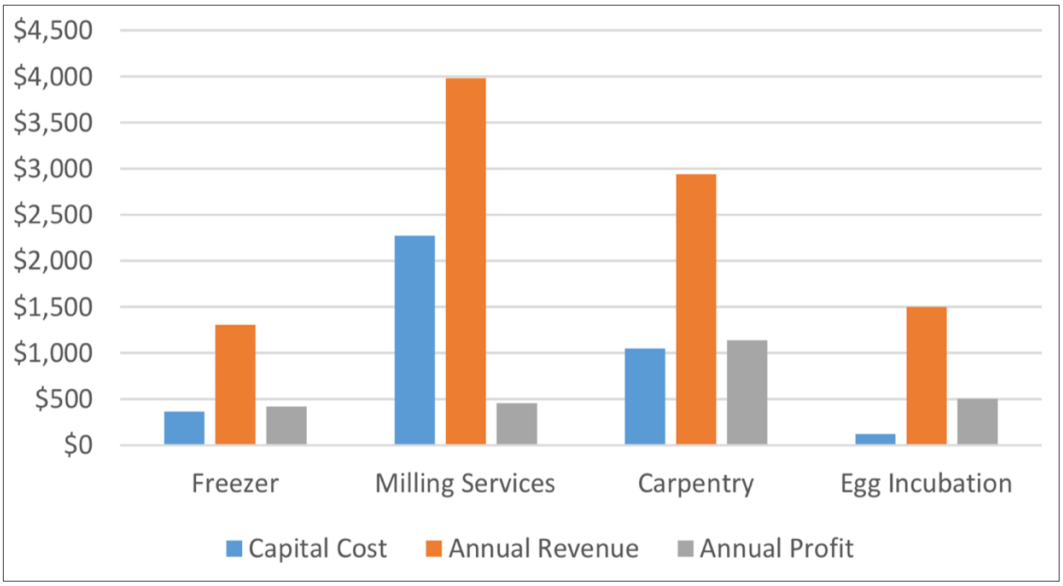


Source: EUEI PDF and GIZ: Productive Use of Energy – A Manual for Electrification Practitioners

[127] "Benin Revealed," Benin Government Action Plan (2016-2021): http://revealingbenin.com/programme-dactions/programme/electricite/

[128] Productive Use of Energy – A Manual for Electrification Practitioners," European Union Energy Initiative Partnership Dialogue Facility (EUEI PDF) and GIZ, (2011): https://www.giz.de/fachexpertise/downloads/giz-eueipdf-en-productive-use-manual.pdf

Figure 32: Analysis of Cost, Revenue and Profit for Various Off-Grid Productive Use Applications[129]



NOTE: Annual profit does not include recovery of cost capital

Source: USAID-NREL and Energy 4 Impact: Productive Use of Energy in African Microgrids

In order to organize and simplify this analysis and to deliver meaningful insights on country-level market sizing, productive solar applications have been divided into three main groups (**Table 29**).

Table 29: Overview of Productive Use Applications

Productive Use Application	Description
1) SME applications for village businesses	Barbers and tailors are the two microenterprises that were analyzed. While these businesses employ people and are critical for off-grid towns, they do not create additional income for towns and are not transformative in nature. SME businesses are therefore most at risk during economic downturns because they are at the mercy of the overall economic and political climate.
2) Value-added applications	Solar-powered irrigation, refrigeration/chilling and milling are the three value-added applications that were analyzed. Value added productive use applications enable businesses to add value to products or services and to build new income streams. This can be done by creating a new product or service or by enhancing the value of an existing product (e.g. milling maize). Water pumping tools that support the agricultural, dairy or fishing value chains are included here (water pumps, refrigerators/chillers, and grain mills).
3) Connectivity / ICT applications	Mobile phone charging is the connectivity application that was analyzed. Connectivity applications enable consumers to communicate and access data from the internet. Following the advent of mobile phones and mobile money in East Africa, solar devices that support connectivity applications became the most important income earning applications in East Africa. Mobile phone charging is extremely important for the telecommunications sector. Other connectivity applications include wi-fi servers, mobile money kiosks, banks, and telecommunications towers.

Source: African Solar Designs

[129] "Productive Use of Energy in African Micro-Grids: Technical and Business Considerations," USAID-NREL and Energy 4 Impact, (August 2018): https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/productive_use_of_energy_in_african_micro-grids.pdf

- **Geographic Locations**

Most PUE sector activities will take place in rural off-grid areas in Benin, particularly in the northern regions of the country. These include areas where there are low levels of grid penetration / connectivity and where rural agricultural livelihoods are the predominant means of income generation.

2.3.2 Analysis of Productive Use Market Segment Demand

Data from the World Bank, Food and Agriculture Organization of the UN (FAO) and GSMA was used to conduct the PUE market study. In order to conduct the analysis, several key assumptions were made about PUE applications, which are presented in the sections below and in **Annex 2** in greater detail. **Table 30** presents the estimated annualized cash market potential for off-grid solar productive use applications.

Table 30: Indicative Total Cash Market Potential for Productive Use Sector[130]

Productive Use Sector		Units	kW Equivalent	Cash Value (USD)
SME Applications for Village Businesses	Microenterprises	692	173	$432,375
Value-added Applications	Irrigation	44,722	5,367	$29,069,444
	Milling	323	2,100	$5,250,099
	Refrigeration	107	587	$1,467,813
	Subtotal	45,152	8,054	$35,787,356
Connectivity Applications	Phone Charging	5,669	2,268	$4,886,476
TOTAL		**51,513**	**10,495**	**$41,106,207**

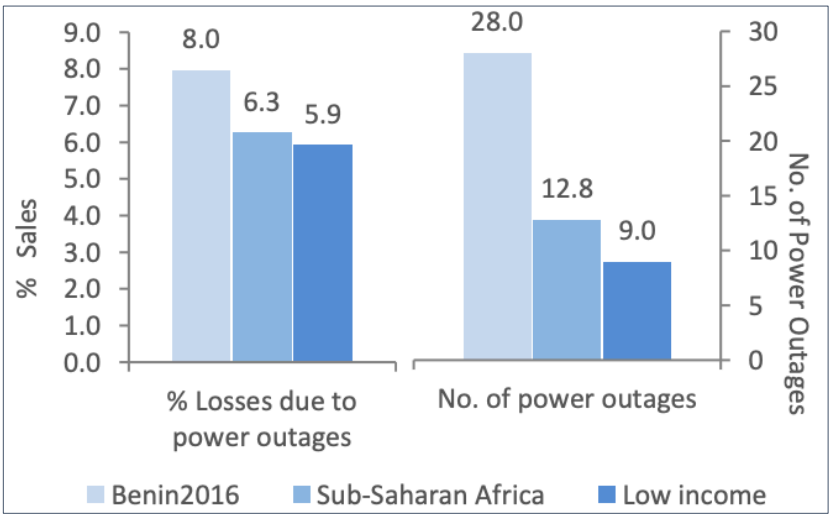
Source: Food and Agriculture Organization, GIZ and GSMA; African Solar Designs analysis

- **SME Applications for Village Businesses**

Access to solar powered appliances can have a wide-ranging impact on SMEs, many of which would otherwise rely on diesel generators to power their enterprises. Close to 33% of SMEs in emerging markets use fossil fuel powered generators in order to address energy insecurity.[131] For ECOWAS countries, independent power generation via fossil fuel powered generators is especially prevalent.[132] Electricity supply to Beninese firms for has significantly worsened in the last decade. In 2016, firms experienced approximately 28 electrical outages in a month, an over fivefold increase in outages since 2009.[133] This deterioration in power supply has led to business sales losses (8%) and an increase in the percentage of firms that use generators – a World Bank study found that 18% more firms owned or shared a generator in 2016 compared to 2009 **(Figure 33)**.[134] In response, the GoB and donor led initiatives such as the Millennium Challenge Corporation's Benin Compact are addressing the challenge of unreliable power for businesses.

[130] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[131] Foster, V., and Steinbuks, J., "Paying the Price for Unreliable Power Supplies: In-House Generation of Electricity by Firms in Africa," World Bank Policy Research Working Paper, (2009): https://openknowledge.worldbank.org/handle/10986/4116
[132] Ibid.
[133] "Power outages in firms in a typical month (number) – Africa," IndexMundi, https://www.indexmundi.com/facts/indicators/ic.elc.outg/map/africa
[134] "Enterprise Surveys, Benin Country Highlights," World Bank (2016): http://documents.worldbank.org/curated/en/775631533619836955/pdf/129264-WP-PBULIC-Benin-2016.pdf

Figure 33: Percentage of Sales Lost due to Power Outages in Benin[135]



Source: World Bank

While many rural microenterprises would benefit from access to solar power, it may not be a requirement for a commercial enterprise to have access to electrical appliances. Further, while petit trade is facilitated greatly by the availability of electricity (kiosks and retail shops can be open longer hours and sell more and fresher products), electricity is not essential for SMEs because even without lighting, small shops can still sell their merchandise. Additionally, unlike value-added applications, there is not as strong a correlation between the value of the electric appliance and the economic capability of the SME. For example, a refrigerator used to preserve perishable food and chill beverages, irrespective of the value of food and beverages, may be used by either a large hotel or a street side vendor.

With the exception of replacing diesel gensets, the estimation of the available market for off-grid solar appliances for SMEs is not as closely correlated with economic indicators. Nonetheless, some widely marketed solar powered appliances are more centrally related to the revenue generation of SMEs. Investments in such appliances in off-grid and low-income settings are more likely to be sustainable. This study analyzed barbering and tailoring appliances (i.e. hair clippers and sewing machines designed or marketed for off-grid solar powered settings) with respect to microenterprises that face difficulty in accessing outside capital, as the two appliances would provide an economic opportunity for such entrepreneurs that are demographically most likely to be in off-grid communities. A study undertaken in West Africa that found little correlation between electricity access and a firm's profitability did, however, find that tailors do consistently benefit from electricity access.[136]

Focus group participants also highlighted the potential for solar power to support service-based industries, specifically those participating in retail sales of fish, meat, beverages, entertainment and phone charging. The calculation of the estimated OGS market focused only on barbering and tailoring appliances, which comprises a small portion of overall SME sector demand. These two microenterprises are indicative of the service-based SME off-grid solar market, as they benefit most from extended working hours and the use of modern appliances/machinery. The quantitative demand estimate for this market segment is therefore

[135] Ibid.

[136] Grimm, M., Harwig, R., Lay, J., "How much does Utility Access matter for the Performance of Micro and Small Enterprises?" World Bank (2012): http://siteresources.worldbank.org/INTLM/Resources/390041-1212776476091/5078455-1398787692813/9552655-1398787856039/Grimm-Hartwig-Lay-How_Much_Does_Utility_Access_Matter_for_the_Performance_of_MSE.pdf

intended to provide a baseline for future research, as a more robust analysis would be necessary to assess OGS demand from all SMEs.

According to the analysis, estimated annualized off-grid solar cash market potential for barbers and tailors is USD 432,375 (**Table 31**).

Table 31: Estimated Cash Market Potential for SMEs – Barbers and Tailors[137]

No. of SMEs with Constrained Access to Finance[138]	Units	kW Equivalent	Cash Value (USD)
3,459	692	173	$432,375

Source: World Bank

- **Value-Added Applications**

Agricultural practices, especially for smallholder farmers, can benefit from a wide range of off-grid solar technologies. Cold rooms and ice production are valuable investments for economies engaged in aquaculture. Solar refrigeration, cooling and processing equipment would enable traders and livestock farmers to sell dairy products. Solar drying of cocoa and palm oil processing are productive use applications that would greatly benefit rural farmers in countries where these products contribute to export revenues.

In Benin, there are a wide range of OGS applications that are relevant to the agricultural value chain. Much of Benin's agricultural processing takes places at the household or small firm scale, and the most prominent processed crops are cotton, edible oils (such as cottonseed and palm oil), sugar refining and juice processing.[139] Cotton is an especially important cash crop and is often cultivated by smallholder farmers in northern parts of the country, particularly in the departments of Borgou, Atacora and Zou.[140] Shea butter processing has become an important source of livelihoods for women's cooperatives and is a significant source of exports for the country. Thus, solar powered ginning of cotton and pressing of oils would serve as important and widely applicable productive use of solar power.

The three value-added applications that were analyzed include solar pumping for agricultural irrigation, solar milling and solar powered refrigeration.

Solar Powered Irrigation:

In most West African countries, the national government is typically responsible for carrying out irrigation initiatives, which vary by the scale of the project and often require the construction of civil works such as dams, canals, embankments, and piping. Donor agencies and development partners provide funding for such projects. This analysis focused instead on a small-scale private sector driven approach and estimated the market potential for off-grid solar pumping systems to support smallholder farmers.

Solar pumping systems vary in their wattage depending on the area of land irrigated, the depth of water abstracted and the quality of the soil and crops among other factors.[141] GIS analysis demonstrated that access to the water table and surface water is not a major determinant of the costing of applicable solar

[137] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[138] "MSME Finance Gap," SME Finance Forum: https://www.smefinanceforum.org/data-sites/msme-finance-gap
[139] "Global Agricultural Information Network: Benin," USDA: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Agricultural%20Situation_Lagos_Benin_3-20-2014.pdf
[140] "Benin Agricultural Situation, Global Agricultural Information Network (GAIN)," USAID, (2014): https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Agricultural%20Situation_Lagos_Benin_3-20-2014.pdf
[141] *See* GIZ Powering Agriculture Toolbox on Solar Powered Irrigation Systems: https://energypedia.info/wiki/Toolbox_on_SPIS

irrigation systems, as most farming settlements in Benin are within close proximity to either surface water or relatively easily extractable sources of water (**Figure 34**).

It is important to note that very little land in Benin is registered and most land is managed on a local customary basis.[142] Consequently, this creates uncertainty, which hinders investment in agricultural production, limits access to finance for landowners and more generally constrains economic growth.[143]

In analyzing the available market for solar-powered irrigation, this market scoping exercise focused exclusively on smallholder farmers and solar water pumping irrigation technologies to address their needs. In doing so, this analysis took into consideration the emerging experience with small-scale productive use pumping in East Africa. Small pumps of 80 Wp-150 Wp (e.g. Futurepump and SunCulture) make up the bulk of sales, while larger-sized pumps (e.g., Grundfos) are also frequently marketed to address differing water access and crop conditions.

Table 32 presents the estimated annualized off-grid solar cash market potential for smallholder value-added solar irrigation applications in Benin, which has an estimated cash value of USD 29 million (see **Annex 2** for more details).

Table 32: Estimated Cash Market Potential for Value-Added Applications – Irrigation[144]

Estimated No. of Smallholder Farms Suitable for OGS Pumping for Irrigation	Units	kW Equivalent	Cash Value (USD)
268,333	44,722	5,367	$29,069,444

Source: Food and Agriculture Organization; World Bank; African Solar Designs analysis

Solar Powered Milling:

Cereal crops like maize, sorghum, millet, and rice provide an opportunity for value addition through hulling or milling. Off-grid communities use maize or rice milling equipment that is typically powered by diesel generators. Discussions with off-grid community groups revealed that although many are aware of the long-term cost savings associated with solar powered mills, the up-front cost of purchasing equipment was viewed as too high.

Table 33 presents the estimated annualized off-grid solar market potential for smallholder value-added solar grain milling applications in Benin, which has an estimated cash value of USD 5.2 million (see **Annex 2** for more details).

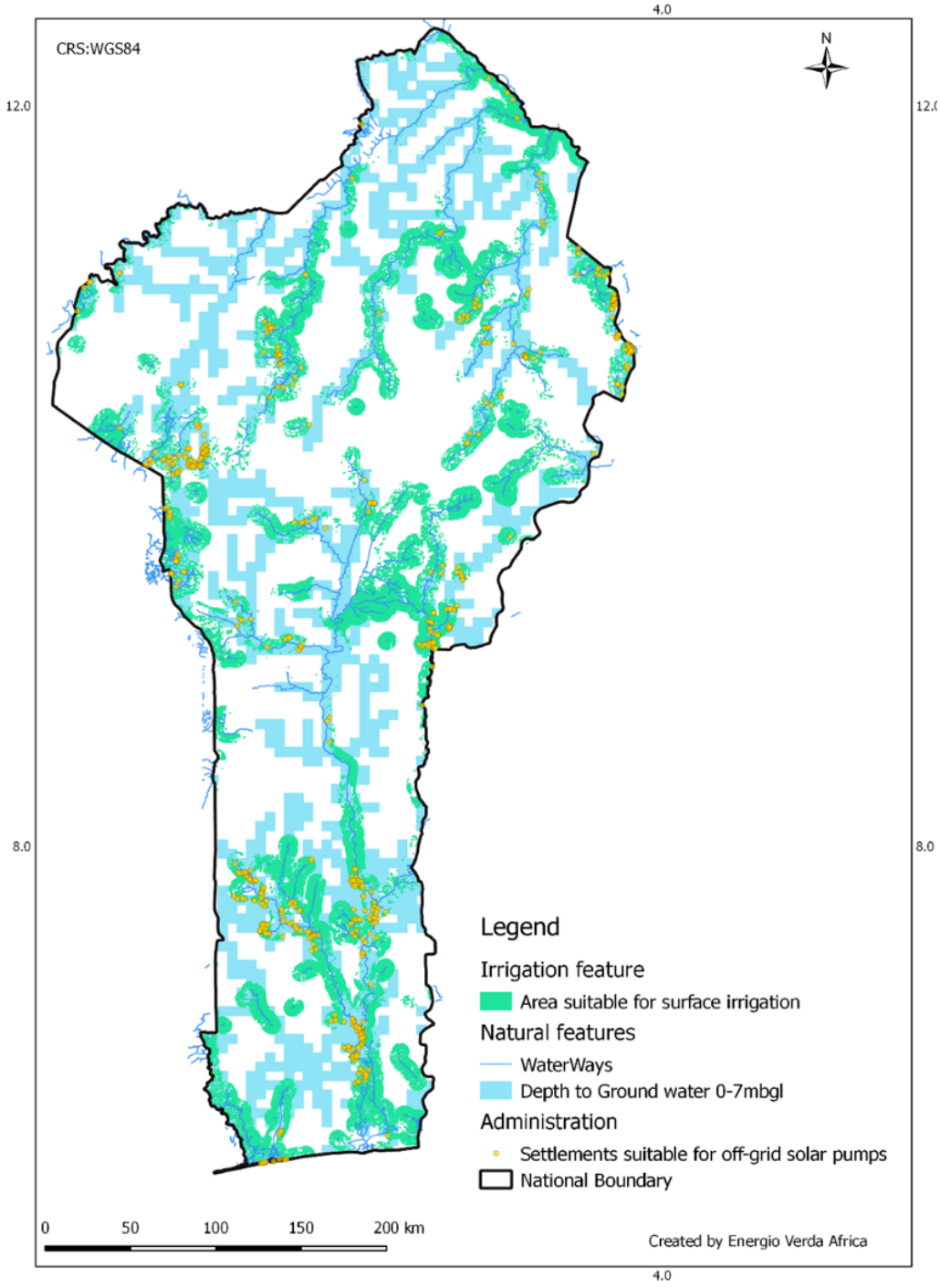
Table 33: Estimated Cash Market Potential for Value-Added Applications – Milling[145]

Estimated No. of Solar Mills	Units	kW Equivalent	Cash Value (USD)
6,462	323	2,100	$5,250,099

Source: Food and Agriculture Organization; African Solar Designs analysis

[142] "Benin, Food Security and Land Governance Sheet," http://www.landgovernance.org/system/files/Benin%20Factsheet%20-%202012.pdf
[143] "Benin Access to Land Project," Millennium Challenge Corporation: https://www.mcc.gov/blog/entry/blog-020714-land-titles-and
[144] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[145] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

Figure 34: Area Suitable for Surface Irrigation and Identified Settlements Suitable for Off-Grid Solar Pumps



Source: British Geological Survey, Bureau of Statistics; ESA Climate Change Initiative; Humanitarian Data Exchange (HDX); Energio Verda Africa GIS analysis[146]

[146] NOTE: mbgl = meters below ground level
Sources: Mapping provided by British Geological Survey © NERC 2012. All rights reserved; Irrigation area identified from a Land Cover data set through the ESA Climate Change Initiative, Land Cover project 2017. © Modified Copernicus data (2015/2016): https://www.esa-landcover-cci.org/?q=node/187; Settlements provided by the Humanitarian Data Exchange (HDX)

Solar Powered Cooling and Refrigeration:

Solar-powered refrigerators and freezers in rural areas serve multiple purposes, including to store milk, fish, meat and vegetables to extend the life of produce and reduce losses. In addition to storing produce, ice-makers can increase the income of rural SMEs by providing ice to businesses that require cold storage (stores, restaurants etc.).

Table 34 presents the estimated annualized off-grid solar market potential for smallholder value-added solar refrigeration applications in Benin, which has an estimated cash value of USD 1.4 million (see **Annex 2** for more details).

Table 34: Estimated Cash Market Potential for Value-Added Applications – Refrigeration [147]

Off-Grid Market Centers	Units	kW Equivalent	Cash Value (USD)
2,135	107	587	$1,467,813

Source: Food and Agriculture Organization; African Solar Designs analysis

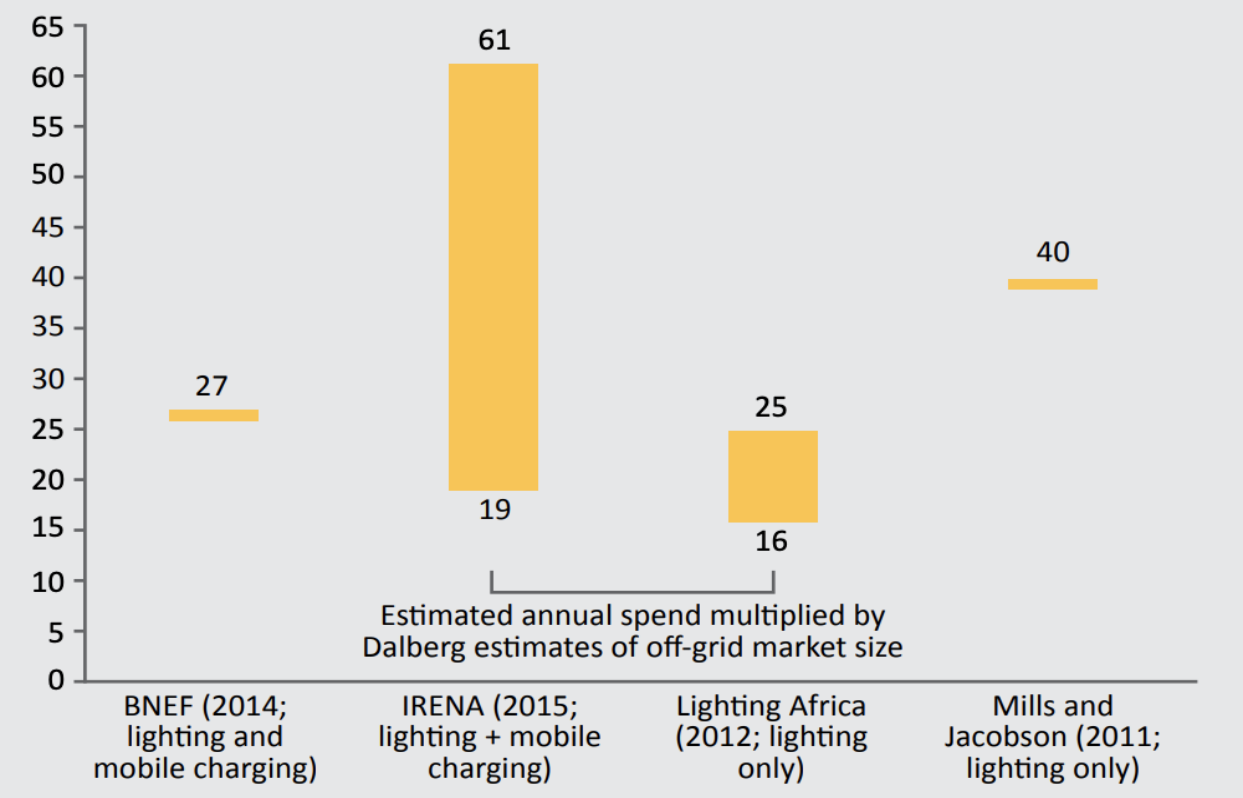
Ultimately, the ability for an agricultural community to benefit from productive use applications has as much to do with access to markets and improved crop inputs, as it has to do with the pricing and availability of financing to purchase the equipment. Hence, the macroeconomic approach used to carry out this market sizing does not account for country-specific cost and supply chain constraints.

- **Connectivity Applications**

Mobile phone charging stations/kiosks make up a critical segment of off-grid solar demand, as the market for solar phone charging is expected to grow significantly in the near-term. Household rates of mobile phone ownership often greatly exceed rates of electricity access, while households spend a significant share of income on lighting and phone charging (**Figure 35**). Increasingly, off-grid solar devices, such as lighting devices, also include phone-charging capabilities that enable owners to engage in mobile-phone charging businesses.

[147] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

Figure 35: Estimated Annual Off-Grid Household Expenditure on Lighting and Mobile Phone Charging[148]



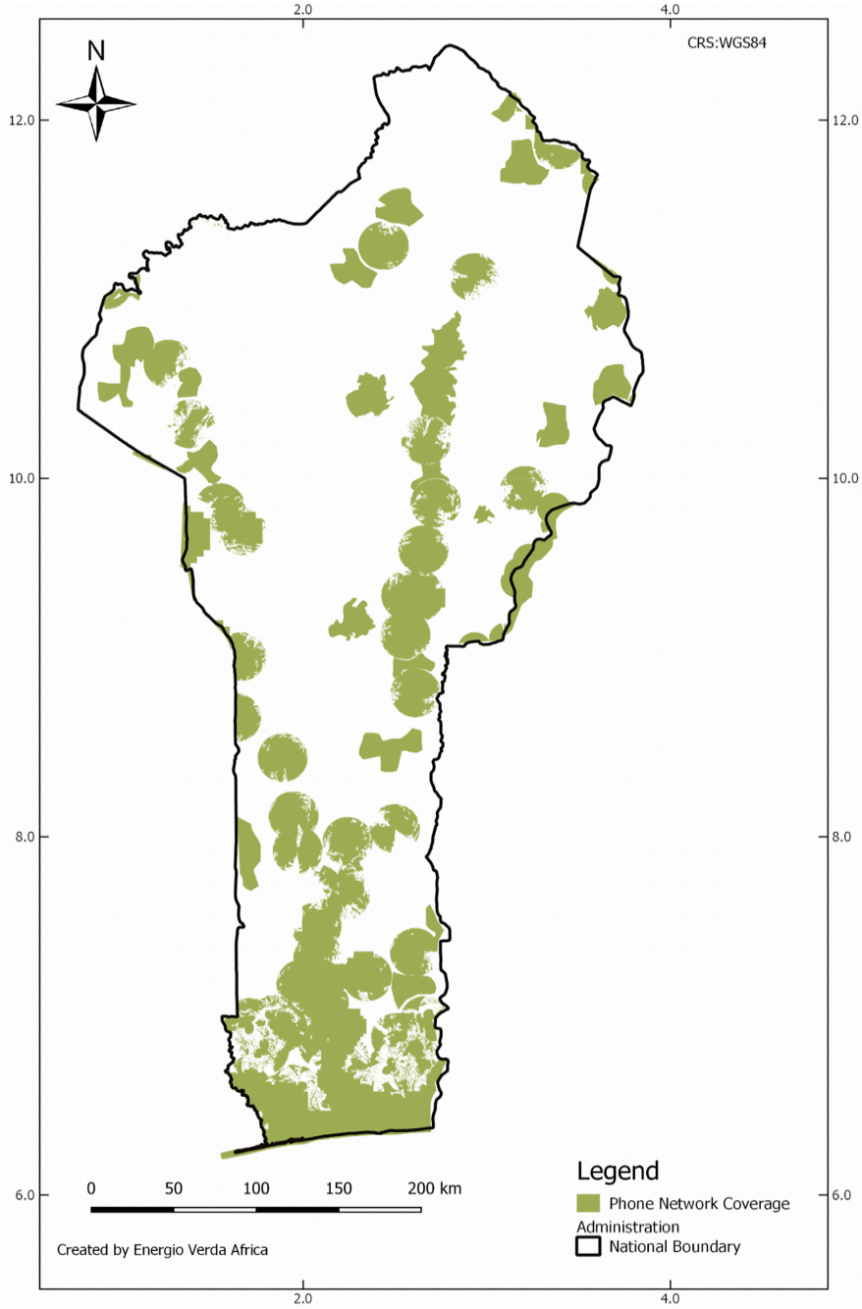
NOTE: Figures in Billion USD

Source: Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP

Figure 36 shows the relatively broad geographic coverage of cellular signals across the region. Cellular connectivity is essential for solar PV markets. In many African countries, mobile phone charging provides a primary productive use application for off-grid solar. Mobile phone access – and more importantly connectivity – helps drive commerce and employment in rural areas. The penetration of mobile money services is also critical, as it drives greater financial inclusion, expands consumer financing options and further increases demand for phone charging enterprises. Above all, mobile phones and connectivity are a necessary precursor to PAYG solutions in the OGS sector. Countries with expanding mobile phone coverage and especially broadband internet users are more attractive to PAYG solar companies (**Figure 15**).

[148] "Off-Grid Solar Market Trends Report 2018," Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf

Figure 36: Mobile Phone Network Geographic Coverage[149]



Source: GSMA

The analysis of the potential solar-powered phone charging market was based on the country's mobile phone penetration rate, rural population rate, and the average costs of OGS phone charging appliances. **Table 35** presents the estimated annualized cash market potential for off-grid solar mobile phone charging enterprises in Benin, which has an estimated cash value of USD 4.8 million (see **Annex 2** for more details).

[149] See **Annex 2** for more details

Table 35: Estimated Regional OGS Cash Market Potential for Connectivity Applications[150]

Mobile Subscribers[151]	Rural Population (%)[152]	Units	kW Equivalent	Cash Value (USD)
5,100,000	56%	5,669	2,268	$4,886,476

Source: GSMA; World Bank; African Solar Designs analysis

2.3.3 Ability to Pay and Access to Finance

The above analysis illustrates that there is a sizeable off-grid solar cash market for productive use applications in Benin. However, more research needs to be done in each segment to better understand affordability of OGS appliances and equipment based on ability and willingness to pay as well as other factors such as access to finance and ultimately whether the expenditure for the equipment is justifiable given increased revenue/productivity in the long-term.

The value-added market for water pumping for irrigation indicates that increased revenues from the use of solar appliances would justify the expenditure for the equipment – although as mentioned, agricultural productivity also depends on other environmental and market factors that are specific to each country. Solar powered irrigation systems may require a financed solution to be profitable investments for farmers, as their cost may exceed benefits depending on how the systems are designed and what components are used.

With regard to microenterprises, further study would be needed to determine the impact of off-grid solar on this sector, especially as it relates to income and affordability of the sectors analyzed (phone charging, barbers and tailoring). Land rights issues, specifically the lack of land titles, agricultural loans, and inadequate bookkeeping practices among smallholder farmers combine to impede access to finance for off-grid solar appliances in this sector.[153]

The focus group discussions in countries across the region yielded additional insights into the off-grid solar PUE sector from a consumer point of view:

- There is need to promote awareness through increase in availability of off-grid solar solutions and highlighting successes of solar use so that communities as well as banks can invest and support the sector. A potential solution to scaling this effort could be achieved through subsidizing upfront costs.
- There is recognition that promotion of favorable regulatory environment will encourage private sector investment. This could potential be achieved through tax and duty exemptions on such appliances.
- Further, most companies cannot afford the up-front cost of solar solutions. A potential solution to this could be to implement consignment schemes to allow distributors to better engage retailers for solar appliances and power systems.
- Despite public and donor-led interventions to lower financial constraints, firms in rural areas still struggle to access financing solutions. This is especially the case for farmers that have invested in milling or solar drying but have not implemented irrigation schemes that would allow them to harvest crops year-round.
- There is also a high degree of skepticism regarding the reliability and quality of solar powered appliances, and as a result, more should be done to raise awareness and set appropriate standards for solar products.

[150] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[151] "The Mobile Economy: Sub-Saharan Africa," GSMA, (2017): https://www.gsmaintelligence.com/research/?file=7bf3592e6d750144e58d9dcfac6adfab&download
[152] World Bank: Rural Population (% of total population) https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS
[153] Global Agricultural Information Network: Benin, USDA: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Agricultural%20Situation_Lagos_Benin_3-20-2014.pdf

2.4 Supply Chain

This section reviews the off-grid solar supply chain in Benin, including an overview of key actors, solar products and services, business models, and sales volumes. The section also analyzes the role of informal market players and the impact of uncertified products. The section concludes with an assessment of local capacity and the needs of the supplier market segment. The data presented in this section was obtained through desk research, interviews with local officials and industry stakeholders, focus group discussions and surveys of international and local solar companies (see **Annex 2** for more details). The tier system used to classify solar companies throughout this section is described in **Table 36**.

Table 36: Solar Company Tier Classification

	Classification	Description
Tier 1	Startup companies	• Less than 3 full time employees • Less than 300 SHS or Less than 1,500 lanterns sold • Less than USD 100,000 annual revenues • Does not have access to outside finance except personal loans and may have a business account
Tier 2	Early stage companies	• 3 to 25 full time employees • 300 to 30,000 solar home systems or 1,500 to 50,000 lanterns sold
Tier 3	Growth/Mature	• More than 25 full time employees • More than 30,000 solar home systems or 50,000 lanterns sold • More than USD 3 million annual revenues • Has a credit line at a bank and financial statements • Raising equity or other outside financing

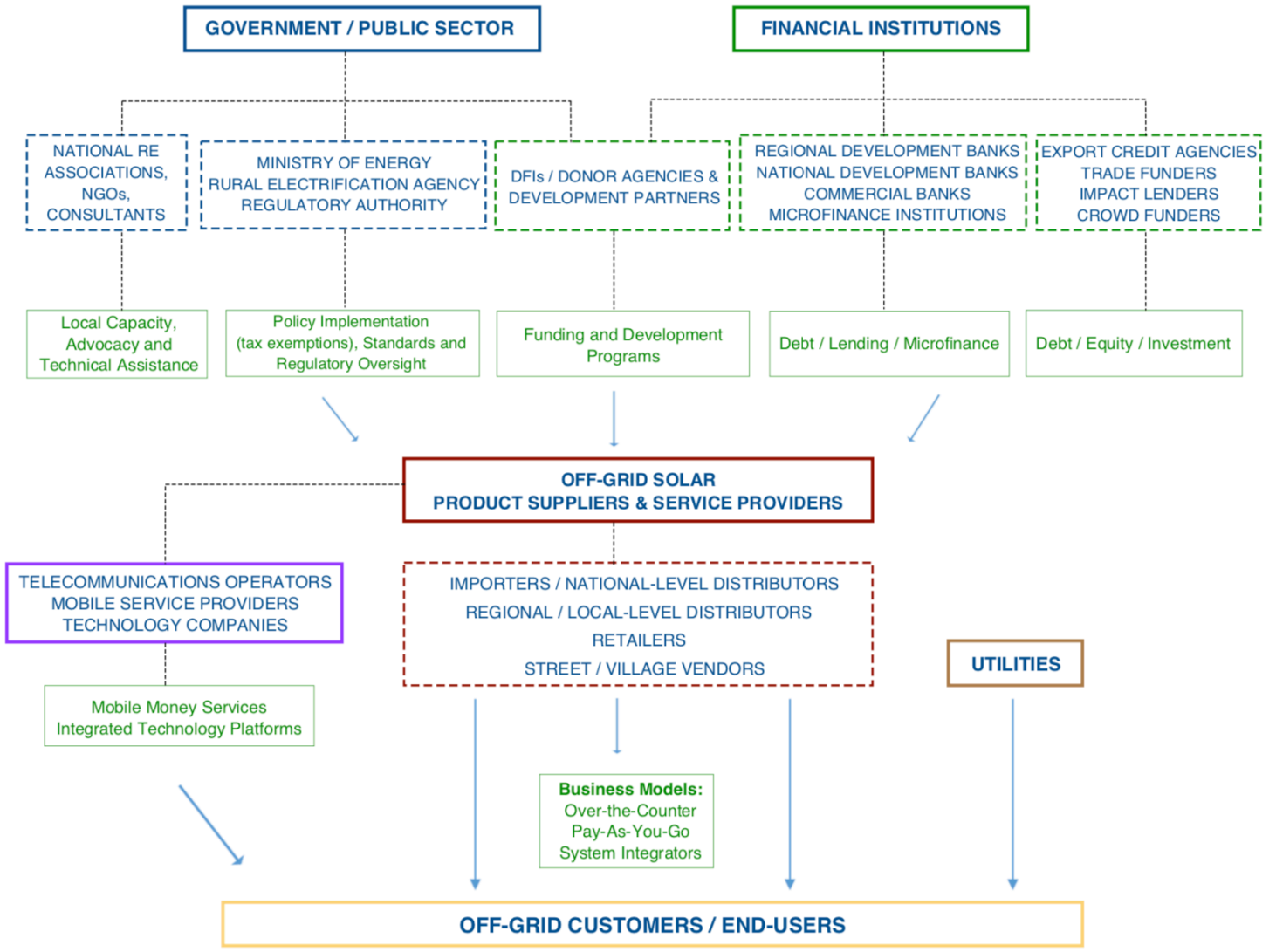
Source: ECOWAS Center for Renewable Energy and Energy Efficiency

2.4.1 Overview of Commercial Market for Solar PV Equipment

The off-grid solar supply chain in Benin is made up of a wide range of stakeholders – importers, distributors, wholesalers, retailers, NGOs, and end-users (**Figure 37**). Benin is a small but quickly growing solar market, as the country's overall market environment and opportunity for solar companies is improving (**Figure 12**). A variety of solar products and systems are offered by companies in the market (by both the formal and informal sector) and, as examined in further detail below, there are a number of business models being utilized. Rural households make up the main market for off-grid lighting products in the country, as the demand for lighting products and household electrical appliances is growing. Urban households, both electrified and non-electrified, are also a key consumer market, as they may have greater ability to afford OGS products and systems. Moreover, despite the high level of grid connectivity in urban areas, power supply is often not sufficient, continuous, or reliable (**Figure 3**), further supporting expanded use of solar PV equipment by this consumer segment.

The main business model deployed by local solar companies is cash/over-the-counter sales, while a few companies have started to utilize PAYG sales. Though large companies selling certified products play a central role in the market, the informal sector remains a key factor. Surveys of local industry players and focus group discussions noted that a clear regulatory framework was necessary to provide appropriate incentives for the private sector and to address the widespread sale of low-quality, uncertified products, which is hindering development of the country's OGS market.

Figure 37: Off-Grid Solar Market and Supply Chain Overview



Source: GreenMax Capital Advisors

2.4.2 Overview of OGS Companies in Africa and Level of Interest in the Region

The African off-grid solar market has experienced rapid growth over the last five years. This growth can largely be attributed to the emergence of a progressively diverse, global pool of manufacturers and distributors, decreased system costs and an increase in three major product categories – pico solar, plug-and-play SHS, and component-based systems.[154] Leading solar companies such as Greenlight Planet, D.Light, Off-Grid Electric, M-KOPA Solar, Fenix International, and BBOXX represent the largest share of the African off-grid market and are joining other players in West Africa and the Sahel, including Lumos Global, PEG Africa, Barefoot Power, Yandalux, Schneider Electric, Azuri Technologies, Solarama, AD Solar, Enertec, SmarterGrid, GoSolar, Total, Oolu Solar, EnergenWao and SunTech Power to list a few.

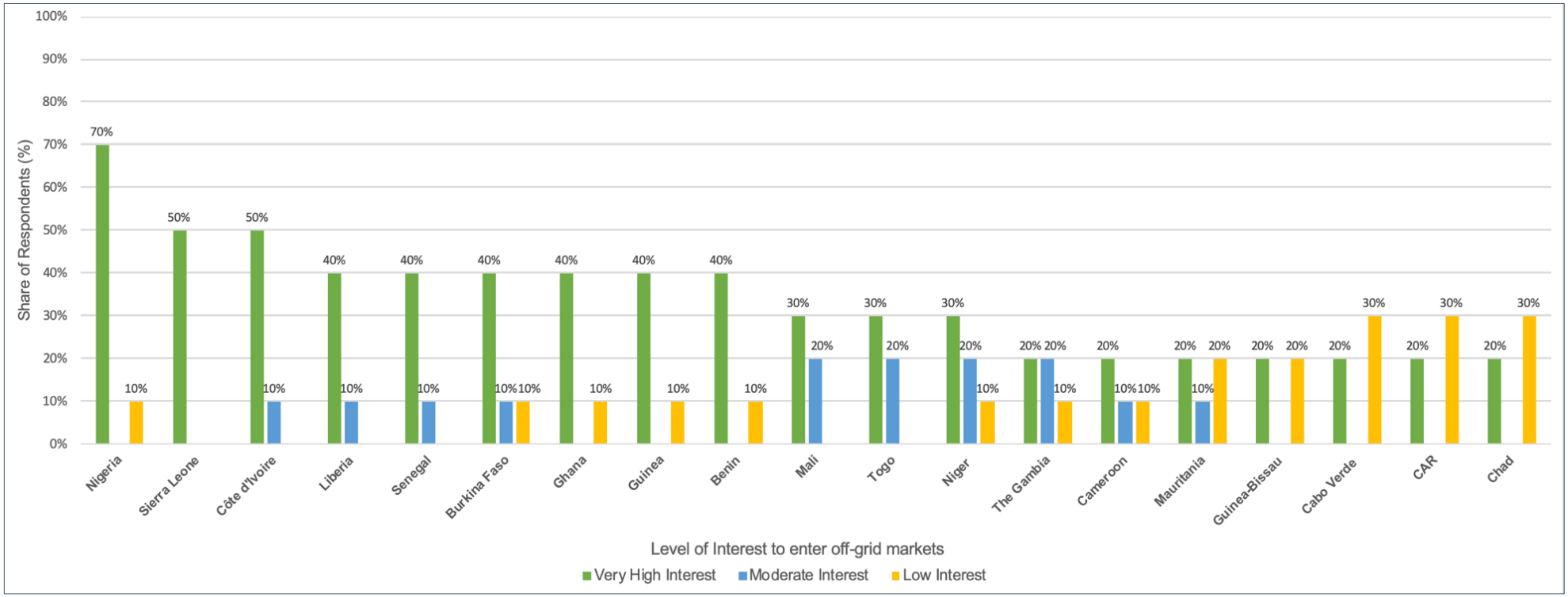
Market entry into Africa began in East Africa for a majority of the leading companies, a trend that can be attributed to advancements in mobile money transfer systems such as M-Pesa that have facilitated the PAYG off-grid business model. As the East African market becomes more crowded and mobile money services spread across the Continent, many international off-grid solar companies have recently entered markets in West Africa and the Sahel. The regional market grew from being nearly non-existent in 2013 to accounting for 9% of worldwide sales (20% of SSA) with over 2 million systems sold in 2017.[155]

Over 500 solar companies have been identified operating across the region, many of which are small local players. These local distributors either operate independently or act as local affiliates of larger international companies operating in this space. The majority of companies in the region are primarily Tier 1 and Tier 2 companies, with relatively few Tier 3 companies. The highest concentration of Tier 3 companies was identified in Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Mali, Nigeria and Senegal.[156]

A survey of large international solar companies that assessed *inter alia* their level of interest in entering the off-grid markets of West Africa and the Sahel is presented in **Figure 38**. The survey found that among respondents, companies expressed the most interest in Nigeria, Sierra Leone, and Côte d'Ivoire, with at least half of respondents indicating a "very high level of interest" in these markets. There was also a relatively high level of interest in Liberia, Senegal, Burkina Faso, Mali and Togo, with at least half of respondents indicating a "very high" or "moderate" level of interest in these markets.

[154] "Off-Grid Solar Market Trends Report, 2018," Dahlberg Advisors and Lighting Africa, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf
[155] Ibid.
[156] "Insights from Interviews with Off-Grid Energy Companies," ECREEE, (June 2018).

Figure 38: Level of Interest in Off-Grid Markets in West Africa and the Sahel among Major Suppliers[157]



Source: Stakeholder interviews; GreenMax Capital Advisors analysis

[157] NOTE: This is not a representative sample of respondents (sample size = 10 respondents). The figure is meant to provide feedback from "major suppliers" of off-grid solar products and services and gauge their level of interest in entering specific ROGEP country off-grid markets. Respondents are all GOGLA members and are either already active in the West Africa and Sahel region or seeking to enter it. The figures presented are the share of respondents (%) who indicated their level of interest in a given country.

2.4.3 Solar Market, Products and Companies in Benin

This section characterizes the current formal market (local and international companies) including recent sales trends, the main solar products, brands and prices.

- **The Formal Market – Local and International Companies**

Focus groups and stakeholder interviews identified nearly 40 companies operating in Benin's solar sector, offering a wide range of products and services to consumers throughout the country (see **Annex 2** for a complete list of identified companies). In addition to local firms, the formal market includes international players that enter the market to install systems for donor-funded projects. As of 2018, most of the solar companies operating Benin were Tier 1 companies, with only three firms identified as Tier 2 companies, and none having reached the Tier 3 level.

Focus groups and stakeholder interviews identified several experienced companies including manufacturer representative ARESSS, wholesaler and retailer, ASEMI, and retailer Jesuton. These companies offer a wide range of services, including design, installation, and post-sale O&M. While a few companies are manufacturer representatives (e.g. ARESSSS, Ismast, Soconeme and Mise), major companies are typically both wholesalers and retailers (e.g. Enerdas, Asemi, Générale Énergie, Atiwib Group, Bio Solar Energie Plus), or just retailers (e.g. Benergies). There are currently no solar manufacturers in the country and most products are imported from China.

Although, there is no Tier 3 company in Benin, FGDs and stakeholder interviews identified several companies that have formed key partnerships with global brands and suppliers and offer a wide range of products and services. Ego Services, Ismast Energy and Cetra are the main distributors of pico solar products in the country, while ARESSS, ASEMI, Enerdas and Soconeme are the main distributors of solar home systems. Most of the remaining local companies are Tier 1 firms that typically offer pico solar and/or solar home system products to households and institutional/social users. Bio Solar Energy Plus and Enerdas are the only two companies that offer plug and play systems to their clients.

Most of the surveyed local companies buy their products either directly from manufacturers outside of the country and act as local representatives of their products and brands, or from other local or regional distributors. These companies are mainly self-financed, with the exception of a few that also have access to bank financing. External sources of financing are available to customers (e.g. through MFI loans). These companies typically also offer installation and O&M services for the products they sell to customers, including repairs under warrantee.

- **Sales Volumes and Revenue**

Focus group participants indicated that it is challenging to assess the size of the current market due to a lack of standardization in pricing from one company to another and a shortage of sound statistical data. Moreover, during surveys and FGDs, companies were reluctant to share confidential data on sales volumes and market shares. Local industry stakeholders described the market as having significant volume of sales distributed between hundreds of larger installations (>1 kW) and tens of thousands of consumer product sales along with institutional system market activity.

Using reports published by GOGLA, some basic market information is presented in **Table 37** and **Table 38**. It is important to note that this data only includes figures from GOGLA-affiliated companies and certified product sales and is therefore not fully representative of off-grid solar market activity in Benin.

Table 37: Total Sales Volume and Cash Revenue for Stand-alone Systems in Benin, 2016-2017[158]

Sales Volume / Revenue	2016	2017	Total
Total Volume of Products Sold (Units)			
Total Volume of Products Sold	175,434	15,949	**191,383**
Pico Solar	149,119	14,992	**164,111**
SHS	26,315	957	**27,272**
Total Cash Sales Revenue (USD)			
Total Cash Sales Revenue	$1,507,935	$544,195	**$2,052,130**
Pico Solar	$1,447,935	$468,008	**$1,915,943**
SHS	$60,317	$76,187	**$136,504**

Pico solar products categorized as 0-10W
SHS products categorized as >10W

In 2016-2017, about 90% of the overall share of OGS products sold and 92% of total sales revenue in West Africa were pico solar products compared to 10% of products sold and 8% of sales revenue were SHS.

Source: GOGLA, Lighting Global and World Bank; GreenMax Capital Advisors analysis

Table 38: Cash and PAYG Sales Volume and Revenue for Pico Solar Products, H1 2018[159]

Sales Volume / Revenue	Cash	Share (%)	PAYG	Share (%)	Total
Total Sales Volume Benin	**5,733**	**100%**	no data	-	**5,733**
Total Sales Volume West Africa	194,521	65%	104,520	35%	299,041
% of Total Sales Volume in West Africa	3%	-	no data	-	2%
Total Sales Revenue Benin	**$372,935**	**100%**	no data	-	**$372,935**
Total Sales Revenue West Africa	$14,972,591	50%	$15,008,999	50%	$29,981,590
% of Total Sales Revenue in West Africa	2.5%	-	no data	-	1.2%

NOTE: H1 = First half of year

Source: GOGLA, Lighting Global and World Bank; GreenMax Capital Advisors analysis

- **In 2016-2017, 191,383 units were sold in Benin for a total cash sale revenue of over USD 2 million.** Benin recorded the third highest sales volume (behind Nigeria and Burkina Faso) and the sixth highest sales revenue (behind Nigeria, Burkina Faso, Guinea, Ghana, and Mali) in West Africa over this period.

- **Sales figures remain volatile, as Benin is still a nascent off-grid solar market.** In H1 2018, sales volume dropped by 64% compared to H1 2017, reflecting the dynamic nature of the market. With 5,733 units sold in H1 2018, Benin's sales volume was above only Togo (4,505 units) and Niger (3,955 units) for this period. This can in part be attributed to the relatively low utilization of the PAYG business model, which has only been adopted by a few companies to date.

[158] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth2-2017_def20180424_web_opt.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth12017_def.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2016): https://www.gogla.org/sites/default/files/recource_docs/final_sales-and-impact-report_h22016_full_public.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2016): https://www.gogla.org/sites/default/files/recource_docs/global_off-grid_solar_market_report_jan-june_2016_public.pdf

[159] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2018): https://www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h1_2018-opt.pdf

- **Pico PV products represent the vast majority of products sold**. Based on regional sales data on product categories, pico solar products accounted for 76% of sales volume and 89% of total cash sales revenue in H1 2018 in Benin.

➢ Main Solar Products and Components

Table 39 lists the brands of common solar products and components in Benin. The list does not include non-certified brands that are also common in the country's grey market.[160]

Table 39: Off-Grid Solar Products and Components in Benin

Systems	Companies
Distributors of Pico Solar Lanterns	Ego Services, Ismast Energy, Cetra
Single Module distributors	Ibig, ARESSS
Multi module system distributors	Enerdas, Ibig, ARESSS, Soconeme, Asemi Group
Very large system supplier	Enerdas, ARESSS, Asemi Group
Products/Components	**Brands**
Pico solar lanterns	GLP (USA/China), Yingli Solar (China)
Solar modules	BP Solar (France), Jinco QXPV (China), ET Tino (Canada), Suntech (China), Hoppeck (Germany)
Inverters	Kisae (USA), Steca (Germany), Victron/Steca (France, China), SMA (France)
Lead Acid Batteries	Ritar, North Star (USA), OutDo (China), Victron (Netherlands), Victron (Germany)
Solar Water Pumps	Grundfos Pump, Lorentz Pump
Misc. (PV modules, controllers (PWM and MPPT), Batteries (VRLA-GEL, VRLA-AGM, liquid electrolyte), Inverters, solar air conditioners, pumps etc.	Sun King, Victron, Steca, Schneider, SMA, Hoppecke, GACIA, Safepower, SuKam, Luminous, Solar BP, Sharp, Jinko Solar, My Home, Grundfos Pump, Lorentz Pump

Source: Stakeholder interviews

➢ Market Prices

Table 40 presents average prices for off-grid systems and components in Benin's solar market.

Table 40: Estimated Prices of Solar Systems and Components in Benin

Off-Grid System / Component	Price range (USD / per unit)
Pico solar and Plug and Play (10 Wp)	$22-$100
SHS (small, 35WP-12Wp)	$35-$100
SHS (medium)	$700-$1,200
SHS (large, >600Wp)	>$2,000
Solar Module (150 Wp - 250 Wp)	$100-$244
Inverter (180 Wp - 15,000 Wp)	$100-$6,000
Lead Acid Battery (150 Ah - 1,520 Ah)	$23-$2,000

Source: Stakeholder interviews

[160] In this context, "grey market" refers to products that are not Lighting Global or IEC certified that are typically sold over-the-counter at low prices. Some grey market products are counterfeit or replicas of certified products that undercut the markets of certified products.

➢ **Importation Clearance Processes**

The Rural Electrification Agency (ABERME) is the main government agency involved in the importation of solar products into the country. In Benin, any type of off-grid solar products ordered by ABERME are exempt from import duties. For other products, only solar panels are tax free, while other products and components are taxed at 8%. It takes about 75 business days for importers to get solar products into Benin – about 45 business days for freight (time it takes for equipment to arrive in the country) and about one additional month for customs clearance. GOGLA and Lighting Africa standards are applied in the country but only for some products imported through specific government or donor funded programs (e.g. GIZ and SNV). Otherwise, it is not compulsory to comply to GOGLA and Lighting standards at national level. To date, there is no agency in charge of making the standardization process more efficient at national level.

2.4.4 Overview of Business Models

➢ **Company Approach to Market**

Historically, solar companies in Benin have developed as vertically integrated companies, based on in-house design of solar systems, outsourcing of manufacturing and partnerships with international brands. About two-thirds of the companies surveyed have been in business for more than five years and are well established local players, while most of the remaining surveyed firms have been operating in the solar sector for fewer than three years. Most companies continue to sell a wide range of products to all market segments; their most important clients are large institutional groups such as NGOs and public health facilities or large high-income clients. Focus group participants estimated that households account for the majority of installed off-grid solar sales (about 60%), followed by SMEs (35%) and institutional users (5%). The main business model is cash/over-the-counter sales, as only a small number of firms have started to utilize PAYG to target low-income households and reach base of the pyramid users in the market.

➢ **Business Models**

There are four primary business models used in the market (**Table 41**), although in reality solar companies utilize a number of business models to reach a variety of clients:

- **Over-the-counter cash sales** include both formal and informal retailers. Many traders simply offer solar products over-the-counter. Formal sector solar companies also stock modules, batteries and balance of system and offer them over-the-counter to do-it-yourselfers and agents.
- **System integrators** handle large systems and projects. They design, procure and install systems which range from high-end residential sites, to institutional power to mini-grids. Local integrators represent international solar, inverter and battery brands with whom they partner with on projects.
- **Plug and play and pico suppliers** cooperate with many of the major OGS brands to distribute products in the country. Sellers of plug and play systems target customers who can afford more than simple pico lanterns (products are usually sold through PAYG). A few companies have started providing plug and play systems in Benin.
- **The PAYG sector** is still in its early stages in Benin. Under this business model, suppliers are gradually building up client bases which number in the tens of thousands and are quickly evolving to develop credit mechanisms that fit with local income patterns. Margins are made from subscriptions of thousands of consumers who buy systems through created accounts. The task of installation and after sales services is undertaken by agents. Common products sold include plug and play systems that are fully designed. Only two identified suppliers in Benin currently utilize this business model.

Table 41: Overview of Off-Grid Solar Business Models

Business Model	Strategy and Customer Base	State of Development
Over-the-counter solar market	**Formal:** Retailers in Benin are both large-scale (acting as suppliers and distributors) and medium size and are mainly located in large cities and towns around the country. They sell lighting/electrical products, including solar, pico systems and also large panels for urban customers. **Informal:** Kiosks, street vendors form a key pico-product retailer segment (that has not been fully explored). They sell low-priced products which are often short-lived. They have been seen as the entry points for black market low quality solar products to the country.	Mature commercial market Early stage commercial development
System integrator	Integrators operate out of central offices with small specialized staff. They do not typically carry stock for sale over-the-counter. Instead, they deal directly with consumers and institutional clients and provide as per orders. Integrators target the NGO/donor market and participate in procurement tenders for supply and installation of larger systems.	Mature commercial market
Plug and Play system supplier	These suppliers distribute equipment to retailers' projects, rural agents, community groups and over-the-counter. Traders of plug and play often sell these devices as part of other businesses.	Early stage commercial development
PAYG Sales	PAYG companies seek to implement the rent-to-own payment-based models used successfully in other countries. The business model is data-driven and relies on mobile money services and a network of agents to meet last-mile customers. Innovative OGS PAYG collaborations between shop-owners, mobile-operators and other larger local businesses are being tested. While a minority of companies utilize the PAYG model, hire-purchase, MFI loans and consumer subsidies (e.g. GIZ's EnDev projects) among other sources of consumer finance are available in Benin.	Early stage commercial development

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

- **Company Financing**

With overall lack of financial assistance and dedicated financing mechanisms available for the off-grid sector, it can become difficult for companies to finance their operations and grow their business. In addition to financing customer payment options (hire purchase), suppliers also require significant working capital to purchase equipment, conduct marketing campaigns, cover field costs, high cost of merchandise transportation from supplier and estimated high risk of theft. Distributors of international OGS products receive basic trade finance and marketing support options, though typically limited. Most of the firms surveyed in Benin are self-financed with cash flow covered by shareholders and founders and from on-going business transaction. A few firms are supported by FI/MFI loans, donor funding/grants (e.g. GIZ's EnDev project) and CSR, but these resources are limited for most. Most companies receiving GIZ's grants are initially self-financed, as grants are only awarded upon delivery of the off-grid systems and after a quality check by GIZ to verify the system is working properly.

As the majority of players are local companies operating in the country, they do not have access to loans, equity and other international funds to finance their growth and development. As a result, most of the solar companies in Benin are unable to raise funds to expand their business. Local financiers have yet to develop an appetite for the solar sector. Local banks are extremely conservative with regard to solar enterprises. Commercial financiers – including banks and MFIs – are not set up to service solar distributor financing requirements. Local SME financing is not available to support businesses in their growth phase. If it was available, companies would make use of cash-flow/credit line financing against the signed contracts with major commercial clients, large NGOs or donors.

When importing, companies are exposed to considerable FOREX risks because they must cover costs of equipment in foreign currency. When projects are delayed, during seasonal low-income periods or when products are delayed in port, dealers must bear FOREX losses. The lack of consumer financing arrangements impedes the growth of the solar market because distributors must take all finance risks and cannot plan with commercial or MFI financing to grow their business.

- **Evolving Business Models**

Benin presents a fertile ground for new business model innovations. New models will require partnerships between developers, solar distributors, telecommunications companies, commercial finance and the retail sector. One of the results of the FGDs was a list of potential partnerships that can be explored to enhance existing and new business models (**Table 42)**.

Table 42: Evolving Off-Grid Solar Business Models

Partnership	Description
Solar Distributors	• Improve efficiency within the supply/distribution chain, positioning them to be able to manage distribution, seek potential for long-term credit lines and capital infusions • Develop better contract terms between large local suppliers in Benin with foreign manufacturers • Test new sales and distribution strategies that increase sales at minimum cost • Prove solar market potential, ultimately attracting a strong group of competing players that scale up solar product access
Commercial financiers	• Commercial financiers are key to unlocking working capital and consumer finance and enabling the market by providing both the funds and means of transferring these funds • Develop financial products for both distributors (financing for working capital needs) and off-grid solar consumers (consumer financing for purchase of systems)
Telecommunications companies and technology providers	• Bring together telecommunications operators, mobile service providers and technology companies and solar supplier/distributor companies to develop Pay-As-You-Go technology platforms • Encourage telecommunications partners to distribute OGS systems through their existing network of agents
Business/Retail Sector	• Comprises networks of retail stores that cover the entire country and provide all types of domestic and agriculture goods for the rural community • Encourage linkages between specialized solar companies and these networks so as to facilitate the increase of the distribution network at a lowest cost possible • Provide promotional tools for local retailers to promote solar products to households/SMEs • Facilitate microfinancing for the domestic market through these networks
Advocacy Bodies	• Capitalize on GoB and donor efforts to (i) facilitate interagency dialogue and oversee policy proposals on new business models and (ii) enhance legislative changes to support the sector

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

2.4.5 The Role of Non-Standard Players in the Market

Stakeholder interviews and FGDs were not able to estimate the size of the over-the-counter informal market. Informal traders sell modules, inverters, batteries and pico-products. Given that informal sellers are largely unregulated and do not report sales figures, very little data is available on this sector. The sector, however, is very influential as it also controls the delivery of lighting products imported mainly from East Asia. Informal traders understand growing consumer interest in solar solutions and sell competitively-priced low-quality products. Informal traders do not actively cooperate with the GoB or formal projects. In Benin, surveyed stakeholders indicated that some informal suppliers sell low-quality products at the price of high-quality products.

Informal traders play an important role in the market because they respond to consumer demand rapidly. Many traders do provide IEC-approved components – this means knowledgeable consumers and technicians can assemble quality systems from over-the-counter selections of components that informal

traders sell. It is notable that some informal traders are gaining skills and improving product offerings. The presence of a large informal market, however, leads to issues with equipment quality that hamper development of the country's OGS market.

2.4.6 Equipment Quality and the Impact of Uncertified Equipment

Benin's solar market is largely dominated by informal market players, selling equipment through electronics shops, hardware stores, kiosks and even street vendors. The over-the-counter sales strategies of this group is to provide low-cost, fast moving products. As a sector, informal retailers provide widely-used lighting products mainly from East Asia to rural customers. However, most of their product range does not meet Lighting Global standards. Moreover, given that the most of their lighting products are low-cost and short-lived, they also ignore and avoid regulations and their products lack warrantees.

Poor-quality and/or counterfeit products negatively impact the entire market by creating a misperception about product quality, which in turn undermines consumer confidence in solar equipment. Moreover, grey-market traders significantly undercut the prices of registered businesses who are still subject to taxes and import duties. Low prices of over-the-counter products make compliant products uncompetitive as many customers opt to buy non-compliant goods that are cheaper.

In Benin, surveyed stakeholders expressed concerns about the overall quality and reliability of equipment in the market. They also highlighted the success of a GIZ initiative in which high-quality products were a prerequisite for distributors to obtain a grant. Feedback from focus group meetings suggested that a price-cap policy on standard products should be implemented, for products to be more affordable to clients (GIZ has already started to harmonize prices, but it is limited to EnDev project beneficiary distributors).

2.4.7 Local Capacity to Manage Business Development, Installation and Maintenance

Benin's nascent solar market is poised to grow if requisite technical assistance (TA) is provided. The existing market environment is challenging for solar companies. To operate effectively, companies need a significant amount of both local and international technical and financial expertise, and an ability to make practical decisions about their operations. Companies face a number of technical competency requirements – the selection of approaches and solar PV technologies, the design of their associated marketing instruments and the implementation of related initiatives.

The synergy with formal training institutions has yet to be fully explored and most of the players in the industry are not adequately equipped with the skills needed to design and assess policies, understand and deploy technologies, grasp electricity user needs and ability to pay, and operate and maintain systems. Some of the other areas where TA and capacity building is needed to support growth of the solar market include:

- Provision of TA and training to public and private partners on the development of OGS power projects.
- Support in development of vocational training curricula for solar technicians by working with education institutions to adopt the curricula and implement training programs. This support could include development of community training materials to raise community awareness about the importance of solar PV technologies, the various uses ranging from household use, productive uses and institutional uses of energy, and related safety aspects.
- In order to ensure that interaction with local communities is seamless, the collaborating partners could develop a management training manual for villages addressing the different aspects of solar technologies as well. This could include supporting technicians with troubleshooting posters for on-site display that could help identify and tackle operational issues as they arise.
- Solar technicians were noted to be sparse for some areas and lacking in other areas; as a result, solar businesses send out teams from major cities/towns for any installation and maintenance work. Training

people based locally in remote areas to support O&M of solar systems (e.g. battery replacement) could help address this issue and expedite market uptake.

2.4.8 Capacity Building Needs of the Supplier Market Segment

An analysis of the supplier market segment revealed a number of interrelated challenges, including financial, capacity, awareness and regulatory challenges. The focus groups and supplier surveys found that:

- Tax exemptions could apply to all solar products, not only ABERME/Government's market.
- Local financing is largely not available (or affordable) to support the sector's development, except for a minority of large local companies; as a result, many companies are self-financed and do not have the working capital they need to grow and expand their operations.
- Reasons for denied finance by financial institutions included lack of collateral, lack of expertise in finance, the high cost involved in small transactions, and risk aversion.
- An improved regulatory framework is necessary to ensure product quality. The lack of control of product quality and import process has led to an increase in low-quality equipment, which negatively impacts perceptions of solar. There are no standards in place (outside of donor-related equipment) to address this critical issue. Tackling this challenge also requires harmonization of pricing in the market.
- Capacity building efforts are also lacking. The main areas that would require capacity building are at the technical level (installation, operation and maintenance of systems), and also marketing and sales.
- Knowledge, technical capacity and expertise is reserved to a few professionals in the industry working for large established solar companies; the majority of vendors lack the expertise or knowledge necessary to adequately service the market.

Table 43 presents various areas of support and associated capacity building for the OGS supply chain in Benin. Attention should be given to the following:

- **Importers/Suppliers**: Reducing the cost of importing solar PV products and components must be a priority as a lack of financial incentives is a major barrier to market growth. Make financing available for importers and distributors to allow suppliers to more easily stock and renew inventory. The way the market is currently structured inhibits their growth. Financing should also be made available by suppliers to end-users to enable them to purchase OGS systems.
- **Over-the-counter/ System Integrators/PAYG**: Focus on growing the number of solar technicians who are adequately skilled to support the supplier network, especially in rural areas. Formalizing this through regulation to require only licensed technicians to design and install solar PV systems is critical. This should be complemented by equally robust efforts to build the capacity of all stakeholders.
- **Consumers**: Deal with sociotechnical barriers: Although PV technology has advanced tremendously in the last decades, there are still several sociotechnical barriers to adoption, including the local conditions of end-users and the political and financial arrangements of the market. Like most countries in the region, various counterfeit solar PV products have infiltrated the market. Implementation of regulations and quality/standards to ensure product quality could significantly boost market growth.

Table 43: Capacity Building and Technical Assistance for the OGS Supply Chain in Benin[161]

Area of Support	Description	Rationale
Tax exemptions on solar technology	• Implementation of VAT and import duties exemption on all solar products, not only solar panels and donor or Government-related equipment	• Costs of solar products are inflated by import duties (8%); costs are passed on to customers, making solar less affordable.
Quality control/certification agency	• Suppliers are able to effectively monitor the quality of products imported in Benin • Ensure that imported products are suitable/relevant to the local context (local standards) in Benin	• Ensure the quality of products and face the influx of low-quality products • Maintain the trust established between solar industry and customers
Consumer education programs	• Supplier and consumer education and benefit awareness campaigns, targeting both segments, distributors and retailers, with a focus on rural populations	• Overcome negative perceptions and strengthen trust established over the years • Influence purchase decisions, with a focus on rural areas and ease access to distribution channels
Inventory financing facility	• Concessionary credit line so financial institutions can access liquidity for solar market lending; create frameworks that avail loans to solar companies (small household systems, larger PV installations, and mini-grids), pilot with aim of scaling out	• Long inventory financing periods present a key challenge to growth for solar lantern and solar home system distributors • High upfront financing requirements present a key challenge to distributors of larger PV systems (including pumps)
Credit guarantee scheme for inventory financing	• Private sector lending portfolio is de-risked through guarantees/loss sharing agreements	• De-risking encourages private sector lending to solar sector; initial security until economic viability of lending to solar businesses has been established
Market entry and expansion grants	• Combination of upfront grants and results-based financing to invest in infrastructure and working capital	• Significant upfront investment to build distribution network and source inventories to serve household market
Technical assistance	• Help solar companies set up technology platforms for PAYG • Capacity building for solar technicians to enable installation and O&M of equipment • Assess rural communities needs to inform the right business model case by case • Capacity building for rural suppliers	• Make the business environment more conducive and profitable • Strengthen the overall ecosystem surrounding the solar market • Strengthen capacity across the sector • Ensure knowledge transfer from abroad for faster, more cost-efficient progress

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

[161] Capacity building interventions are proposed for all ROGEP countries at national and regional level under ROGEP Component 1B: Entrepreneurship support, which includes TA and financing for companies in the solar product value chain. Through this component, TA to solar companies can build on existing ECREEE training programs as well as through a new regional business plan competition. Technical assistance can leverage national solar ecosystem stakeholders, and operational national service providers identified and mobilized through this component. The market entry and expansion grants suggested here would also align with Component 1B planned financing interventions for matching grants, repayable grants, co-investment grants, and be connected to the technical assistance interventions.

2.5 Key Market Characteristics

This section reviews the main characteristics of the off-grid solar market in Benin, including a summary of key barriers to and drivers of market growth and an overview of gender considerations. The synopsis presented below is largely based on feedback obtained from interviews with local officials and industry stakeholders, as well as focus group discussions and surveys assessing the demand and supply side of the market (see **Annex 2**).

2.5.1 Barriers to Off-Grid Solar Market Growth

Table 44 examines the key barriers to OGS market growth from the perspective of both the demand and supply side of the market. See **Section 1.3.5** for an overview of the gaps in the country's off-grid policy and regulatory framework.

Table 44: Key Barriers to Off-Grid Solar Market Growth in Benin

Market Barrier	Description
Demand[162]	
Consumers are unable to afford solar systems	• Low-income consumers, particularly in rural areas, lack of access to finance • Purchasing solar products of all varieties among end-consumers remains relatively low
Lack of initial funding by HHs, businesses and institutions for the initial capital investment	• Relatively high costs of OGS systems (compared to more mature markets in the region) • Consumers rather choose cheaper one-off solutions – like generators and fuel – rather than more expensive up-front solutions that will be cheaper long-term (especially with incremental payments, e.g. PAYG)
A lack of understanding of and trust in solar solutions among consumers impedes development of the market	• There is still considerable lack of general awareness about solar solutions • There is an inability to distinguish between solar products or product quality • Consumers lack information about the most suitable design options, funding options, PAYG benefits and options, points of sales and support, etc. • Products are still not widely available in rural areas, so consumers are unfamiliar with them • Any poor history / track record with OGS will deter consumers from taking expensive risks
Informal sector competition and market spoilage	• The non-standard / unlicensed market still accounts for a majority of OGS product sales • Consumers need to understand the quality and value issues of quality solar products vis-a-vis inferior over-the-counter lighting products and generators. Educated consumers drive markets.
Lack of experience in maintaining the systems and sourcing qualified technicians	• A sustainable approach to O&M is critical for long-term success
Supply	
Technical capacity	• Technical skills lack through the supply chain within the sector, affecting both the upstream, midstream and downstream, thus adversely affecting the ability of the sector to pick up and grow. Majority of the firms decry lack of adequate number of technicians to support the downstream side of the market
Transportation costs	• High transportation costs of inventory deter new entrants; devices and equipment are shipped either from China or from Europe, creating long delivery lead times of up to three months and long inventory holding times once products have arrived in country • Typical supplier payment terms are 30% upon placement of the production order and the remaining 70% upon shipment before any cargo has even left its port of origin. • Transport by container would reduce the costs dramatically; however, this requires purchases in bulk, which local solar distributors aren't able to make without financing
Poor sales and performance history of the sector	• A lack of investment into the sector prevents growth; this is due to perceived high risks resulting primarily from lack of track record of sales • Solar distributors have limited alternative financing options. Solar suppliers are unwilling to provide trade financing while commercial financiers in Benin, including banks and MFIs, are currently not positioned to service the financing requirements of solar distributors.

[162] The barriers described here apply to some combination of the Household, Institutional, and SME / Productive Use market segments

Company finance	• Entrants into the sector require significant working capital, which is not readily available • Equity investments are needed into the local distribution/sales companies. It is quite easy to obtain debt financing and other loans once the solar companies have sufficiently grown and reached the "level of interest" of the larger funds; however, until the number of customers and sales volumes are reached, they need some equity investors to share higher risks with the original founders of the companies
Informal sector competition and market spoilage	• Several informal entrepreneurs have taken advantage of high import duties by illegally importing low-quality solar products ranging from solar lanterns to larger home installations • Black-market traders are able to significantly undercut the prices of registered businesses who are still subject to high taxes and import duties • These products are largely low-grade, failure-prone counterfeits with short lifespans • Damaged perceptions of solar systems durability and reliability hinders market uptake
Lack of data	• No clear figures on the actual needs, actual usage or experience of consumers • The data for the private market players on the available opportunities is very limited and not concise due to fragmented data
High 'transaction costs' for solar installations	• Cash-flow and bureaucratic hurdles for the local suppliers • Sales and O&M services in remote areas can be costly, especially for small businesses

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

2.5.2 Drivers of Off-Grid Solar Market Growth

Table 45 is a summary of the key drivers of OGS market growth in the country.

Table 45: Key Drivers of Off-Grid Solar Market Growth in Benin

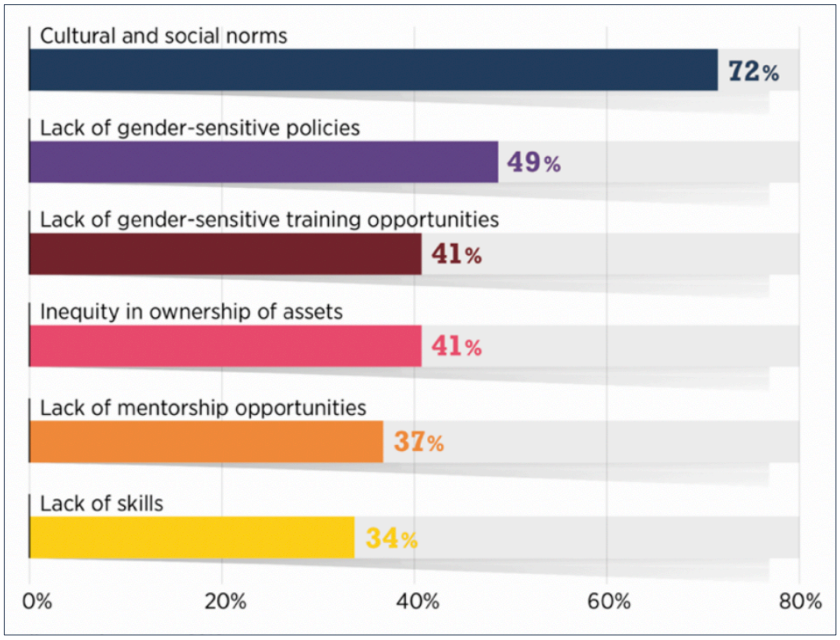
Market Driver	Description
Strong off-grid electricity demand	• Consumers from every market segment are aware of the high costs associated with energy access and consumption and are willing to take on quality, cost-effective alternatives
Willing government to support the industry	• The Government is viewed by sector players as forward- leaning and action-oriented, creating and supporting momentum and positive attention for the solar sector, which helps attract substantial and sustained investment to the market
Increased utilization of PAYG	• While Benin's OGS market is only starting to utilize PAYG financing solutions, this model has the ability to grow rapidly by leveraging increasing rates of mobile phone ownership and mobile internet usage in rural areas
Engaged and open-minded private sector	• Local OGS suppliers are actively engaged in efforts to improve / reform the sector, accept new business models and strategies and take measures to attract external investment
Strong donor/NGO presence	• The presence and wide range of donor-funded activities in the country's off-grid sector provides confidence that the market will continue to receive financial and policy support to develop (i.e. Millennium Challenge Corporation EHR and OCEF)

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

2.5.3 Inclusive Participation[163]

Given that the off-grid market is only beginning to emerge in Benin, women are not yet highly engaged in the sector. The overall lack of inclusive participation in the off-grid space is attributable to a wide range of factors. In a 2018 survey that assessed barriers to women's participation in expanding energy access, nearly three-quarters of respondents cited cultural and social norms as the most common barrier, which reflects the need for gender mainstreaming (**Figure 39**). 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.[164]

Figure 39: Key Barriers to Women's Participation in Expanding Energy Access



Source: International Renewable Energy Agency

As a starting point, electrification (whether grid-connected or off-grid) increases access to information, which can help challenge gender norms and increase the autonomy of women.[165] Access to electricity can save women time and/or enable them to complete domestic activities in the evening, thus allowing them to participate in paid work during the day. Many opportunities also exist for women in the productive use of energy, including solar-powered machinery that can support productive applications, particularly in the agricultural sector in the areas of irrigation, water pumping, and milling/food processing.[166]

Women, who are often the primary energy users in households, have a strong influence on the energy value chain. Women can take on different roles, including as engaged end-users, community mobilizers,

[163] See **Annex 4** for more details
[164] "Renewable Energy: A Gender Perspective," International Renewable Energy Agency, (2019): https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf
[165] "Productive Use of Energy in African Micro-Grids: Technical and Business Considerations," USAID-NREL and Energy 4 Impact, (August 2018): https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/productive_use_of_energy_in_african_micro-grids.pdf
[166] "Turning promises into action: Gender equality in the 2030 Agenda for Sustainable Development," UN Women, (2018): http://www.unwomen.org/-/media/headquarters/attachments/sections/library/publications/2018/sdg-report-fact-sheet-sub-saharan-africa-en.pdf?la=en&vs=3558

technicians, and part time and full-time employees and entrepreneurs.[167] Women also have unique social networks that typically offer greater access to rural households, which can be important to deploying energy access solutions.

Despite these opportunities, women are typically not part of key decision-making processes at nearly all levels of society. Women tend to have limited access to land and capital, as these are often determined by traditional and religious customs that remain deeply rooted in patriarchal traditions. Women also have more difficulty accessing finance due in part to lack of collateral required to guarantee payment and often resort to obtaining loans from money lenders who charge exorbitant interest rates.[168]

The gender analysis undertaken in Benin corroborated many of these trends, and revealed several interrelated challenges that women face in the off-grid sector:

- Women lack access to skills, technical capacity, and education/training
- Women broadly lack access to capital, asset ownership, collateral and credit (e.g. to start a business)[169]
- Extensive household responsibilities reduce their ability to generate income and service credit
- Financial literacy among women remains low and there is a lack of education and information available to women on access to financial resources

A number of initiatives exist that seek to address some of these challenges and help improve the rate of participation among women in the country's energy and off-grid sectors. In the off-grid space, NGOs like Solar Electric Light Fund promote rural agricultural development using solar irrigation technology to support women farmers. The Africa Renewable Energy Access Gender Program, managed by the World Bank's Africa Energy Unit and funded by the World Bank Energy Sector Management Assistance Program (ESMAP), is active in West Africa and has plans to expand its operations into Benin.[170]

In 2018, ECREEE partnered with AfDB 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 2% 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 Benin.[171]

[167] "Renewable Energy: A Gender Perspective," International Renewable Energy Agency, (2019): https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf

[168] See **Section 3.2** for more details.

[169] This is a huge challenge for women in the country, particularly in rural areas, where the population depends on seasonal income from the agricultural sector for their livelihood, which makes loans inaccessible or only available at extremely high interest rates. This issue is examined in further detail in **Section 3.2.**

[170] "Mapping of Energy Initiatives and Programs in Africa," Africa-EU Energy Partnership, (May 2016): http://www.euei-pdf.org/sites/default/files/field_publication_file/annex_5_aeep_mapping_of_energy_initiatives_overview_of_initiatives_0.pdf

[171] "Feasibility study promotes women's participation in energy transition," ESI Africa, (7 May 2018): https://www.esi-africa.com/feasibility-study-promotes-womens-participation-in-energy-transition/

III. ANALYSIS OF THE ROLE OF FINANCIAL INSTITUTIONS

This section begins with an introduction to financial products for the off-grid sector, including for end-users and stand-alone solar companies (**Section 3.1**). This is followed by a comprehensive overview of the country's financial market and commercial lending environment (**Section 3.2**), including an assessment of financial inclusion and a summary any off-grid solar lending activity/programs. **Section 3.3** examines other financial institutions (in addition to commercial banks) that are active in the country. **Section 3.4** presents a summary of key findings from the Task 3 analysis. The data presented in this section was obtained through desk research as well as interviews with/surveys of key officials and representatives from local financial institutions. **Annex 3** provides an overview of the Task 3 methodology.

3.1 Introduction to Financial Products for the Off-Grid Sector

A wide range of financial products can be utilized to support development of the stand-alone solar sector in West Africa and the Sahel. 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) and medium-term loans secured on assets or receivables from a portfolio of installed projects. This "financial supply chain" consists of capital delivered at different stages of stand-alone solar enterprise development, by financial sector players that have risk appetites well matched to each specific stage. This section focuses on the roles of commercial financial institutions (FIs) and microfinance institutions (MFIs) in providing debt financing to off-grid solar consumers and enterprises.

3.1.1 Financial Products for End-Users

In order to determine what kinds of debt instruments are available to support stand-alone solar purchases for end-users, it is important to identify the different end-users.

- **Households**

Households represent the majority of end-users in the West Africa and Sahel region and the level of cash flow this market segment has available for energy access depends heavily upon the formal and/or informal economic activity they are engaged in. In general, 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 off of the radar of mainstream FIs (with the exception of households where members have regular sources of income from urban centers). MFIs in fact are generally more appropriate sources of household finance. Most of a given country's households can access external funding typically only through microfinance or informal financial services such as local money lenders, cooperative societies and rotating savings and credit associations.

- **Public Institutions**

The main public institutional facilities that require funding for off-grid electrification are directly linked to national, provincial or local administrations and budgets, including schools, health facilities, and other public buildings/lighting systems. Sustainable energy finance for community facilities is typically provided through a ministry, department or agency if the facility falls under the purview of the national or provincial

budget. The challenge is that budget resources are severely limited and constantly face competing priorities; as a result, many public community facilities are left without access to energy.

In order to implement financial products targeting public institutional projects, a few critical questions need to be answered, such as who would be the borrower and whether there are sufficient financial resources available in the budget to pay for the service over a long period of time. This question is also important if these public community facilities end up being included alongside households as part of a local mini-grid.

- **Productive Use**

Financial instruments for SMEs 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 other sources of income or budget being allocated to cover the cost of service, SMEs use energy for income-generating activities and can therefore cover electricity costs through the income generated by their business. An enterprise 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 company's ability to service the debt would be a strong and commercially viable option. MFIs often provide short-term loans to micro enterprises on this basis while FIs often limit their lending to SMEs with strong balance sheets and available collateral.

- **Commercial and Industrial**

Commercial and industrial (C&I) facilities such as industrial plants, mining operations, shopping malls, logistics and distribution centers or commercial office buildings generally have considerable power consumption requiring energy supply from much larger solar systems that can range from several hundred kW to several MW in capacity. Where there is particularly high cost advantage for stand-alone solar systems over existing energy supply (i.e. vs. diesel generators), some C&I facility owners may find the payback of these investments so attractive that they will seek to purchase the solar power plant outright, often requiring debt financing to complete the transaction. This entails a corporate loan backed by the full faith and credit of the company, a pledge on the installed assets and usually supplemented by additional collateral and personal guarantees posted by the C&I facility owners. Many commercial FIs will offer credits to their existing C&I customers for this purpose but the C&I facility loan applicants are often unable or unwilling to post the required collateral for this specific purpose as their assets may already be encumbered for other business needs.

3.1.2 Financial Products for Suppliers/Service Providers

The stand-alone solar sector remains nascent in most markets across West Africa and the Sahel. The companies offering standalone solar products and energy services are therefore often at start-up or early development stage. Overall by number of players, small indigenous entrepreneurs are well in the majority; however, a few international companies dominate the overall market share. Most equipment is imported with purchases denominated in hard currency, while sales to consumers – whether on a direct purchase, lease-to-own (LTO) or pay-as-you-go (PAYG) basis – are almost always in local currency. At start-up or early stages of operation, local entrepreneurs, although in need of funding, are usually not ready to take on debt financing and should rely more on seed capital investment and grants until they are able to generate an initial book of business. Once orders begin to materialize, these enterprises have growing funding needs suitable for debt financing instruments which may include the following:

- **Working Capital**

All entrepreneurs need working capital to fuel their business growth and cover basic overheads for operations, marketing and sales. Throughout West Africa and the Sahel, there is a dearth of working capital financing for businesses in all sectors, and the situation is no different for stand-alone solar companies. When available, working capital loans have very short tenors of 3-12 months, must be secured on confirmable cash flows, have difficult-to-meet collateral requirements and carry high interest rates. Since their costs and income are in local currency, local entrepreneurs are best served by working capital loans also denominated in local currency. However, due to high cost of local currency debt, many companies will see advantages in borrowing at much lower interest rates in hard currency as the perceived risk of currency fluctuations across such short tenors is relatively low. Some international companies operating in the West African off-grid solar sector may prefer hard currency financing at the offshore holding company level, depending on how they have structured their local subsidiaries or affiliates in the region.

- **Inventory and Trade Finance**

To fulfill orders, solar system providers need inventory on hand. Equipment suppliers to the off-grid sector in West Africa and the Sahel are usually unwilling or unable to offer generous terms, often requiring down payments with balance due in full at cash-on-delivery (COD). Therefore, these businesses are in dire need of short-term loans of up to 12 months duration to finance inventory purchases. Yet, such loans are hard to come by for developing off-grid enterprises. Since equipment purchase arrangements are usually denominated in hard currency, loans also in hard currency over such short tenors are often acceptable. Trade finance from export credit agencies (ECAs) and private trade funders may also provide good solutions, but these lenders are often unwilling to finance orders under a few million USD or EUR in value.

- **Asset-Based or Receivables Financing**

Once stand-alone solar system providers achieve a portfolio of operating PAYG or LTO installations, the system assets and revenues from customer payments can be used to leverage debt financing to fund business activities and expansion. Typically, a Special Purpose Vehicle (SPV) is established to house the asset portfolio, which is sold by the solar provider to lenders. This form of financing has been widely deployed in East Africa and is also increasingly available in West Africa through a variety of regionally focused specialized debt funds that are focused on portfolio financings in the range of USD 1-10 million.[172]

- **Crowd Funding**

Crowd funding platforms have played an important role in offering working capital, inventory financing and smaller increment asset or receivables-backed loans to off-grid entrepreneurs. Loans of two-five years have been provided to both locally-owned and international solar enterprises with a good number of financings in the USD 150-500K range occurring in Nigeria, Ghana and Côte D'Ivoire.[173]

[172] A total of 11 such specialized debt funds were identified, including those managed by: Sunfunder, responsAbility, Lendable, Sima Funds, Solar Frontier, Neot, Deutsche Bank, Triple Jump, Crossboundary, Lion's Head, Shell and Solar Connect. Only a handful of these have vehicles that are fully funded and deploying capital but as of mid-2018 they reported expectations for financial closings that would make roughly USD 1.5 billion in off-grid focused debt available across Sub Saharan Africa by 2020.

[173] The most active crowd funding platforms in the off-grid space have been Kiva, TRINE, Lendahand and Bettervest with the latter two most focused on West Africa.

3.2 Financial Market Overview

3.2.1 Market Structure

As a member of the West African Economic and Monetary Union (WAEMU, or Union Économique et Monétaire Ouest Africaine, UEMOA), Benin shares a currency with seven other countries in the economic community, the West African CFA Franc, which is pegged to the euro. FIs in Benin are regulated by the Central Bank of West African States (Banque Centrale des États de l'Afrique de l'Ouest, BCEAO) and supervised by the WAEMU Banking Commission. Within this macroeconomic environment, Benin has experienced relatively low rates of inflation and low interest rates, especially compared to non-WAEMU countries. Between 2009 and 2014, the average inflation rate for WAMEU countries was approximately 1%, while the average inter-bank interest rate during the same period was about 4%.[174]

The country's financial market is largely made up of three sectors – commercial banks, MFIs and non-bank FIs. Although stable, Benin's financial sector remains highly concentrated; of the country's 15 commercial banks, the five largest banks account for 90% of total commercial banking assets (**Table 46**). Compared to other WAEMU countries, Benin possesses a very high ratio of non-performing loans (NPLs), while other liquidity and profitability indicators also rank below the monetary union's average. In 2015, total assets for the banking sector were estimated to be CFA 2.7 billion (USD 4.7 million), approximately 62% of the country's GDP that year.

The microfinance sector also plays a critical role in the overall financial system, as it provides a source of financing to the country's rural population as well as to individuals and businesses that are unable to obtain funding from commercial banks. MFIs account for roughly 5% of total assets in the financial sector, as they provide credit ranging from CFA 20,000 (USD 34) to CFA 5 million (USD 8,600). The sector includes a total of 721 MFIs, of which 226 are licensed. Non-bank FIs, including insurance companies, pension funds and postal checking services, account for the remainder of the financial system.

The banking sector does not contribute significantly to financing private investments, as the country's institutional framework discourages banks from taking on risks. Instead, local commercial banks typically engage with WAEMU sovereign borrowing due to higher yields of about 6-7%.[175]

Table 46: Licensed Financial Institutions in Benin[176]

License Type	Number of FIs
Commercial Banks	15
Microfinance Institutions	721
Non-banking Financial Institutions	16
Asset concentration of five largest banks	90%

Source: World Bank and IMF

[174] "The Landscape for Impact Investing in West Africa: Understanding the current trends, opportunities and challenges," Dalberg and Global Impact Investing Initiative, (December 2015): https://thegiin.org/assets/upload/West%20Africa/RegionalOverview_westafrica.pdf

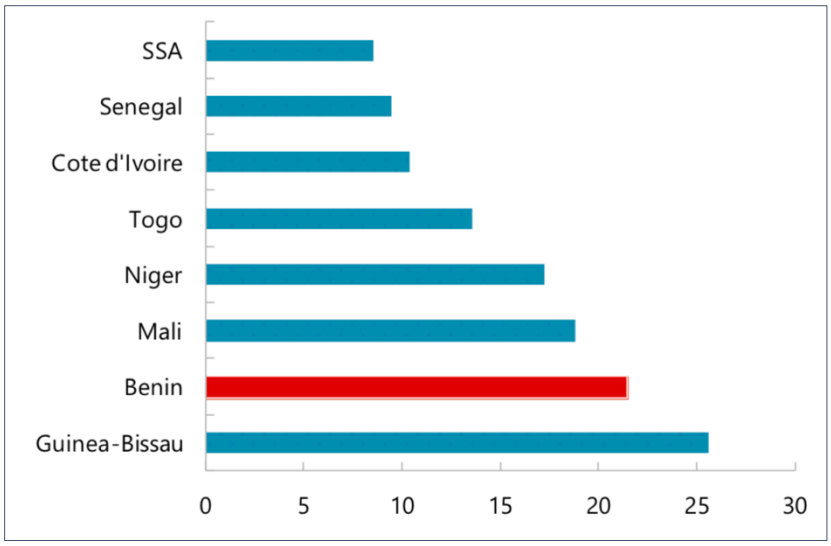
[175] "Benin," International Monetary Fund, (January 2018): https://www.imf.org/en/Publications/CR/Issues/2018/01/05/Benin-Selected-Issues-45534

[176] "Bank Asset Concentration for Benin," World Bank Global Financial Development Database (Federal Reserve Economic Data): https://fred.stlouisfed.org/series/DDOI06BJA156NWDB

- **Banking Sector Financial Soundness Indicators**

Asset-Based Indicators: The ratio of NPLs among commercial banks in Benin remains high compared to other countries in WAEMU. Among the monetary union's eight member states, only Guinea-Bissau had a higher share of NPLs to total loans between 2013-2016 than Benin (**Figure 40**).[177]

Figure 40: Non-Performing Loans to Total Loans (%), 2013-2016



Source: International Monetary Fund

Capital-Based Indicators: Between 2013-2016, the banking sector's capital adequacy has remained largely above the 8% WAEMU minimum (**Table 47**). Yet, Benin still scores below average when compared to other countries in WAEMU and Sub-Sharan Africa (**Figure 41**), which suggests that the country's commercial banks are less resilient to potentially detrimental economic shocks.[178]

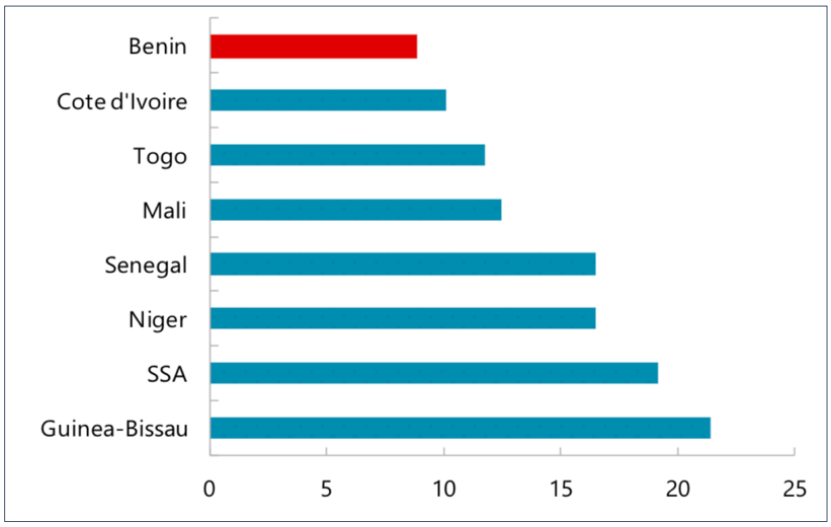
Table 47: Banking Sector Capital Adequacy Indicators

Indicator	2013	2014	2015	2016
Regulatory Capital to Risk Weighted Assets	12.9%	12.7%	12.6%	9.5%
Core Capital to Risk Weighted Assets	11.8%	11.2%	10.5%	7.6%
Provisions to Risk Weighted Assets	10.3%	10.7%	11.7%	15.6%
Capital to Total Assets	7.2%	6.7%	5.7%	3.8%
Total Loans to Assets	55.9%	54.6%	53.1%	39.3%

Source: International Monetary Fund

[177] "Benin," International Monetary Fund, (January 2018): https://www.imf.org/en/Publications/CR/Issues/2018/01/05/Benin-Selected-Issues-45534
[178] Ibid.

Figure 41: Regulatory Capital to Risk-Weighted Assets (%), 2013-2016



Source: International Monetary Fund

Profitability Indicators: Key income and expense-based indicators for the commercial banking sector are presented in **Table 48**.

Table 48: Banking Sector Profitability Indicators[179]

Indicator	2012	2013	2014	2015	2016
Return on Assets (ROA)	0.4%	0.1%	0.9%	0.3%	0.4%
Return on Equity (ROE)	5.4%	2.2%	14.4%	4.9%	7.2%

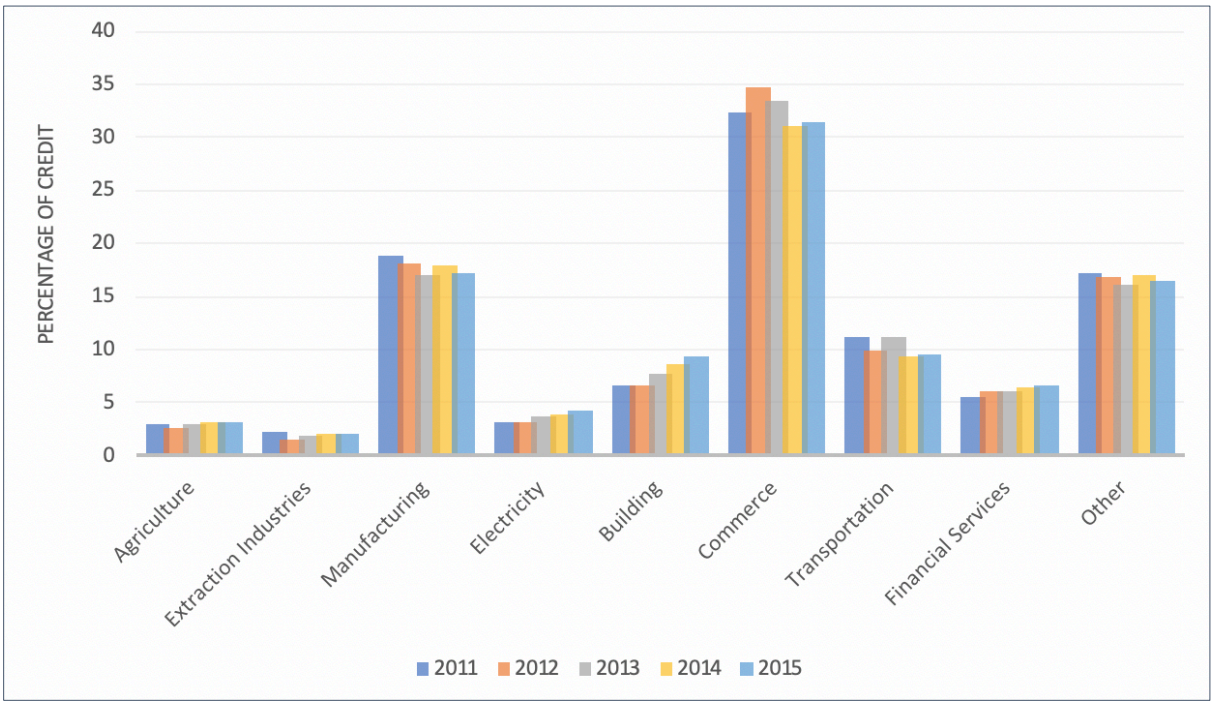
Source: West African Monetary Agency

- **Distribution of Credit by Sector**

Between 2011 and 2015, the distribution of credit by sector was relatively consistent, as manufacturing, commerce, and other services were the sectors with the highest shares of credit. These industries received an average of 17.82%, 32.62% and 16.72% of credit available within the banking system, respectively (**Figure 42**).[180]

[179] "Financial Sector Developments and Stability in ECOWAS, 2016 Report," West African Monetary Agency, (2016): http://amao-wama.org/wp-content/uploads/2017/11/Financial-Stability-2016-Report.pdf
[180] "Benin," International Monetary Fund, (January 2018): https://www.imf.org/en/Publications/CR/Issues/2018/01/05/Benin-Selected-Issues-45534

Figure 42: Distribution of Credit by Sector



Source: International Monetary Fund

3.2.2 Financial Inclusion

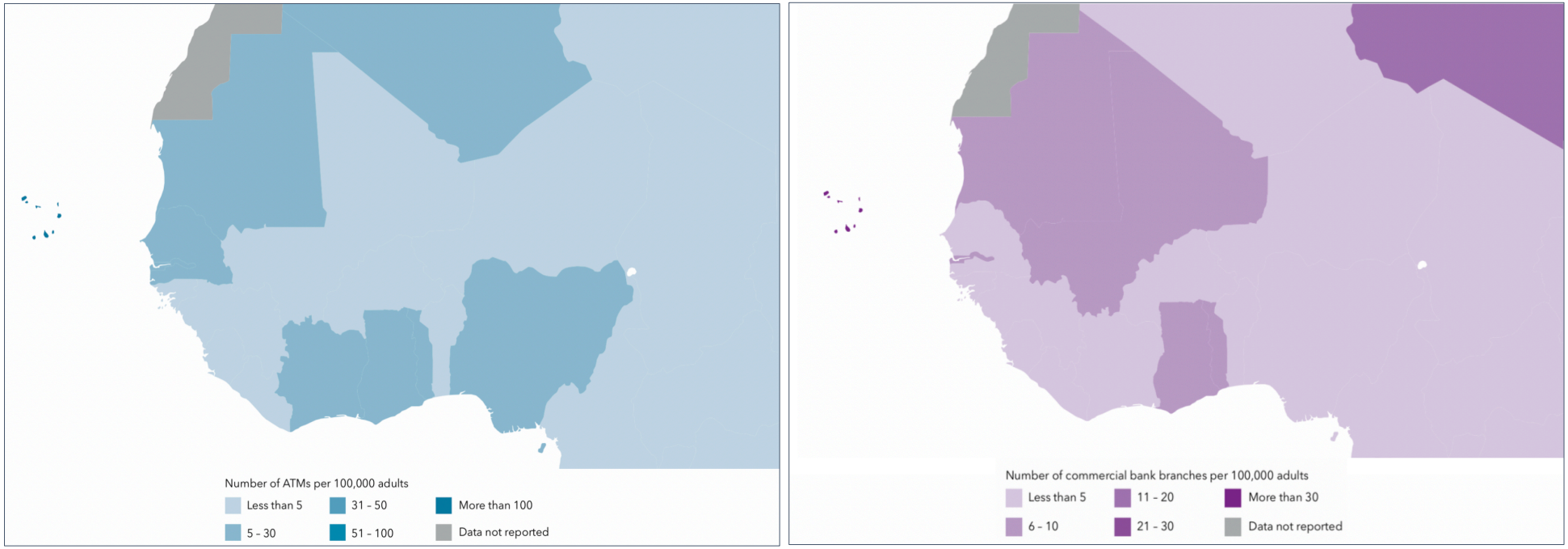
- **Access to Financial Services**

Access to financial services represents an ongoing challenge in West Africa and the Sahel. Overall, about three-quarters of the region's population remains financially excluded, lacking access to banking and financial services through formal institutions (**Figure 43**).[181] There are, however, notable signs of progress. Between 2011 and 2017, the share of the population covered by formal financial institutions increased by nearly 10%.[182] Many countries across the region, including Benin, have also seen a sharp increase in mobile money account ownership (**Figure 44**) and transaction volume (**Figure 45**).

[181] "Le secteur bancaire en Afrique De l'inclusion financière à la stabilité financière," European Investment Bank, (October 2018): https://www.eib.org/attachments/efs/economic_report_banking_africa_2018_fr.pdf

[182] Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., and Hess, J., "The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution," World Bank, (2017): http://documents.worldbank.org/curated/en/332881525873182837/pdf/126033-PUB-PUBLIC-pubdate-4-19-2018.pdf

Figure 43: ATMs and Branches of Commercial Banks per 100,000 Adults in West Africa and the Sahel, 2017[183]

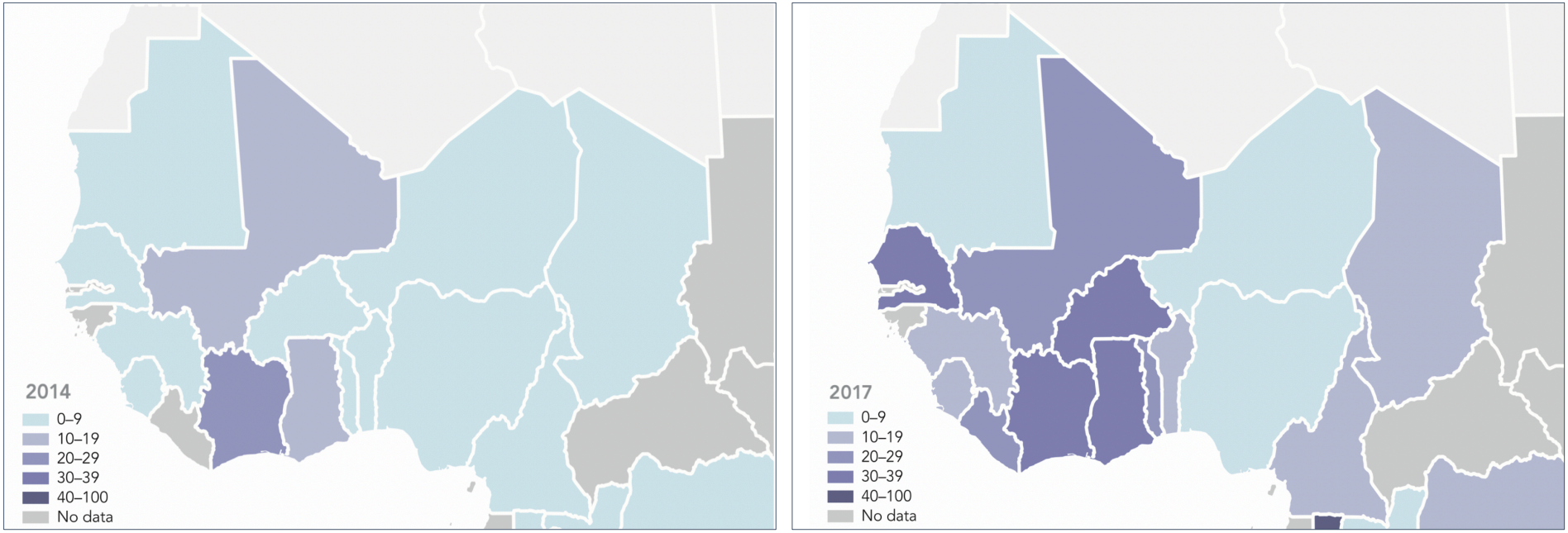


Source: International Monetary Fund

Figure 43 shows the number of ATMs (left) and commercial bank branches (right) per 100,000 adults across West Africa and the Sahel. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. As of 2017, Côte d'Ivoire, Ghana, Mauritania, Nigeria, Senegal and Togo had a relatively higher number of ATMs per 100,000 adults compared to the rest of the region, while The Gambia, Ghana, Mali, Mauritania and Togo had a relatively higher number of commercial bank branches per 100,000 adults. Cabo Verde ranked above all countries in the region on both indicators.

[183] International Monetary Fund – Financial Access Survey: http://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C&sId=1460054136937

Figure 44: Share of Adults with a Mobile Money Account in West Africa and the Sahel (%), 2014 and 2017[184]



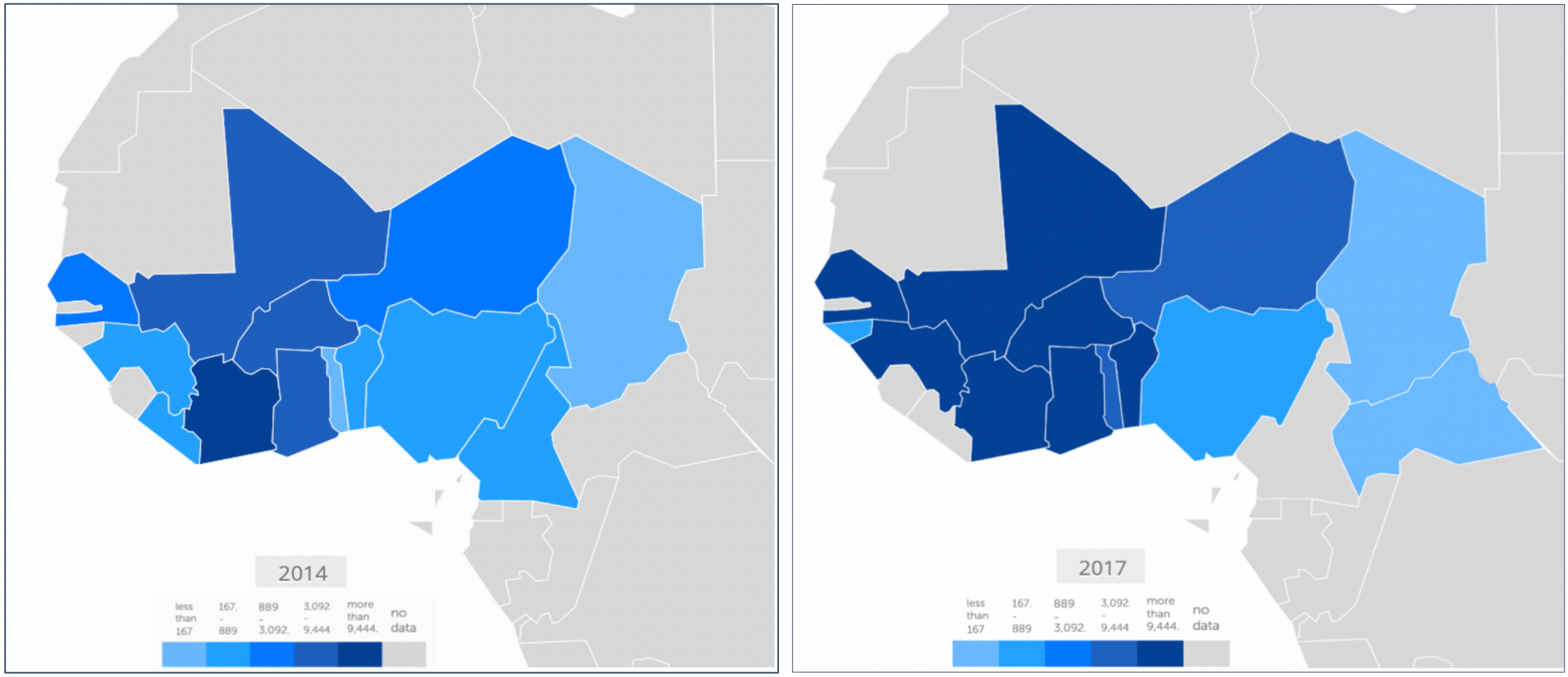
NOTE: Maps exclude Cabo Verde (no data)

Source: World Bank Global Findex Database

Figure 44 shows the increase in the share of adults (%) owning a mobile money account across West Africa and the Sahel between 2014 and 2017. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. As of 2017, the share of adults owning a mobile money account is about 33% in Burkina Faso, Côte d'Ivoire, and Senegal, and 39% in Ghana. Between 2014 and 2017, mobile money account ownership also increased significantly in **Benin**, Cameroon, Chad, Guinea, Mali, Sierra Leone and Togo. There was either no data or insufficient data available to assess account ownership in Central African Republic, The Gambia, Guinea-Bissau, and Liberia.

[184] Demirguc-Kunt et al., 2017.

Figure 45: Mobile Money Transactions per 1,000 Adults in West Africa and the Sahel, 2014 and 2017[185]



NOTE: Maps exclude Cabo Verde (no data)

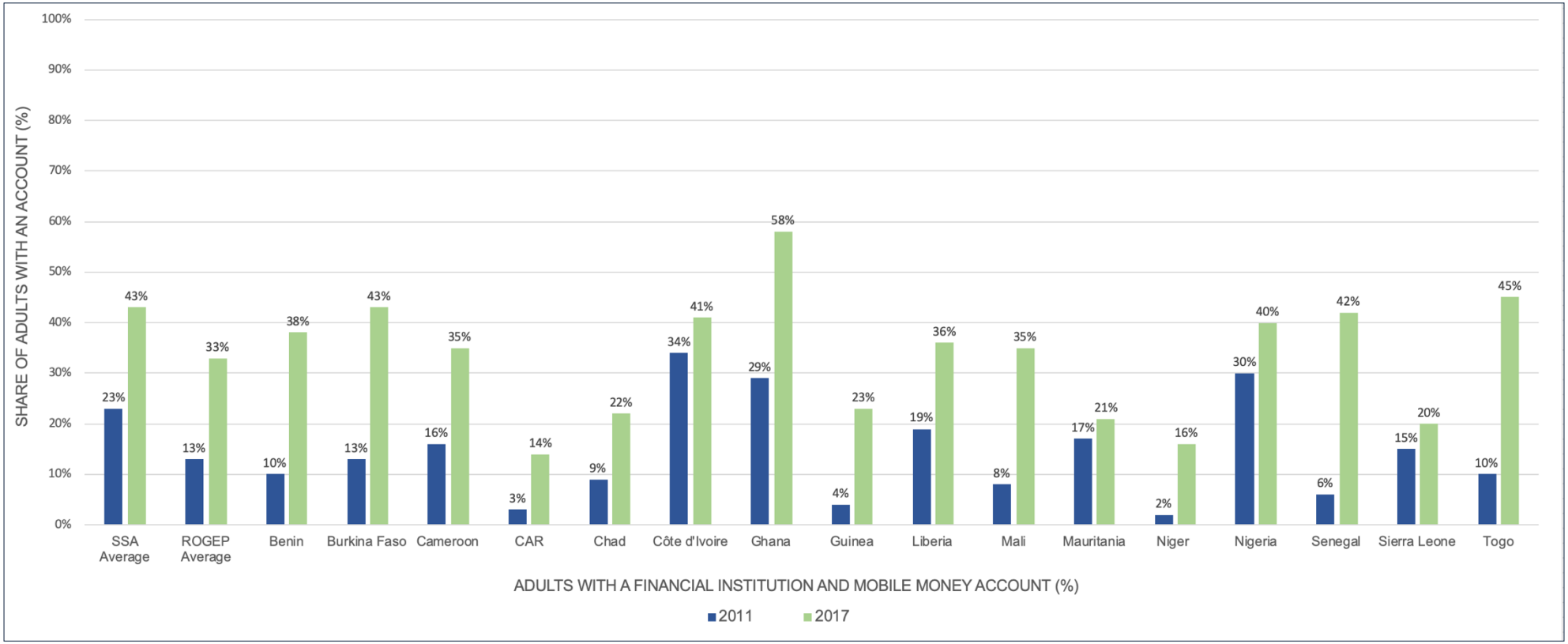
Source: International Monetary Fund

Figure 45 shows the increase in the number of mobile money transactions across West Africa and the Sahel between 2014 and 2017. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. Between 2014 and 2017, mobile money transaction volume increased significantly in **Benin**, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger, Senegal and Togo. There was either no data or insufficient data available to assess transaction volume in Cameroon, Central African Republic, The Gambia, Guinea-Bissau, Liberia and Sierra Leone.

[185] International Monetary Fund – Financial Access Survey: http://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C&sId=1460054136937

In 2017, 38% of Benin's adult population had an account at a financial institution or with a mobile money service provider, up from 10% in 2011. In 2017, the country's rate of financial inclusion was slightly above the West Africa and Sahel region's average, but still below the average for Sub-Saharan Africa (**Figure 46**).

Figure 46: Share of Adults with Access to Financial Services in West Africa and the Sahel (%), 2011 and 2017[186]



NOTE: Cabo Verde, Guinea-Bissau and The Gambia excluded (no data); data for Côte d'Ivoire is from 2014 and 2017

Source: World Bank Global Findex Database

[186] Demirguc-Kunt et al., 2017.

With 15 commercial banks in Benin, the number of institutions relative to the population is extremely low. Moreover, commercial banks operate mainly in urban areas, leaving many rural and low-income people and businesses with limited access to financial services. MFIs have helped fill this void, as about 700 of these institutions serve roughly one-third of the country's adult population. Although the number of MFIs has grown significantly over the past decade, access to financing remains a significant barrier for Beninese companies, with 43.2% of surveyed firms identifying this as a major constraint to their business in 2016.[187] Nevertheless, there are signs of improvement, as the reported number of firms with checking or savings accounts increased from 28% in 2013 to 93% in 2016 – above the average for Sub-Saharan African countries (**Table 49**).[188]

Table 49: Access to Financial Services in Benin and Sub-Saharan Africa, 2016

Indicator	Benin	Sub-Saharan Africa
Percent of firms with a checking or savings account	92.5%	85.6%
Percent of firms with a bank loan/line of credit	24.0%	21.6%
Proportion of loans requiring collateral (%)	79.2%	85.3%
Value of collateral needed for a loan (% of the loan amount)	231%	213.5%
Percent of firms using banks to finance investments	12.0%	20.1%
Proportion of investments financed internally (%)	90.5%	74.2%
Proportion of investments financed by banks (%)	3.6%	9.7%
Percent of firms using banks to finance working capital	26.0%	22.6%
Percent of firms using supplier/customer credit to finance working capital	14.2%	24.2%
Proportion of working capital financed by banks (%)	10.9%	8.6%
Percent of firms identifying access to finance as a major constraint	43.2%	39.2%

Source: World Bank

The strength of MFIs in Benin can largely be attributed to the traditional use of community-based group savings, loan schemes, and government promotion. Despite this, the limitations facing this market segment of borrowers (e.g. issues surrounding collateral, borrower information etc.) hinder the potential for further development of the sector. Furthermore, due to the inability of regulatory agencies to keep up with the rapid growth of the sector, a relatively small percentage of MFIs are licensed.

The advent of digital financial services and availability of mobile banking has the potential to improve financial inclusion in the country; indeed, the number of mobile money accounts (**Figure 44**) and transactions (**Figure 45**) increased sharply between 2014 and 2017.

- **Gender and Women's Financial Inclusion**

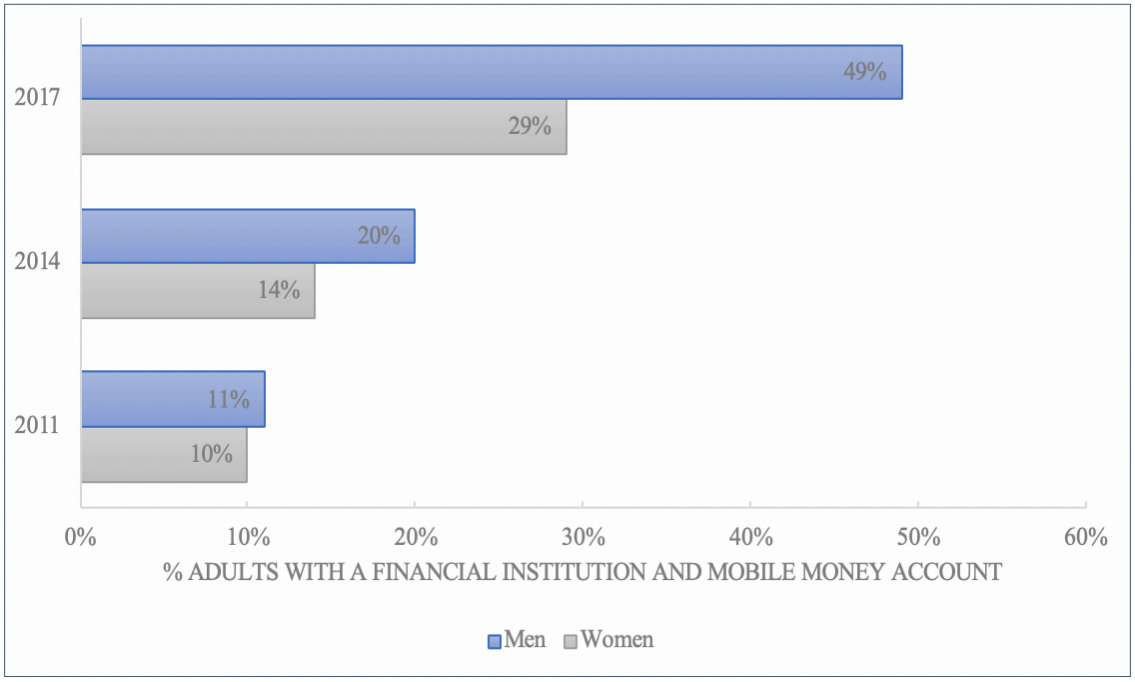
According to data from the World Bank's 2017 Global Findex survey – which examines, among many things, the extent of financial inclusion in Sub-Saharan Africa (SSA) – women in the region are about 10% less likely to have an account at a financial institution or with a mobile money service provider than men. In Benin, the gender gap is double the regional average, with 29% of women compared to 49% of men holding an account. The size of the financial inclusion gender gap has increased steadily since 2011, an outlier in the region, where the gender gap growth rate slowed between 2014 and 2017. However, in absolute terms, as of 2017, 29% of women had financial and mobile money accounts in Benin, more than double the percentage in 2014 (**Figure 47**).[189]

[187] "Enterprise Surveys: Benin," World Bank, (2016): http://www.enterprisesurveys.org/data/exploreeconomies/2016/benin#finance
[188] Ibid.
[189] Demirguc-Kunt et al., 2017.

Studies have found that increasing financial inclusion can significantly empower women by increasing savings, reducing levels of inequality, and improving decision-making power in the household. Supportive government policies and regulations are therefore critical to overcoming the barriers that women face and driving overall progress towards greater financial inclusion.[190]

The growth in the financial inclusion gender gap could be related to the relative weakness of Benin's market for digital financial services. Expanding these services, especially mobile money, can create new opportunities to better serve women, the lower-income population, and other groups that are traditionally excluded from the formal financial system. As of 2018, Benin's digital financial services market included only three licensed mobile money service providers and distribution challenges persist.[191] As of 2017, 25% of adult men only had a mobile money account, compared to 13% of women, which is below the regional average (**Figure 48**).[192]

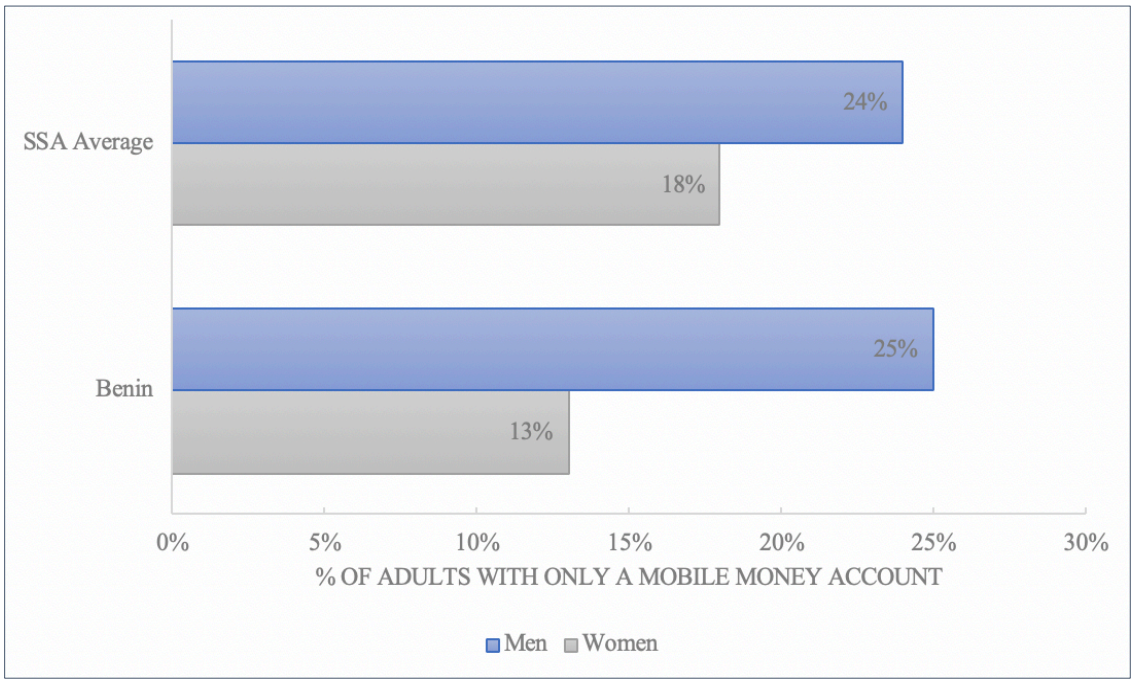
Figure 47: Financial Inclusion Gender Gap in Benin



Source: World Bank Global Findex Database

[190] El-Zoghbi, M., "Measuring Women's Financial Inclusion: The 2017 Findex Story," Consultative Group to Assist the Poor (CGAP), (30 April 2018): https://www.cgap.org/blog/measuring-womens-financial-inclusion-2017-findex-story
[191] "Digital Financial Services in Benin: Sector Overview," Mobile Money for the Poor (United Nations Capital Development Fund), (17 April 2018): https://www.uncdf.org/article/3516/digital-financial-services-in-benin
[192] Demirguc-Kunt et al., 2017.

Figure 48: Gender Gap in Mobile Money, 2017



Source: World Bank Global Findex Database

In response, the GoB aims to increase levels of financial literacy and to develop a system/registry to improve access to borrower information in the country. The Government also intends to build upon policies that are being pursued at a regional level. In 2016-2017, the BCEAO, in partnership with the UN Capital Development Fund and the IMF, organized a series of high-level meetings of key West African policymakers to develop a regional policy and strategic framework to improve financial inclusion. Ultimately, the WAEMU Council of Ministers adopted an action plan that aimed to expand access to financial services to 75% of the WAEMU adult population over a five-year period. The implementation of this strategy is expected to benefit from financial support from various DFIs as well as technical assistance from the World Bank.[193]

Widespread mobile phone ownership, rapidly growing mobile internet usage (**Figure 15**) and extensive network coverage (**Figure 36**), have led to the proliferation of mobile money services and platforms in the country. These dynamics are collectively increasing usage of mobile banking services, expanding overall access to financial services and driving financial inclusion in Benin. Mobile money technology also plays a critical role in the application of off-grid solar solutions, particularly for Pay-As-You-Go systems that rely on the interoperability between digital financial services and stand-alone solar devices.

[193] "West African Economic and Monetary Union: Common Policies of Member Countries," International Monetary Fund, (April 2018): https://www.imf.org/en/Publications/CR/Issues/2018/04/25/West-African-Economic-and-Monetary-Union-WAEMU-Common-Policies-for-Member-Countries-Press-45815

3.2.3 Commercial Lending Environment

- **Maturity Structure of Bank Deposits and Credit**

On average, short-term loans are the dominant means of credit in WAEMU countries. On an annual basis, financing provided through short-term loans outweighs that of medium to long-term loans by CFA 386 billion CFA (USD 665 million). This trend does not hold true for Benin, however, as the maturity structure of bank deposits witnessed an increase in time and savings deposits and a corresponding decrease in demand deposits from 2005 to 2015 (**Figure 49**). Over the same period, the share of short-term loans steadily decreased as the share of medium and long-term loans increased; since 2015, there has been an even share of each type of loan (**Figure 50**).[194]

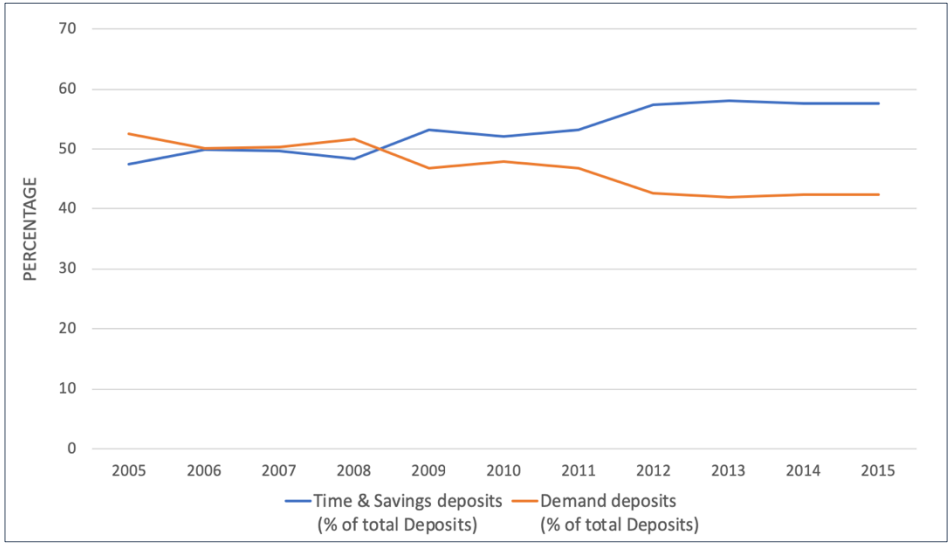
- **Interest Rates**

As a member state of WAEMU, Benin's monetary policy is decided by the BCEAO. The BCEAO regional monetary policy is heavily dependent on two types of open market operations: (i) refinancing for one week, and (ii) refinancing for one month, allocated at variable rates.[195] In 2017, the weighted average rates for refinancing for one week and one month were around 3.75%. The BCEAO central benchmark rate, or central bank rate, has sustained around 2.5% since 2013, while the marginal lending rate, has hovered around 4.5% in recent years.[196]

The average interest rates on bank loans and deposits between 2005 and 2015 were 9.6% and 5.1%, respectively, with an average spread of 4.5% (**Figure 51**).[197]

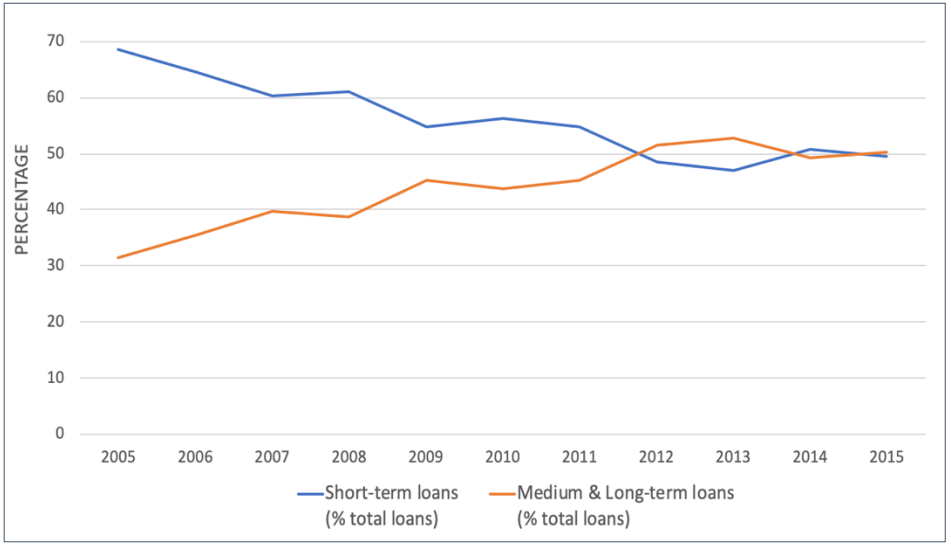
[194] "African Financial Sector Database," African Development Bank, (2016): http://dataportal.opendataforafrica.org/AFDBFP2016/african-financial-sector-database-2016
[195] "West African Economic and Monetary Union: Common Policies of Member Countries," International Monetary Fund, (April 2018): https://www.imf.org/en/Publications/CR/Issues/2018/04/25/West-African-Economic-and-Monetary-Union-WAEMU-Common-Policies-for-Member-Countries-Press-45815
[196] "Rapport Annuel de la Commission Bancaire de l'UMOA – 2017," BCEAO, (2018): https://www.bceao.int/sites/default/files/2019-01/Rapport_Annuel_CB_2017.pdf
[197] "African Financial Sector Database," African Development Bank, (2016): http://dataportal.opendataforafrica.org/AFDBFP2016/african-financial-sector-database-2016

Figure 49: Maturity Structure of Deposits



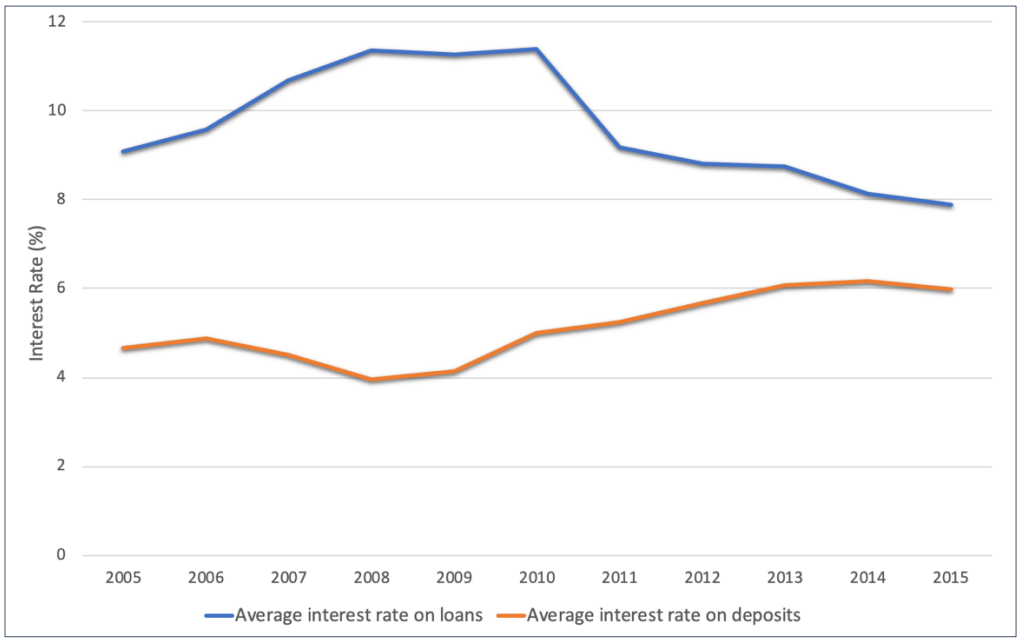
Source: African Development Bank

Figure 50: Maturity Structure of Loans



Source: African Development Bank

Figure 51: Interest Rates on Deposits and Loans



Source: African Development Bank

Regarding inflation, the average BCEAO rate was 0.3% in 2016, compared to 1% in 2015. General price trends in 2016 reflected the slowdown of commodity prices mainly due to the persistently low price of oil. Locally, Benin had a lower average annual growth rate in consumer prices than WAEMU, while experiencing disinflation of 0.8% in 2016 **(Table 50)**.[198]

Table 50: Trends in Consumer Prices in Benin and WAEMU

	2015		2016	
	Annual Average	Year-over-year change	Annual average	Year-over-year change
Benin	0.3%	2.3%	-0.8%	-2.8%
WAEMU	1%	1.3%	0.3%	-0.2%

Source: BCEAO

- **Foreign Exchange Market**

As a member state of WAEMU, Benin's currency, the CFA franc, is pegged to the euro. The BCEAO therefore follows the monetary policy of the European Central Bank, which effectively sets interest rates for the CFA franc zone. This pegged exchange rate system limits the ability of member states to quickly respond to shocks. At the same time, CFA zone countries survived the recent collapse of oil prices and commodities without suffering from currency collapse, inflation and fiscal distress like other West African countries.[199] In general, the CFA franc monetary zone consistently outperforms other Sub-Saharan countries in terms of inflation rate and overall macroeconomic stability.

[198] "2016 Annual Report," Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO), https://www.bceao.int/sites/default/files/2017-12/2016_annual_report_2.pdf

[199] Cappola, F., "In Africa: Understanding the CFA Franc and its Foreign Exchange Rate Impact," https://www.americanexpress.com/us/foreign-exchange/articles/cfa-franc-and-its-foreign-exchange-rate-impact/

The CFA franc is backed by a guarantee from the French treasury for the convertibility of the CFA franc into euros at the fixed exchange rate at the Paris Stock Exchange.[200] This provides stability and credibility to the currency. The common currency also expedites trade by removing foreign exchange between the eight member states of WAEMU as well as the six countries in the Economic and Monetary Community of Central Africa (Communauté Economique et Monétaire de l'Afrique Centrale, CEMAC). On a regional level, there are plans to implement a single currency across all of West Africa by 2020, although there are many hurdles to overcome before this degree of macroeconomic convergence can be achieved.[201]

Table 51: Official Exchange Rate (CFA-USD)[202]

Exchange Rate	2013	2014	2015	2016	2017	2018
End of Period	475.64	540.28	602.51	622.29	546.95	572.89
Period Average	494.04	494.41	591.45	593.01	582.09	555.72

Source: International Monetary Fund

- **Collateral Requirements**

A common problem in the West African Economic and Monetary Union is poor judicial processes regarding collateral registry and recovery, as well as a lack of available credit information about the borrower. Hence, most commercial banks require high amounts of collateral in order to mitigate consumer credit risk. In Benin, collateral requirements are on average 231% of the required loan; this figure is 17.5% higher than the average for Sub-Saharan Africa[203] and more than 80% higher than the ECOWAS average (**Table 52**).[204] As a result, a majority of firms in the country are unable to obtain loans due to high costs of credit, insufficient funds offered, the short maturity of the loans, and/or the amount of required collateral.

Table 52: Collateral Requirements for a Loan

Indicator	Collateral Requirement
Benin	231%
Sub-Saharan Africa	213.5%
ECOWAS	147.4%

Source: World Bank and ECOWAS

- **Banking Supervision**

The corporate financial regulatory framework is determined by legislation issued by WAEMU and the Organization for the Harmonization of Business Law in Africa (L'Organisation pour l'Harmonisation en Afrique du Droit des Affaires, OHADA). In 2016, the WAEMU Council of Ministers adopted measures to implement the Basel II and Basel III rules into the monetary union, designed to further preserve resilience in the banking sector by increasing capital requirements and controlling risk profiles. In addition, BCEAO

[200] Hallet, M., "European Economy: The role of the Euro in Sub-Saharan Africa and in the CFA franc zone," European Commission Directorate-General for Economic and Financial Affairs, (2008): http://ec.europa.eu/economy_finance/publications/pages/publication13478_en.pdf
[201] Liedong, T., "Could West Africa introduce a single currency?" CNN, (August 8, 2017): https://www.cnn.com/2017/08/08/africa/single-currency-west-africa/index.html
[202] International Financial Statistics (IMF): http://data.imf.org/regular.aspx?key=61545862
[203] "Enterprise Surveys: Benin," World Bank, (2016): http://www.enterprisesurveys.org/data/exploreeconomies/2016/benin#finance
[204] Quartey, P., Turkson, E., Abor, J., Abdul Iddrisu, A., "Financing the growth of SMEs in Africa: What are the constraints to SME financing within ECOWAS?" Review of Development Finance, (June 2017): https://www.sciencedirect.com/science/article/pii/S1879933717300362?via%3Dihub

adopted regulations to establish Credit Information Bureaus (Bureaux d'Information sur le Crédit, BICs) within the monetary union, which were designed to reduce asymmetric information between customers and banks by providing economic and financial information to customers.

The central bank also implemented regulations to improve its ability to enforce existing regulations. The instructions focused on how to set up internal audit systems, compliance audit systems and provisional administration for BICs. The provisions also defined the sanctions applicable to BICs and established the amounts required to set up a special reserve to ensure their long-term viability. Reporting systems and procedures were also put in place to ensure that financial statements of credit institutions were reliable and also prepared in a timely manner.[205] Benin adopted these regulations in 2016.

3.2.4 Lending to the Off-Grid Solar Sector

While there are several donor and DFI-funded programs and initiatives that have provided financing to support development of Benin's off-grid solar market (e.g. OCEF), these funds have not been channeled through local commercial banks or MFIs. ROGEP is therefore a pioneering initiative in the country, as it endeavors to boost OGS lending via engagement with local financial partners. Local FIs are increasingly becoming more aware of the opportunities in the off-grid space, and interviews FIs revealed a willingness to participate in providing financing to the sector.

3.2.4.1 Programs Supporting Financial Institutions in Off-Grid Solar Lending

- **AFD Sustainable Use of Natural Resources and Energy Finance (SUNREF)**

SUNREF is a credit line provided by AFD for financial institutions and their clients that aim to fund clean energy projects. SUNREF includes TA and credit facilities to provide banks with the necessary long-term financing to overcome financial barriers met by project sponsors. The program is open to companies seeking to obtain easier access to green finance and banks seeking to develop their green finance portfolios. In 2014, Orabank, Société Générale and AFD signed a partnership agreement to launch SUNREF's West Africa program, which makes a EUR 30 million (CFA 19.6 billion) credit line available to banks in WAEMU (Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo).[206] In Benin, SUNREF West Africa partnered with Orabank Benin to provide a EUR 30,000 loan to finance the building of an 11 kWp solar PV mini power station and to cover nearly 80% of the project's financial requirements for a Beninese company, PA Conseils. Additionally, SUNREF West Africa provided TA to the bank in the form of identifying investment opportunities, setting-up the project, assisting with the selection of the most appropriate technologies, and supporting analysis of the environmental and social impacts of the investment.[207]

3.2.4.2 Key Barriers to Off-Grid Solar Lending

- **Unfamiliarity with the Off-Grid Solar Sector**

Much like other African markets, local FIs in Benin are unfamiliar with lending to off-grid solar projects and companies and have a limited understanding of the nascent sector. During stakeholder interviews, many of the FIs noted a lack of expertise in assessing OGS risks and in structuring/developing customized products for the sector. While programs such as SUNREF have supported participating FIs, there remains

[205] "2016 Annual Report," Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO), https://www.bceao.int/sites/default/files/2017-12/2016_annual_report_2.pdf
[206] SUNREF: https://www.sunref.org/en/sunref-elue-meilleure-solution-financiere-pour-lenergie-durable-en-afrique-de-louest/
[207] SUNREF – Benin: https://www.sunref.org/en/projet/un-mini-reseau-solaire-pour-lelectrification-dune-ferme-avicole-au-benin/

a significant gap in overall local capacity. Nearly all of the interviewed FIs stressed that technical assistance would be necessary to facilitate off-grid solar lending.

- **Maturity Structure of Bank's Funding**

The sizable share of short-term deposits limits the ability of banks to offer longer-tenor consumer financing products, which are necessary to accelerate off-grid solar market growth. In more mature off-grid solar markets, Lease-to-Own and Pay-As-You-Go (PAYG) payment models reduce entry barriers for consumers by allowing for small, incremental payments for electricity which are more affordable, rather than demanding a high up-front cost for installation and service.

- **Low Private Sector Credit**

Commercial bank credit to the private sector remains weak and continues to constrain development of the OGS sector. As described in **Section 3.2.2**, access to finance remains a key barrier for businesses in the country. The use of bank loans for working capital and investment is extremely low in Benin, as the proportion of investment that is internally financed by firms is nearly 20% higher than the average in Sub-Saharan Africa. This hinders solar companies from investing in the growth of their business and expansion of their operations.

- **Lack of Credit History/High Collateral Requirements**

As described in **Section 3.2.3**, consumers in Benin face very strict collateral requirements – significantly higher than other countries in the region (**Table 52**). Many consumers also lack basic financial literacy and knowledge about the terms and conditions of financial products and therefore struggle to obtain loans.[208] The lack of credit history/track record and the weak balance sheet of most off-grid solar enterprises is a critical barrier that often prevents these firms from meeting the collateral requirements of banks. When compared to domestically-owned enterprises, foreign-owned firms are typically more likely to obtain financing. All of the interviewed commercial banks indicated that credit guarantees would be necessary to encourage lending to the sector.

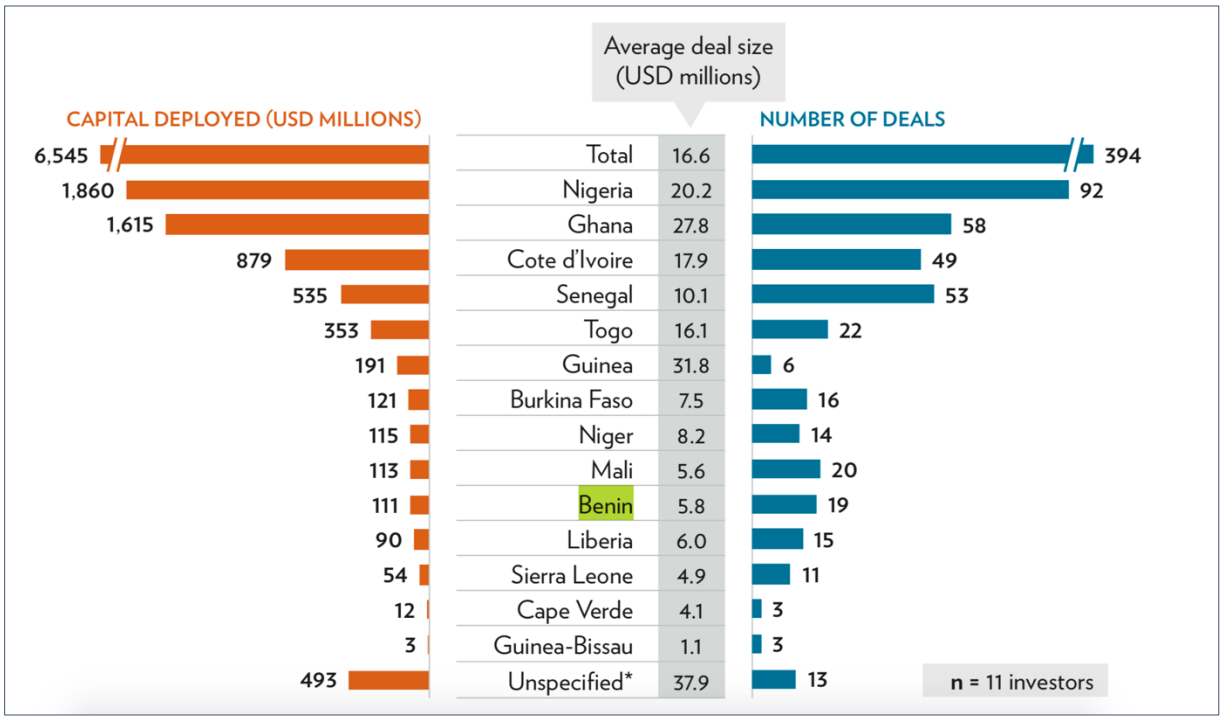
[208] Sanford, C., Meka, S., Cojocaru, L., Ahmed, W., "Client Voices: Benin Country Report - Vulnerable Clients in a Lightly Regulated Market: Consumer Protection in Microfinance in Benin," Bankable Frontier Associates, (October 2015): http://smartcampaign.org/storage/documents/Client_Voices_Benin_Eng_FINAL.pdf

3.3 Financial Institutions[209]

3.3.1 Development Finance Institutions

Between 2005 and 2015, Benin received a total of USD 111 million in DFI funds with an average deal size of USD 5.8 million; the amount comprised about 2% of the total DFI investment across West Africa over this period (**Figure 52**).[210]

Figure 52: DFI Investment in West African Countries, 2005-2015



Source: Global Impact Investing Network and Dahlberg

Several DFIs are active in Benin, including AfDB, AFD/PROPARCO, and World Bank/IFC among others. Benin's flagship Off-Grid Clean Energy Facility (OCEF), launched by the US Millennium Challenge Corporation, provides a platform for organizations and companies to search for potential partners to finance and develop off-grid clean energy projects in the country. The third window includes funding for the stand-alone solar market segment (see **Section 1.2.2.1** for more details).

- **AfDB Facility for Energy Inclusion**

Benin's OCEF has several key financial partners,[211] including the AfDB's Facility for Energy Inclusion's Off-Grid Energy Access Fund (FEI OGEF), structured by Lion's Head in partnership with the Nordic Development Fund. The FEI is a USD 500 million Pan-African debt facility created by the AfDB to support the achievement of its access to energy goals by providing debt capital to SHS companies, small

[209] Excluding commercial banks, which are reviewed in detail in **Section 3.2**.
[210] "The Landscape for Impact Investing in West Africa: Understanding the Current Status, Trends, Opportunities and Challenges," Global Impact Investing Network and Dahlberg, (2015): https://thegiin.org/assets/upload/West%20Africa/RegionalOverview_westafrica.pdf
[211] Off-Grid Clean Energy Facility (OCEF) – Financiers: https://ocef.bj/en/financing

independent power producers and mini-grid developers. The FEI OGEF supports transaction structuring, provides local currency options to reduce risk for borrowers and their customers, and also offers technical assistance to companies to support off-grid market development.[212]

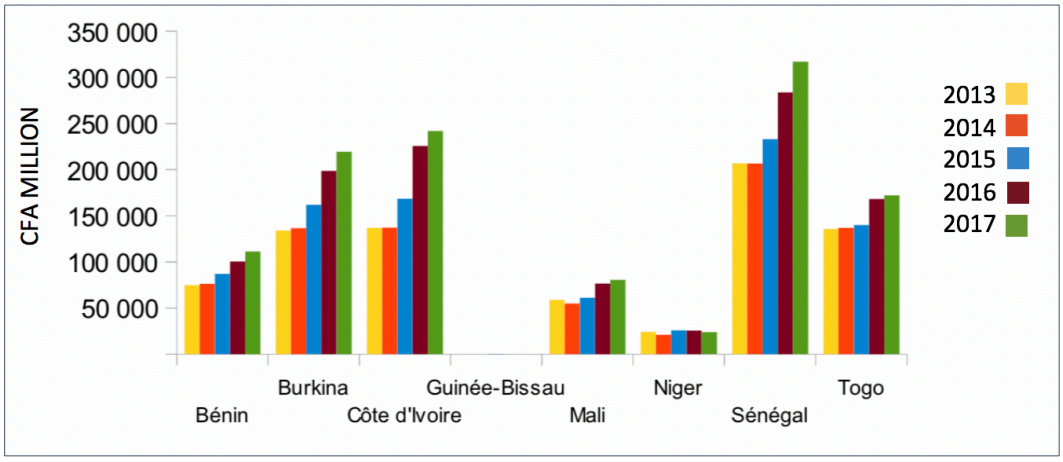
- **International Finance Corporation (IFC)**

In June 2018, the IFC announced it had invested USD 60 million in a regional risk-sharing facility to support Bank of Africa Group's lending to SMEs in eight African countries, including Benin. Half of the facility is earmarked for women-run businesses, and for climate-related improvements, such as energy efficient equipment upgrades, small solar systems, and climate-smart agricultural supply chains. IFC's investment will cover up to 50% of the risk on these SME loans.[213]

3.3.2 Microfinance Institutions

The microfinance sector in the WAEMU region was formally organized under the Regulatory Program for Mutual Support (Programme d'Appui à la Réglementation des Mutuelles d'Epargne et de Credit, PARMEC), which authorized BCEAO to regulate MFIs through the WAEMU Banking Commission. MFIs with deposits greater than CFA 2 billion (USD 3.4 million) are regulated under PARMEC, while all others are governed through local institutions. As of 2017, there were over 650 MFIs active in WAEMU countries, with 13 million individuals as direct beneficiaries.[214] **Figure 53** and **Figure 54** illustrate trends in MFI deposits and loans, respectively, in WAEMU between 2013 and 2017. Benin has witnessed a steady increase in both deposits and credits over this period.

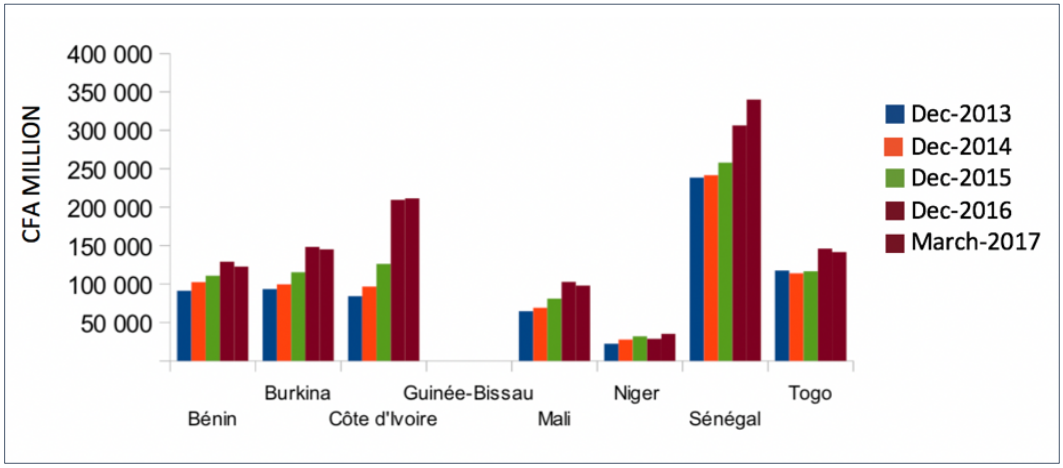
Figure 53: Microfinance Deposits in WAEMU



Source: BCEAO

[212] Facility for Energy Inclusion – Off-Grid Energy Access Fund: https://www.ogefafrica.com
[213] "IFC Invests in Bank of Africa to Expand SME Lending in Eight Countries," International Finance Corporation, (4 June 2018): https://ifcextapps.ifc.org/ifcext/pressroom/ifcpressroom.nsf/0/947B76E4C106A246852582A200440E1C?OpenDocument
[214] "Situation du Secteur de la Microfinance dans L'UMOA au 31 Mars 2017," BCEAO (2017): https://www.bceao.int/sites/default/files/2017-11/situation_de_la_microfinance_a_fin_mars_2017_1.pdf

Figure 54: Microfinance Loans in WAEMU



Source: BCEAO

In Benin, local MFIs are governed by the Ministry of Finance and Economy. The net income for the 10 largest MFIs was recorded at CFA 4.5 billion (USD 7.7 million) in 2014; however, Beninese MFIs profitability ratios were below the BCEAO average. Overall, the profitability of this sector was driven by the Federation of Savings and Rural Loan Cooperatives (Fédération des Caisses d'Épargne et de Crédit Agricole Mutuel, FECECAM), which accounted for 63% of net income for MFIs in 2014. Four out of the 10 largest MFIs do not adhere to the 15% minimum capital adequacy requirement. Furthermore, although the mandatory interest rate ceiling is set at 24% by WAEMU, many are unable to adhere to this regulation. Consequently, of the 721 MFIs operating in the country, 226 are licensed, which makes supervision of these institutions a significant challenge for national and regional regulatory bodies.[215]

3.3.3 Informal Financial Institutions

A 2017 World Bank study found that 38% of adults in Africa had borrowed money from an informal FI as opposed to 5% who borrowed from a formal FI. Although informal borrowing occurs at different rates across Africa, roughly 100 million adults in Sub-Saharan Africa use informal sources of finance.[216] The informal financial sector often serves as a major source of savings and credit services for women, the low-income population and others who lack access to formal institutions. Informal financial institutions typically include individual money lenders as well as collective entities such as Rotating Savings and Credit Associations and Accumulated Savings and Credit Associations, among other groups.[217]

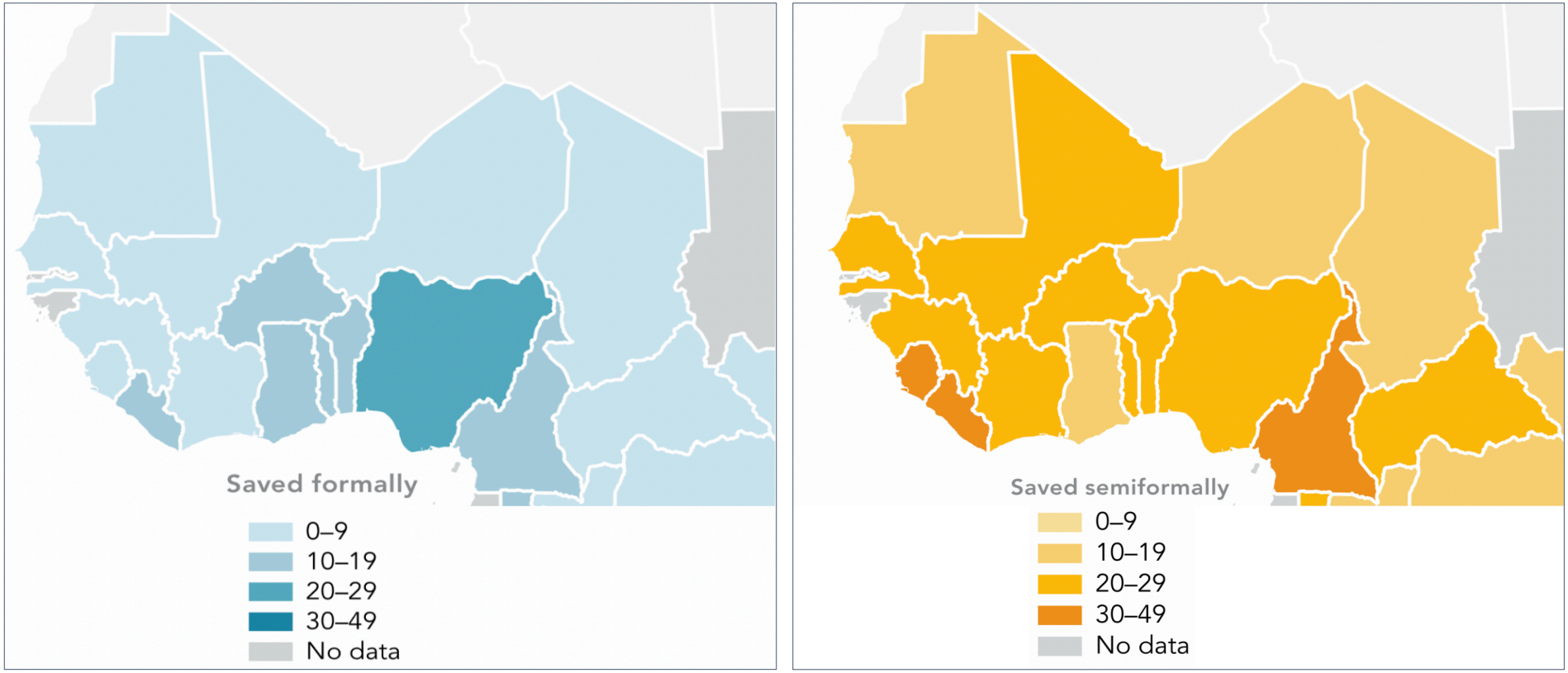
Much like in other African states, there is a large informal financial sector in Benin (**Figure 55**). Data from this sector remains limited, largely due to the informal nature of these institutions, which does not facilitate access to information on their practices, cost standards and transaction levels. The World Bank's Findex survey suggests that between 2011 and 2014, borrowing from FIs increased while borrowing from informal lenders decreased over the same period (**Figure 56**).

[215] "Benin," International Monetary Fund, (January 2018): https://www.imf.org/en/Publications/CR/Issues/2018/01/05/Benin-Selected-Issues-45534

[216] "Demirguc-Kunt, A., Klapper, L., and Singer, D., "Financial Inclusion and Inclusive Growth: A Review of Recent Empirical Evidence," World Bank Policy Research Working Paper 8040, (April 2017): http://documents.worldbank.org/curated/en/403611493134249446/pdf/WPS8040.pdf

[217] Klapper, L., Singer, D., "The Role of Informal Financial Services in Africa," Journal of African Economies, (24 December 2014): https://academic.oup.com/jae/article-abstract/24/suppl_1/i12/2473408?redirectedFrom=fulltext

Figure 55: Share of Adults Saving in the Past Year (%), 2017[218]



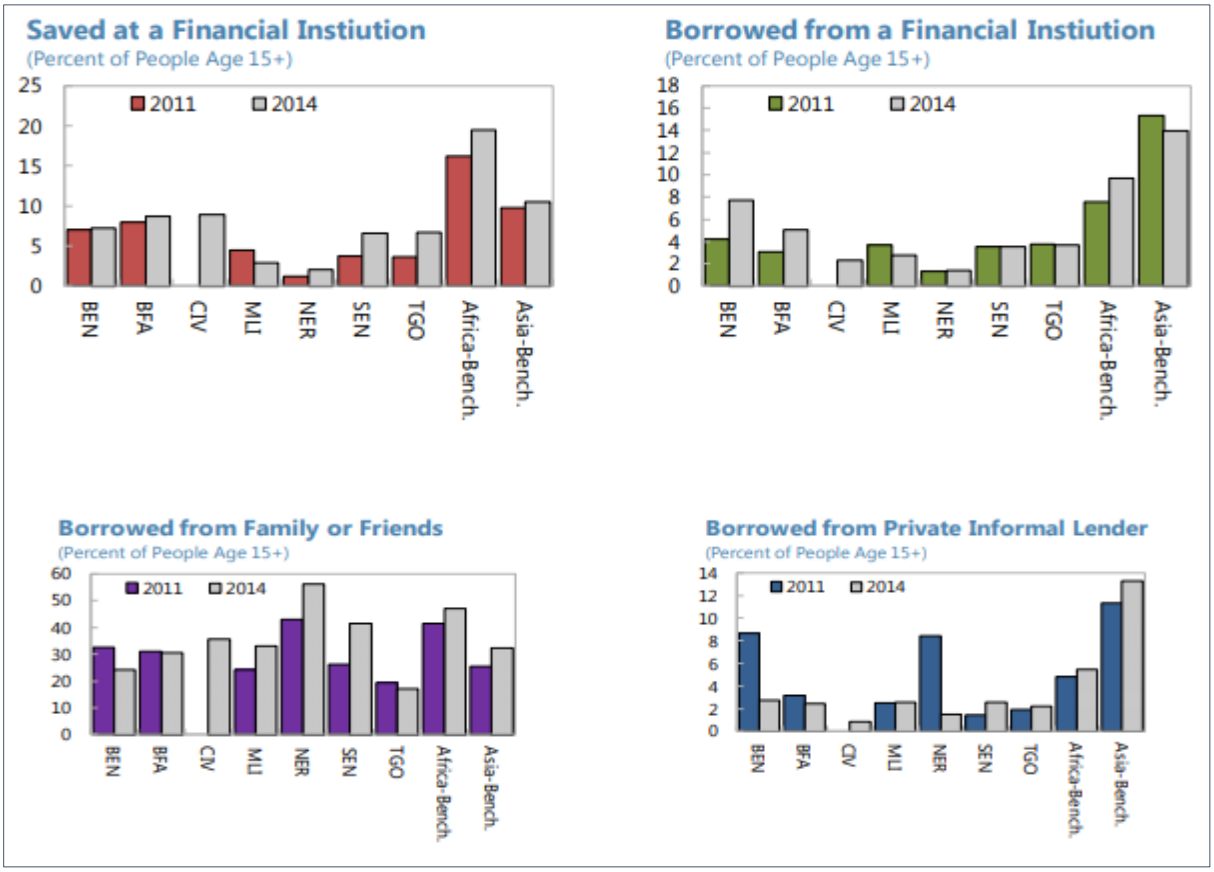
NOTE: Maps exclude Cabo Verde (no data)

Source: World Bank Global Findex Database

Figure 55 shows how the savings behavior of adults varies in West Africa and the Sahel. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. Saving semi-formally is much more common than saving formally across the region, including in Benin.

[218] Demirguc-Kunt et al., 2017.

Figure 56: Informal Financial Sector Indicators in WAEMU, 2011-2014[219]



Source: International Monetary Fund

3.3.4 Impact Investors

An assessment carried out by the Global Impact Investing Network (GIIN) found that while impact investing steadily increased across Africa between 2005-2015, most of the investment in West Africa has been highly concentrated. Nigeria and Ghana are the two largest recipients of all impact capital deployed in West Africa, while Benin ranked fifth in the region (**Figure 57**). Moreover, investments are largely focused on the financial services industry and the agriculture sector. An overall lack of readiness by local African companies, relatively high levels of political and regulatory uncertainty, and difficulty in raising capital are some of the main barriers that impact investors face across the region.[220]

- **FRAGG Investment Management**

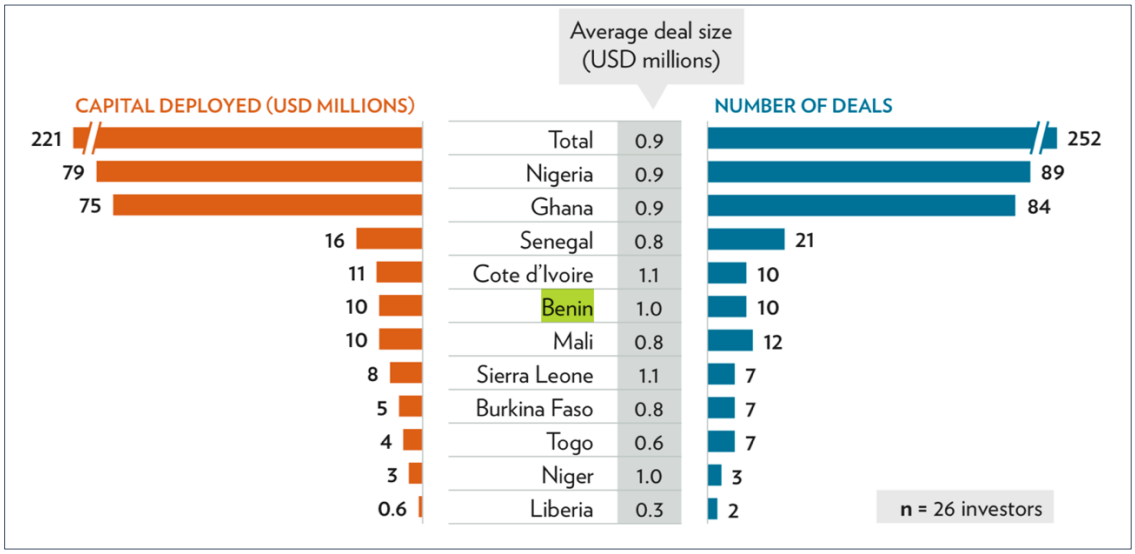
One of the key financial partners of Benin's OCEF is FRAGG Investment Management – an impact investor and SME-focused fund that mobilizes investment and raises capital for high-growth companies in West Africa. FRAGG finances and invests in growing and inclusive SMEs that create social and environmental impact but are not able to attract capital for their business at affordable conditions. The fund provides businesses with long-term risk capital that allows them to operate at their full potential; these come by way

[219] "West African Economic and Monetary Union," International Monetary Fund, (2016): https://www.imf.org/~/media/Websites/IMF/imported-full-text pdf/external/pubs/ft/scr/2016/_cr1698.ashx

[220] "The Landscape for Impact Investing in West Africa: Understanding the Current Status, Trends, Opportunities, And Challenges," Global Impact Investing Network and Dahlberg, (2015): https://thegiin.org/assets/upload/West%20Africa/RegionalOverview_westafrica.pdf

of long-term debt facility and equity investments.[221] Outside of Benin, the fund is also engaged in Nigeria, Togo, Ghana and Côte d'Ivoire.

Figure 57: Non-DFI Investment in West African Countries, 2005-2015



Source: Global Impact Investing Network and Dahlberg

3.3.5 Crowd Funders

Crowdfunding in Benin has been limited. Although the demand for capital continues to grow, crowdfunding remains a challenging source of financing for SMEs. Across Africa as a whole, crowdfunding amounted to USD 70 million in 2015 – less than 1% of global crowdfunding.[222] Moreover, roughly 75% of the capital raised by African start-up companies in 2017 was raised in Kenya, Nigeria, and South Africa.[223] Additionally, unlike most emerging markets, countries in West Africa and the Sahel do not have regulatory frameworks in place to offer protection to investors, which discourages potential investment. The following crowd-finding platforms have been identified in Benin:

- **Kiva** is a crowdfunding platform designed to connect entrepreneurs to potential investors to help alleviate poverty in low-income counties. The platform offers USD 25 loans to small business as seed capital or for expansion, loans for education, or to grant access to clean and reliable energy. Since 2005, Kiva has created $575 million in microloans to over 1.3 million entrepreneurs in 75 countries, with a 98% repayment rate. Kiva has been active in Benin since 2009.
- **PowerON:** Thorough crowdfunding, PowerON built a grid servicing 3,000 people in Igbere village in rural Benin. Villagers have access to the grid using prepaid mobile money contracts. The platform is currently seeking to expand to hundreds of villages throughout the country.[224]

[221] FRAGG Investment Management: http://www.fragginvest.com/about-us/
[222] "Crowdfunding in Emerging Markets: Lessons from East African Startups," World Bank (2015): https://www.infodev.org/infodev-files/crowdfunding-in-east-africa.pdf
[223] "Disrupt Africa Funding Report 2017," Silicon Cape Initiative, (18 January 2018): https://www.siliconcape.com/disrupt-africa-funding-report-2017/
[224] PowerON: https://en.turnthepoweron.co

3.4 Summary of Findings

- **Opportunity for ROGEP Credit Lines:** Beninese banks lack access to funding with the interest rates and tenors required to make off-grid solar projects attractive to end-users and SMEs. Local currency cost of capital remains very high for FIs, which in turn results in prohibitively high pricing for typical loans. Furthermore, loans are usually short-term, as customer deposits (mostly short-term) remain the largest source of funding for banks. This dynamic severely constrains OGS market growth. Stakeholder interviews revealed that there is indeed an opportunity for ROGEP credit lines to provide liquidity to local commercial banks and MFIs to support lending to the off-grid solar sector.

- **Local Currency and Pricing:** Most loans to off-grid enterprises and all loans for consumer purchases of stand-alone solar devices must be denominated in local currency. However, taking up hard currency denominated credit lines presents challenges for local lenders who would have to bear the FX risk. This risk is somewhat mitigated in Benin, however, as the CFA franc is pegged to the euro, which shields it from volatile currency fluctuations. As a result, even after pricing in a hedge to cover this risk, many hard currency denominated credit lines can stay attractive, as the all-in cost of capital to local FIs is manageable to provide competitive offers to borrowers.

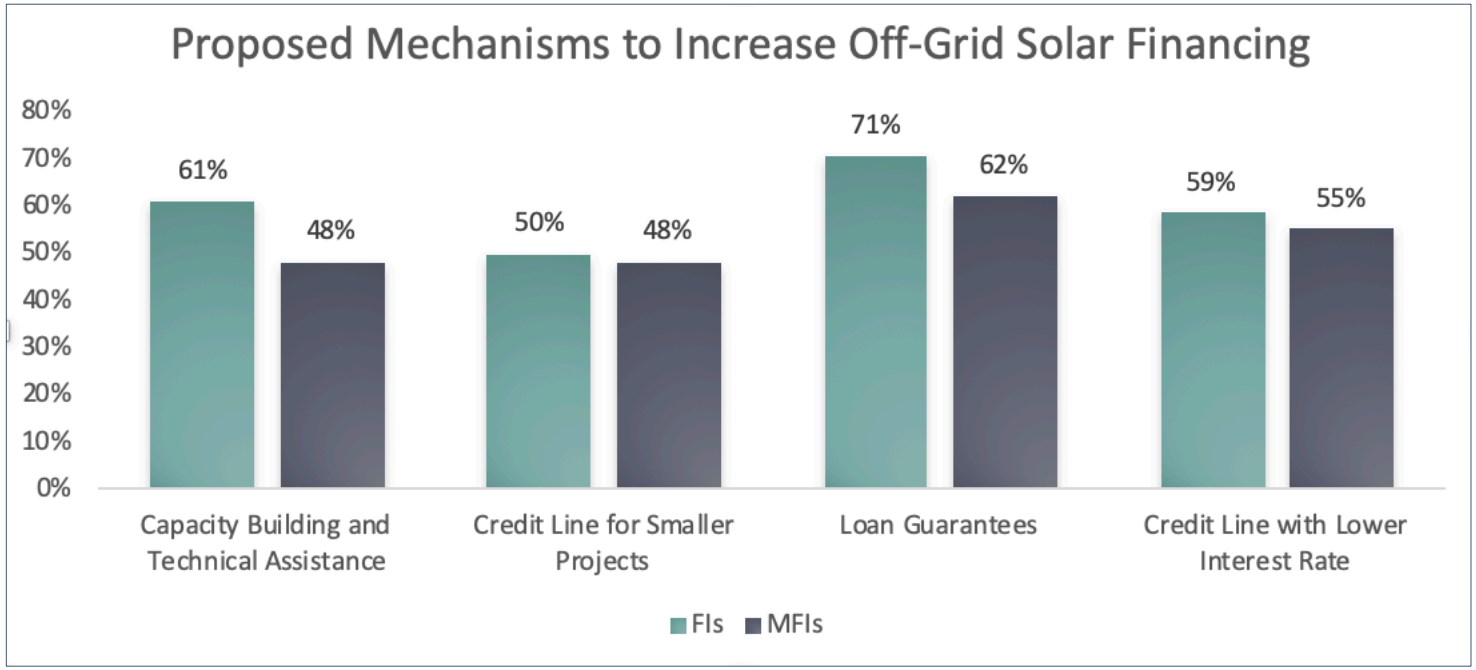
- **Collateral Requirements**: The collateral requirements of commercial banks in Benin are extremely high, particularly for small firms. Moreover, lenders already in the space are deeply constrained from originating loans where the borrower cannot meet these requirements. Hence, the use of third-party *pari-passu* guarantees as an alternative form of collateral would enable banks to extend loans to borrowers without such high collateral requirements. Accordingly, many of the interviewed commercial banks emphasized the need for partial credit guarantees to encourage lending to the OGS sector (50% coverage is helpful; 70-80% coverage could be transformative). However, pricing from most available third-party guarantors can be in the range of 3%+ per annum, which some lenders view as too high to remain competitive. This creates an opportunity for ROGEP to either provide low-cost guarantees directly or to subsidize the premiums offered by existing third-party guarantors such as GuarantCo, Afrexim and Africa Guarantee Fund.

- **Risk Perception of New Lenders**: In order to attract additional lenders into the off-grid solar market segment, there is need for strong, reasonably priced credit enhancement mechanisms. In order to cover "market entry" risks for lenders unwilling to enter this market, guarantee instruments that cover first loss are needed. However, first-loss coverage, while necessary for attracting new lenders to the off-grid sector, does not address the key issue of collateral and is therefore likely insufficient on its own to stimulate growth in FI engagement unless coupled with third-party guarantee coverage.

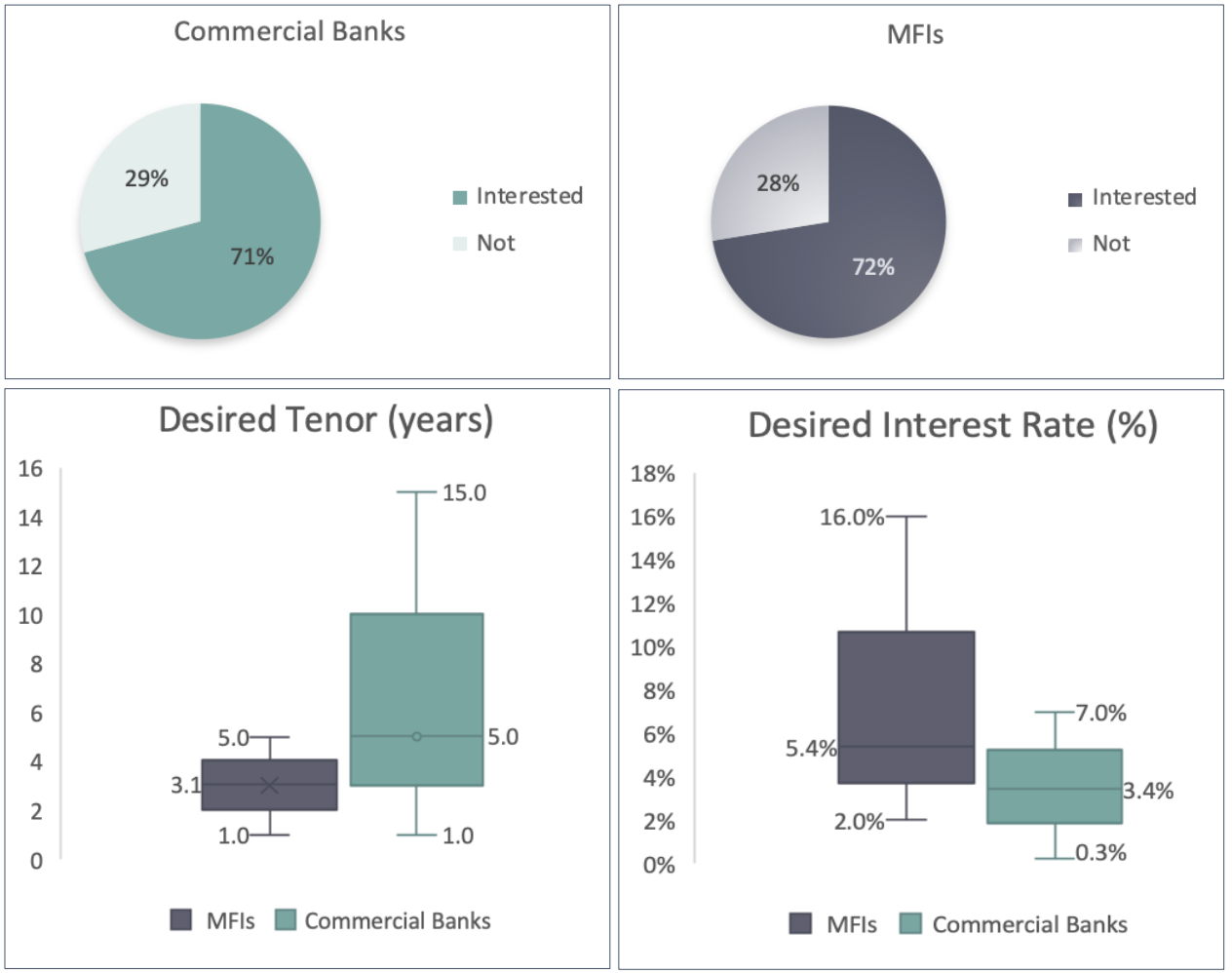
- **Technical Assistance:** A well designed TA intervention is critical to accelerating OGS lending in the country. Stakeholder interviews revealed the following key areas of support: training of bank credit department and account representative personnel to originate deals and appropriately assess the credit risk of stand-alone solar firms and projects; extensive due diligence support to qualify products and approve vendors; and targeted support for new lenders to the sector with product structuring and development as well as building deal-flow. The TA intervention should build upon previous and existing programs such as the OCEF and SUNREF to avoid duplication of efforts. Special attention should also be paid to offering advisory services on the side of the stand-alone solar enterprises. Lenders opine that these entrepreneurs often do not have proper financial management and accounting systems in place, are unable to present quality financial models and lack the expertise required to structure their companies to take on debt obligations.

- **Digital Financial Services**: The advent of digital financial services and mobile money is one of the most important developments in off-grid solar market development to date, as it has allowed new and innovative business models to emerge that are now driving unprecedented growth in the sector. Mobile communication technology facilitates payments for solar products and systems (lease-to-own, pay-as-you-go) and/or for electricity usage (energy-as-a-service) and enables monitoring for operations and maintenance of equipment. Expanding access to mobile money services also creates new opportunities to better serve women, the lower-income population, and other groups that are traditionally excluded from the formal financial system. The Government should take steps to support capacity building of and foster linkages between off-grid solar companies operating in the market and key stakeholders from various sectors, including energy access policymakers and regulators, financial and telecommunications companies, mobile network operators, financial service providers (commercial banks and microfinance institutions), mobile money service providers, international organizations, NGOs and civil society groups involved in financial inclusion etc.

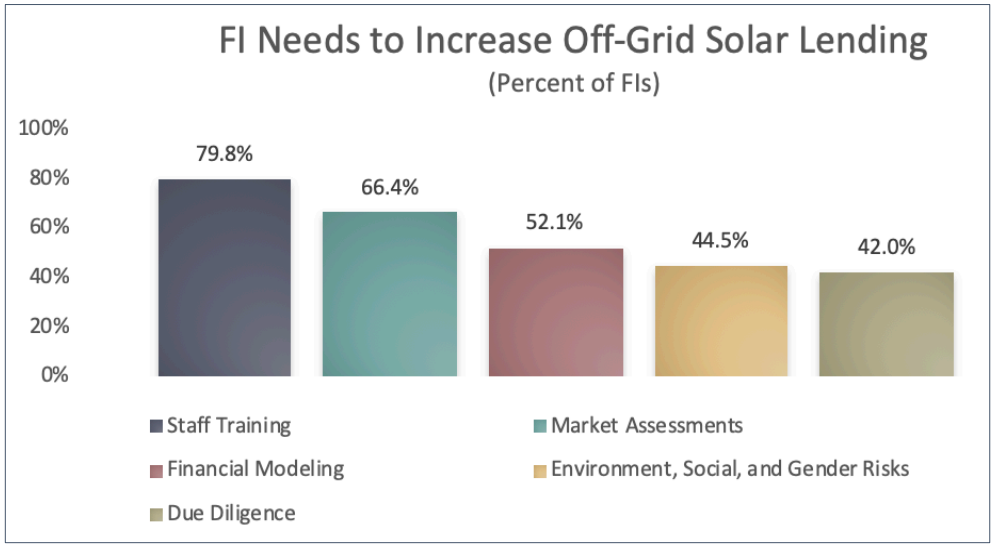
Key findings from the Task 3 FI survey activity are presented below. The results are based on feedback from a total of 121 FIs (including commercial banks, microfinance institutions and other non-bank FIs) that were interviewed across the 19 ROGEP countries. This summary only focuses on responses from commercial banks and MFIs, which together account for 92% of all respondents. See **Annex 3** for more details.



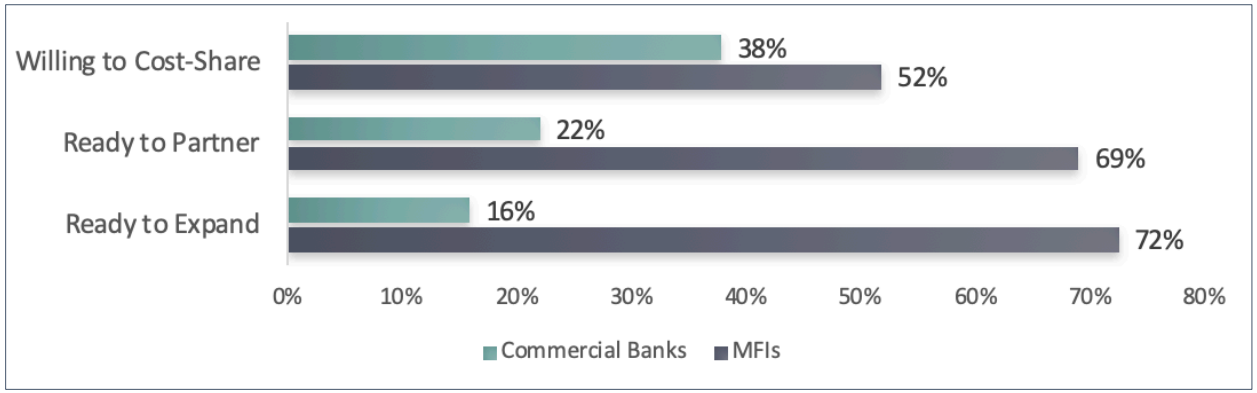
According to the survey, there is strong financial-sector interest across ROGEP countries to finance renewable energy projects, especially in off-grid solar. Commercial banks and MFIs identified loan guarantees as the most important measure that could improve their capacity to lend to the renewable energy sector. Most of the surveyed institutions also identified clear interest in credit lines.



More than 70% of surveyed commercial banks and MFIs are interested in a credit line to finance off-grid solar projects. Commercial banks want tenors of 1-15 years and interest rates from 0.25-7%. MFIs are seeking tenors of 1-5 years with interest rates from 2-16%. On average, commercial banks want a credit line with a 5-year tenor and 3.4 % interest rate, and MFIs want a 3.1-year tenor with 5.4% interest rate.



In addition to their clear interest in credit lines and loan guarantees to finance off-grid projects, surveyed financial institutions (commercial banks and MFIs) in ROGEP countries also identified several areas of internal capacity that require improvement in order to lend (or increase lending) to the off-grid solar sector.



Compared to commercial banks, MFIs reported a greater willingness to cost-share capacity building activities and a higher level of readiness to partner with solar companies and expand operations to serve rural and off-grid areas.

ANNEX 1: TASK 1 METHODOLOGY

STATE OF ENERGY ACCESS AND ENABLING MARKET ENVIRONMENT

Data presented in this section was collated from a range of public documents and reports as well as primary source documents either provided by ECREEE or obtained through supplemental market research (desk research and interviews with local public officials and industry stakeholders). These findings were subsequently corroborated by attendees of national validation workshops held in each country at the conclusion of the market assessment. Information obtained from the Task 2 focus group discussions and surveys of industry stakeholders (see **Annex 2**) was also used to support the Task 1 analysis.

GIS DATA ANALYSIS APPROACH / METHODOLOGY

1. Categorizations, key definitions and datasets for geospatial least-cost analysis

The main steps of the GIS analysis are as follows:
(i) Categorization/definition of settlements: scenario 2023;
(ii) Categorization/definition of settlements: scenario 2030;
(iii) Definition of un-electrified settlements within grid areas; and
(iv) Determination of population per settlement

1.1. Categorization/definition of settlements: Scenario 2023

1.1.1. *Electrification by grid extension* – settlements which are located within 5 km of the current electrical grid network[225] (according to WAPP densification plans).

1.1.2. *Electrification by mini-grid* – settlements that:
- Are located within 15 km of areas that have a high night-lights value (above 50/225 on grayscale raster)[226] and outside the buffer area established for the electrification by grid extension
- Are located within areas that have a population density of more than 350 people per km^2 (as defined by Eurostat for rural areas),[227] plus an additional 50 people per km^2 for greater feasibility of mini-grids[228] and are within 1 km[229] of a social facility (education center or health facility) and existing mini-grids of 2018.

1.1.3. *Electrification by off-grid stand-alone technologies* – settlements that do not fall into the above categories

1.2. Categorization/definition of settlements: Scenario 2030

1.2.1. *Electrification by grid extension* – settlements which are located within 15 km of the current electrical grid network (average distance mentioned by energy utilities in West Africa) or within 5 km of planned future line extensions[230]

[225] NOTE: Low-voltage distribution lines were not considered in this analysis (data was unavailable)
[226] The 50/225 classification represents the areas emitting light of the country with reduction of scattering light. The classification was first introduced in the USAID report ZAMBIA ELECTRIFICATION GEOSPATIAL MODEL and evaluated in cross-checks throughout the country. USAID: https://pdf.usaid.gov/pdf_docs/PA00T2JC.pdf
[227] http://ec.europa.eu/eurostat/web/rural-development/methodology
[228] Identified in discussions with different international mini-grid developer.
[229] Preferred maximum distance for mini-grids from discussions with different international developer.
[230] NOTE: Low-voltage distribution lines were not considered in this analysis (data was unavailable)

1.2.2. *Electrification by mini-grid* – settlements that:
- Were defined as mini-grid settlements in the 2023 scenario
- Are located within 1 km of the above mini-grid settlements, which is the preferred distance of mini-grid developers for their grid according to discussions with several international developers.
- Are located within 15 km of economic growth centers – airports, mines and urban areas; average worker distance in Africa is 10 km, a distance of 5 km is added to include the growth of businesses in the periphery of the growth centers.[231]

1.2.3. *Electrification by off-grid stand-alone technologies* – settlements that do not fall into the above categories

1.3. Definition of un-electrified settlements within grid areas

To identify settlements that are located close to the national electrical grid but are not served by it, the following criteria were used:

- Within the main grid line zones (see buffer zones for *electrification by grid extension* above)
- Outside 15 km night-lights of buffered areas to capture the densification within 5 years
- Within areas of low population density (less than 350 people per km^2)

1.4. Determination of population per settlement

A key component of the least-cost analysis was the number of people living in each settlement (city, town, village, hamlet) of a given country. While there are different publicly available sources of information on total population (e.g. World Bank demographic data), a more granular view of the population distribution was necessary to perform the geospatial analysis.

Another difficulty was the identification of locations of settlements. The exact location of each settlement (with given coordinates) was not available / accessible in many of the countries. As a result, the least-cost analysis had to revert to other studies of population distribution – such as the population distribution developed by WorldPop. WorldPop utilizes a range of geospatial datasets to develop accurate population data:

"New data sources and recent methodological advances made by the WorldPop program now provide high resolution, open and contemporary data on human population distributions, allowing accurate measurement of local population distributions, compositions, characteristics, growth and dynamics, across national and regional scales. Statistical assessments suggest that the resultant maps are consistently more accurate than existing population map products, as well as the simple gridding of census data." [232]

A Voronoi polygon analysis[233] was used to create boundaries for each identified settlement. These boundaries were then used in combination with the population density layer to estimate the total settlement population of the given year. The current annual national population growth rate of 2.8%[234] was applied to the geospatial analysis to project populations for the Scenario 2023 and 2030 analyses.

[231] Lall, Somik Vinay; Henderson, J. Vernon; Venables, Anthony J. 2017. Africa's Cities: Opening Doors to the World. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/25896 License: CC BY 3.0 IGO.
[232] https://www.worldpop.org
[233] To learn more about Voronoi polygons, see wikidot: http://djjr-courses.wikidot.com/soc128:qgis-voronoi-polygons
[234] https://data.worldbank.org/indicator/SP.POP.GROW?locations=BJ

2. Summary of Key Datasets

The table below summarizes the key datasets used for scenarios 2023 and 2030 as well as the criteria applied and sources used.

Overview of Key Datasets of the Least-Cost Electrification Analysis								
Dataset	Description	Criteria used by technology						Source and Year
		Scenario 2023			Scenario 2030			
		On-grid	Mini-grid	Off-grid	On-grid	Mini-grid	Off-grid	
Electricity grid network (current)	Current national grid network (HV & MV lines)	≤ 5km distance	≥ 5km distance	≥ 5km distance	≤ 15km distance	≥ 15km distance	≥ 15km distance	ECOWREX, 2018[235]
Electricity grid network (planned)	Future network planned to be built (HV & MV lines)	Not considered	Not considered	Not considered	≤ 5km distance	≥ 5km distance	≥ 5km distance	ECOWREX, 2018
Mini-grids	Existing mini-grids in 2018	Not considered	≤ 1km distance	≥ 1km distance	Not considered	≤ 1km distance from all identified mini-grids in Scenario 2023	≥ 1km distance from all identified mini-grids in Scenario 2023	ECOWREX, 2018
Night-lights	Night-time light emissions used to identify electrified areas	Not considered	≤ 15km distance	≥ 15km distance	Not considered	Not considered	Not considered	NASA Earth Observatory, 2016
Population density	Population distribution in people per km^2.	≥ 350 people per km^2 [236]	≥ 350 people per km^2	≤ 350 people per km^2	Not considered	Not considered	Not considered	WorldPop, 2015
Settlements	Settlement layer giving location of settlements across Benin (cities, towns, villages, hamlets)	Used	Used	Used	Used	Used	Used	HDX, 2018 - Second Administrative Level Boundaries (SALB) Project[237]

[235] http://www.ecowrex.org/mapView/index.php?lang=eng

[236] Based on Eurostat definition plus an additional 50 people per km2 for greater feasibility of mini-grids as identified in discussions with different international mini-grid developer. Source: http://ec.europa.eu/eurostat/web/rural-development/methodology

[237] Humanitarian Data Exchange, 2015.

Social facility: education centers	Primary schools, 1st and 2nd level colleges; Indicator of active local economy	Not considered	≤ 1km distance[238]	≥ 1km distance	Not considered	Not considered	Not considered	SIG, 2013 (collected in 2018)
Social facility: health centers	Hospitals and clinics only; Indicator of active local economy	Not considered	≤ 1km distance[239]	≥ 1km distance	Not considered	Not considered	Not considered	SIG, 2013 (collected in 2018)
Growth center: airport, mines, urban areas	Economic growth centers for the analysis up to 2030 - defined for mini-grid areas; Urban areas as defined by Electricity Demand	Not used	Not used	Not used	Not considered	≤ 15km distance	≥ 15km distance	airports: Humanitarian Data Exchange (HDX), 2017 mines: HDX, 2015 urban areas: ECOWREX website, 2015[240]

[238] Preferred maximum distance for mini-grids from discussions with different international developer.
[239] Preferred maximum distance for mini-grids from discussions with different international developer.
[240] http://www.ecowrex.org/mapView/index.php?lang=eng

ANNEX 2: TASK 2 METHODOLOGY

OFF-GRID SOLAR PV MARKET ASSESSMENT METHODOLOGY

Focus group discussions (FGDs) were held in Cotonou in July 2018 with key stakeholders from each of the four off-grid market segments analyzed under Task 2: (i) household, (ii) institutional, (iii) productive use, and (iv) supplier. Focus group participants included representatives from government, the donor community, NGOs, solar companies, business and industry associations, academia, community groups, and women's groups. Each market segment had its own dedicated meeting, although some stakeholders attended more than one discussion. Each FGD lasted approximately 90 minutes and covered a range of topics related to demand for off-grid solar vis-à-vis each market segment.

In addition to the FGDs, three additional survey activities were undertaken to support the Task 2 analysis: (i) a survey of large-scale international solar companies to gauge their level of interest in the country and wider region; (ii) a survey of local small-scale retail suppliers of solar equipment; and (iii) an assessment of an off-grid village to better understand how solar was being utilized for productive uses. The FGDs and surveys largely yielded qualitative inputs to supplement the quantitative analysis that was undertaken.

The methodology and assumptions utilized to assess each market segment under Task 2 is presented below.

1. HOUSEHOLD DEMAND

1.1 Household market segments

1.1.1 Total population without access to electricity was calculated using World Bank total population figures,[241] multiplied by electricity access rates from the International Energy Agency (IEA),[242] and translated to households using World Bank open data average household size. This method is used to align population data throughout the report, with IEA seen as an overarching source for energy access data and the World Bank providing important population and household income data. See **Annex 1** for more details.

1.1.2 Based on the country demographic and income data, the household solar market was broken down into segments by income quintile, as shown in **Section 2.1.1**. For the purpose of this analysis, income quintiles were aligned with energy tiers, as indicated by the Multi-Tier Energy Access Framework, which is roughly determined by household ability to pay for tier levels of energy. Quintiles were also aligned roughly with geographic segments.

1.1.3 World Bank demographic data used does not provide household income data broken down by rural, urban, on-grid or off-grid. For example, the data shows the total population falling under a certain poverty line, shows the total population that does not have access to electricity, and shows the total population that is rural, but does not cross reference any of these indicators to show the total rural population without access to electricity living under the poverty line. For this reason, assumptions were made regarding the number of households per income quintile that are off-grid (detailed in section 1.3.1 of these assumptions). It was assumed that the majority of off-grid households are rural. The data gap prevents the presentation of an overlapping map of the traditional poverty line income pyramid with electricity access.

[241] World Bank Open Data, 2017: https://data.worldbank.org/

[242] IEA Energy Access Outlook, 2017: https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf

1.1.4 Tier 4 is not included in this analysis since the off-grid solar systems that can provide a Tier 4 level of service are beyond the reach of the vast majority of the population.

1.2 Household energy expenditure and potential savings

1.2.1 Current household expenditure on energy-related items (believed to be candidates for replacement with solar products) was estimated using information from the FGDs.

1.2.2 From the existing household expenditures, "typical" monthly costs were estimated that households would incur in order to receive a standard level of electricity service according to the Multi-Tier Energy Access Framework.

1.2.3 The unit monthly costs were used for each of the energy-related items identified above.

1.2.4 The cumulative monthly expenditure was then determined for each tier.

1.2.5 Monthly expenditure by tier was compared with monthly cost associated with OGS products by tier to estimate potential household cost savings. Monthly cost for OGS products was based on representative data from the West African region.

1.2.6 In the process of this analysis, the following assumptions were made:

1.2.6.1 Solar system sizes and costs:

- Cost per watt on solar systems vary greatly and have changed rapidly in the past five years. Smaller pico and plug and play systems have a much higher per cost per watt. The USD/Watt prices are based on sample cost ranges from Lighting Global equipment available on the open market.
- Average system size by watts: values are chosen as representative values for solar systems from each of the Tier values. They are intended to represent system sizes that typical members of each group would purchase.
- Average system life values represent typical expected operating life of Lighting Global products.

1.2.6.2 Current household energy usage:

Current Household Energy Usage (# Units/HH)				
Technology	**Tier 1**	**Tier 1.5**	**Tier 2**	**Tier 3**
Torch lights/Lanterns	1	2	3	
Mobile Phone Charging	1	1	2	
DC Radio	-	1	-	-
DC Music Player/Radio	-	-	1	-
Small Generator	-	-	-	1

- Numbers of units of torch lights/lanterns, cell phones, dc radio, and small generator represent the numbers of appliances that are demonstrated to be in use in typical households of each tier based on FGDs and multiple survey documents.

1.2.6.3 Current household energy costs

- Typical purchase and operation costs of HH off-grid appliances were based on FGDs, field energy surveys and reports.

1.3 Total Cash and Financed Market for Off-Grid Solar

1.3.1 Beginning with World Bank demographic and population data for Benin, the number of off-grid households by income quintile was derived. For this, a percentage of off-grid households by quintile was assumed, as follows:

Quintile	% Off-Grid
Highest 20%	1%
Fourth 20%	50%
Third 20%	90%
Second 20%	99%
Lowest 20%	100%

It was assumed that there is a general correlation between income and access to electricity. The highest quintile has the highest percentage of population that are both urban and connected to the grid. Evidence indicates that the vast majority of households connected to the grid are from the top two quintiles Similarly, it was assumed that virtually all people in the bottom two quintiles are off-grid.

1.3.2 From this, average household energy expenditure was determined based on income, with the assumption that all households spend an average of 10% of their income on energy.

Average rural household expenditure on energy varies considerably. A study from Sierra Leone found that the "cost of lighting, on average, occupied between 10-15% of household incomes. Households using generators were found to spend a greater proportion of their income (upward of 20%) on lighting."[243] Other research has shown household energy spending between 6-12% for low income segments in sub-Saharan Africa.[244] For the purpose of this research, we have assumed that households can allocate 10% of their income on average to energy.

1.3.3 The monthly energy budget for each household per quintile was calculated by multiplying monthly Household income by the assumed 10% of Household income spent on energy. Monthly Household income per month was calculated by multiplying per capita income per month by the avg. # of persons/household. Per capita income per month for each quintile is calculated by dividing the Share of the country GDP for each quintile by the population of each quintile, which is one-fifth of the country population. The share of the country GDP for each quintile is based on World Bank, World Development Indicators demographic data.

1.3.4 A simple model was used to evaluate the market using the World Bank income quintile data and average energy expenditures as input data.

1.3.5 In determining the monthly energy expenditure related to each tier, the following assumptions were made with guidance from the FGDs output:

[243] Lai, K., Munro, P., Kebbay, M., and Thoronko, A., "Promoting Renewable Energy Services for Social Development in Sierra Leone: Baseline Data and Energy Sector Research, Final Report," European Union, (July 2015).
[244] 10% is an acceptable figure for lighting and cell phone charging costs for low income groups. See: https://www.brookings.edu/blog/africa-in-focus/2017/03/17/figures-of-the-week-benefits-of-off-grid-electricity-solutions/

- **Tier 0**: Assumed to be an absolute energy poor household, relying solely on kerosene and charcoal both for cooking and lighting.
- **Tier 1**: The household was assumed to have access to 1 torch light/lantern powered by dry cells, charging services for a phone charged on average 8 times a month.
- **Tier 1.5**: The household was assumed to have access to 1 torch light and 1 lantern each powered by dry cells, one regular cell phone charged on average 8 times a month, and a radio powered by dry cells (assume access to 2 low quality cells) replaced 4 times a month.
- **Tier 2**: The household was assumed to have access to 1 torch light and 2 lanterns each powered by dry cells, one regular cell phone charged on average 8 times a month, and one smart phone charged on average 16 times a month, a radio/music player powered by dry cells (assume access to 4 low quality cells), replaced 4 times a month.
- **Tier 3**: The household was assumed to have access to a generator powering a number of appliances but available only for 2-3 hours a day.
- **Annualized energy costs** for each of the systems = ([Capital system cost/average system life in years]+[Monthly operating cost*12])

1.3.6 The potential market size for each solar tier was then calculated by multiplying the number of off-grid households per quintile that will be willing to pay for each solar tier by the cost of each system (system cost is based on representative data from Benin, as shown in 2.2.5).

1.3.7 In determining the number of off-grid households per quintile that will be willing to pay for each solar tier, the key assumption of the model is that each off-grid household purchases only one system and that they will opt for the highest solar system tier they can afford.

- For cash purchases, the assumption was that they will be willing to save (set aside) up to 3 months (number of months can be adjusted on the 'HH Assumptions' tab) of their monthly energy budget to purchase the system.
- For PAYG/financed, the assumption was that they will be willing if their monthly energy budget is less than or equal to the monthly PAYG payment AND if the PAYG upfront payment is less than or equal to 3 months of their monthly energy budget.

1.3.8 The interest rate for consumer finance was conservatively estimated to be 24% p.a., based on the interest rate cap for Microfinance Institutions in WAEMU countries.[245]

2023 and 2030 Household Demand Scenario: Assumptions

1. The GIS analysis[246] estimated that by 2023, 74.7% of the population will be grid connected, 6.6% will be connected by mini-grids, and 18.7% of the population will be connected by off-grid stand-alone systems. By 2030, the GIS analysis estimated that 93.2% of the population will be grid connected, 0.5% will be connected by mini-grids and only 6.3% of the population will be connected by off-grid stand-alone systems. Based on these dynamics in demographic patterns, coupled with the existing government plans, the following assumptions regarding the off-grid population based on the quintiles were made:

- In the 2023 scenario, it was assumed that as the grid gets extended and mini-grids are deployed (based on GIS analysis), the households in the quintiles with the highest income will be given priority due to their relatively higher power demand and ability to pay for power consumption. Hence, the highest four quintiles were assumed to have only 1%, 2%, 3%, and 4% off-grid

[245] Ferrari, A., Masetti, O., Ren, J., "Interest Rate Caps: The Theory and the Practice," World Bank Policy Research Working Paper, (April 2018): http://documents.worldbank.org/curated/en/244551522770775674/pdf/WPS8398.pdf

[246] See **Annex 1** for GIS methodology.

households respectively, while the lowest quintile was assumed to have 84% off-grid households. These assumptions were made such that the total number of off-grid households assumed was equal to the GIS data 2023 estimate.

- Similarly, in the 2030 scenario, it was assumed that the higher income quintiles will be prioritized for electrification, based on economic considerations, above the lower quintiles. Hence, the highest four quintiles were assumed to have only 1%, 2%, 3%, and 4% off-grid households respectively, while the lowest quintile was assumed to have 22% off-grid households. These assumptions were made such that the total number of off-grid households assumed was equal to the GIS data 2030 estimate.

Quintile	% Off-Grid (2023)	% Off-Grid (2030)
Highest 20%	1%	1%
Fourth 20%	2%	2%
Third 20%	3%	3%
Second 20%	4%	4%
Lowest 20%	84%	22%

2. Inflation rates for Benin: According to the IMF World Economic Outlook data, inflation in Benin was estimated to be at 2.7% in 2023. It was assumed that the rate will remain the same through 2030. Based on this assumption, the expected prices of the current household energy technologies and the solar alternatives were estimated using an annual price escalation factor of 1.027.

3. Based on a 2.8%[247] population growth rate from the World Bank and the population density dataset used in the study, the estimated total population will be 13,515,490 in 2023 and 16,397,725 in 2030.

4. The least-cost electrification analysis found that the share of the population with access to electricity via the national grid and mini-grids will be 81.6% in 2023 and 93.6% in 2030.

5. To estimate GDP, it was assumed that the current annual GDP growth rate of 5.5% will be maintained through 2023 and 2030:

Parameter	2023	2030
Population	13,515,490 (GIS estimate)	16,397,725 (GIS estimate)
GDP (constant 2010 USD)	$13,251,460,282	$19,276,623,127

6. According to the Lighting Global Off-Grid Solar Market Trends Report 2018,[248] the price of pico solar products is expected to fall to USD 10.60 in 2020 and USD 10.10 in 2022 down from USD 10.90 in 2016. Based on these 2020 and 2022 figures, the average annual decrease in prices from 2020 was estimated at 2.36%. It was assumed that the annual price decrease will be maintained at this rate through 2030 (annual cost reduction factor of 0.98).

7. According to the same report, the price of small SHS components is expected to fall to USD 60.40 in 2020 and USD 47.40 in 2022, down from USD 77.80 in 2016. Based on these 2020 and 2022 figures, the average annual decrease in prices from 2020 was estimated at 10.76%. It was assumed that the annual price decrease will be maintained at this level through 2030 (annual cost reduction factor of 0.89).

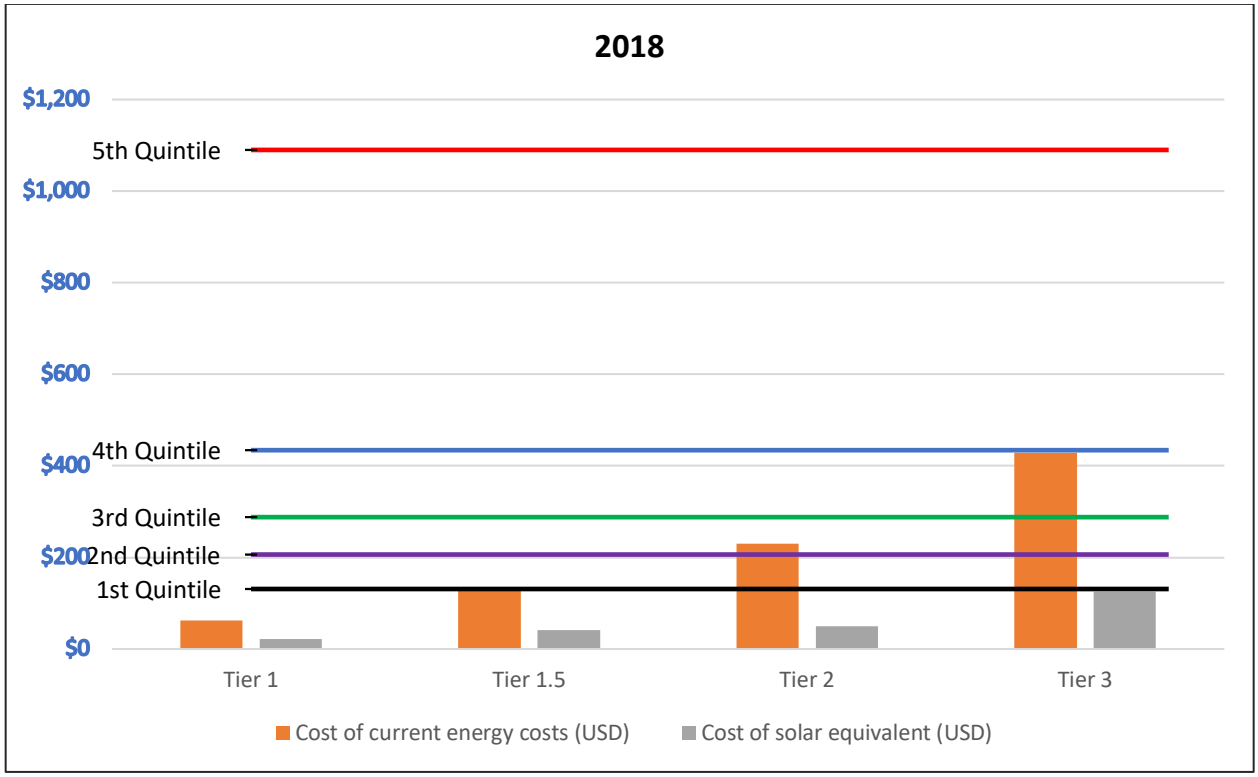
[247] https://data.worldbank.org/indicator/SP.POP.GROW?locations=BJ

[248] "Off-Grid Solar Market Trends Report 2018," Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf

8. It was assumed the maximum interest rates in Benin will stagnate at the current rate of 24% or possibly decline.

Household Cost Savings and Affordability Calculation

Annual Household Energy Budget by Quintile, Annual Energy Costs and Annual Costs of Solar Equivalents



- This analysis presents annualized costs (not including financing cost) of current energy technologies for each energy tier, compared with the annual cost of an equivalent solar product. The same analysis was also completed for the 2023 and 2030 scenarios.

- Both the annual costs of current energy technologies and equivalent solar solutions considered the capital cost of each unit as well as the operating cost over the average lifetime of a unit.

- These costs were compared with a 10% monthly energy budget for households of different income quintiles. The analysis did not assess affordability for a cash vs. financed purchase over time.

2. INSTITUTIONAL DEMAND

2.1 Country Categorization

To assess institutional sector demand, the ROGEP countries were grouped into four categories based on income and population density, which are two key factors that influence the number of public service institutions in a given country. The countries were categorized as follows:

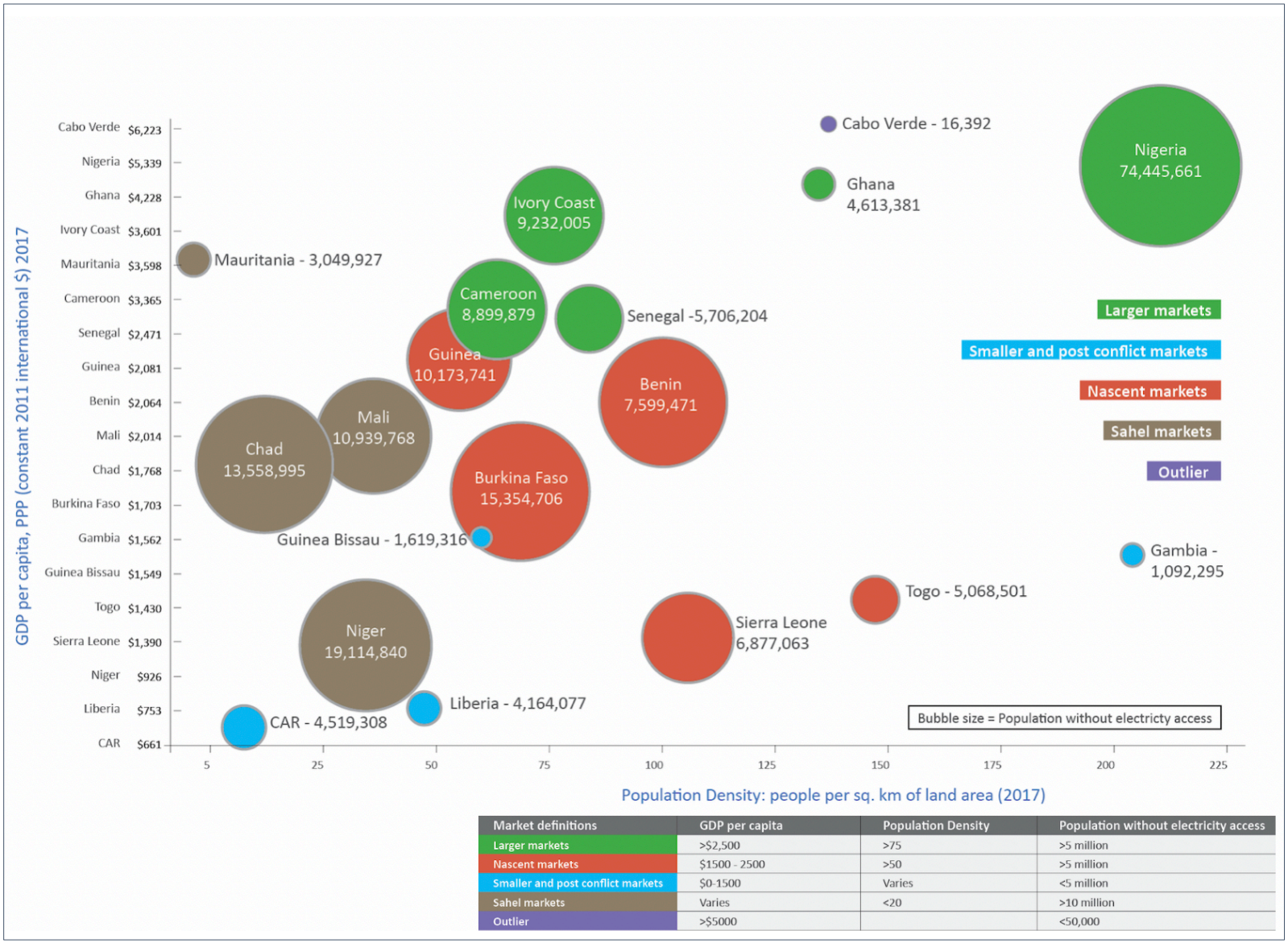
Country Categorization by Income and Population Density			
Category 1: Low-income / low population density	**Category 2:** Low-income / high population density	**Category 3:** High-income/ low population density	**Category 4:** High-income / high population density
Niger Burkina Faso Chad Mali Guinea Guinea-Bissau Central African Republic Liberia	Benin Sierra Leone Togo Gambia	Cameroon Côte d'Ivoire Mauritania Senegal	Nigeria Ghana Cabo Verde

These categories were used to address data gaps, as obtaining accurate and comprehensive data on the number of off-grid public institutions in many of the countries was challenging. Where data was not available, per capita assumptions based on data from similar countries in the same category were used. The following countries were used as reference countries for each category:

Category 1	Guinea, Liberia, Niger
Category 2	Benin, Sierra Leone
Category 3	Côte d'Ivoire
Category 4	Ghana

Categories are defined as follows (and illustrated in the figure below):

- Low population density: <95 people per square km of land area
- High population density: >95 people per square km of land area
- Low income: <$2,200 GDP per capita
- High income: >$2,200 GDP per capita



Market definitions	GDP per capita	Population Density	Population without electricity access
Larger markets	>$2,500	>75	>5 million
Nascent markets	$1500 - 2500	>50	>5 million
Smaller and post conflict markets	$0-1500	Varies	<5 million
Sahel markets	Varies	<20	>10 million
Outlier	>$5000		<50,000

Source: African Solar Designs analysis

2.2 Energy Needs by Institutional Market Segment

Institutional Sector	Description	Rating (W)	Time of use (hrs)	Total Wh/day	Total Load	Recommended system (W)
Water Pumping						
Low power		1,500	6	9,000		1,500
Medium power		4,000	6	24,000		4,000
High power		10,000	6	60,000		10,000
Healthcare						
HC1 Health post	Lighting	30	8	240		
	Communication	20	8	160		
	ICT	100	8	800	1,200	250
HC2 Basic healthcare facility	Lighting	200	8	1,600		
	Maternity	200	4	800		
	Vaccine refrigeration	100	8	800		
	Communication	100	4	400		
	Medical exams	200	2	400		
	ICT	200	8	1,600		
	Staff housing	50	8	400	6,000	1,500
HC3 Enhanced healthcare facility	Lighting	400	8	3,200		
	Communication	200	8	1,600		
	Medical exams	600	2	1,200		
	ICT	300	8	2,400		
	Maternity	600	4	2,400		
	Laboratory	1,000	2	2,000		
	Sterilization	1,200	1	1,200		
	Vaccine refrigeration	150	8	1,200		
	Staff housing	200	8	1,600	16,800	4,200
Education						
Primary school	Communication	20	8	160		
	Lighting	80	8	640		
	ICT	100	8	800		
	Staff house	50	8	400	2,000	500
Secondary school	Communication	20	8	160		
	Lighting	240	8	1,920		
	ICT	400	8	3,200		
	Laboratory use	100	8	800		
	Staff house	200	8	1,600	7,680	1,920
Public Lighting						
Street lighting	Lights	200	8	1,600	1,600	500

Source: The estimates in the table above are based on data obtained from local experts, interviews with solar industry stakeholders and corroborated by secondary desk research.

CALCULATIONS: Rating of systems is based on data for sizes of the appliances from a 2016 GIZ solar PV catalogue.[249] The solar PV sizing factor is based on the peak sun hours available across most of Africa.

[249] "Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances," GIZ, (2016): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/GIZ__2016__Catalogue_PV_Appliances_for_Micro_Enterprises_low.pdf

Energy Needs Assumptions:

Water Supply: Power requirements (low, medium, high) are based on the type of water point:

- Borehole: 40% low power pumps; 40% medium power; 20% high power
- Protected dug well: 80% no pump; 10% low power pumps; 10% medium power; no high-power
- Unprotected dug well: No pump
- Protected spring: No pump
- Unprotected spring: No pump
- Public tap/standpipe (stand-alone or water kiosk): No pump
- Sand/Sub-surface dam (with well or standpipe): No pump
- Piped water into dwelling/plot/yard: No pump
- Rainwater harvesting: No pump

Healthcare: The size of the healthcare facility (HC1, HC2, HC3) determines the amount of energy each facility requires.

Education: The size of the school and number of students determines the amount of energy each school requires.

Public lighting: It was assumed that two [2] public lighting points would be required to meet the energy needs of a town/market center.

2.3 Institutional Market Sizing Calculations

Household systems, cost and price per watt:

System Type	Tier Rating	USD/Watt[250]	Average Size (Watts)	Total Cost (USD)
Pico solar system	Tier 1	$15.00	3	$45.00
Basic Plug and Play system	Tier 1.5	$12.50	10	$125.00
Small HH solar system	Tier 2	$5.00	50	$250.00
Medium HH solar system	Tier 3	$2.50	250	$625.00

Size of systems used in institutional sector market sizing calculation:

Sector	Description	Size (corrected for time of use)	HH systems
Water Supply	Low Power	1,500	N/A
	Medium Power	4,000	N/A
	High power	10,000	N/A
Healthcare	HC1	250	Tier 3
	HC2	1,500	N/A
	HC3	4,200	N/A
Education	Primary	500	N/A
	Secondary	1,920	N/A
Public lighting		500	N/A

[250] Cost per watt derived from African Solar Designs analysis and from IRENA: https://www.irena.org/publications/2016/Sep/Solar-PV-in-Africa-Costs-and-Markets

Institutional Sector Market Sizing Calculations:

NOTE: Prices cover only solar components (except for the HC1 tier 3 system, which comes with lighting)

Water Supply						
# of water pumps	X	Size of solar system (watts) (low, medium, high power)	X	Cost per watt for pumping ($2.50) divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Water Supply Sector

Healthcare						
# of healthcare facilities						
HC 1	X	Cost per tier 3 system ($625)	X	Divided by system lifetime of 5 years	=	Estimated Annualized Off-Grid Solar Market Potential for Healthcare Sector
HC 2		Size of solar system in Watts (1500W)		Cost per watt ($2.50) divided by system lifetime of 20 years		
HC 3		Size of solar system in Watts (4200W)		Cost per watt ($2.50) divided by system lifetime of 20 years		

Education						
# of schools						
Primary	X	Size of solar system in Watts (500W)	X	Cost per watt ($3) divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Education Sector
Secondary		Size of solar system in Watts (1920W)		Cost per watt ($2.50) divided by system lifetime of 20 years		

Public Lighting						
# of lights required	X	Size of solar system in Watts (500W)	X	Cost per watt ($3) divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Public Lighting Sector

2.4 Data Collection Approach by Institutional Market Segment

BENIN			
Water Supply	**Healthcare**	**Education**	**Public Lighting**
GIS data	GIS data	GIS data	Per capita assumption

Data was collected on the total number of off-grid institutions by institutional market segment for Benin from a combination of available GIS data, input from local experts, stakeholder interviews and desk research. Where there were gaps in available data, per capita assumptions were made, as explained in **Section 2.2**.

Assumptions:

Water Supply: Of the identified potable water points, it was assumed that 50% would be equipped with a solar-powered water pump. Of the equipped water sources, the division of pumps between low, medium and high-powered pumps was: 50%, 35% and 15%, respectively. The lower cost of the low power pumps

is the driving factor for this assumption. Where this information was not available, a per capita comparison was made with a country in the same category.

Healthcare: Wherever possible, specific data on the number of off-grid healthcare facilities by size was used (i.e. HC1, HC2, HC3). Where this information was not available, a per capita comparison was made with a country in the same category.

Education: Wherever possible, specific data on the number of off-grid primary and secondary schools was used. Primary schools encompass both primary and nursery schools. Vocational schools and universities were not considered because they tend to be in cities, which are often grid-electrified. Where this information was not available, a per capita comparison was made with a country in the same category. The following per-capita assumptions were made:[251]

- **Primary school**: Per capita calculation using the off-grid population that is 0-14 years
- **Secondary school**: Per capita calculation using the off-grid population that is 15-19 years

Public lighting: Using population figures by region, and assuming that the population per market center was 5,000 people, the number of market centers was calculated. An assumption of two [2] public lighting points per market center was used in the calculation. No data on street lighting was included, as it was assumed that street lighting projects are linked to road infrastructure rather than institutions.

2.5 Ability to Pay Analysis (Strongest Potential Market Segment)

Data was not available to estimate the monthly energy expenditures of institutional users. Secondary data was available through government and donor program annual budgets for public services but was not comprehensive. A rudimentary analysis was undertaken based on these funding sources and compared to the total solar product market estimate for each institutional market segment in order to discuss the realistic potential market outlook based on the ability to pay. Due to a lack of data, the analysis was not able to take into account other potential sources of funding, such as funds pooled at the national or local level, fees for services etc.

[251] Population without access to electricity: https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
Population ages 0-14: https://data.worldbank.org/indicator/SP.POP.0014.TO
Population ages 15-19: https://data.worldbank.org/indicator/SP.POP.1519.MA.5Y; https://data.worldbank.org/indicator/SP.POP.1519.FE.5Y

3. PRODUCTIVE USE DEMAND

3.1 PUE Applications for Off-Grid Microenterprises (barbers and tailors)

The market sizing calculation for the barbers and tailors sector assumed that hair cutting and sewing appliances will be retrofitted to be powered by a Tier 3 DC solar system (5-year system life). By using a single price for all of the ROGEP countries, this methodology does not take into account country-specific cost and supply chain constraints.

Microenterprises					
# of financially constrained SMEs[252]	X	Cost per tier 3 system ($625)	Divided by system lifetime of 5 years	=	Estimated Annualized Off-Grid Solar Market Potential for SMEs

3.2 Value-Added PUE Applications

Available data from various sources such as the World Bank, the UN's Food and Agriculture Organization and GSMA was used to estimate the potential OGS market for productive use applications in each of the analyzed market segments – solar pumping for agricultural **irrigation**, solar powered **milling** and solar powered **refrigeration**.

3.2.1 Irrigation

The market sizing calculation for solar-powered irrigation was based on smallholder irrigation potential (i.e. the amount of irrigable land suitable for smallholder farmers) that could benefit from a solar pumping system ($650, 6-year system life, 120 W system). This methodology does not take into account affordability (ability to pay) nor does it account for country-specific cost and supply chain constraints.

Value-Added PUE Applications – Solar Irrigation											
Irrigation Potential (hectare)[253]	X 25%	=	Smallholder Irrigation Potential (hectare)[254]	Divided by 0.3[255]	=	Estimated No. of Smallholder Farms Suitable for Solar Irrigation	X	$650 (cost of solar pumping kit)[256]	Divided by 6 year (life of system)	=	Estimated Annualized Off-Grid Solar Market Potential for irrigation

Methodology for identifying areas suitable for irrigation activities on farms:

The areas for potential irrigation activities were calculated using the visible cropland[257] adjacent to permanent surface water sources. As identified by experts in a study in Zambia[258] and based on other expert consultations, beyond a 5 km distance from surface water, the returns are not economically feasible. **Figure 34** is a map of the cropland within a 5 km distance from permanent surface water.

[252] "MSME Finance Gap," SME Finance Forum: https://www.smefinanceforum.org/data-sites/msme-finance-gap
[253] AQUASTAT – Food and Agriculture Organization: http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en
[254] Assumption that 25% of irrigable land irrigated by smallholder farmers;
See: "Lessons Learned in the Development of Smallholder Private Irrigation for High Value Crops in West Africa," World Bank, (2011): http://siteresources.worldbank.org/INTARD/Resources/West_Africa_web_fc.pdf
[255] Assumption that smallholder private irrigation consists of small farms (0.3 hectare);
See: "Off-grid Solar Market Assessment in Niger and Design of Market-based Solutions," World Bank, (December 2017): https://www.lightingafrica.org/publication/off-grid-solar-market-assessment-niger-design-market-based-solutions/
[256] 120W solar pumping kit: https://futurepump.com/futures-bright-farmers-kenya/
[257] "Prototype Land Cover Map over Africa at 20m Released," Esa, (February 2018): https://www.esa-landcover-cci.org/?q=node/187
[258] "Zambia Electrification Geospatial Model," USAID and Power Africa, (April 2018): https://pdf.usaid.gov/pdf_docs/PA00T2JC.pdf

3.2.2 Milling

The market sizing calculation for solar-powered milling utilized a series of inputs from the UN Food and Agriculture Organization to estimate the smallholder milling potential that could benefit from a 6.5 kW solar powered milling system (20-year system life). Cereals (e.g. rice, maize, millet and sorghum) as well as roots and tuber crops (e.g. cassava, yams and potatoes) were analyzed, as they provide an opportunity for value addition through hulling or milling.

Value-Added PUE Applications – Solar Milling												
Cereals, roots tuber crops (tons)[259]	X	70%[260]	X	50%[261]	=	Smallholder Milling Potential (tons)	Divided by 2 tons per day X 70% capacity factor[262]	=	Estimated No. of Solar Mills	X	6,500 W x $2.50 per watt Divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Milling

Ultimately, the ability for an agricultural community to benefit from productive use applications has as much to do with access to markets and improved crop inputs, as it has to do with the pricing and availability of financing to purchase the equipment. Hence, the macroeconomic approach used to carry out this market sizing does not account for country-specific cost and supply chain constraints.

3.2.3 Refrigeration

The market sizing calculation for solar-powered refrigeration utilized the estimated number of off-grid market centers in each country to estimate the number that could benefit from a 5.5 kW solar refrigeration system (20-year system life).

Value-Added PUE Applications – Solar Refrigeration							
# Off-Grid Market Centers by country[263]	X	5,500 W[264]	X	$2.50 per watt	Divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Refrigeration

3.3 PUE Applications for Connectivity/Mobile Phone Charging Enterprises

The market sizing calculation for solar-powered phone charging enterprises was based on each country's mobile phone penetration rate (number of unique subscribers), rural population rate, and the average costs of OGS phone charging appliances ($862, 5-year system life, 400 W system).

Mobile Phone Charging Enterprises							
# of Mobile Phone Subscribers in 2017[265]	X	% rural population	Cost of solar phone charging appliances* divided by lifetime of 5 years	X	0.01 (assuming 1 phone charger per 100 mobile phone users)	=	Estimated Annualized Off-Grid Solar Market Potential for Phone Charging Enterprises

[259] Food and Agriculture Organization: http://www.fao.org/faostat/en/#data/RF
[260] Assumption that 70% of crops are milled
[261] Assumption that 50% of milled crops are processed at smallholder farmer level
[262] Solar mill (6.5 kW system) can mill 2 tons of produce per day; assume capacity factor of 70% (for maintenance/seasonality) *See*: "Off-grid Solar Market Assessment in Niger and Design of Market-based Solutions," World Bank, (December 2017): https://www.lightingafrica.org/publication/off-grid-solar-market-assessment-niger-design-market-based-solutions/
[263] https://www.citypopulation.de
[264] 5.5kW solar powered refrigeration system – *See*: https://www.deutschland.de/en/solar-powered-coldhubs-nigeria
[265] "The Mobile Economy, Sub-Saharan Africa," GSMA Intelligence, (2017): https://www.gsmaintelligence.com/research/?file=7bf3592e6d750144e58d9dcfac6adfab&download

* Indicative Costs for Phone Charging Appliances[266]

Charging Stations	Cost (USD)	Manufacturer
Charging ECOBOXX Qube (sizes - 50) 5Wp panel	$83	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Charging ECOBOXX Qube (sizes - 90) 10Wp panel	$205	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Charging ECOBOXX Qube (sizes - 160) 2*10Wp panel	$209	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Portable charging station ECOBOXX 300	$681	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Portable charging station ECOBOXX 600	$965	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Portable Charging Station ECOBOXX 1500	$1,532	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Portable charging station BOSS Kit Portable	$3,025	Phaesun GmbH
Charging Sundaya Charging Station	$193	Sundaya
Average Cost	**$862**	

Source: GIZ and African Solar Designs analysis

Identifying areas of phone network coverage

The mobile phone network geographic coverage was mapped across each country (**Figure 36**). The source for this data is GSMA, which gives a radius ranging between 2-30 km. The radius is affected by a number of variables including tower height, power output, frequencies in use, and antenna type. Since this does not indicate the quality of network, the data was compared with data from OpenSignal, which tracks the signal from users registered on the platform.

Green: Strong Signal (>-85dBm)
Red: Weak Signal (<-99dBm)
Source: Open Data Signal

[266] "Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances," GIZ, (2016): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/GIZ__2016__Catalogue_PV_Appliances_for_Micro_Enterprises_low.pdf

4. SUPPLY CHAIN ANALYSIS

The Task 2 supply chain analysis was based on the following key sources of data:

- Supplier focus group discussions held in Cotonou in July 2018
- Survey of 10 locally-based solar companies/suppliers in the country
- Survey of 10 larger international solar product suppliers
- ECREEE supplier database
- GOGLA semi-annual sales reports[267]
- Additional supplemental desk research and solar industry stakeholder interviews

These findings were subsequently corroborated by attendees of national validation workshops held in each country at the conclusion of the market assessment.

A list of identified solar companies that are active in Benin is included below:

1	Agethur
2	AGR Group
3	Aiser Benin
4	ARESSS
5	ASEMI
6	Atiwib Group
7	Benelec
8	Benergie
9	Bio Solar Energy Plus
10	BMI
11	Cetra
12	Cina
13	Dabitron Renewable Energy Microgrid Systems
14	Derca Energies Durables
15	Dulosolar Benin
16	Diamant Le Clair Inter
17	Ego Services
18	Elan Consulting Et Services
19	Enerdas Ingenierie
20	Esttech Benin
21	Etisalat Benin
22	Finadev
23	Gage SA

[267] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2018): https://www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h1_2018-opt.pdf
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth2-2017_def20180424_web_opt.pdf
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth12017_def.pdf
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2016): https://www.gogla.org/sites/default/files/recource_docs/final_sales-and-impact-report_h22016_full_public.pdf
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2016): https://www.gogla.org/sites/default/files/recource_docs/global_off-grid_solar_market_report_jan-june_2016_public.pdf

24	Gamma CI
25	Générale Énergie
26	Globale Dimension
27	Groupement ASEMI Benin
28	Ibig
29	Ismast Energie
30	Jesuton
31	Mise
32	Naange
33	Power Afrika
34	Soconeme
35	Solariss Ing
36	Sunsolar
37	T Com Benin
38	Techpool

Source: ECREEE, Focus Group Discussions; Stakeholder interviews

ANNEX 3: TASK 3 METHODOLOGY

FINANCIAL INSTITUTION ASSESSMENT METHODOLOGY

Data collection under Task 3 included a combination of desk research, collaboration with local experts, and extensive stakeholder engagement with key officials and representatives from local and regional commercial banks, microfinance institutions and other development banks and agencies in Benin. Interviews were also conducted with regional development banks (namely BOAD and EBID) and other financiers active in the African off-grid solar sector, including export credit agencies, trade funders, crowd funders and impact investors.

The stakeholder engagement activity, which included both phone interviews as well as in-person meetings with key representatives from each FI, was undertaken across the 19 countries with extensive support from ECREEE. As a follow up to each interview/meeting, a questionnaire was administered in order to gather critical data on each institution, including *inter alia* their level of experience and capabilities with off-grid sector lending, SME and consumer lending, relationships with local and international partners etc. Feedback from the interviews and questionnaire, as well as quantitative data from each bank's published annual reports, was compiled and analyzed in order to assess which FIs could be most suitable local partners / implementing agents for the proposed ROGEP facility.[268]

The questionnaire that was administered to FIs in the country and across the ROGEP region is included below.[269] The results of the survey are summarized in **Section 3.4**.

- Has the bank provided any loans to any segment of the off-grid sector? If so, please describe.
- Has the bank received any inquiries from any segment of the off-grid sector? How many inquiries?
- Did the bank engage in serious discussions or dismiss the inquiry(ies) as not within the bank's area of lending or not interesting as a new business line? If dismissed, please provide the bank's reasons.
- If the bank engaged in serious review/discussions and rejected the opportunity, please describe the bank's due diligence approach and reasons for rejection.
- Is the bank interested to pursue lending to any segment of the off-grid sector? Which segment and which of the bank's departments and existing products apply?
- Describe the bank's current loan products and lending activity for the SME, Corporate, Consumer and Agri markets. Please provide rough figures on volumes in number of loans and value in each category. For each category please provide average margins, pricing, loan tenors to borrowers, collateral requirements.
- Does the bank have a structured finance department? Has the bank provided financing to any IPPs? If so, please provide details on the transactions (location, technology, size, maturity, portion of bank engagement in the total financing)
- Does the bank have a trade finance department? What are standard terms and conditions? What are the volumes in number of loans and values?
- Does the bank operate nationwide or only in certain regions? Does the bank have a presence in rural areas and is rural consumer and SME and Agri lending a key business focus?
- Does the bank have experience with managing DFI credit lines? In which sectors/departments? Which DFIs? What volumes? Were the lines fully committed and disbursed? What was the bank's overall experience with these credit lines?
- Has the bank had dealings with the ECOWAS Bank for Investment and Development (EBID)? What type of relationship? Credit lines? Co-lending? Credit enhancement? Have the experiences been positive?
- What is the bank's view on accepting hard currency credit lines and on-lending in hard currency? Would the bank hedge hard currency credit lines and on-lend in local currency?

[268] The results of this assessment and corresponding recommendations were prepared for ECREEE in a separate, confidential report.
[269] The survey was adapted based on the type of FI that was being interviewed (commercial banks, MFIs, Regional Development Banks)

- Is the bank interested to explore a credit line with ROGEP? What size of credit line would the bank be comfortable launching with initially?
- Does the bank feel that it would need a third-party guarantee in order to reduce risk enough to make loans to off-grid enterprises? If so, would it be enough if a guarantor were to cover 50% of losses on par with the bank? Or will the bank need the guarantor to take the first 10-20% of losses in an off-gird loan portfolio?
- What pricing does the bank consider to be fair and affordable for third party pari-passu guarantees? For first loss coverage?
- Has the bank had experience with any of the following as guarantors on the bank's loans: Africa Guarantee Fund, Africa Trade Insurers, Afrexim Bank, GuarantCo, IFC, USAID DCA? Has their pricing been fair and affordable? Does the bank have any preference in working with one over the others?
- To engage in lending to the off-grid market segments, would Technical Assistance be helpful? What types of TA would be most useful? Outside consultants to help design specific loan products and underwriting guidelines for the off-grid sector? Outside consultants to develop deal flow and conduct due diligence? Training of bank credit department and account representative personnel? Direct funding to the bank to develop marketing and promotional materials and hire staff?
- Does the bank adhere to and is in compliance with all aspects of the Basel II and III accords?
- Does the bank adhere to and have implemented controls for the Equator Principals and the World Bank/IFC Environmental and Social Standards?

ANNEX 4: GENDER ASSESSMENT

1. Context and Purpose of the Gender Analysis

Within the context of this assignment, a gender-focused analysis was undertaken to assess the level of participation of women in each country's off-grid energy sector. This analysis is critical to the overall market assessment given the clear linkages between energy and gender, namely different rates of access and use as well as the impacts of energy sources and appliances in the home, community and wider society. Energy sector studies often fail to obtain gender-disaggregated data, which is necessary to inform policymakers and better understand the needs and priorities of women in the context of sustainable development.

Women in energy-poor households are at substantially higher risk of illness attributable to indoor air pollution and solid fuel (biomass) use.[270] Moreover, the significant time burdens that women and girls face in collecting fuel and water, cooking and processing food often keep girls from attending school; there is evidence that electrified milling equipment and water pumps can significantly reduce this burden. Lack of access to electricity also means that women do not have access to information and communication technologies that could improve their lives.[271]

As a region, West Africa and the Sahel has remained traditionally gender-stratified whereby males on average have greater access to resources, are more empowered by society and have more opportunities than women.[272] To address these challenges, governments across the region have adopted a range of policies to improve gender equality and promote gender mainstreaming. Member states of ECOWAS have adopted a Policy for Gender Mainstreaming in Energy Access, an initiative committed to promoting favorable policies and frameworks and mobilizing resources to more fully engage women in all areas of energy access, including as energy suppliers, planners, financiers, educators and customers.[273] ECREEE, the agency that is administering this policy throughout the region, is supporting implementation of regulatory and institutional measures that aim to improve inclusive energy access in each country by 2030. ECREEE has also partnered with AfDB to launch a separate regional initiative to advance the participation of women entrepreneurs in the renewable energy sector.[274]

Outside of ECOWAS, Cameroon, Chad and Central African Republic are pursuing gender mainstreaming at a regional level through the Economic Community of Central African States (ECCAS) Regional Policy for universal access to modern energy services and economic and social development (2014-2030).[275] Mauritania is also implementing a national policy to address this issue – the National Strategy of Institutionalization of Gender (la Stratégie Nationale d'institutionalisation du genre).

[270] "The Energy Access Situation in Developing Countries: A Review Focusing on the Least Developed Countries and Sub-Saharan Africa," UNDP and World Health Organization, (2009): http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Sustainable%20Energy/energy-access-situation-in-developing-countries.pdf

[271] Rewald, R., "Energy and Women and Girls: Analyzing the needs, uses, and impacts of energy on women and girls in the developing world," Oxfam, (2017): https://www.oxfamamerica.org/static/media/files/energy-women-girls.pdf

[272] "Situation Analysis of Energy and Gender Issues in ECOWAS Member States," ECREEE, National Energy Laboratory, (2015): https://www.seforall.org/sites/default/files/Situation-Analysis-of-Energy-and-Gender-Issues.pdf

[273] Ibid.

[274] "Feasibility study promotes women's participation in energy transition," ESI Africa, (May 7, 2018): https://www.esi-africa.com/feasibility-study-promotes-womens-participation-in-energy-transition/

[275] "Central Africa Regional Integration Strategy Paper," African Development Bank, (2011-2015): https://www.afdb.org/fileadmin/uploads/afdb/Documents/Policy-Documents/RISP%20CENTRAL%20AFRICA-ECCAS%20English%20FINAL.pdf

➢ Description of Approach / Methodology

While the data collection for this assignment was not sex dis-aggregated (which was beyond the scope of work), a gender-focused perspective was applied to the overall analysis. The methodology adopted to carry out this exercise included a combination of desk research, literature review, focus group discussions (FGDs) and face-to-face interviews with key gender "focal points" identified by ECREEE in each country. Representatives from women's groups, female-led businesses and energy sector organizations attended the focus group meetings that were held in Cotonou in July 2018 to share their insights and inform the overall market study. A gender questionnaire was also distributed to key stakeholders in Benin to assess the main barriers/constraints for inclusive participation in the country. The survey examined a number of key gender issues, including *inter alia* access to credit, access to education and information, entrepreneurial and income-generating activities for women (including productive use of energy), representation of women in leadership positions in business and government.

➢ Gender Questionnaire

The following questionnaire was administered to key stakeholders in each country. Respondents were asked to reply Yes/No to each question and elaborate as needed.

HOUSEHOLD

Are women generally involved in influencing decisions on household energy use/services?
Are off-grid solar solutions (E.g. solar lanterns, solar home systems) largely accessible/made available to the household sector, particularly women-headed households?
Are there any related programs and initiatives (donor, government, private sector, NGO etc.) that are specifically targeting energy access for women in the household sector?
Are off-grid solar products and services generally affordable for households headed by women? If not, are Microfinance Institutions or other organizations in the country providing credit/financing (grants/loans) to the household sector, particularly women-headed households to increase energy access?
Are women aware of the health impact of unclean energy (e.g. fuel-wood for cookstoves) and the solutions (i.e. solar) to address it?

COMMUNITY/INSTITUTIONAL

Are women represented in any high-level energy sector positions? Please provide names/examples, if available, of women in senior management positions in government, committees, boards etc.
Is the mobility and safety of women constrained due to poor energy services (e.g., unavailability of streetlights due to unreliable electricity supply)?

PRODUCTIVE USE

What kind of productive use activities do women engage in and what women-led productive use activities can be supported by off-grid solar solutions?

- Agriculture (irrigation, water pumping etc.)
- Shops (retail, artisanal/handicrafts, grocery, salons etc.)
- Restaurants (bar, cafe etc.)
- Kiosks (e.g. mobile money etc.)
- Tourism
- Other

SUPPLIER

Please describe the level of engagement that women have in in the off-grid energy services sector. Are women highly employed in this area (e.g. is there data collected on the number of women-owned businesses/SMEs)?

Are there any related programs and initiatives (donor, government, private sector, NGO etc.) that provide training for women to manage or be employed by energy-related enterprises?

ADDITIONAL:
What are the main barriers women face to access information?
What are the main barriers/constraints for women entrepreneurs to have access to credit?
Do women have equal access to capacity building and training services (e.g. vocational training/technical education) or do they experience discrimination in access to these services?
What policy, regulatory and institutional framework(s) exist, if any, to address gender mainstreaming[276] (e.g. national gender action plans/related policies etc.)?
Are gender-related issues taken into consideration in energy policy provisions and/or are energy-related issues reflected in gender policies (e.g. existence of 'gender units' within public sector agencies and/or 'gender audits' in energy sector)?

2. Gender Profile

2.1 The state of gender equality in Benin

Structural inequalities and gender discrimination against women and girls persist in Benin, as inclusive participation remains an ongoing challenge. The gender assessment found that while there have been modest improvements in recent years to certain social indicators, gender disparities still exist across the economy, particularly in access to resources, higher education, land ownership, and inheritance systems, political power and decision-making. These findings are supported by the UNDP Human Development Index on Gender Inequality, where Benin performs poorly, ranking 163 out of 189 countries in the index.[277]

2.2 Gender and Poverty

Poverty remains widespread in Benin, particularly in rural areas where a large share of the country's poor population lives. It is estimated that about 40% of the population lives below the poverty line. According to UNDP statistics, 73.5% of the labor force is considered working poor at PPP USD 3.10/day.[278] HDI indicators and income levels are comparatively much lower for women, who constitute a disproportionate share of the country's poor and extremely poor population.

2.3 Gender, Human Capital and Economic Empowerment

2.3.1 Education, Skills Development and Training

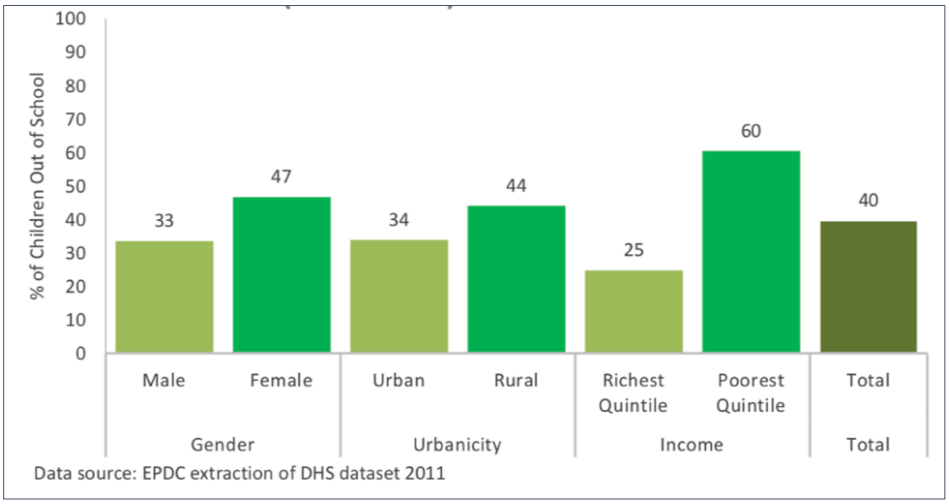
While Benin has achieved gender parity in rates of access to primary education, there is still a considerable gap in higher levels of education; only 18.2% of adult women in Benin have attained some level of secondary education compared to 32.7% of men.[279] The gender gap is even worse for tertiary education (see **Section 1.2.2.5**).

There are also many troubling signs in the primary and secondary education sector. An estimated 24% of children of official primary school age are out of school. Approximately 21% of boys of primary school

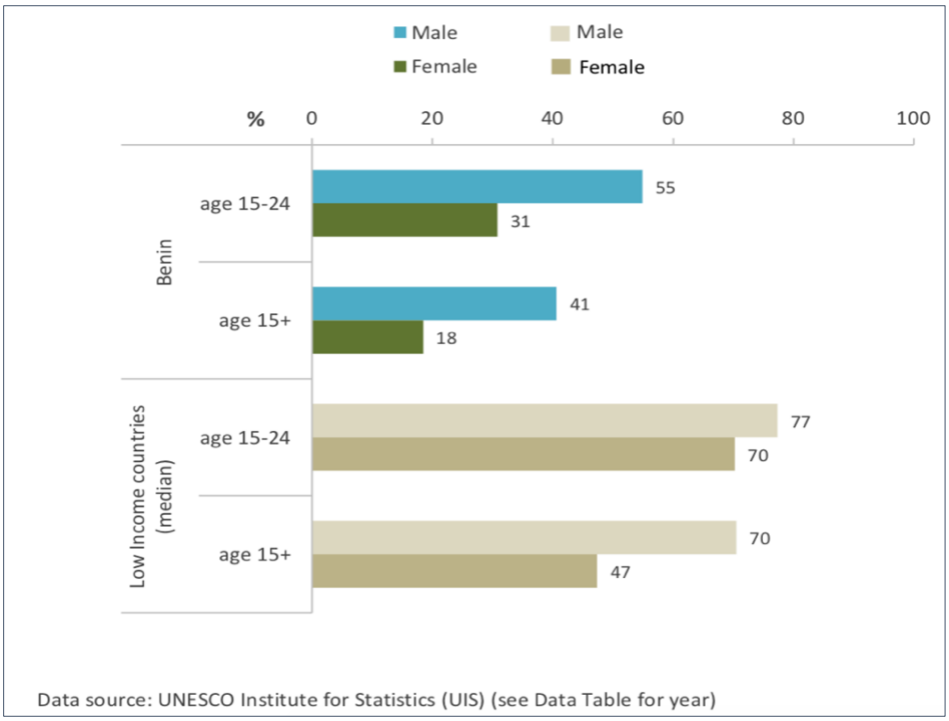
[276] **Gender mainstreaming**: The process of ensuring that women and men have equal access to and control over resources, development benefits and decision-making, at all stages of development process, projects, programs or policy.
[277] "UN Human Development Reports: Gender Inequality Index (GII)," UN Development Programme, (2018): http://hdr.undp.org/en/composite/GII
[278] "UN Human Development Indicators: Benin," UN Development Programme, (2018): http://hdr.undp.org/en/countries/profiles/BEN
[279] Ibid.

age are out of school compared to 27% of girls of the same age. Nearly 47% of female youth of secondary school age are out of school compared to 33% of male youth of the same age. Across the entire sector, there are huge disparities between the poorest and the richest youth in terms of access to education.[280] This trend remains consistent in literacy rates among Benin's youth and adult populations, as just 18% of the country's female adult population is literate, compared to 41% of the adult male population.[281]

Percentage of Children of Secondary School Age (13-19) Out of School



Literacy Rate Among Youth and Adult Population



Source: UNESCO Institute for Statistics

[280] "Benin: National Education Profile, 2014 Update," Education Policy and Data Center, (2014): https://www.epdc.org/sites/default/files/documents/EPDC%20NEP_Benin.pdf
[281] Ibid.

Varying formal and informal Technical and Vocational Education and Training (TVET) programs are offered at institutions across the country. The percentage of females pursuing non-traditional technical skills programs (e.g. electronics, masonry, carpentry, plumbing, auto-mechanic) in Technical and Vocational schools accounts for a small share of total enrollment.

According to the UN, as of 2017, 28.6% of women in Benin had an account at a financial institution or with a mobile money service provider.[282] This can be attributed to the country's elevated levels of poverty, low or irregular sources of income, low rates of financial literacy, and a perceived lack of need. This is also a result of the fact that most banks are focused on serving the formal sector, while many women remain engaged in informal economic activities – especially subsistence agriculture.

2.3.2 Fertility Rates and Reproductive Health

As of 2017, the fertility rate in Benin remained high, at five children per woman. The country also has a high maternal mortality rate; for every 100,000 live births, 406 women die from pregnancy related causes. An estimated 33.1% of women have an unmet need for family planning.[283]

2.3.3 Participation and Decision-Making

Socio-cultural perspectives in Benin remain male-dominated, as conventional gender roles continue to hold women back. This is reflected in household decision-making, which often plays a role in restricting the rights and empowerment of women. These dynamics are also present in the rates of representation of women in the labor market as well as in leadership positions in business and government.

Although women's level of participation in the economy is growing, they still lag behind men, with an adult labor force participation rate of 68.7% compared to 73.1% for men.[284] As of 2018, women held 7.2% of the country's seats in parliament.[285]

2.4 Gender Policy, Institutional and Legal Framework in Benin

2.4.1 Gender Mainstreaming initiatives by the Government

The GoB has adopted several policies and action plans to promote gender mainstreaming and equality and has signed on to key international and regional framework agreements protecting women's rights. At the international level, Benin has ratified the Convention on the Elimination of All Forms of Discrimination Against Women[286]and is also signatory to the Protocol to the African Charter on Human and People's Rights on the Rights of Women in Africa, the Solemn Declaration on Gender Equality in Africa and the Beijing Platform for Action, among others.

Benin's policy framework for promoting gender equality and women's empowerment is guided mainly by two policies : (i) National Policy for the Advancement of Women (Politique Nationale de Promotion de la Femme) adopted in 2001 and implemented under the 2006-2011 strategic guidelines for development which

[282] "Human Development Indices and Indicators: 2018 Statistical Update," UN Development Programme, (2018): http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
[283] Ibid.
[284] "UN Human Development Indicators: Benin," UN Development Programme, (2018): http://hdr.undp.org/en/countries/profiles/BEN
[285] Ibid.
[286] Ratification Table : Protocole to the African Charter on Human and People's rights on the Rights of Women in Africa: http://www.achpr.org/instruments/women-protocol/ratification/

seek, among other things, the promotion of gender equality, women's empowerment and improved social protection; (ii) National Policy for Gender Promotion (2009), which aims to achieve by 2025, equality and equity between the sexes with a view towards sustainable human development, in line with the government's efforts to reinforce gender mainstreaming.

The 1990 Constitution of Benin prohibits discrimination based on race, sex and religion, and grants men and women equal economic and social rights as citizens. A number of favorable global or sectoral policies for the promotion of gender have been developed including Policy of the Advancement of women (2001), Policy of promoting literacy (2001), Policy of the advancement of women in the agricultural/rural sector (2001). It was followed by the adoption in April 2007 of a National Policy to eliminate gender inequality in education and training. In order to promote gender equality, the Government has developed and implemented the National Policy for the Advancement of Women and Gender Equality 2009–2016 and publicized relevant laws. Finally, in January 2012, a law on the prevention and punishment of violence against women was enacted.

In the energy sector, efforts have been made to implement measures at the national level. As part of this process, the Government has conducted a Gender Audit of the sector and has designated gender focal points in the energy ministry to direct and coordinate gender mainstreaming activities. As an example, the Government has identified gender indicators for energy projects such as "the number of jobs created for men and women as a result of renewable energy generation" etc.

2.4.2 Gaps in the Gender Policy/Legal Framework

Despite the Government's policy initiatives and legislative reforms, gender inequality remains an ongoing challenge across the country's political, economic and socio-cultural landscape, as women still face many barriers to inclusive participation. Benin's legal system consists of statutory, customary, and religious laws, leading to contradictions and inconsistencies among the three. Benin also has two parallel and overlapping judicial codes: one based on western, mainly French, systems and one based on traditional systems. These codes often disagree, particularly in areas related to gender.

As described above, significant gender gaps persist in the areas of education, literacy, access to information and decision-making. There is also still a lack of sex-disaggregated data across all sectors of the economy, which is critical to inform policy decision and promote gender mainstreaming on a national scale.

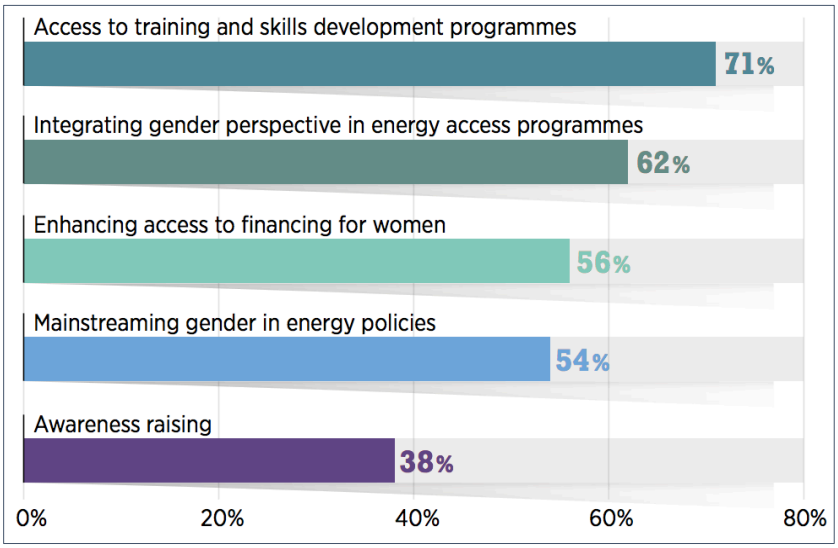
2.5 Summary of Recommendations

Given the increased attention that gender inclusion has received in development planning, there are a number of tools that are now available to policymakers that can be utilized to support gender mainstreaming and encourage women's participation in the energy sector. Despite encouraging progress in the discourse on gender and energy access, substantial efforts are still needed, especially in enabling women's participation in the sector in different roles, including as energy entrepreneurs and in leadership positions.[287]

In seeking solutions to improve women's engagement in energy access, a 2018 IRENA survey found that access to necessary technical, business or leadership skills development programs was the single most important measure that could be taken. Over half of survey respondents also highlighted the need to integrate gender perspectives in energy access programs as well as enhanced access to finance.[288]

[287] "Renewable Energy: A Gender Perspective," International Renewable Energy Agency, (2019): https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf
[288] Ibid.

Measures to Improve Women's Engagement in Energy Access



Source: International Renewable Energy Agency

In addition to the measures highlighted in the figure above, below is a list of additional policy recommendations that could further improve gender equality in Benin's energy sector:[289]

- Take measures to close the gender gap in access to education, particularly in higher levels of education
- Implement a quota system to increase the number of women employed in government's energy ministry and ensure that women are part of decision-making processes in the energy sector
- Implement policy and budgetary measures to support programs that aim to raise awareness and promote opportunities for women as energy customers, suppliers, financiers, and educators
- Commission studies to collect, synthesize and publish gender-specific/sex-disaggregated data on women's energy access and usage to inform (i) public policy development to improve rates of access for women; and (ii) private sector on potential customer needs (e.g. clean cooking technologies, productive use of energy applications etc.)
- Undertake a "gender audit" of the energy sector and develop a gender action plan to inform long-term policy objectives targeting gaps in the existing framework and promoting inclusive participation (e.g. by adding gender categories to policies and projects and accounting for gender impacts in strategic planning).
- Establish a Gender Focal Point or Unit within key national and local institutions in order to administer targeted gender policies and programs
- Raise awareness / provide training and technical support to private sector businesses / SMEs on (i) the benefits of gender inclusion and in viewing business decisions through a gender lens; (ii) the value of gender-disaggregated data; and (iii) how to develop and implement gender strategies to encourage inclusive participation.[290]

[289] **NOTE**: This is not an exhaustive list of recommendations as it is only intended to address inclusive participation in the energy sector; there are many gender-related challenges that warrant further study and attention within the context of the country's complex economic and social structures that are beyond the scope of this analysis

[290] "ECOWAS-CTCN Project on Mainstreaming Gender for a Climate Resilient Energy System in ECOWAS Countries: Final Report," ECREEE and CTCN, (May 2018): https://www.ctc-n.org/system/files/dossier/3b/180627_final_report-uk.pdf

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