WORLD BANK GROUP

ECREEE

TOWARDS SUSTAINABLE ENERGY

REGIONAL OFF-GRID ELECTRIFICATION PROJECT

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

CHAD REPORT

JULY 2019

GreenMax Capital Advisors

Energio Verda
Renewable Energy for Development

ASD

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ABBREVIATIONS & ACRONYMS

ADER	Agence des Energies Renouvelables (Agency for Renewable Energy Development)
AFD	Agence Française de Développement (French Development Agency)
AfDB	African Development Bank
APT-EMF	Association Professionnelle Tchadienne des Établissements de Microfinance
ASD	African Solar Designs
ASDEC	Association pour le Développement de l'Épargne et du Crédit
BAC	Banque Agricole et Commerciale
BCC	Banque Commercial du Chari
BEAC	Banque des États de l'Afrique Centrale (Bank of Central African States)
BSIC-Tchad	Banque Sahélo-Saharienne pour l'Investissement et le Commerce au Tchad
C&I	Commercial and Industrial
CAPEX	Capital Expenditure
CAPP	Central African Power Pool
CBT	Commercial Bank Tchad
CCI	Community Integration Contribution
CEMAC	Communauté Economique et Monétaire de l'Afrique Centrale (Central African Economic and Monetary Community)
CEPRIC	Centre d'Études pour la Promotion et la Rentabilisation des Initiatives Communautaires
CET	Common External Tariff
CFA	Communauté Financière Africaine (African Financial Community)
COBAC	Commission Bancaire de l'Afrique Centrale (Central African Banking Commission)
COD	Cash-on-Delivery
DFI	Development Finance Institution
DGEER	Direction Générale de l'Energie et des Energies Renouvelables
EBID	ECOWAS Bank for Investment and Development
ECA	Export Credit Agency
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Center for Renewable Energy and Energy Efficiency
EEA	Electric Energy Authority
EU	European Union
EUR	Euro
FAO	Food and Agriculture Organization of the United Nations
FCFA	Central African franc
FEI	Facility for Energy Inclusion
FGD	Focus Group Discussion
FI	Financial Institution
FX	Foreign Exchange
GDP	Gross Domestic Product
GIS	Geographic Information System
GoC	Government of Chad
GOGLA	Global Off-Grid Lighting Association
GSMA	Groupe Spéciale Mobile Association (Global System for Mobile Communications)
HC	Health Center
HFO	Heavy Fuel Oil
HH	Household
ICT	Information and Communications Technology
IEA	International Energy Agency

IEC	International Electrotechnical Commission
IMF	International Monetary Fund
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
kW	Kilowatt
kWh	Kilowatt-hour
LTO	Lease-to-Own
MEP	Ministry of Petroleum and Energy
MFI	Microfinance Institution
MoE	Ministry of Energy
NGO	Non-Governmental Organization
NPL	Non-Performing Loan
O&M	Operations and Maintenance
OGS	Off-Grid Solar
OHADA	L'Organisation pour l'Harmonisation en Afrique du Droit des Affaires (Organization for the Harmonization Business Laws in Africa)
OPIC	Overseas Private Investment Corporation
PAFIT	Programme d'Appui à la Finance Inclusive (Support Program for Financial Inclusion in Chad)
PARCEC	Projet d'Appui au Réseau de Coopératives d'Épargne et de Crédit
PAYG	Pay-As-You-Go
PROMOSOL	Center for the Promotion of Solar Energy
PUE	Productive Use of Energy
PV	Photovoltaic
RE	Renewable Energy
RISE	Regulatory Indicators for Sustainable Energy
ROGEP	Regional Off-Grid Electrification Project
SDEnR	Schéma Directeur pour les Énergies Renouvelables (Renewable Energy Master Plan)
SEFA	Sustainable Energy Fund for Africa
SEforALL	Sustainable Energy for All
SHS	Solar Home System
SME	Small and Medium Enterprise
SNE	Société Nationale d'Electicité
SPV	Special Purpose Vehicle
SSA	Sub-Saharan Africa
STEE	Chadian Water and Electricity Company
TA	Technical Assistance
UN	United Nations
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USD	United States Dollar
VAT	Value Added Tax
WAEMU	West Africa Economic and Monetary Union
WAPP	West African Power Pool
WB	World Bank
Wh	Watt-hour
Wp	Watt peak

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NOTE: The findings, analysis, conclusions and recommendations expressed in this report are those of the authors – they do not necessarily represent the views of ECREEE, the World Bank, or any of the individuals and organizations that contributed to this study.

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

ATTRIBUTES			TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
	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

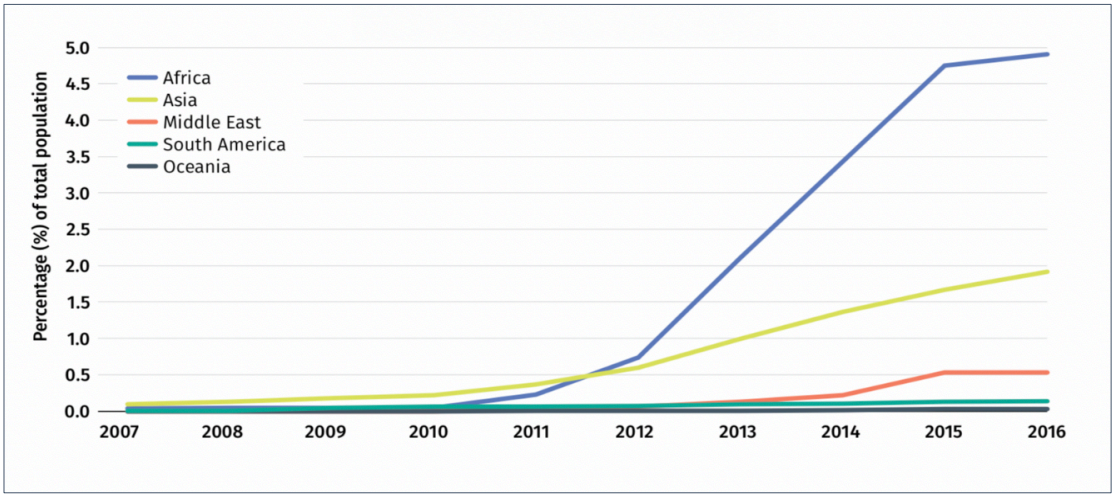
The term "West Africa and the Sahel" as it is used to throughout this report refers to the 19 countries covered by the first phase of the Regional Off-Grid Electrification Project (ROGEP). The countries include the 15 member states of the Economic Community of West African States (ECOWAS) – Benin, Burkina 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).

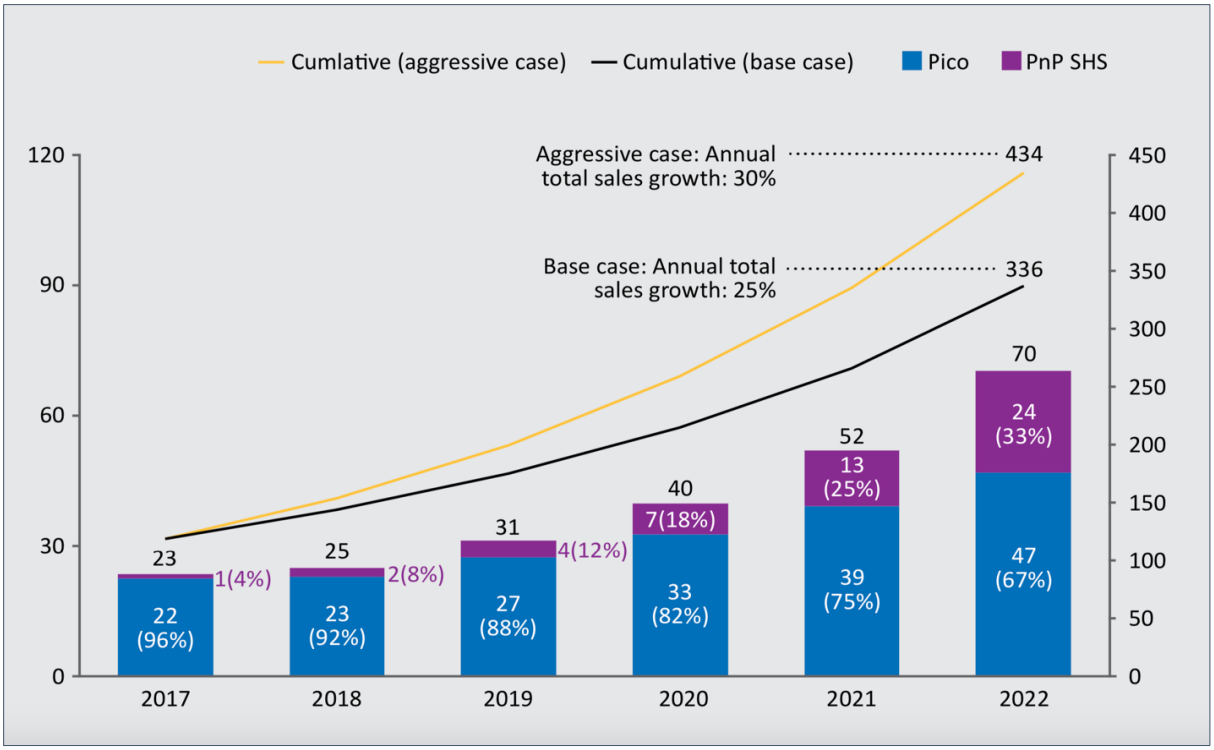
Until recently, diesel generators largely served as the expensive alternative both for rural electrification and for urban and peri-urban "bad grid" areas, where electricity was unreliable or only available for part of the day. However, the advent of decentralized renewable energy technologies, particularly 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.

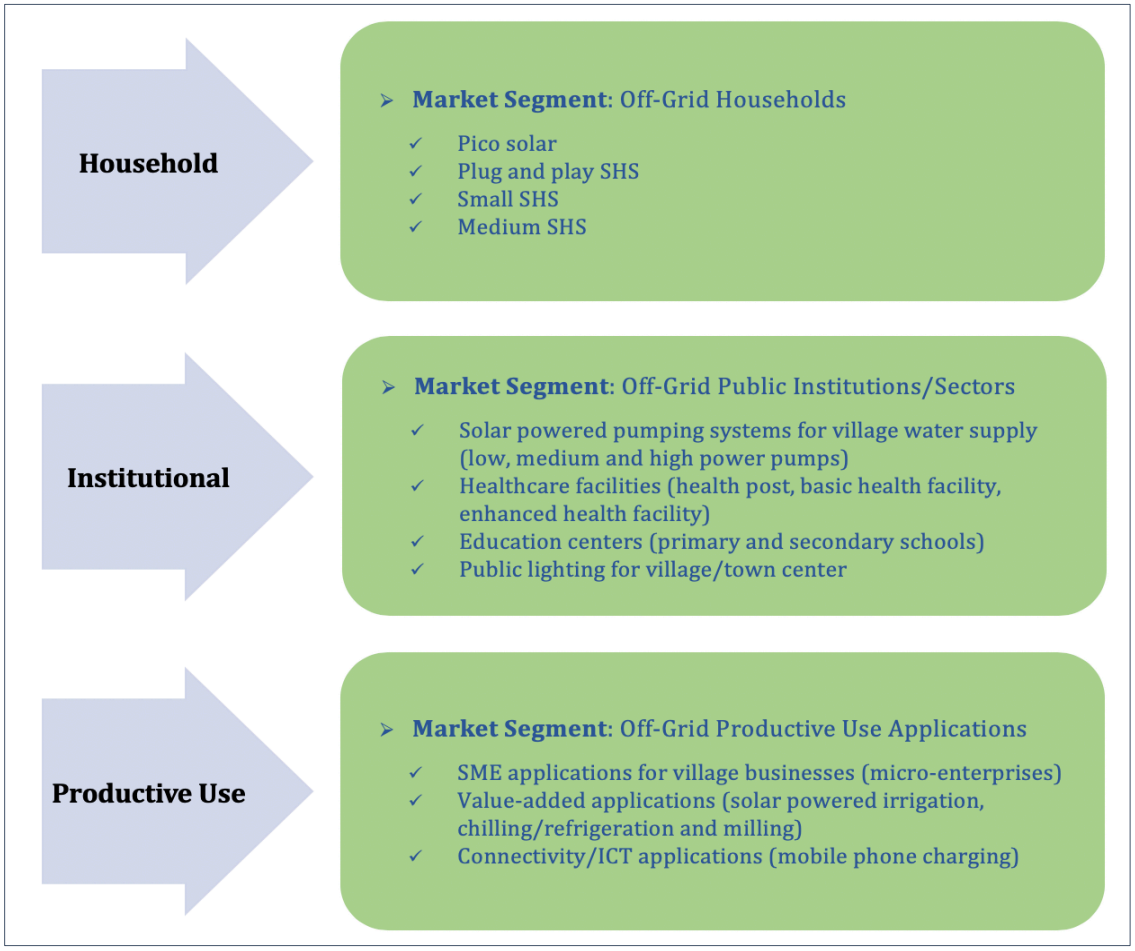
The institutional sector analysis combines available GIS data with secondary research to estimate potential demand based on assumptions about the electricity needs, usage patterns and associated costs of solar electrification of four public/institutional markets – water supply for off-grid communities, 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

The Republic of Chad is a landlocked country in Central Africa and is among the least-developed in the world. Poverty is widespread, particularly in rural areas where over three-quarters of the population lives and relies on subsistence farming and livestock raising. Chad is currently providing humanitarian assistance to over 400,000 refugees from neighboring Sudan, the Central African Republic and Nigeria.[24] Chad faces considerable development challenges in its efforts to reduce poverty, adapt to volatile commodity prices and worsening impacts of climate change, and meet the needs of a young and rapidly growing population.

Access to electricity remains an ongoing challenge. In 2016, approximately 90% of the overall population – an estimated 13 million people – lacked access to electricity, with a significant disparity in rates of access between urban (32%) and rural (1%) areas.[25] Even where grid connections exist, power supply is often unreliable, with firms reporting an average of 20 power outages per month when surveyed.[26] Off-grid electrification is a policy priority for the Government of Chad (GoC), which is committed to achieving a universal electricity access by 2030. To date, the Government's efforts to establish a supportive policy and regulatory framework for the off-grid sector have been limited, as evidenced by the country's relatively low energy access score in the World Bank Regulatory Indicators for Sustainable Energy (RISE) evaluation. In 2017, Chad ranked last in West Africa and the Sahel and was among the lowest scoring countries in the world.[27]

The GoC is working with several development partners to address these challenges. Chad's National Development Strategy prioritizes energy access in development planning and seeks to improve the reliability of electricity production, transmission, and distribution. These efforts are supported by the World Bank's Electricity Transmission and Access Project, with additional technical assistance from the AfDB and USAID's Sector Reform and Utility Commercialization initiative. Additionally, with support from UNDP, the GoC has adopted a National Strategy for the Promotion of New and Renewable Energies in Chad (Strategie Nationale pour la Promotion des Energies Nouvelles et Renouvelables au Tchad), which aims, among other objectives, aims to increase renewable electricity generation, with a target of increasing the country's rural electricity access rate to 7% by 2020. [28] With support from the EU, Chad's Agency for Renewable Energy Development (Agence des Energies Renouvelables, ADER) is developing a corresponding action plan – the Renewable Energy Master Plan (Schéma Directeur pour les Énergies Renouvelables, SDEnR) – to support implementation of this strategy through 2030.[29]

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 Chad (**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 125.8 million. The household sector (USD 60.8M) makes up the majority of estimated demand, followed by the productive use (USD 45.6M) and institutional (USD 19.4M) sectors.

[24] "Chad Country Overview," The World Bank: https://www.worldbank.org/en/country/chad/overview
[25] IEA Energy Access Outlook, 2017.
[26] "Power outages in firms in a typical month (number) – Africa," IndexMundi, https://www.indexmundi.com/facts/indicators/IC.ELC.OUTG/map/africa
[27] "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
[28] "Promotion des Énergies Nouvelles et Renouvelables au Tchad," UNDP: http://www.td.undp.org/content/dam/chad/docs/fiches_projets/UNDP_td_ENR.pdf
[29] "Projet Adaptation aux Effets du Changement Climatique et Développement des Énergies Renouvelables: Termes de référence pour l'atelier de validation du Schéma Directeur pour les Énergies Renouvelables (SDEnR) au Chad," EU AMCC in Chad and the Ministry of Environment, Water and Fisheries, (2018): http://amcc.tchadenvironnement.org/wp-content/uploads/2018/07/TDR_validation_SDEnR_vubob.pdf

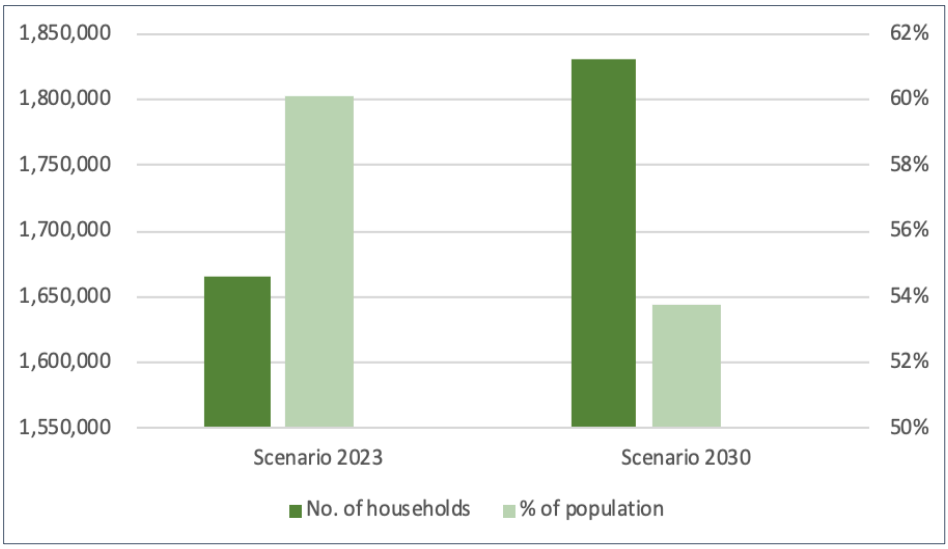
Figure ES-4: Indicative Total Cash Market Potential for Off-Grid Solar Products in Chad, 2018

Source: African Solar Designs

The least-cost electrification analysis found that by 2023, 28 settlements across Chad (319,390 households) will be connected to the main grid, representing 11.5% of the population. By 2030, this figure will increase to 119 settlements (553,144 households), equivalent to 16.2% 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 10,929 settlements (1,664,713 households) and 60.1% of the population as suitable for stand-alone solutions in 2023. By 2030, while the number of settlements decreases to 10,135, the number of households increases to 1,830,259 households, representing 53.7% of the population in that year (**Figure ES-5**). While the total size of the off-grid solar market will slightly decrease over the analyzed timeframes, the geographic distribution of off-grid households across the country will remain relatively unchanged through 2030.

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

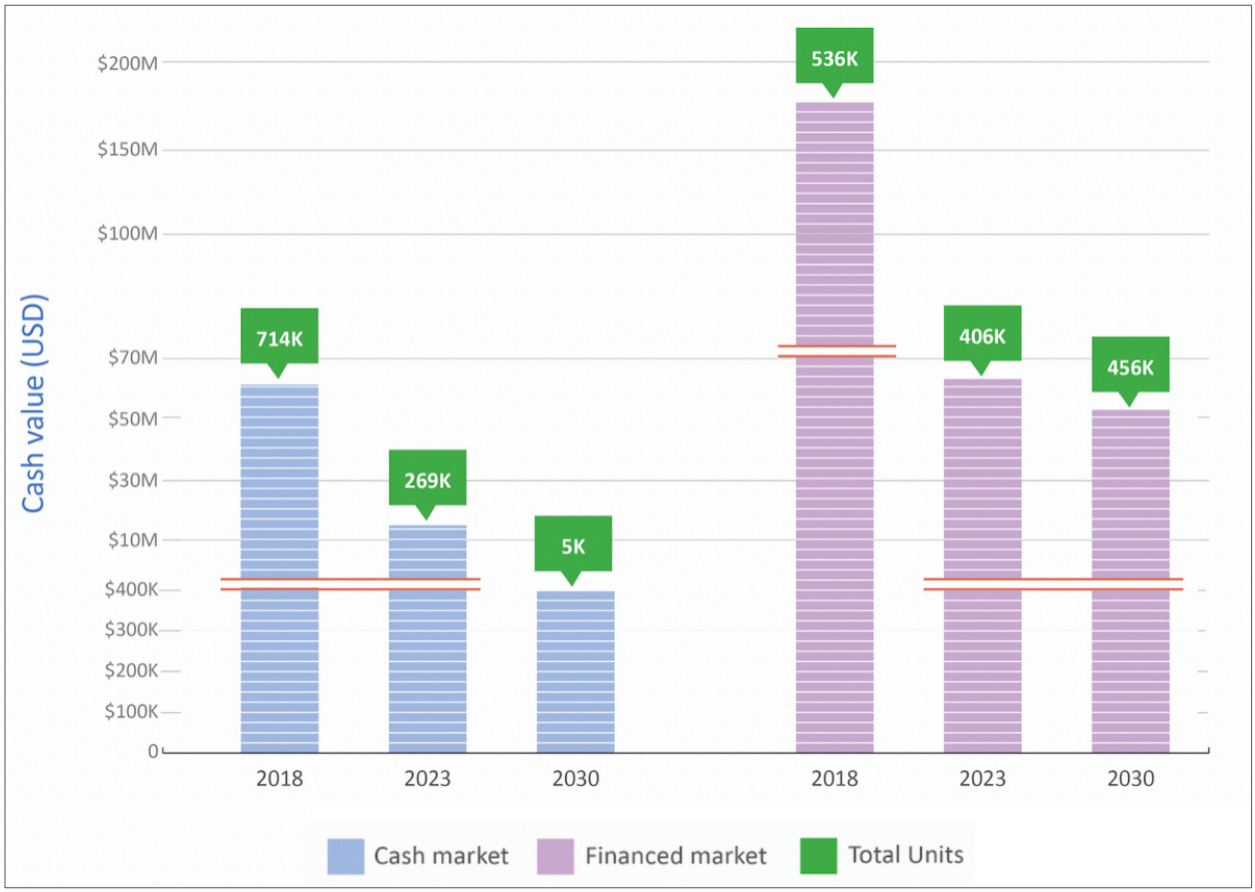


Source: Energio Verda Africa GIS analysis

According to the analysis, the annualized off-grid solar cash market potential for the household sector in 2018 is USD 60.8 million, with the estimated market value nearly tripling in size to USD 176.5 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.

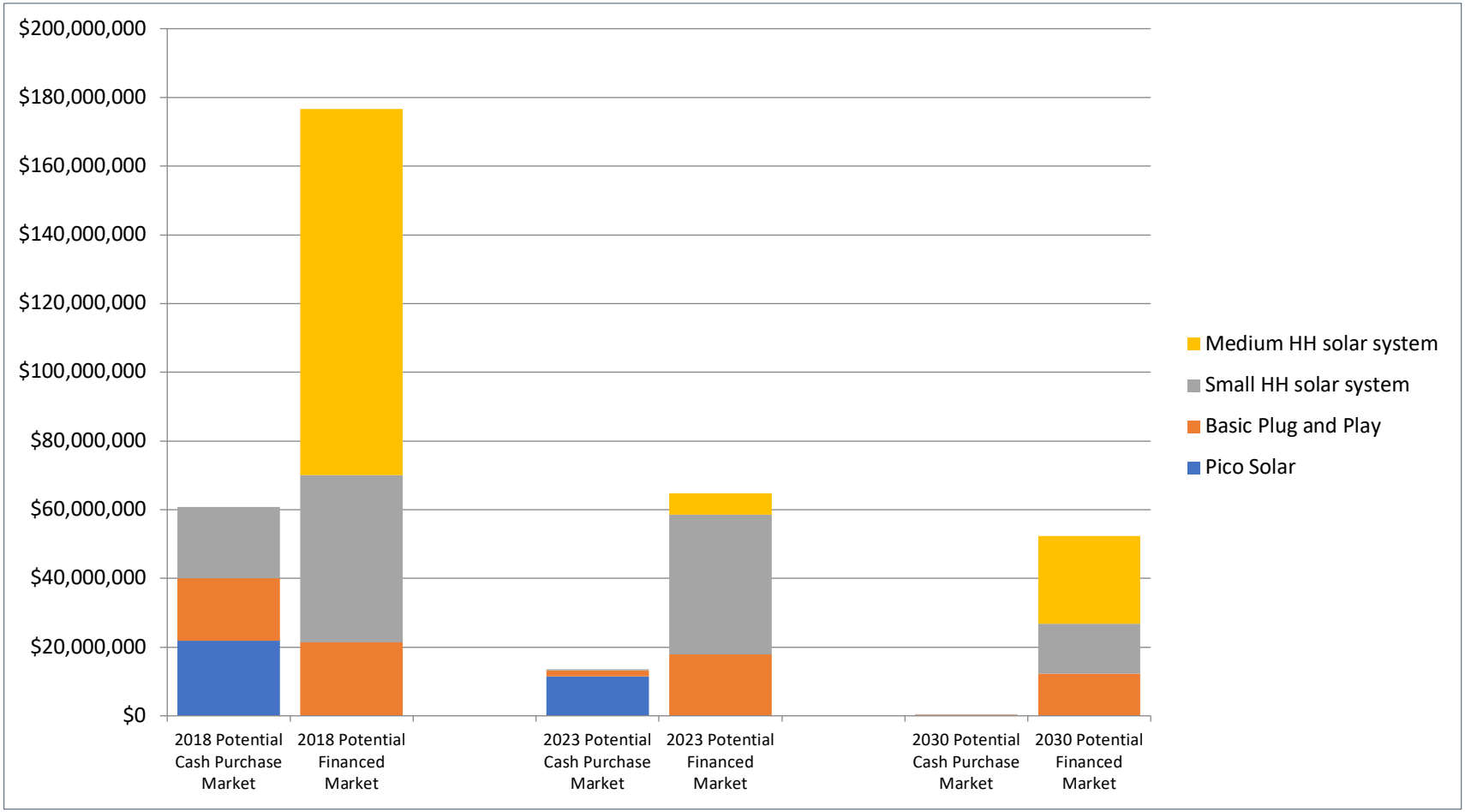
According to the assessment, the most common types of systems the market can afford on a cash basis are pico solar, small plug and play systems and small HH solar systems; however, this changes significantly with the introduction of financing (**Figure ES-7**). While affordability improves over time, 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



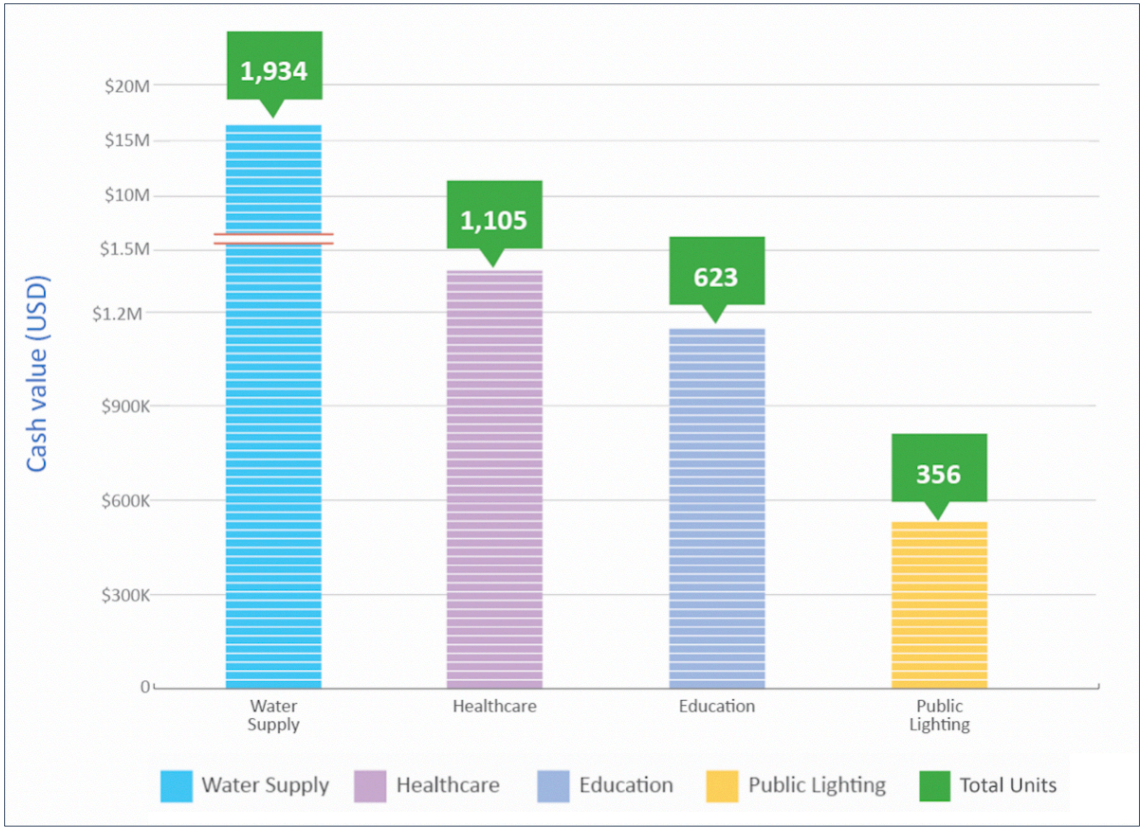
Source: African Solar Designs analysis

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

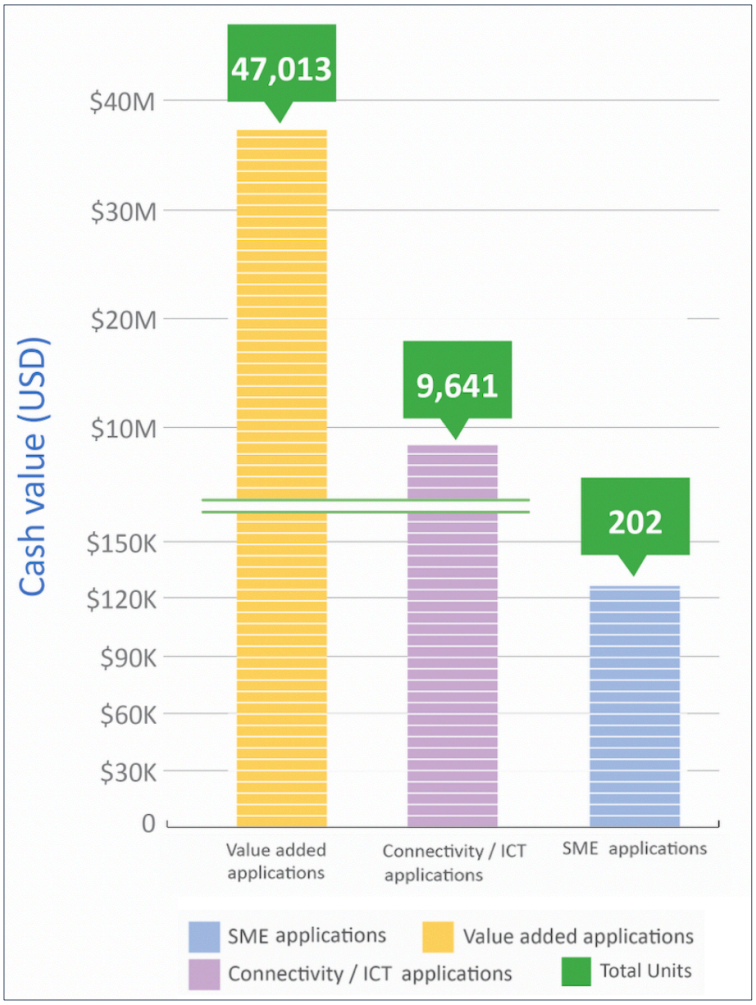


Source: African Solar Designs analysis

The estimated annualized cash market potential for Chad's public/institutional sector in 2018 is USD 19.4 million (**Figure ES-8**). The institutional market segments with the largest potential are water supply (USD 16.4M), followed by healthcare (USD 1.3M), education (USD 1.1M) and public lighting (USD 533K). 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 45.6 million (**Figure ES-9**). The estimated demand from value-added applications represents most of the PUE market potential (USD 37.2M), followed by applications for connectivity (USD 8.3M) and SMEs (USD 126K).

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.

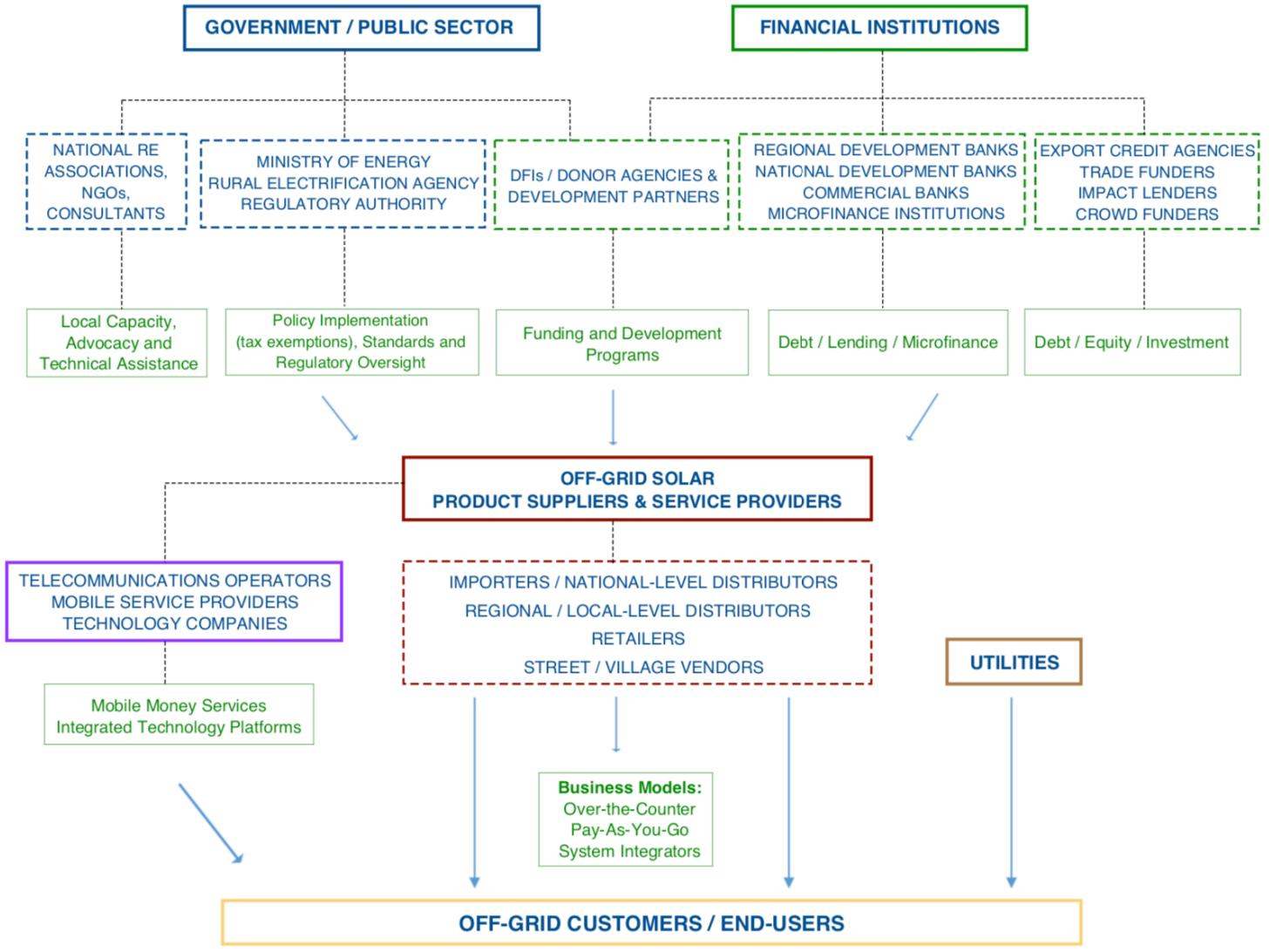
For household demand, the off-grid solar market is already tangible. Still, many factors will affect household demand for solar products, such as distribution realties, consumer education, competing economic priorities for households, financial shocks, etc. The institutional market will be affected largely 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 Chad, which includes a wide range of stakeholders, including importers, distributors, wholesalers, retailers and end-users (**Figure ES-10**). Chad has a relatively small solar market, as the country's overall market environment and opportunity for solar companies remains limited. The supply chain 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.

Chad'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 must manage a number of technical competency requirements, including the selection of business models, importation and distribution channels, solar PV technologies, as well as the design and implementation of associated marketing instruments and 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 Chad:

Key Barriers to Off-Grid Solar Market Growth
• Security concerns prevent companies from operating in certain regions (e.g. Lake Chad)
• Government taxation policy for mobile technology sector inhibiting off-grid solar PAYG business model
• Low consumer purchasing power and lack of consumer financing options
• Low levels of consumer awareness of solar solutions, particularly in rural areas
• Lack of policy support for PAYG business models and mobile technology platforms
• 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
• 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

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 Chad and throughout the region to support development of the OGS sector. Although access to banking and financial services through formal institutions remains limited, Chad 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, 22% of the country's adult population had an account at a financial institution or with a mobile money service provider, up from 9% in 2011. Despite this improvement, Chad still has one of the lowest rates of financial inclusion in West Africa and the Sahel. There is also a significant gender gap in rates of access to financial services, as women in Chad are 14% less likely than men to have an account at a financial institution or with a mobile money service provider.[30]

The country's modest improvements in financial inclusion between 2011 and 2017 were driven primarily by the proliferation of mobile money services. By 2017, more adults in the country had an account with a mobile money service provider than at a financial institution. Expanding mobile money services 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-grid solar solutions, particularly for PAYG systems that rely on the interoperability between digital financial services and stand-alone solar devices.

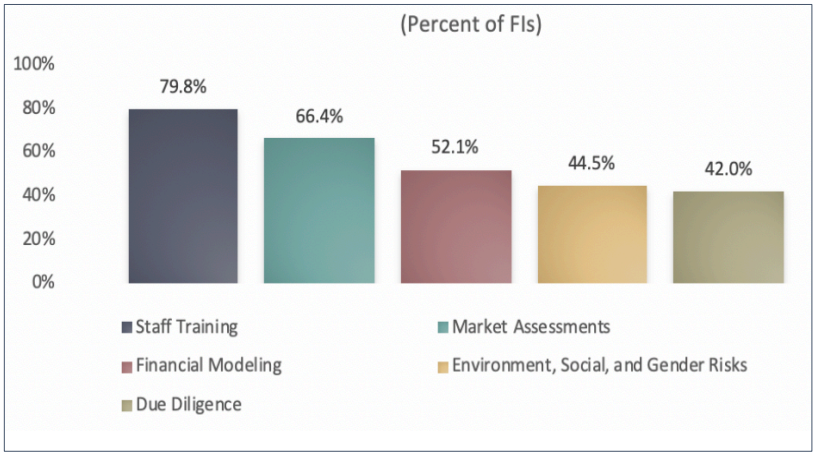
While there are several donor and DFI-funded programs and initiatives that have provided financing to support development of Chad's off-grid solar market, these funds have not been channeled through local commercial banks or MFIs. ROGEP is therefore a pioneering initiative in the country, as it endeavors to boost OGS lending via engagement with local financial partners. Local FIs are increasingly becoming more

[30] 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

aware of the opportunities in OGS, and interviews FIs revealed a willingness to provide financing to the sector.

According to the Task 3 survey of financial institutions in Chad and across the region,[31] 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

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 Chad, 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.[32] 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**).[33]

[31] 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.
[32] "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
[33] Ibid.

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

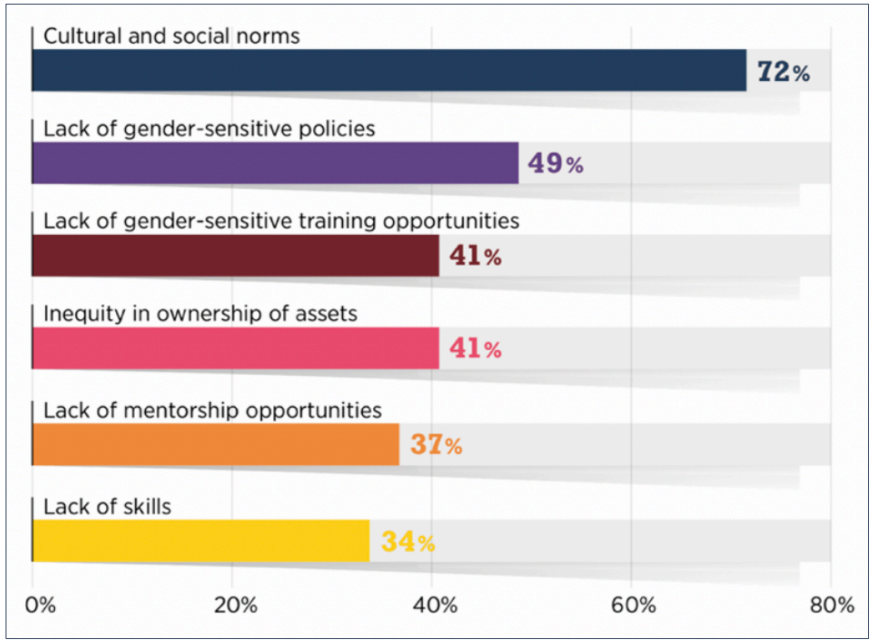
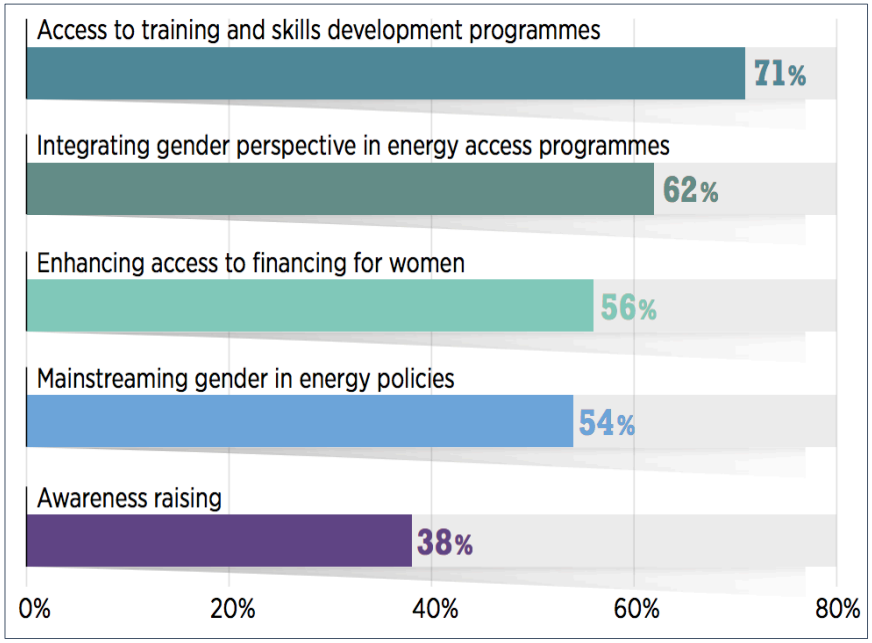


Figure ES-13: Measures to Improve Women's Engagement in Energy Access



Source: International Renewable Energy Agency

The gender analysis undertaken in Chad 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 Chad.[34]

[34] "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 Chad (**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 stand-alone systems[35] in Chad 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

The Republic of Chad is a landlocked country in Central Africa that is home to over 200 different ethnic and linguistic groups. The country ranks among the least-developed in the world, as poverty is widespread, particularly in rural areas where over 75% of the population lives and relies on subsistence farming and livestock raising. Economic growth has been hampered in recent years by the decline in world oil prices as well as the security and humanitarian crises facing the country – Chad is currently providing humanitarian assistance to over 400,000 refugees from neighboring Sudan, the Central African Republic and Nigeria.[36] GDP growth fell to –6.4% in 2016 but was estimated to rebound slightly in 2017.[37] Chad faces considerable development challenges in its efforts to reduce poverty, adapt to volatile commodity prices and the worsening impacts of climate change, and meet the needs of a young and rapidly growing population.

Table 1: Macroeconomic and Social Indicators

Population	14.9 million[38]
Urban Population	22.7% of total
GDP	USD 9.8 billion
GDP growth rate	-3.14%
GNI per capita*	USD 640
Unemployment rate	5.8%
Poverty rate	46.7% (2011)
Urban	20.9%
Rural	52.5%
Currency	Central African CFA franc (FCFA)
Official language	French, Arabic
Natural resources	Hydrocarbons (oil); ores (gold uranium); agricultural (cotton, livestock)

* World Bank Atlas method (current USD)[39]

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

[35] 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
[36] "Chad Country Overview," The World Bank: https://www.worldbank.org/en/country/chad/overview
[37] "Chad Economic Outlook," African Development Bank, (2018): https://www.afdb.org/en/countries/central-africa/chad/
[38] 50.1% male/49.9% female
[39] "World Bank Open Data: Chad," World Bank (2017): https://data.worldbank.org/country/chad

1.2 Energy Market

1.2.1 Energy Sector Overview

The Ministry of Energy and Petroleum (MEP) oversees the energy sector and coordinates the country's energy policy. The former Chadian Water and Electricity Company was the main public operator in this sector until it was unbundled in 2010 to form the national electricity company, Société Nationale d'Electicité (SNE), which now has a monopoly over electricity generation, transmission and distribution. The company was renationalized in 2004 following the withdrawal of the private consortium Vivendi-Dietsmann, which had previously managed the company between 2001 and 2004. In 2012, the Government of Chad (GoC, or "the Government") established the Agency for Renewable Energy Development (Agence des Energies Renouvelables, ADER) to coordinate the country's renewable energy and rural electrification efforts.

Table 2: Institutional and Market Actors in the Energy Sector

Institution / Company	Role in the Energy Sector
Ministry of Energy and Petroleum (Ministère de l'Energie et du Pétrole, MEP)	Ministry responsible for implementing national energy policy and coordinating all energy sector programs and activities
General Directorate of Energy and Renewable Energy (Direction Générale de l'Energie et des Energies Renouvelables, DGEER)	Entity responsible for coordinating activities related to energy issues in the framework of national development plans. Designs, develops, coordinates and implements the Government's Energy Policy. Participates in the elaboration and enforcement of energy policy, legislation and regulations for research, production, transmission and distribution of electricity and domestic fuels.
National Electricity Utility (Société Nationale d'Electicité, SNE)	Public utility responsible for generation, transmission and distribution of electricity.
Electric Energy Authority (EEA)	Regulatory authority responsible for (i) supervising compliance with all energy laws and regulations by utility operators and IPPs; (ii) proposing electricity tariffs to the state as well as tariffs to access the national grid; (iii) dispute settlement; (iv) protecting the collective interest of electricity consumers; and (v) providing advice and assistance to all electricity operators
Agency for Renewable Energy Development (Agence des Energies Renouvelables, ADER)	Public administrative institution responsible for renewable energy development and rural electrification through grid-extension and off-grid mini-grid systems. ADER implements rural electrification policies, provides technical advice to private operators, and oversees the realization and financing of rural electrification and renewable energy projects.

Source: *Source*: ECOWAS Center for Renewable Energy and Energy Efficiency

1.2.2 Electricity Access: *Grid and Off-Grid*

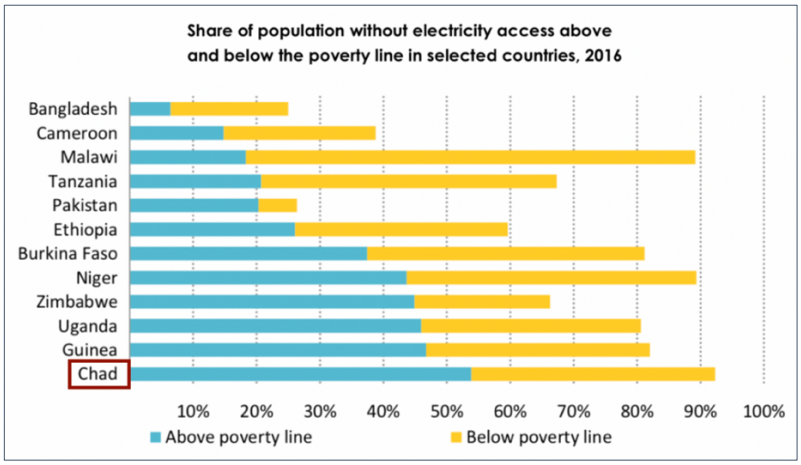
Rates of electricity access in Chad remain among the lowest in Africa, particularly in rural areas. In 2016, approximately 90% of the overall population – an estimated 13 million people – did not have access to electricity, with a significant disparity in rates of access between urban (32%) and rural (1%) areas.[40] The GoC has launched a national effort to be administered by ADER, to coordinate the development efforts necessary to expand electricity coverage and achieve universal access by 2030.

[40] "World Bank Open Data: Chad," World Bank, (2017): https://data.worldbank.org/country/chad; and "Energy Access Outlook, 2017: From Poverty to Prosperity," International Energy Agency, (2017): https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf

1.2.2.1 Off-Grid Market Overview

Despite widespread poverty, a significant portion of the population lives above the poverty line without electricity access, signaling that the lack of access is due in part to systemic issues related to grid infrastructure and the high cost of connection (**Figure 1**). Grid extension is not a feasible option to serve a significant portion of the population residing in rural and peri-urban areas due to their relatively small energy demand and an overall lack of financial resources for SNE to extend existing grid networks into remote areas. Stand-alone solar technologies provide a much more cost-effective and efficient solution to meet electricity demand in these areas.

Figure 1: Rates of Electricity Access and Poverty



The World Bank defines the poverty line at below USD 1.90 a day (USD 2011 PPP)

Source: International Energy Agency

Chad adopted a National Development Strategy in 2013 that prioritized energy access as a key enabler of economic development. In Chad's National Development Plan (2015-2021), off-grid electrification has again been signaled as a policy priority for the Government. A key component of the Government's efforts is to improve the reliability of its electricity production, transmission, and distribution system. These initiatives are supported by the World Bank's Electricity Transmission and Access Project, with additional technical assistance from the AfDB and USAID's Sector Reform and Utility Commercialization initiative. More recently, several private solar companies have entered the country's nascent off-grid market, but the absence of an elaborate supply chain and supportive regulatory framework has hampered their progress.

In partnership with UNDP, the GoC developed a National Strategy for the Promotion of New and Renewable Energies in Chad (Strategie Nationale pour la Promotion des Energies Nouvelles et Renouvelables au Tchad), which aims to (i) increase renewable electricity generation, with a target of increasing the country's rural electricity access rate to 7% by 2020; (ii) increase the share of renewable energy in Chad's energy mix by 38%; (iii) develop renewable energies for the agricultural and pastoral sectors; and (iv) increase the production of solar energy to 200GWh/year.[41] With support from the EU, ADER is developing a corresponding action plan – the Renewable Energy Master Plan (Schéma Directeur pour les Énergies Renouvelables, SDEnR) – to support implementation of this strategy through 2030.[42]

[41] "Promotion des Énergies Nouvelles et Renouvelables au Tchad," UNDP: http://www.td.undp.org/content/dam/chad/docs/fiches_projets/UNDP_td_ENR.pdf

[42] "Projet Adaptation aux Effets du Changement Climatique et Développement des Énergies Renouvelables: Termes de référence pour l'atelier de validation du Schéma Directeur pour les Énergies Renouvelables (SDEnR) au Chad," EU AMCC in Chad and the Ministry of Environment, Water and Fisheries, (2018): http://amcc.tchadenvironnement.org/wp-content/uploads/2018/07/TDR_validation_SDEnR_vubob.pdf

1.2.2.2 Demand and Supply/Generation Mix

In 2017, Chad had 125 MW of installed capacity, operating entirely on diesel and Heavy Fuel Oil (HFO) generation. SNE is currently the only operator in the sector as there are no independent power producers (IPPs) in the country. Levels of electricity consumption and demand are relatively low, yet prices are extremely high. Electricity tariffs, which are set by MoE, are not cost-reflective and do not generate enough revenue for SNE to invest in maintenance, leaving the electricity system in a state of disrepair. The GoC is working with development partners to secure much-needed funding to increase installed capacity and expand access to the network.

Table 3: Electricity Sector Indicators, 2017[43]

Installed Capacity	125 MW
Thermal	125 MW
Hydropower	-
Renewable (non-hydro)	-
National electrification rate (2016)	9%
Urban electrification rate	32%
Rural electrification rate	1%
Population without access	13.6 million
Households without access	2.3 million
Electrification target	Universal access by 2030

Source: IEA, USAID Power Africa and World Bank

Chad is endowed with the tenth-largest oil reserves in Africa, as well as significant renewable energy potential, including solar and wind.[44] Grid-connected solar has not been considered by SNE yet, as solar is more commonly used for pico lighting purposes. The country's wind energy potential is significant in its central region. Biomass energy in the form of agricultural residues are abundant and are valuable for energy production. As a sugar producing country, Chad has large quantities of bagasse available for energy production from co-generation as a surplus from the internal sugar mills. Evidence of geothermal energy activity has been noted in mineral resource surveys in the Tibesti area of the country; however, no study has been undertaken as to the potential of this resource for power generation. The country's economically and technically feasible hydropower potential is estimated to approximately 150 GWh/year. Plans are ongoing to create an inter-connection between hydropower resources in Cameroon and N'Djamena.

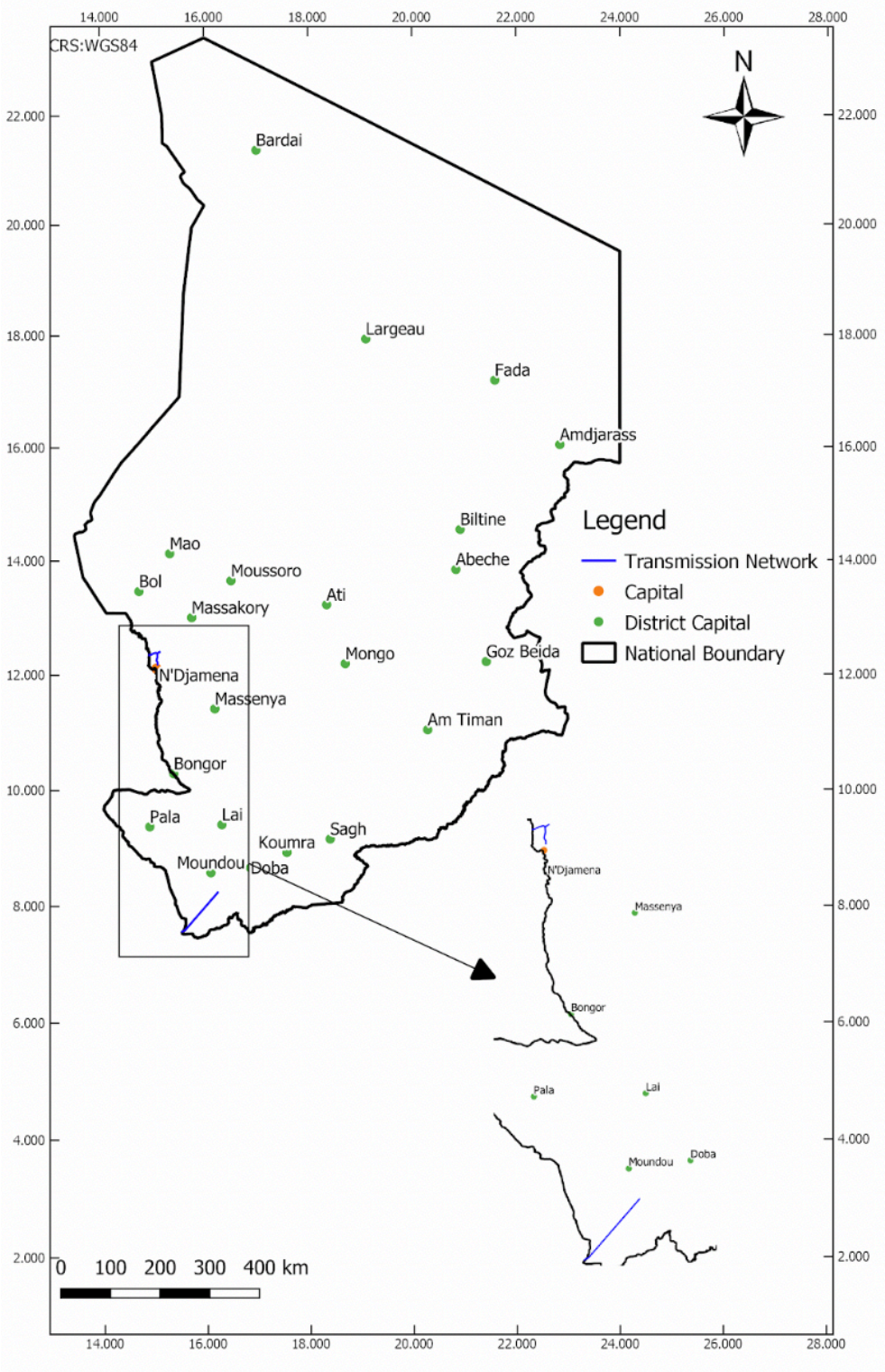
The GoC has made it a priority to decrease electricity prices, as the tariffs in Chad are comparatively higher than in neighboring countries. For low-voltage users (typically residential consumers), the tariff is USD 0.16/kWh (FCFA 85) and increases to USD 0.22 (FCFA 125) as usage increases.

1.2.2.3 Transmission and Distribution Network

SNE operates Chad's electricity transmission and distribution network, which is concentrated almost entirely around the capital N'Djamena (**Figure 2**). The distribution network is obsolete and covers only one-third of the current area of the city. Chad's grid network is limited to three small independent grid networks that supply the cities of N'Djamena and Shar Mouduo Abeché with power. SNE is faced with significant commercial losses due to mismanagement, underinvestment, low billing and collection rates, and electricity gaps caused by fraudulent connections. Overall, a significant gap exists between the infrastructure needs of the sector and the availability of resources to invest in grid maintenance and extension to rural areas. The network is overloaded and unreliable, with frequent outages and load shedding (**Figure 3**). The Governments of Chad and Cameroon have asked the AfDB to support the execution of the Chad-Cameroon 225 kV Electrical Grid Interconnection Project within the Central African Power Pool to address the country's shortfall in installed capacity.[45]

[43] See **Section 2.1** for more details on households/population without access to electricity.
[44] "Chad: Power Africa Fact Sheet," USAID, (2018): https://www.usaid.gov/powerafrica/chad
[45] "Chad-Cameroon 225 kV Electrical Grid Interconnection Project," AfDB, (2017): https://www.afdb.org/fileadmin/uploads/afdb/Documents/Environmental-and-Social-Assessments/Multinational_-_Interconnexion_%C3%A9lectrique_en_225_KV_Tchad-Cameroun_%E2%80%93_R%C3%A9sum%C3%A9_PCR_-_EN.pdf

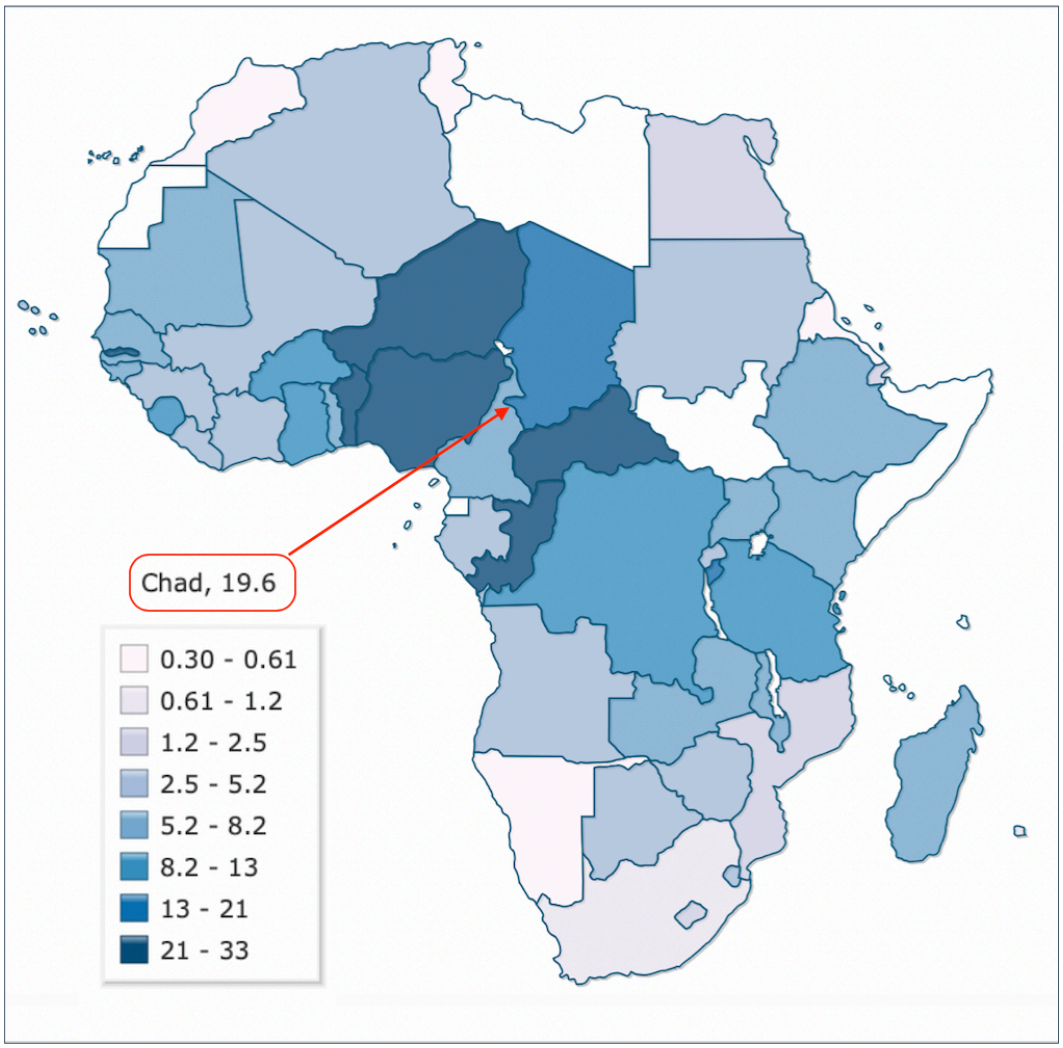
Figure 2: Electricity Transmission and Distribution Network[46]



Source: Energio Verda Africa GIS analysis

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

Figure 3: Average Number of Power Outages in Firms in Africa in a Typical Month[47]



Source: World Bank Enterprise Surveys, 2013-2017

The map in **Figure 3** illustrates how the number of power outages in firms in a given month varies by country in Africa. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. Firms in Chad reported an average of nearly 20 power outages per month – well above the West Africa and Sahel region's average of 12 outages per month and one of the highest reported numbers in Africa.

[47] "Power outages in firms in a typical month (number) – Africa," IndexMundi, https://www.indexmundi.com/facts/indicators/IC.ELC.OUTG/map/africa

1.2.2.4 Least-Cost Electrification Analysis

A least-cost electrification analysis has been performed to assess the potential development of electricity access in Chad through 2023 and through 2030 ("Scenario 2023" and "Scenario 2030").[48] The analysis identifies the scale of market opportunities for off-grid stand-alone solar electrification. A brief summary of the approach and methods used, main assumptions and key results of the analysis in Chad are outlined below. Additional geographic information system (GIS) information, including categorizations, key definitions, and datasets are included in **Annex 1**.

- **Methodology**

This analysis uses GIS techniques to determine the least-cost electrification options for settlements across Chad 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.[49] 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 defined as 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 announced by utilities across West Africa in a 10-year timeline) and 5 km of future planned line extensions are assumed to be connected. Since the GoC didn't formulate concrete plans for grid extension by the time of this analysis, only one 225kV transmission line from the Chad-Cameroon electrical grid interconnection project was taken into account for the scenario 2030 analysis. 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 and urban areas. All other settlements are defined as candidates for off-grid stand-alone systems.

Given the lack of low voltage distribution line data, it is 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 within the scenario 2023.[50] In order to identify the population within each settlement, additional analysis was undertaken to estimate these figures. The current annual national population growth rate of 3.0%[51] was applied to the geospatial analysis to project population figures for the scenario 2023 and 2030 analyses.[52] **Figure 4** shows population density across the country, which served as the basis for this analysis.

[48] NOTE: Rather than presenting a 10-year projection through 2028, the analysis conforms to GoC electrification targets for 2030

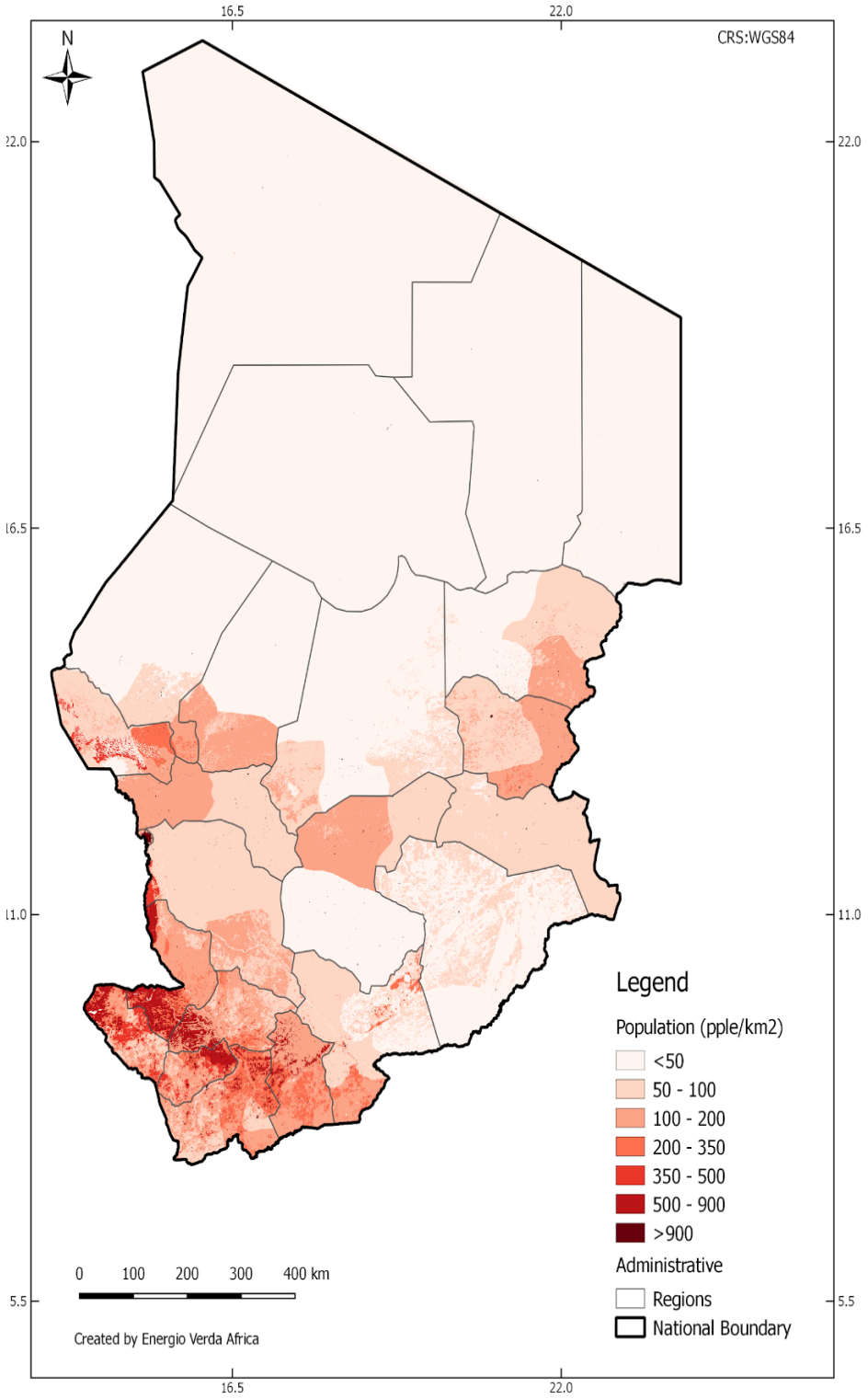
[49] No information for Chad or for the CAPP (Central African Power Pool) was given on the distance for densification. Therefore, the West African Power Pool (WAPP) densification plans were used in the analysis. Low-voltage distribution lines were not considered in this analysis (data was unavailable)

[50] Note that this analysis was performed for the five-year scenario but not for the year 2030 scenario due to uncertainties regarding population densities being too high over such a long timeframe

[51] "World Bank Open Data: Source: https://data.worldbank.org/indicator/SP.POP.GROW

[52] See **Annex 1** for more details on the approach and methods used

Figure 4: Population Density, 2015[53]



Source: Energio Verda Africa GIS analysis

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

- **Results**

Table 4 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 (5.8 persons/household).[54]

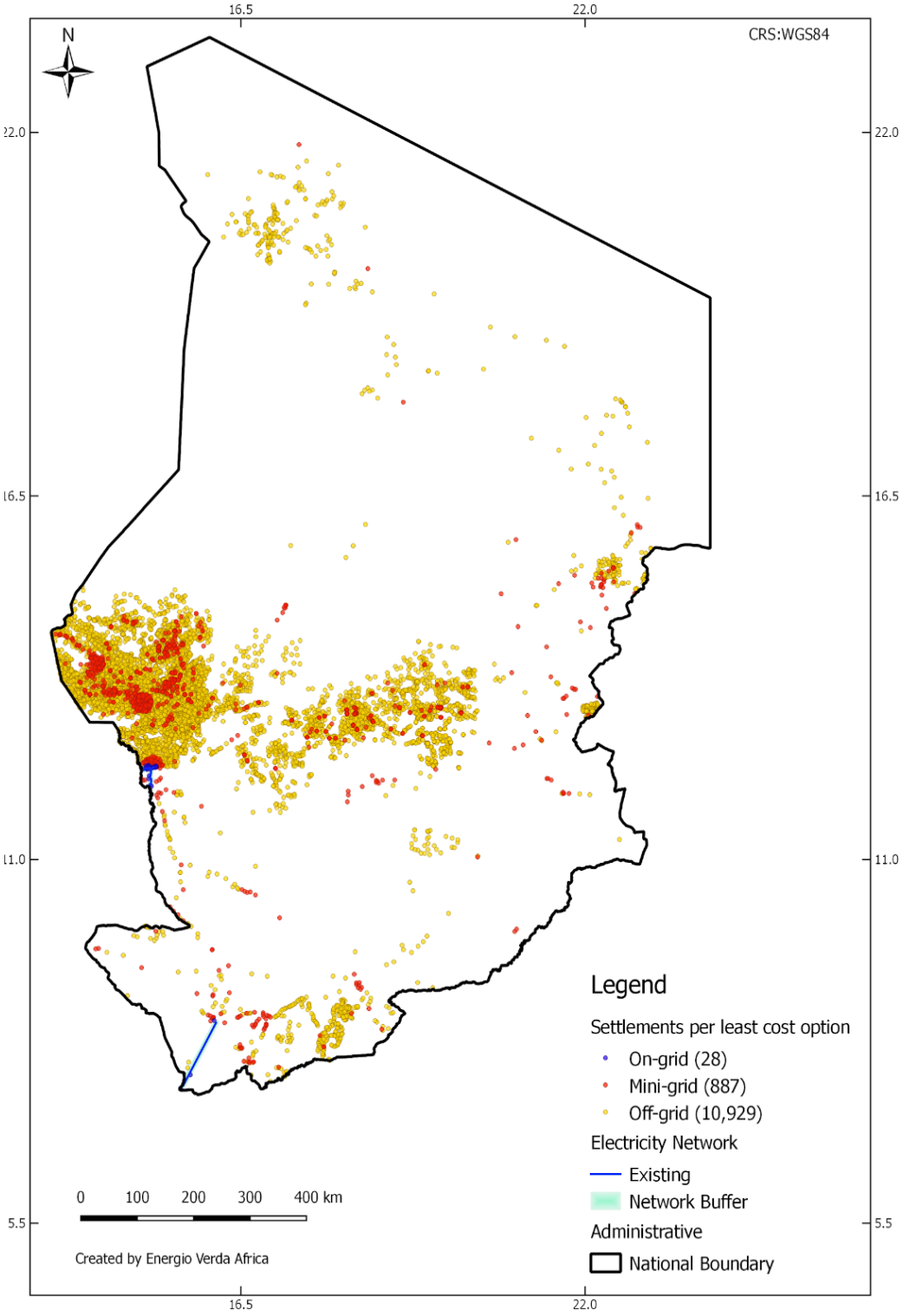
Table 4: Results of Least-Cost Electrification Analysis

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	28	887	10,929	0	28	11,816
	% of settlements	0.2%	7.5%	92.3%	0.0%	0.2%	99.8%
	Total population	1,852,460	4,553,512	9,655,335	0	1,852,460	14,208,847
	% of population	11.5%	28.4%	60.1%	0.0%	11.5%	88.5%
	Number of households	319,390	785,088	1,664,713	-	319,390	2,449,801
Scenario 2030	Number of settlements	119	1,590	10,135	Not calculated	119	11,725
	% of settlements	1.0%	13.4%	85.6%	Not calculated	1.0%	99.0%
	Total population	3,208,237	5,929,644	10,615,500	Not calculated	3,208,237	16,545,145
	% of population	16.2%	30.0%	53.7%	Not calculated	16.2%	83.8%
	Number of households	553,144	1,022,352	1,830,259	Not calculated	553,144	2,852,611

Source: Energio Verda Africa GIS analysis

[54] "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

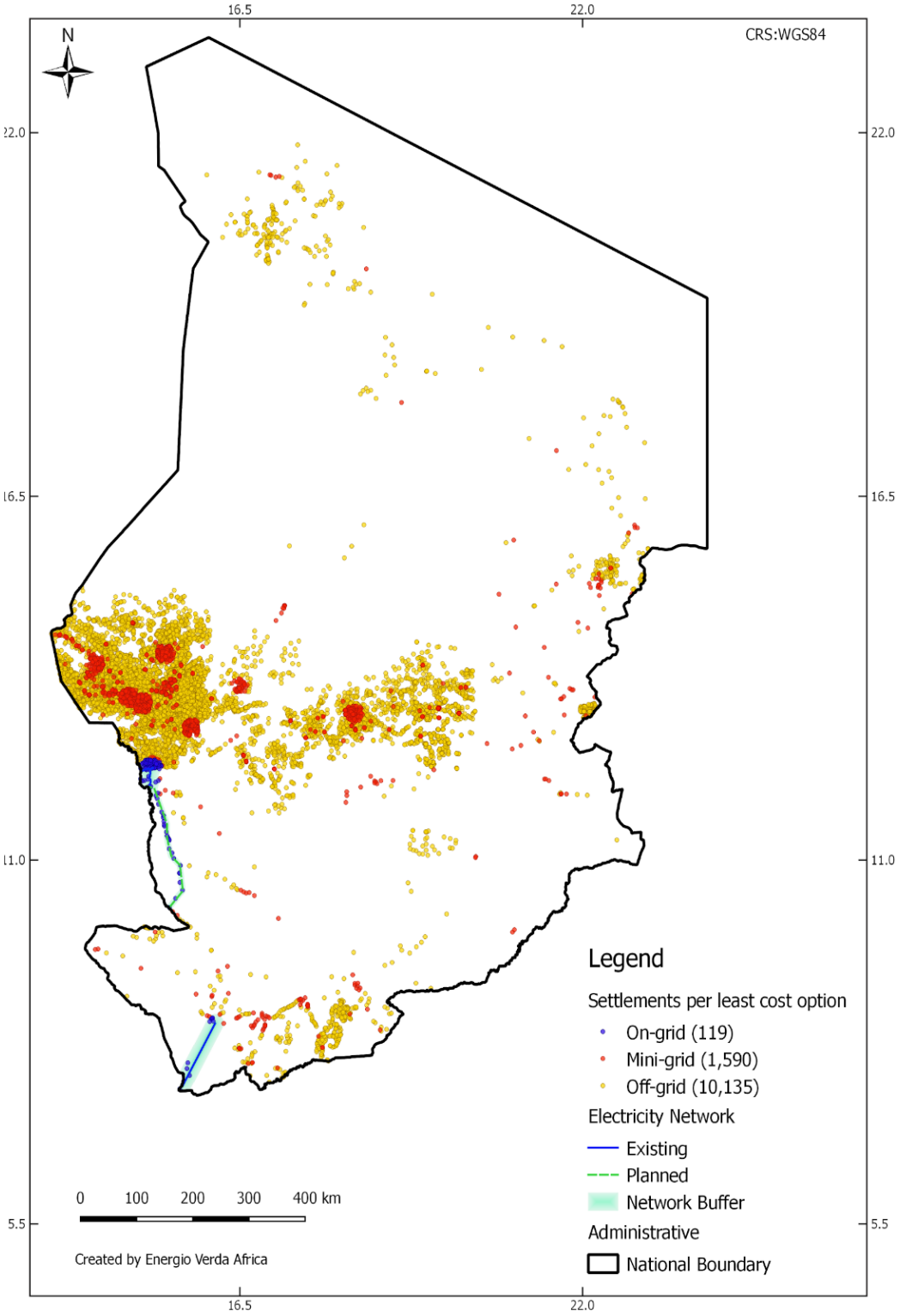
Figure 5: Distribution of Settlements by Least-Cost Electrification Option, 2023[55]



Source: Energio Verda Africa GIS analysis

[55] 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 [56]



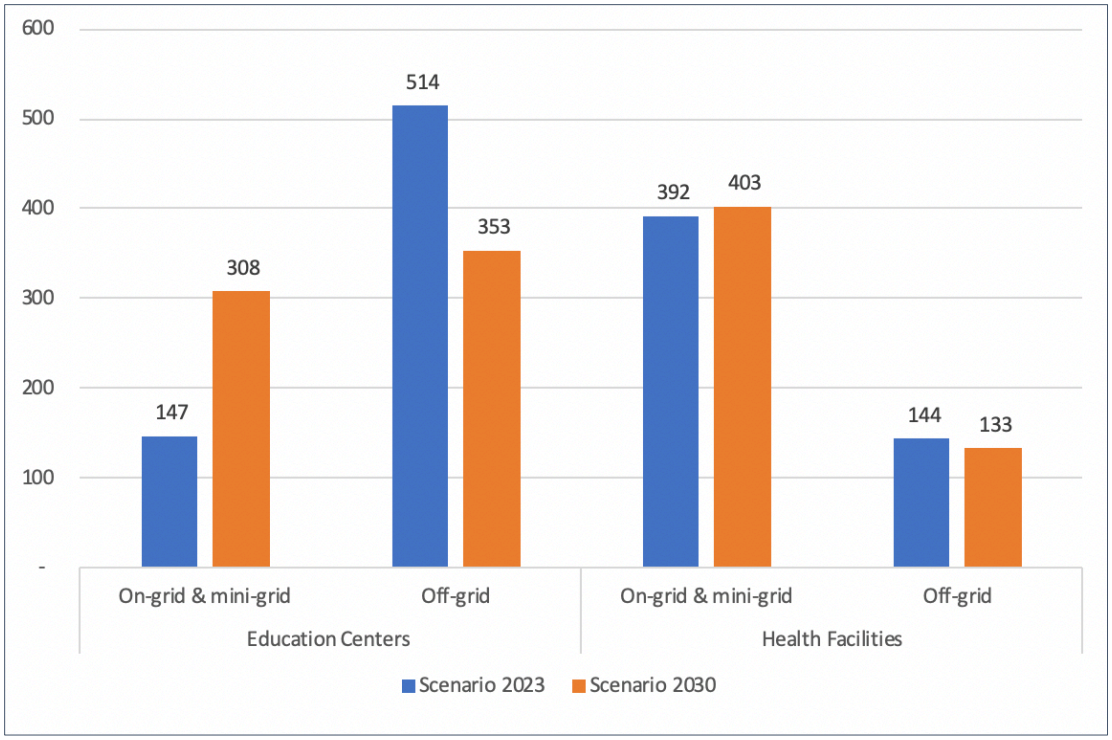
Source: Energio Verda Africa GIS analysis

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

The analysis also covered the education centers and health facilities that will remain off-grid during the analyzed timeframes. The number of education centers (661) and health facilities (536) that were analyzed cannot be seen as comprehensive as not all were available for the geospatial analysis (institutions with known coordinates).

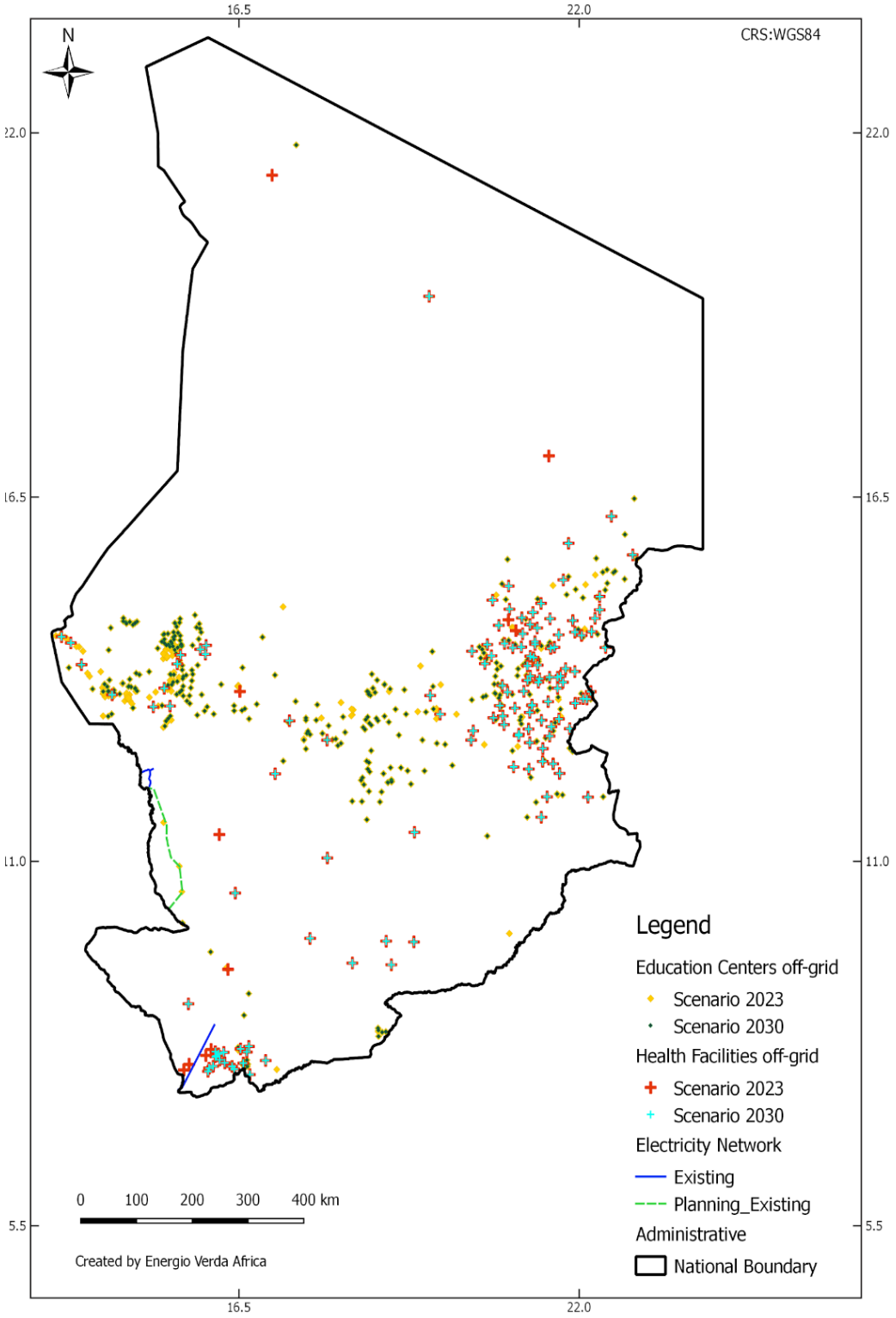
Figure 7 summarizes the number of education centers and health facilities that may be electrified (on-grid and mini-grid) or suitable for off-grid stand-alone solutions in scenarios 2023 and 2030. **Figure 8** illustrates the distribution of potential off-grid facilities across the country under the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

Figure 7: Identified Social Facilities 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[57]



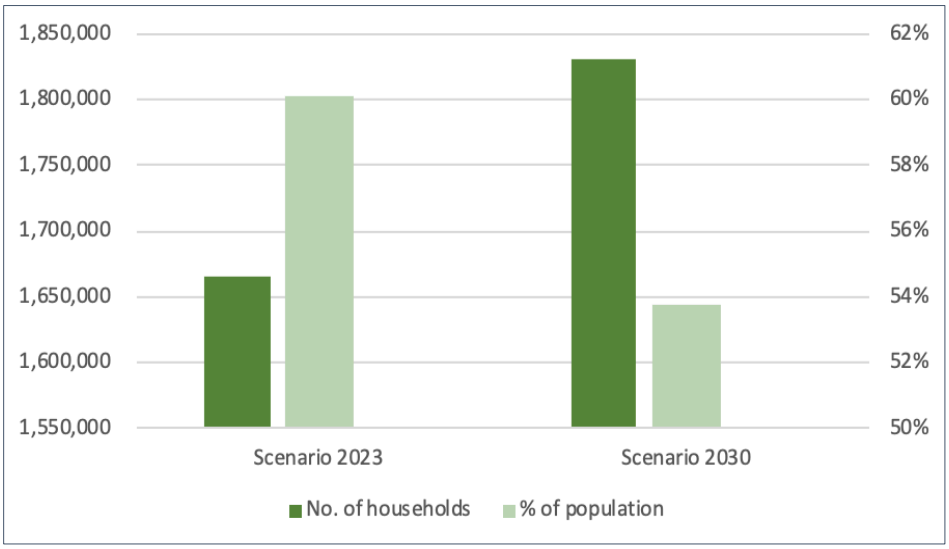
Source: Energio Verda Africa GIS analysis

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

According to the geospatial analysis (**Table 4**), by 2023, 28 settlements across Chad (319,390 households) will be connected to the main grid, representing 11.5% of the population. By 2030, this figure will increase to 119 settlements (553,144 households), equivalent to 16.2% 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).

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 887 settlements (785,088 households), or 28.4% of the population, increasing to 1,590 settlements (1,022,352 households), or 30.0% 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. The analysis identified 10,929 settlements (1,664,713 households) and 60.1% of the population as suitable for stand-alone solutions in 2023. By 2030, while the number of settlements decreases to 10,135, the number of households increases to 1,830,259 households, representing 53.7% of the population in that year.

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 and estimates that over 1.6 million households in 2023 could be suitable for off-grid stand-alone solutions (**figure 9**). The findings of the least-cost analysis suggest that the Government may need to consider increasing the utilization of off-grid solutions (especially 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.

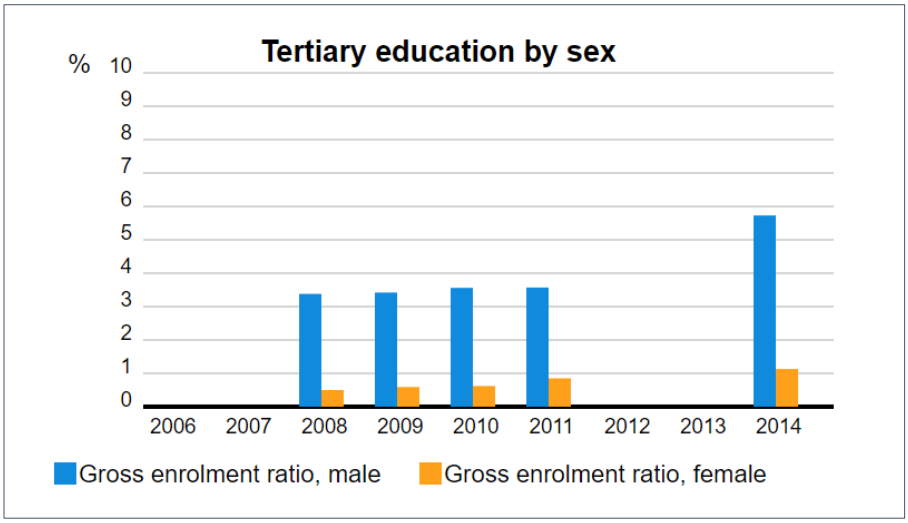
1.2.2.5 Inclusive Participation[58]

Inclusive participation in Chad 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. Chad performs poorly in the UNDP Gender

[58] See **Annex 4** for more details

Inequality Index, which measures several indicators to assess levels of gender inequality in the areas of health, access to education, economic status and empowerment.[59] Female participation in education, particularly higher education, remains disproportionately low (**Figure 10**).[60] While gender discrimination is widespread, these issues tend to be more pronounced in rural areas of the country.

Figure 10: Rates of Enrollment in Tertiary Education



Source: UNESCO Institute for Statistics

The Government has adopted several policies and action plans to promote gender equality. Chad signed the Protocol to the African Charter on Human and Peoples' Rights on the Rights of Women in Africa and ratified the Convention on the Elimination of All Forms of Discrimination against Women. The GoC published a National Gender Policy in 2011 that set ambitious objectives but ended up experiencing delays in implementation. The general coordination of interventions in gender is carried out by the Ministry of Planning, Economy and International cooperation in close collaboration with the Ministry of Social Action, Family and National Solidarity (Ministère de l'Action Sociale, de la Solidarité Nationale et de la Famille). Notably, the country lacks a dedicated ministry in charge of developing and implementing gender policies.

1.2.3 Key Challenges

Some of the key energy sector challenges facing Chad 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 Costs**: The average price of electricity for consumers (USD 0.16/kWh) does not reflect the cost of production.[61] The country's high electricity costs and chronic power outages discourage investment and hinder economic growth.

[59] "Gender Inequality Index," UNDP, (2015): http://hdr.undp.org/en/composite/GII
[60] "Chad Participation in Education," UNESCO Institute for Statistics, (2018): http://uis.unesco.org/en/country/bf?theme=education-and-literacy
[61] Akitoby, B., Coorey, S., "Oil Wealth in Central Africa: Policies for Inclusive Growth," International Monetary Fund, 2012.

- **Utility Financial Performance:** SNE relies heavily on state subsidies and donor funding to conduct its operations as it does not generate enough revenue to invest sufficiently in network extensions or in the maintenance of grid infrastructure. The utility's poor financial performance deters private investment/IPPs from entering the country's energy sector.

- **Electricity Access:** Energy access is a huge challenge for Chad. With a rural electrification rate of only 1% and a large majority of the population still living in rural areas, the IEA estimates that some 13 million people are without access.[62] The grid is limited to the country's capital, where most of electricity demand is located. Extending the grid to other regions in the country may prove to be cost-prohibitive, particularly given the current state of affairs of the electricity sector. It should thus become a key policy priority for the GoC to harness off-grid solar solutions to increase electrification in rural areas.

- **Local Financial Institutions:**[63] 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.[64]

- **Other Challenges:** Successful development of the off-grid sector will require more than just a financial support mechanism – the Government 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.

[62] IEA, 2017.
[63] The role of FIs is examined in further detail in **Section 3**.
[64] 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

Chad's "Policy and Strategy Letter for the Electricity Subsector" (2002-2006) was a policy document whose main objective was to meet the country's electricity needs at the least possible cost before 2006. This strategy document also aimed to promote renewable energy, particularly solar and wind, as means to curtail the negative environmental impacts of traditional biomass usage.

In 2012, the GoC adopted an Energy Master Plan,[65] followed by a gap analysis of the plan in 2016,[66] but still has not fully implemented a national electrification policy. The Master Plan provides an overview of Chad's major energy deficit, highlights the necessity to create a common energy fund, and notably includes recommendations for the use of decentralized electrification solutions. Small off-grid systems are considered to be the most appropriate for rural areas and towns, as detailed in the Government's strategy:

- Solar home systems targeting most households, as 90% of them use kerosene/oil lamps, spend 10% of their income on energy (EUR 10-30/month);
- Hybrid diesel/PV for villages and small towns for water pumping, household lighting, public and private productive use; and
- A grid-connected solar PV plant (maximum capacity of 8 MW and up to 20 MW after the commissioning of Farcha thermal power plant) for the capital N'Djamena.

Chad's renewable energy agency, ADER, is developing a Renewable Energy Strategy under its 2017-2030 Action Plan,[67] while the Renewable Energy Master Plan (Schéma Directeur pour les Énergies Renouvelables, SDEnR) is currently under development.[68] The SDEnR has been developed with the help of the EU, under the 2013 AMCC-Chad Climate Change Mitigation Financing Agreement. The Master Plan intends to:

- Provide supply-demand projections based on extensive socio-demographic data collection; and
- Provide a detailed overview of large-scale RE deployment for each region of Chad, with a corresponding investment plan (estimated at EUR 416 million). In this RE investment plan, the SDEnR will include specific provisions for the large-scale deployment of off-grid solar technologies in 10 regions (Hadjer Lamis and N'Djamena for the pilot phase). The program has a target to supply 555,836 solar kits /solar home systems, 968 PV-B mini-grids, and 79 PV and hybrid solar plants.[69]

1.3.2 Integrated National Electrification Plan

A fully integrated national electrification plan currently does not exist in Chad. The Renewable Energy Master Plan (SDEnR) also intends to lay the basis for the development of Chad Rural Electrification Plan by the MER, which would be the operational document implementing the SDEnR.

[65] "Schéma Directeur de l'Énergie au Tchad, UE, Ministère de l'Énergie et du Pétrole," Ministère de l'Économie et du Plan, 2012
[66] "Rapid Gap Analysis of Chad, Rapport du Tchad," SEforALL, (2016): https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Country_RAGAs/Chad_RAGA_FR_Released.pdf
[67] "Plan général d'action de l'ADER 2017-2030," ADER-Tchad, 2017
[68] "Projet Adaptation aux Effets du Changement Climatique et Développement des Énergies Renouvelables: Termes de référence pour l'atelier de validation du Schéma Directeur pour les Énergies Renouvelables (SDEnR) au Chad," EU AMCC in Chad and the Ministry of Environment, Water and Fisheries, (2018): http://amcc.tchadenvironnement.org/wp-content/uploads/2018/07/TDR_validation_SDEnR_vubob.pdf
[69] "Schéma Directeur des Énergies Renouvelables : Résumé des Phases A et B, " EU AMCC in Chad, (2017): http://amcc.tchadenvironnement.org/energies-renouvelables/calcul-de-facteur-demission-de-co2

1.3.3 Energy and Electricity Law

The electricity legislative framework in Chad has been limited, but was significantly updated in 2017, including special provisions for the creation of an "off-grid solar kit-market":

- Electricity Act No. 014/PR/99 (1999) establishes the regulatory authority and intends to organize the liberalization of the production, transmission and distribution segments (this still has not happened as SNE operates as a vertically integrated monopoly).[70]
- Ordinance No.009/PR/2013 (2013) and its Implementing Decree 1607/PM/MPME/2014 (2014)[71] on the creation the RE agency ADER, whose mandate is to: (i) develop national/sectorial/regional RE Plans, (ii) mobilize funding, (iii) execute RE projects, (iv) develop labels and standard norms.
- Decree No.004/PR/PM/MPECPER/2017 (2017) for a more effective application of RE mandates and the institutional restructuring of the Ministry of Energy and Petroleum, which became the Ministry of Petroleum, Energy and Renewable Energy. The decree facilitates: (i) the creation of the Department for Energy and Renewable Energy (DGEER) in charge of elaborating and implementing the National Energy Policy, (ii) the DGEER itself is composed of two new sub-departments: The Electricity and Energy Plan Department and the Renewable Energy Department. The first department focuses on the development of a rural electrification policy and rural electrification program, with the creation of an off-grid solar kit-market, while the second department seeks to promote all types of RE especially with regards to clean and efficient energy for domestic use.

1.3.4 Framework for Stand-alone Systems

Figure 11 is an overview of the key national policies, programs, laws and regulations pertaining to Chad's framework for stand-alone systems. The gaps in this framework are addressed in **Section 1.3.5** below.

To date, the Government's efforts to establish a supportive policy and regulatory framework for the off-grid sector have been limited, as evidenced by the country's relatively low energy access score in the World Bank Regulatory Indicators for Sustainable Energy (RISE) evaluation. In 2017, Chad ranked last in West Africa and the Sahel and was among the lowest scoring countries in the world (**Figure 12**).

[70] "Chad Energy Profile," UNEP, (2015): http://wedocs.unep.org/bitstream/handle/20.500.11822/20496/Energy_profile_Chad.pdf?sequence=1&isAllowed=y

[71] "Plan général d'action de l'ADER 2017-2030," ADER-Tchad, 2017

Figure 11: Policy and Regulatory Framework for Stand-alone Systems

	CHAD		World Bank RISE 2017 Energy Access Score: 13 World Bank RISE 2015 Energy Access Score: 14
Policy/Regulatory Support and Financial Incentives	**Specific national policies, laws and programs**		
	National electrification policy with off-grid provisions	x	
	Integrated national electrification plan	x	
	Energy/electricity law with off-grid provisions	[ ]	2017 Decree
	National programs promoting off-grid market development	[ ]	Strategie Nationale pour la Promotion des Energies Nouvelles et Renouvelables au Tchad
	Specific target for rural electrification	√	Universal access by 2030
	Financial incentives		
	Subsidies, tax exemptions or related incentives for solar equipment/stand-alone systems	√	Customs duty exemptions for solar projects
	Standards and quality		
	Government-adopted international quality standards for stand-alone systems	x	
	Government-certified program for solar equipment installers	x	
	Consumer awareness/education programs	x	
	Concession Contracts and Schemes	x	
	Business Model Regulation	x	

√ = 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

1.3.4.1 Existence of Specific National Programs

In the off-grid sector, Chad's Renewable Energy Agency (ADER) has prioritized grid connections for rural households, while the Renewable Energy Master Plan – National Strategy for the Promotion of New and Renewable Energies in Chad (Strategie Nationale pour la Promotion des Energies Nouvelles et Renouvelables au Tchad) – includes provisions for off-grid solar development. The regulatory framework is still undergoing further review.

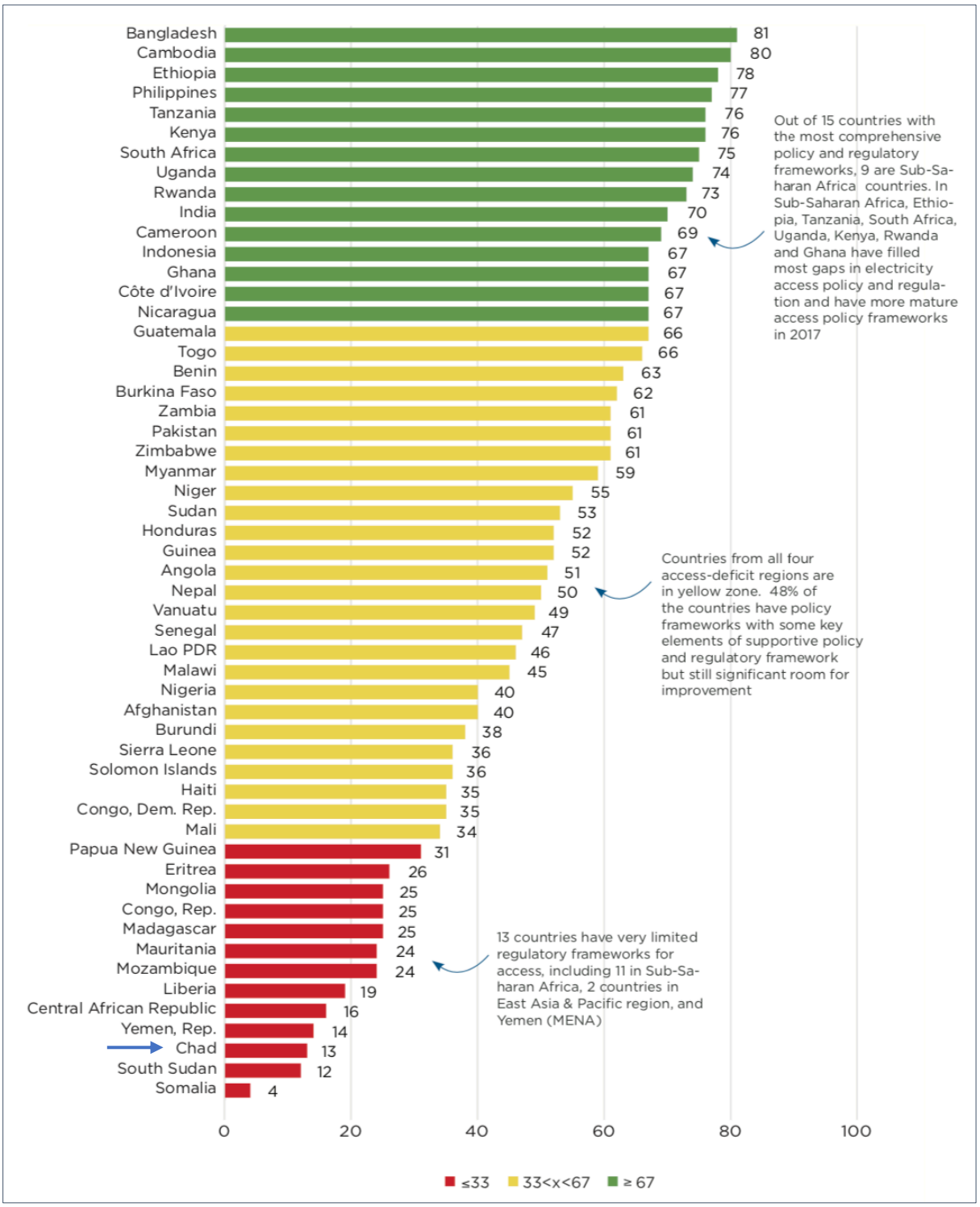
1.3.4.2 Financial Incentives

There are currently few financial incentives in place in Chad to promote off-grid market development. The Renewable Energy Master Plan includes provisions to establish a fund as part of its mandate, but this plan is not yet operational. In addition, the government applies a tax duty exemption for donor financed solar PV projects.

1.3.4.3 Standards and Quality

For the quality of off-grid solar products and systems to meet the expectations of end-users, a set of standards need to be in place to ensure equipment is reliable, adequately covered by warranties and post-sale O&M. However, there are currently no government-adopted technical standards for solar equipment (e.g. IEC-compliant) and/or for the certification of RE installations in Chad.

Figure 12: Distribution of RISE Electricity Access Scores in Access-Deficit Countries, 2017[72]



Source: World Bank Regulatory Indicators for Sustainable Energy

[72] "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

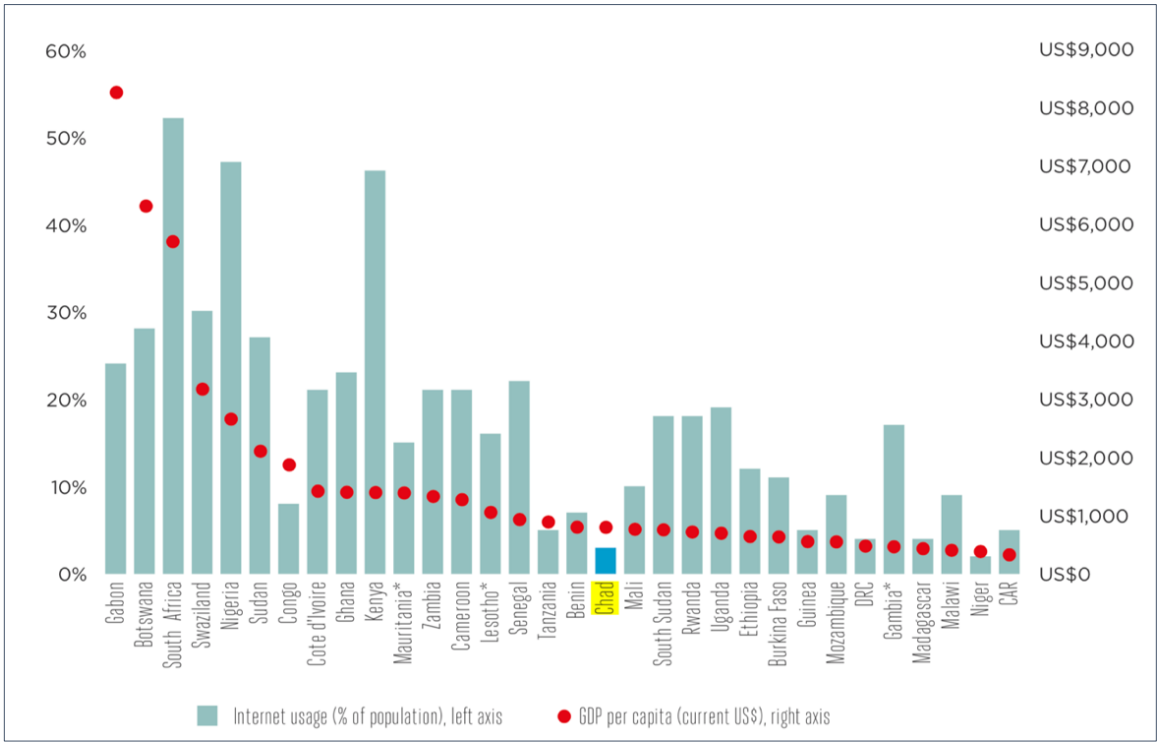
1.3.4.4 Concession Contracts and Schemes

Similarly, Chad lacks an elaborate framework to support off-grid market entrepreneurs. A more comprehensive concession framework is needed to support development of a stand-alone solar market and increase rural electrification.

1.3.4.5 Specific Business Model Regulation

No specific business model regulations exist for the off-grid sector in Chad. As was demonstrated in East Africa in recent years, the proliferation of mobile money platforms can rapidly facilitate energy access. There is an opportunity for the Government to bring together key stakeholders (solar suppliers, technology providers, telecommunications companies etc.) to support development of Pay-As-You-Go (PAYG) business models in the off-grid sector by taking advantage of the country's high rates of phone ownership in rural areas (**Figure 13**). In order to achieve this, however, the GoC must first reform its taxation policy of the mobile sector, which has drastically limited the use of mobile services in Chad. Mobile penetration in Chad lags behind many other African countries; mobile broadband networks are still in their infancy, with 3G penetration only around 2%, and internet usage is the lowest among countries with comparable GDP per capita (**Figure 14**).[73]

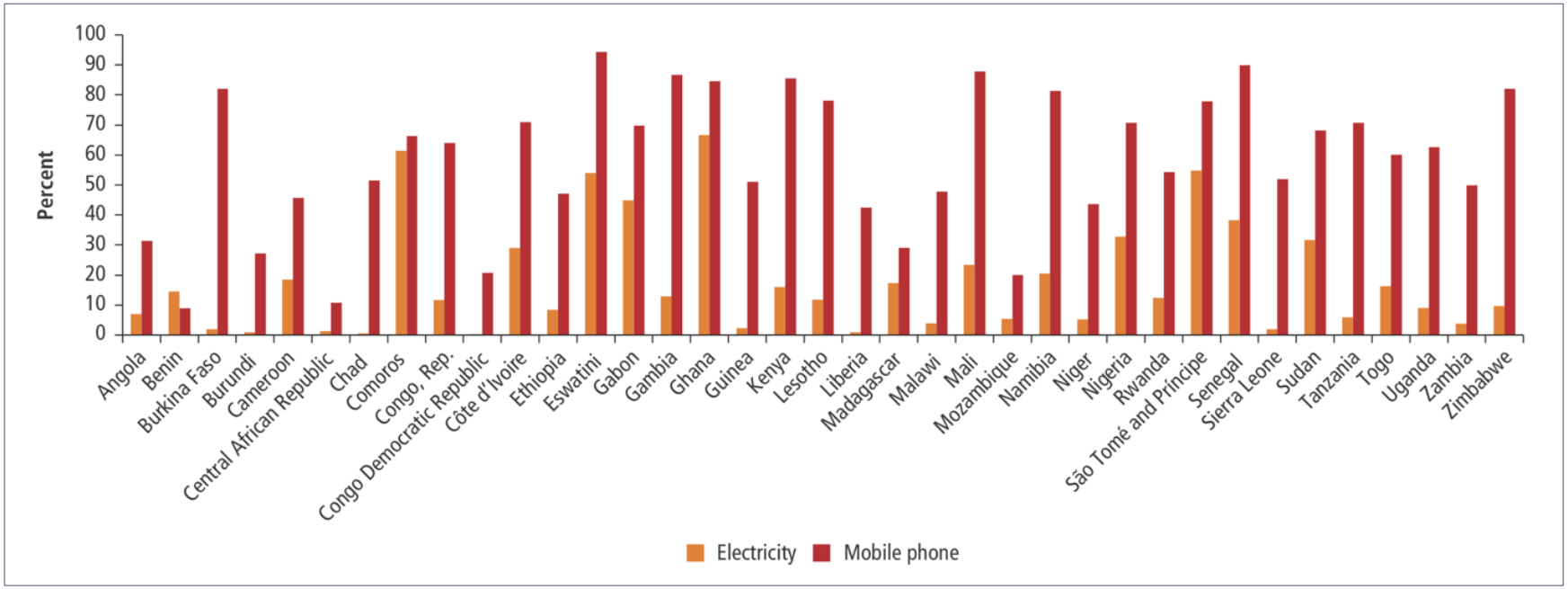
Figure 13: Internet Usage and GDP Per Capita in Selected African Countries, 2015



Source: Deloitte and GSMA

[73] "Digital Inclusion and Mobile Sector Taxation in Chad," Deloitte and GSMA, (November 2016): https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/01/Digital-Inclusion-and-Mobile-Sector-Taxation-in-Chad_English_report.pdf

Figure 14: Electricity Access and Mobile Phone Ownership in Sub-Saharan Africa, 2016 (% of rural households)[74]



Source: World Bank

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

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 ADER and the electricity market regulator, Electric Energy Authority (EEA), 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 5** below identifies some of the policy/regulatory challenges facing off-grid market development in Chad and the proposed mitigation measures/TA interventions to overcome these gaps.

Table 5: Gaps in the Off-Grid Policy and Regulatory Framework[75]

Indicator	Policy/Regulatory/Market Gaps	Recommended TA Intervention
1. Specific National Policies, Laws and Programs	**A. Lack of National Electricity / Electrification Policy**	
	a. No policy exists for rural electrification	a. Help Government establish a clear Rural Electrification Policy which encourages least cost, integrated planning for all options
	b. Main focus of policy is on national grid extension only	b. 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
	c. Government is subsidizing fossil fuel electricity production	c. Help Government analyze where fossil fuel subsidies serve as an impediment to development of safe, clean energy access alternatives (SNE currently relies heavily on government subsidies)
	B. Lack of Integrated National Electrification Plan	
	a. No integrated plan exists	a. Help Government develop a comprehensive, least cost, integrated plan for all rural electrification options (grid, mini-grid and off-grid) with clear and consistent targets and policies
	b. Insufficient focus on or understanding of framework to support private sector participation	b. Help Government develop a 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

[75] "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 Chad (**Table 2**), including the Ministry of Energy and Petroleum (MEP), the General Directorate of Energy and Renewable Energy (DGEER), the Renewable Energy Development Agency (ADER), the Electric Energy Authority (EEA), and the national utility, SNE, among other national and local authorities.

	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 / electricity market liberalization)
	D. Lack of 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 off-grid framework to create appropriate incentives for private sector participation
2. Financial Incentives (import duties, taxes, etc.)	**A. Insufficiently supportive financial incentives / tax regime**	a. Help Government develop appropriate VAT and tariff policies covering the entire off-grid / stand-alone solar product supply chain (including batteries, inverters or other system components) that would provide necessary support to the industry[76] 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 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 (e.g. through ADER) responsible for collaborating with the private sector to compile and regularly update a database of critical off-grid market data (including inter alia solar product imports, costs, sales volumes, resource potential etc., GIS data and other key demographic and socioeconomic indicators) that can be (i) utilized by policymakers to make informed electrification planning decisions based on accurate/updated market information, and (ii) made easily accessible to interested off-grid developers, investors and other key industry stakeholders

[76] Solar projects in Chad are exempt from customs duties

	B. Unclear / lack of quality standards	a. Help Government establish international quality standards for off-grid stand-alone solar products, including minimum technical standards (IEC Technical Specifications), warranties, required availability of and cost guidelines for post-sale services/O&M, etc. b. Help Government integrate standards with appropriate oversight agencies to ensure quality-verification procedures are in place c. Help Government implement a legal framework that provides protections for consumers and suppliers, including *inter alia* regulations that (i) require licensing for the sale and installation of solar equipment; (ii) prohibit the sale of certain brands or models; and (iii) enable companies or public authorities to prosecute those caught distributing counterfeit / inferior products that are not up to promulgated standards
	C. 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/O&M of stand-alone solar systems b. Support development of database of best practices / information sharing services to ensure skills transfer from international, local and regional initiatives (e.g. through ADER)
	D. 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
	E. Insufficient public awareness	a. Support Government, trade associations and civic society organizations to develop and implement consumer awareness/marketing/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 solar products vs. counterfeit products
4. Concession Contracts and Schemes	**A. Lack of clear and transparent licensing and permitting procedures** a. Unclear procedures b. Insufficient communication and streamlining	a. Help Government develop clear licensing and permitting procedures b. Help Government develop systems for sharing and disseminating information to project developers and key stakeholders, including establishment of a "one-stop-shop" for national level permits and approvals of local permits
	B. Lack of experience/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[77]
	b. Need for understanding of emerging models for 'Integrated Private Utilities' or 'Energy Companies of the Future'	b. Help Government to understand and develop approaches to facilitate pilots of 'Integrated Private Utility' or 'Energy Company of the Future' schemes.[78]
	c. Public procurement or public finance/budget 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[79]
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 non-Government stakeholders about different pricing schemes[80] offered by stand-alone solar system providers to improve understanding and help avoid unnecessary interventions to regulate. b. Support regulators and off-grid enterprises to collaborate specifically on developing pricing schemes for productive use market segment[81] c. Support off-grid entrepreneurs and telecommunications companies in building the capacity of and fostering linkages between telecommunications companies / mobile money providers and off-grid solar companies to help roll out technology platforms and PAYG business models

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

[77] 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.

[78] 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.

[79] 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.

[80] 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.

[81] 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 where TA support is much needed to help all stakeholders sort out fair and practical approaches.

1.4 Development Initiatives

1.4.1 National Government Initiatives

The GoC's most relevant national off-grid development initiative to date is the above-mentioned National Strategy for the Promotion of New and Renewable Energies currently under development.[82] Separately, the GoC is also working to improve the financial position of the country's electricity sector in order to make funds available for much-needed grid maintenance and further extension/electrification. One way it is doing this is with the support of the Economic Community of Central African States (CEMAC) Energy Facility, which is financed by the European Union. Through the facility, the Government seeks to undertake intensive peri-urban electrification with a goal of adding 12,500 new electricity connections.

1.4.2 DFI and Donor Programs

Development Finance Institution (DFI) and donor-funded programs and initiatives supporting development of the off-grid sector in Chad are summarized in **Table 6**.

Table 6: DFI and Donor Funded Off-Grid Development Programs

Project/Program	Sponsor / Funding Source	Market Segment(s)	Description
Cameroon-Chad Power Grids Interconnection Project, N'Djamena, Moundou and Sarh Peri-urban Electrification and Power Network Modernization Project	African Development Bank (AfDB)	Grid extension, rural electrification	• In keeping with its energy development strategy, the African Development Bank is supporting regional cooperation by financing the Cameroon-Chad Power Grids Interconnection Project. • Likewise, the N'Djamena, Moundou and Sarh Peri-urban Electrification and Power Network Modernization Project will enable the populations to have enhanced access to power services. • These two projects are aimed at connecting 50,000 households in three major Chadian cities to the power grid, a number expected to increase from the current 50,000 to more than 100,000 in 2020;
UNIDO – Promoting Renewable Energy Based Mini-Grid for Rural Electrification and Productive Uses[83]	UNIDO	Rural electrification, solar PV, mini-grids	• UNIDO operations in Chad include financing rural solar PV electrification, mainly through mini-grids • The following municipalities have benefited from public lighting under the program: Baikoro, Donia, Larmanaye and Mbikou. • Four mini hybrid power plants are under construction in the cities of Moussoro, Adré, Bokoro and Bitkine.
Power Africa	US OPIC	Off-grid solar	• Through the Power Africa initiative, US OPIC has committed to providing USD 10 million to finance off-grid solar connections in Chad.[84] • Initial funding will be extended to FinLux Ellen SARL, which will distribute solar kits and appliances to schools, health centers, and off-grid businesses throughout the country.

[82] "Promotion des Énergies Nouvelles et Renouvelables au Tchad," UNDP: http://www.td.undp.org/content/dam/chad/docs/fiches_projets/UNDP_td_ENR.pdf
[83] "SPWA-CC: Promoting Renewable Energy Based Mini-grids for Rural Electrification and Productive Use Project," UNIDO, (May 2016): https://www.unido.org/sites/default/files/2016-05/Eval_report_GFCHD12001_FINAL_0.pdf
[84] "OPIC to contribute USD 10m for off-grid solar in Chad," Renewables Now, (March 12, 2019): https://renewablesnow.com/news/opic-to-contribute-usd-10m-for-off-grid-solar-in-chad-646110/

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 Chad's off-grid sector:

- **"Union des femmes pour la lutte contre la désertification au Sahel" (UFLCDS**): This is an NGO that provides awareness, training and support to women's in initiatives especially in the area of agriculture, water for drinking and irrigation by employing stand-alone solar kits and solutions e.g. extensive use of Solar water pumps, water purification systems, and food preservation.

- **PROMOSOL:** PROMOSOL is an NGO which promotes and provides off-grid solar products in Chemin Neuf Community, which is in the Village of Ku Jericho (South-West Chad).

II. OFF-GRID SOLAR PV MARKET ASSESSMENT

This section presents the overall market assessment for stand-alone off-grid solar (OGS) energy systems in Chad. **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 7** 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 7: Indicative Total Cash Market Potential for Off-Grid Solar PV Products in Chad, 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	485,534	1,457	$21,849,043	$0.00
Plug and play	145,575	1,456	$18,196,832	$21,408,037
Small SHS	83,234	4,162	$20,808,612	$48,553,429
Medium and Large SHS	0	0	$0.00	$106,612,026
Household Subtotal	**714,343**	**7,075**	**$60,854,487**	**$176,573,492**
Institutional				
Water supply	1,934	6,581	$16,452,750	-
Healthcare facilities	1,105	531	$1,326,450	-
Primary and secondary schools	623	403	$1,144,125	-
Public lighting	356	178	$533,925	-
Institutional Subtotal	**4,018**	**7,693**	**$19,457,250**	
Productive Use				
SME applications for microenterprises	202	51	$126,375	-
Value-added applications	47,013	8,381	$37,236,173	-
Connectivity / ICT (phone charging)	9,641	3,857	$8,310,940	-
Productive Use Subtotal	**56,856**	**12,289**	**$45,673,488**	
TOTAL	**775,217**	**27,057**	**$125,985,225**	

Source: African Solar Designs analysis

2.1 Demand – Households

This section analyzes the main characteristics of the household (HH) OGS demand in Chad. 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 2.3 million households (13.6 million people)[85] in Chad without access to electricity.[86] In that year, an estimated 9% of the population had access to electricity, with the rate of access at 32% in urban areas and 1% in rural areas.

This section gives an introduction to household consumer market segments, their characteristics and size (**Table 8**). 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.

[85] See Annex 2 for methodology regarding population without access to electricity.
[86] See **Annex 2** for more details.

Table 8: Household Consumer Market Segments[87]

Income Quintile	% w/o Access	# of HHs w/o Access	Avg. GDP per HH per year	Energy Tier	% w/o Access	# of HHs w/o Access	Avg. GDP per HH per year	Energy Tier	% w/o Access	# of HHs w/o Access	Avg. GDP per HH per year	Energy Tier	Geographic segments	Description
	2018 Scenario				2023 Scenario				2030 Scenario					
Highest 20%	81%	416,172	$11,653	Tier 3	1%	5,538	$8,927	Tier 3	1%	6,812	$5,806	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[88]
Fourth 20%	85%	436,724	$5,206	Tier 3	11%	58,582	$3,988	Tier 2	2%	13,623	$2,594	Tier 1.5	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%	462,414	$3,534	Tier 2	90%	498,454	$2,707	Tier 2	67%	454,333	$1,761	Tier 1.5		
Second 20%	99%	508,655	$2,316	Tier 2	99%	548,300	$1,774	Tier 1.5	99%	674,340	$1,154	Tier 1	Low income rural	• Engaged in farming, or SME • Lives more than 15km from the nearest grid connection.
Lowest 20%	100%	513,793	$1,170	Tiers 1,1.5	100%	553,838	$896	Tier 1	100%	681,151	$583	Tier 0		
Total Households without Access to Electricity		**2,337,758**			**Total**	**1,664,713**			**Total**	**1,830,259**				

Source: IEA and World Bank; African Solar Designs analysis

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

[88] 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**

Chad has a relatively high level of extreme poverty (households living below USD 1.90 a day). As shown in **Table 9**, the large majority of the country's households have a low income.

Table 9: Poverty Headcount in Chad

Poverty headcount ratio	% of population
Lives at or below $1.90 a day*	38.4%
Lives at or below $3.20 a day*	66.5%
Lives at or below $5.50 a day*	86.2%

*2011 PPP

Source: World Bank

The large majority of the population relies on agriculture and livestock herding as an important source of livelihood. The economy also relies on oil production, which has been depressed in recent years leading to economic contraction. In addition to these sectors, cotton and gum arabic are important sources of income for some households.

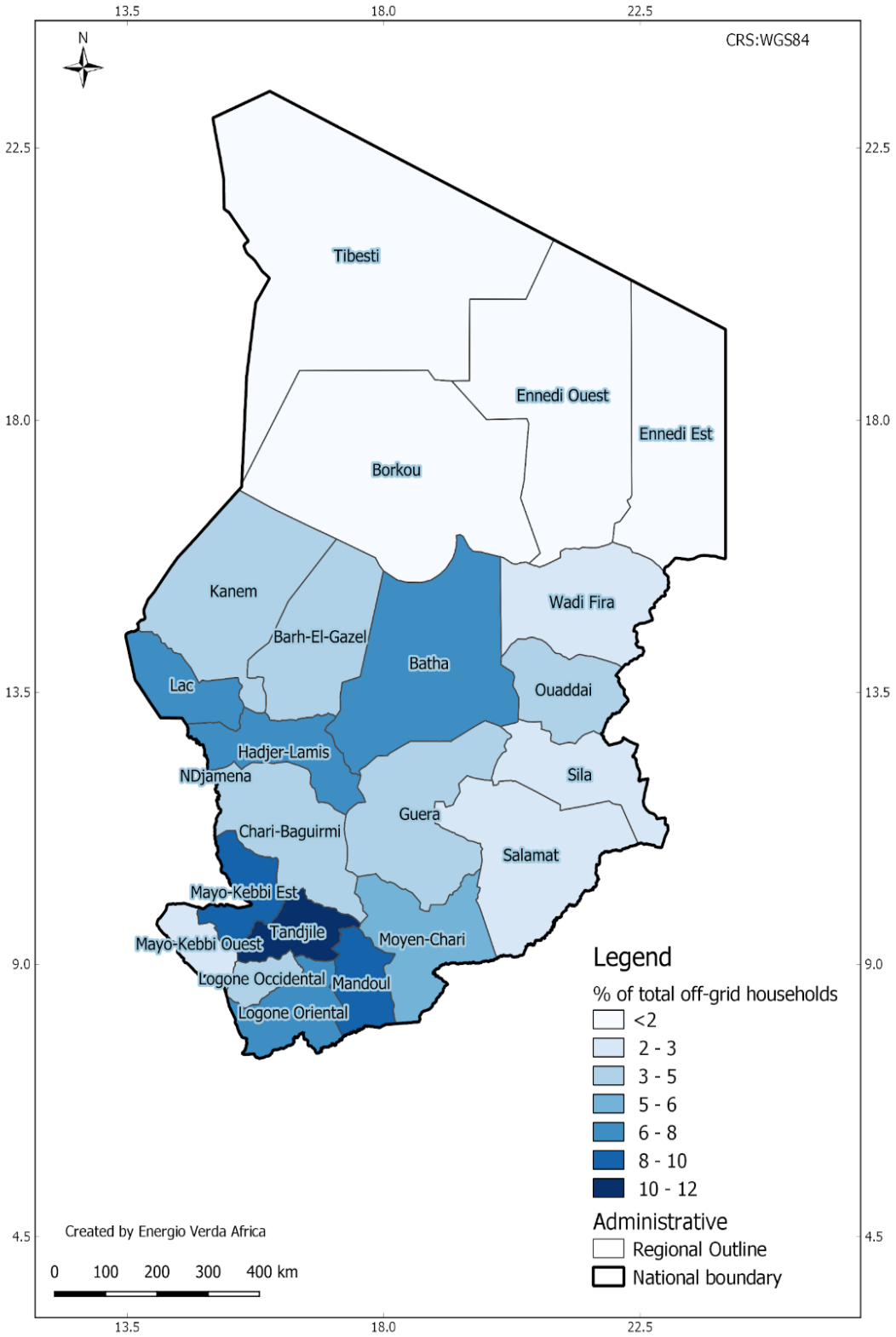
Off-grid households in Chad are mainly concentrated in the southwest part of the country around Lake Chad. In the northern Sahara Desert region, the population is much more dispersed. About 1.3 million people live in the capital, N'Djamena, out of a total population of 14.9 million people, while more than three-quarters of the population lives in rural areas (**Table 1**).

- **Geographic Components of the Solar Market**

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 15-18)** can be found in **Annex 1**.

GIS maps shown here are for 2018-2023 and 2030. Data shown for 2018-2023 includes information on existing grid lines only. As shown in the maps and chart summaries below **(Figures 15-18)**, the total size of the OGS market will decrease only slightly over time, with distribution of off-grid households across districts remaining much the same through 2030.

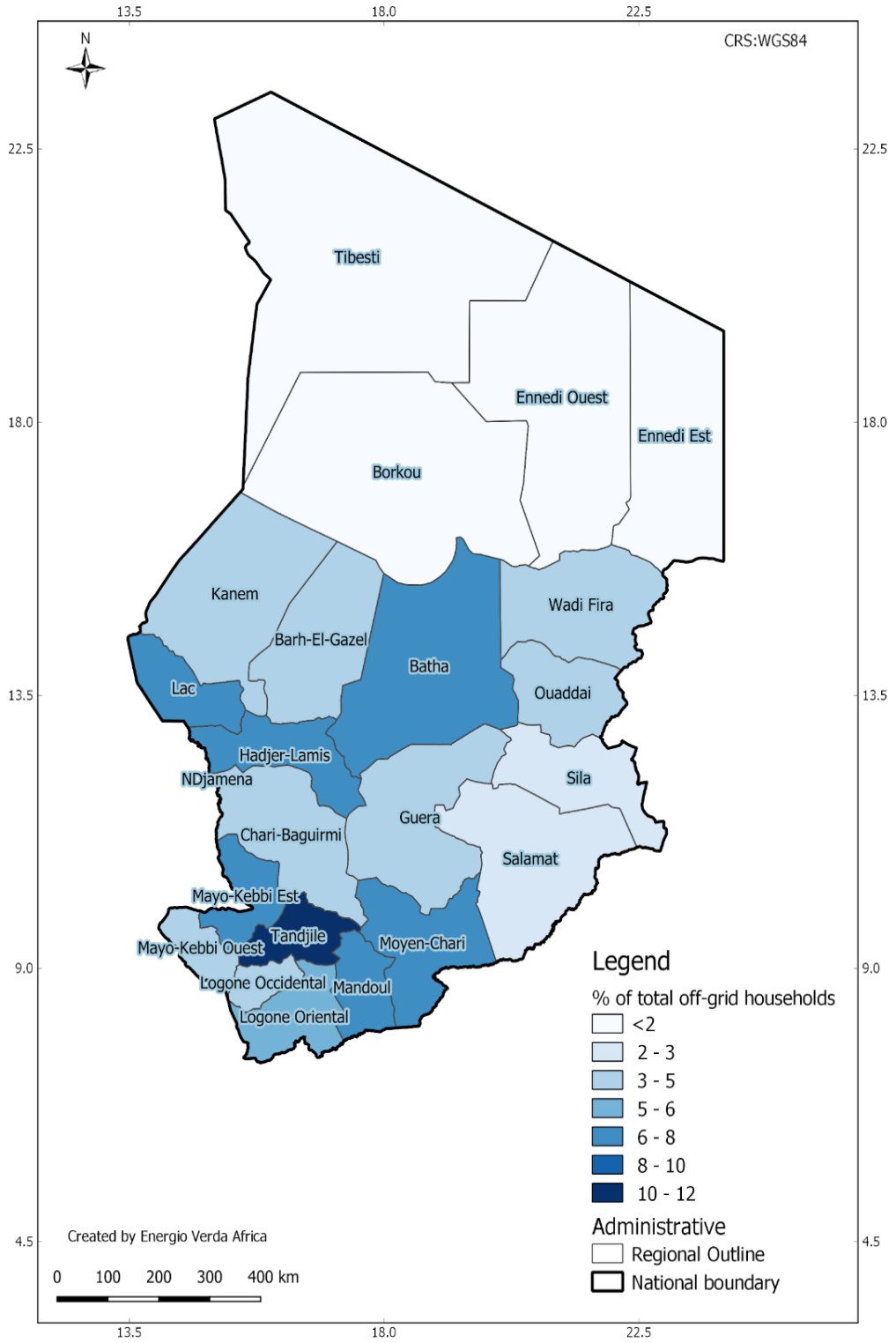
Figure 15: Distribution of Potential Off-Grid Households by Region, 2023[89]



Source: Energio Verda Africa GIS analysis

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

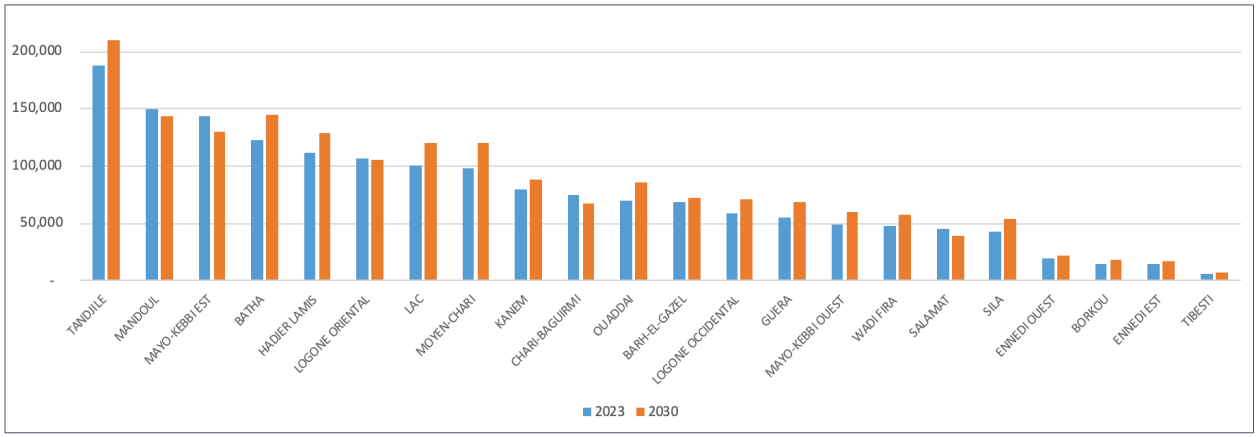
Figure 16: Distribution of Potential Off-Grid Households by Region, 2030[90]



Source: Energio Verda Africa GIS analysis

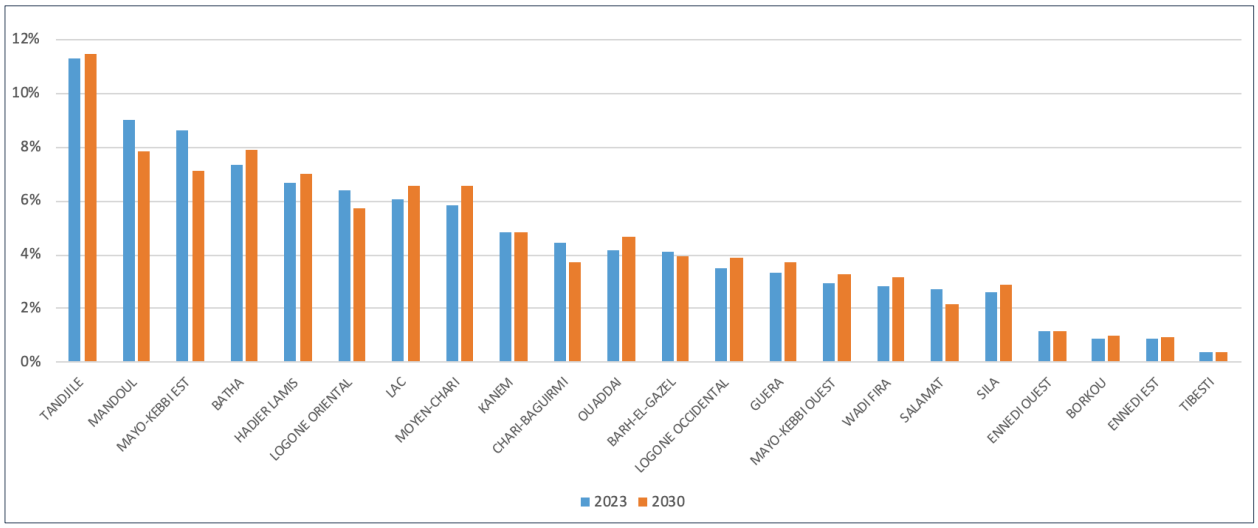
[90] See **Annex 1** for more details, including data sources.

Figure 17: Estimated Number of Off-Grid Households by Region, 2023 and 2030



Source: Energio Verda Africa GIS analysis

Figure 18: 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 analyzes several things:

- 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 at the end of this section 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, common sources of electricity used in off-grid rural households include gas, charcoal, firewood, animal waste and diesel generators. Typical household monthly energy expenditure is estimated to be USD 38-45, variable by season and region. The overall national mean energy expenditure for rural households is estimated at USD 2.5-4.2 per day. According to FGDs, typical household monthly energy expenditure is presented in **Table 10**:

Table 10: Typical Monthly Household Energy Expenditure

Energy use	Cost per month (USD)
Candle	1.0 to 4.5; depending on the size
Dry cell	2 to 10; depending on the size
Car battery	45 to 100
Kerosene	10
Diesel	~65
Phone charge	3 to 4

Table 11 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 12**. 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 19** and **Table 13**.

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 11: Rural Energy Technology and Costs[91]

Technology	Details	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	$0.16	$2.00	$2.56	$2.19	$2.80	$2.69	$3.44
Cell Phone Charging	Done at a charging station	-	8	$0.17	$0.00	$1.36	$0.00	$1.49	$0.00	$1.83
Smart Phone Charging	Done at a charging station	-	16	$0.17	$0.00	$2.72	$0.00	$2.97	$0.00	$3.66
Battery-powered DC Radio	Radio powered by dry cells replaced two times per month	-	8	$0.16	$0.00	$1.28	$0.00	$1.40	$0.00	$1.72
Lead Acid Battery-powered DC TV	DC TV powered by lead acid battery recharged once per week	2	4	$0.90	$50.00	$3.60	$54.64	$3.93	$67.20	$4.84
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	$0.90	$100.00	$27.00	$109.30	$29.50	$134.39	$36.29

Source: African Solar Designs analysis

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

Table 12: 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	$3.92	$4.28	$5.27
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	$7.76	$8.48	$10.43
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	$15.36	$16.78	$20.64
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	$27.00	$29.50	$36.29

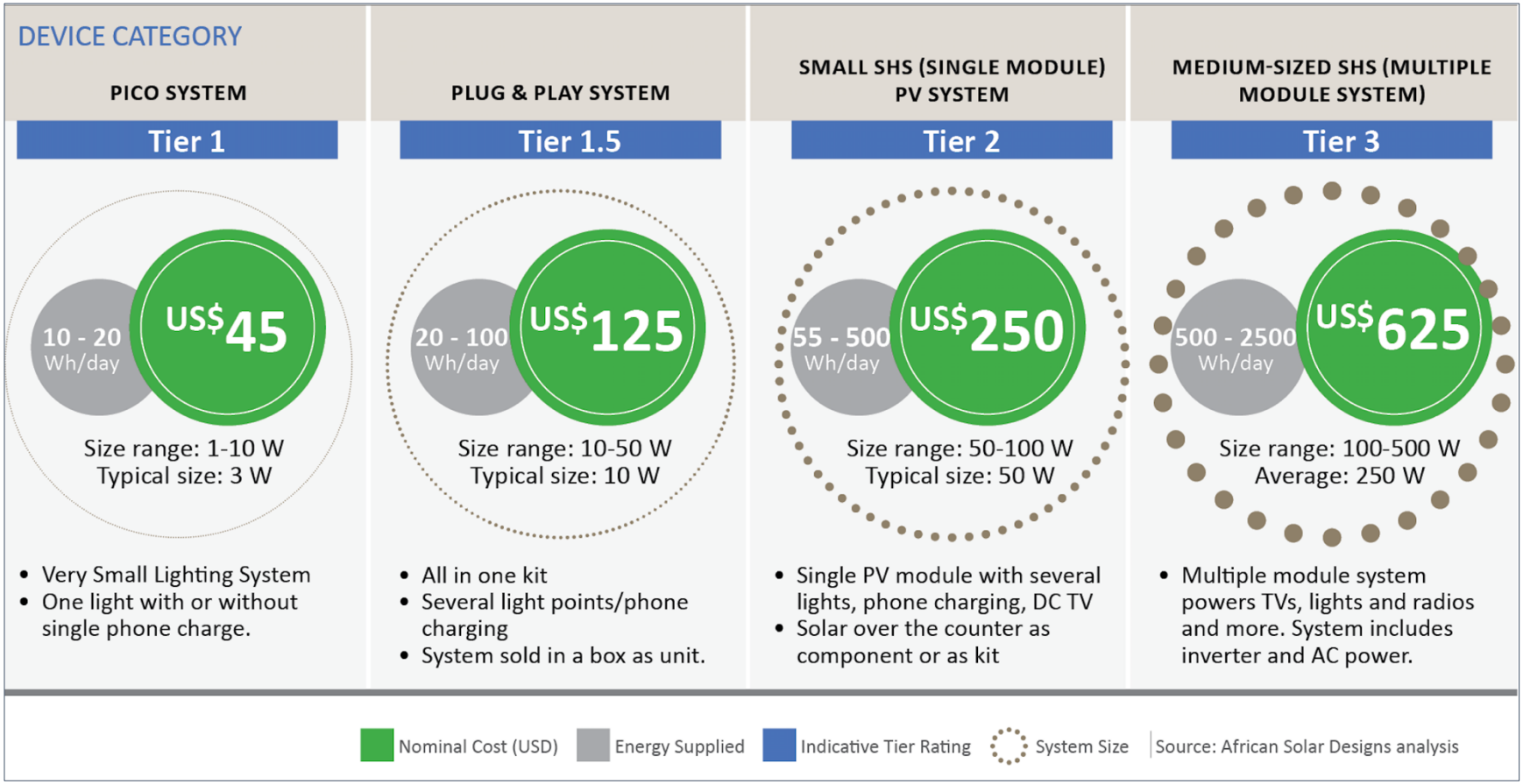
Source: African Solar Designs analysis

Per **Table 12**, 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 listed in **Figure 19**.

Figure 19: Household PV System Descriptions and Market Segments



Source: African Solar Designs analysis

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

According to feedback from focus group participants, about 5% of the population is using solar products. Awareness of solar products is quite low throughout the country and especially in the sparsely populated north, with the exception of activity in large cities such as N'Djamena and Moundou.

Through ADER, the GoC has developed several mini-solar power projects in the provinces of Douguia, Mombou and Guelendeng. Focus group participants reported that the Government has also attempted to distribute solar kits as a pilot project but was largely unsuccessful. Participants also noted that there is a very low incentive to produce and sell solar kits, as suppliers have a very small geographic reach due to poor distribution methods. Most suppliers are resellers of Chinese products, with a lack of technical capacity to install or maintain products. Consumers were said to prefer solar kits because they are a 'plug and play' and do not require technical knowledge to use them. Participants also noted that households see solar energy as a good investment, but that the cost is too high compared to household purchasing power.

- **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 13** 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 (see methodology annex). 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 13: Energy Expenditure of Different Income Groups

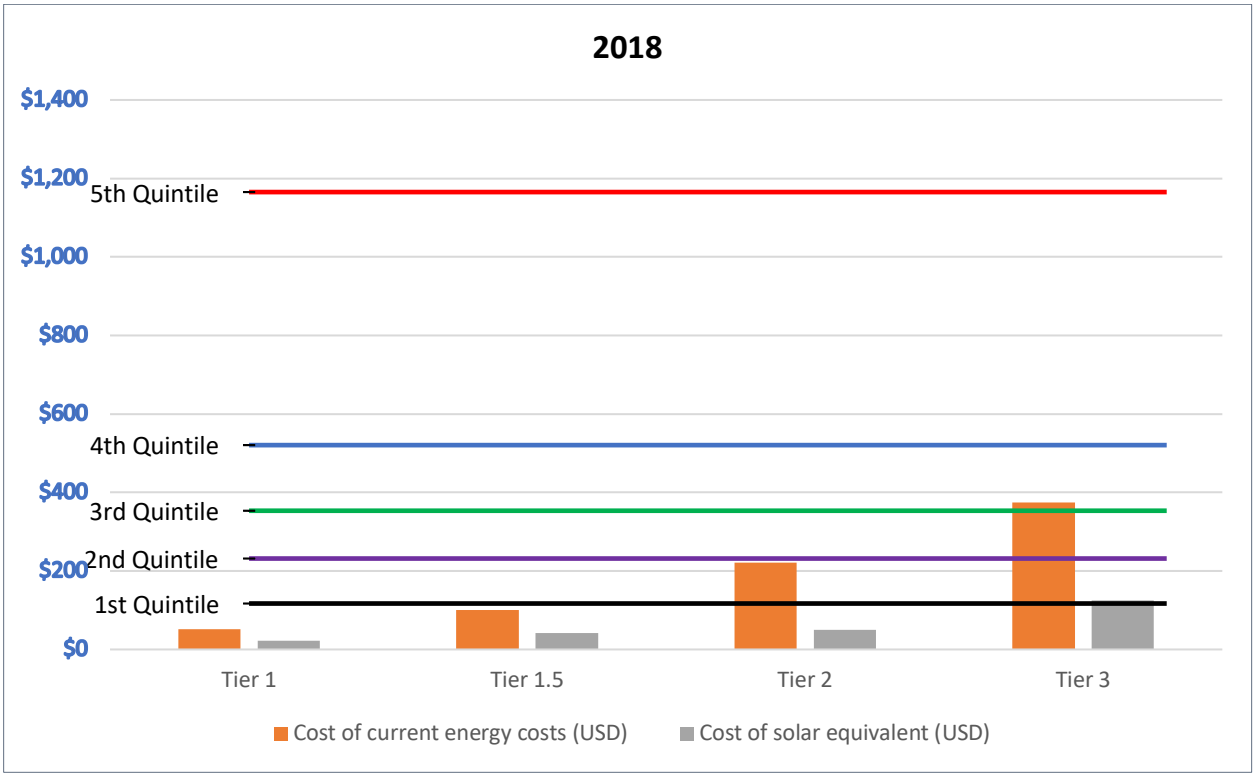
Population Income Quintiles	Per Capita Income (USD per month)	Household Income (USD per month)	Energy as % of Income	Monthly Energy Budget (USD)
2018 Scenario				
Lowest Quintile of Population	$16.81	$97.51	10%	$9.75
2nd Quintile of Population	$33.28	$193.03	10%	$19.30
3rd Quintile of Population	$50.78	$294.52	10%	$29.45
4th Quintile of Population	$74.80	$433.81	10%	$43.38
Highest Quintile of Population	$167.43	$971.10	10%	$97.11
2023 Scenario				
Lowest Quintile of Population	$12.88	$74.70	10%	$7.47
2nd Quintile of Population	$25.50	$147.87	10%	$14.79
3rd Quintile of Population	$38.90	$225.62	10%	$22.56
4th Quintile of Population	$57.30	$332.33	10%	$33.23
Highest Quintile of Population	$128.27	$743.94	10%	$74.39
2030 Scenario				
Lowest Quintile of Population	$8.38	$48.58	10%	$4.86
2nd Quintile of Population	$16.58	$96.17	10%	$9.62
3rd Quintile of Population	$25.30	$146.73	10%	$14.67
4th Quintile of Population	$37.26	$216.14	10%	$21.61
Highest Quintile of Population	$83.42	$483.83	10%	$48.38

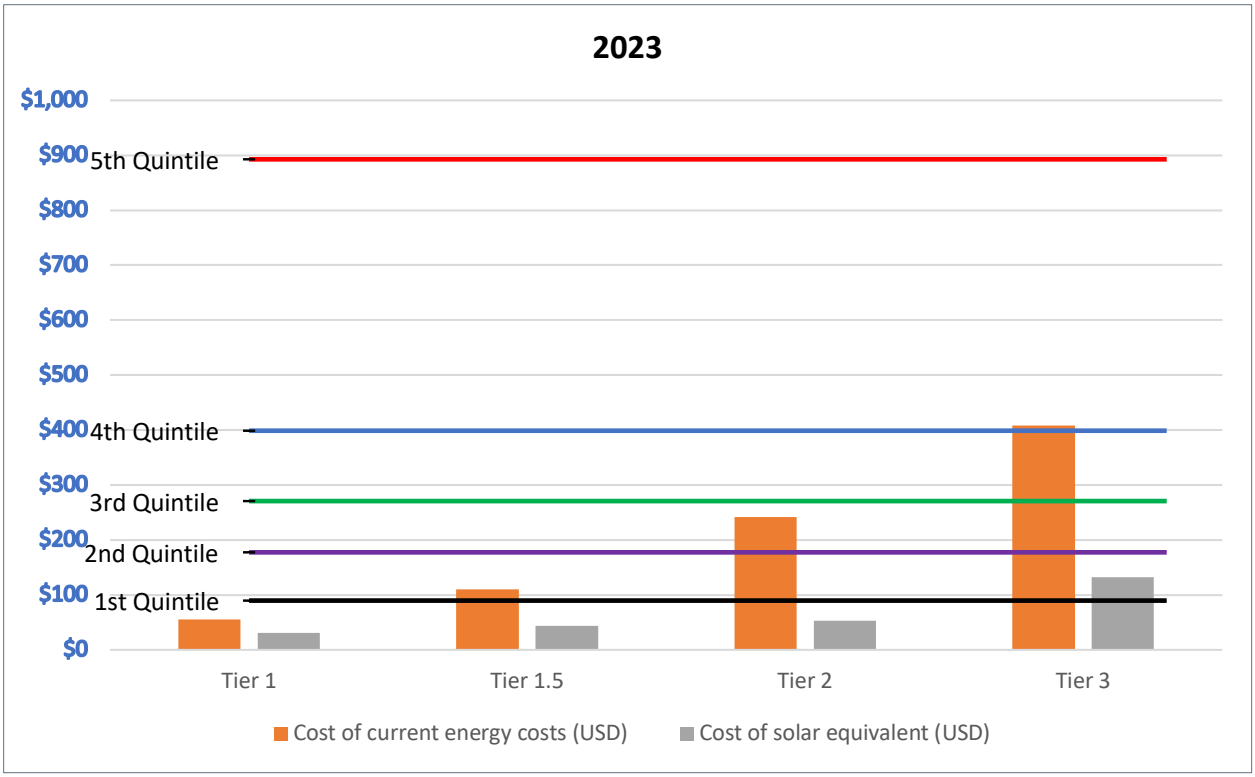
Source: African Solar Designs analysis

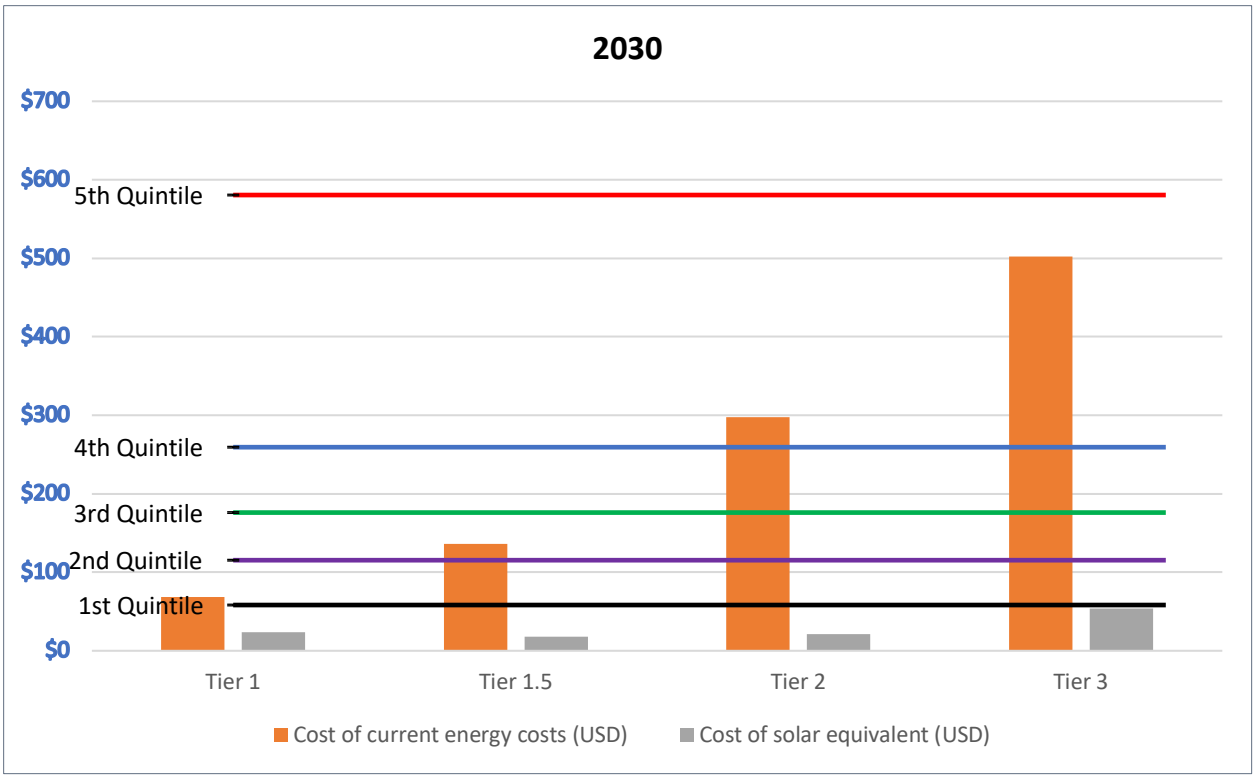
Figure 20 summarizes the preceding data in this section by comparing household energy spending with typical rural energy costs and their solar equivalents. This analysis presents annualized costs (not including financing cost) of current energy technologies for each energy tier, compared with the annual 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 20: Annual Household Energy Budget by Quintile, Annual Energy Costs and Cost of Solar Equivalents







Source: African Solar Designs analysis

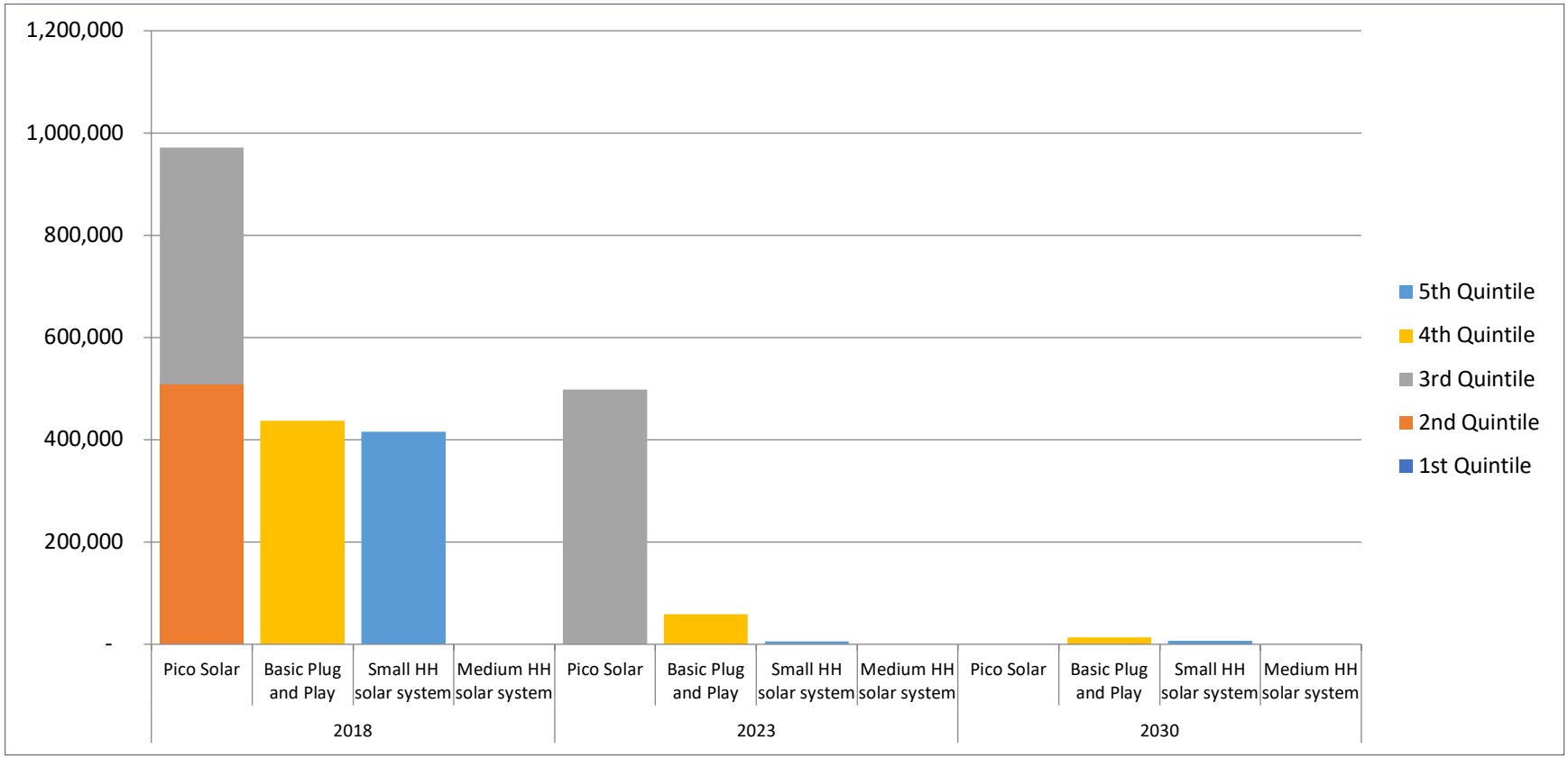
2.1.3 The Market for Household Devices without Consumer Finance

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 13**. 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 all but the lowest income quintile can afford a solar product unfinanced. The need for financing solutions for the lower income quintiles is clear.

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



Source: African Solar Designs analysis

Table 14 presents the estimated annualized cash market potential for off-grid solar product sales in the country's household sector.

Table 14: Estimated Cash Market Potential for Household Sector

Solar System	Annualized Demand (Units)	Annualized Demand (kW)	Annualized Market Value (USD)
2018 Scenario			
Pico Solar	485,534	1,457	$21,849,043
Basic Plug and Play	145,575	1,456	$18,196,832
Small HH solar system	83,234	4,162	$20,808,612
Medium HH solar system	0	0	$0.00
Total	**714,343**	**7,075**	**$60,854,487**
2023 Scenario			
Pico Solar	249,227	748	$11,407,826
Basic Plug and Play	19,527	195	$1,895,591
Small HH solar system	1,108	55	$215,052
Medium HH solar system	0	0	$0.00
Total	**269,862**	**998**	**$13,518,469**
2030 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	4,541	45	$244,360
Small HH solar system	1,362	68	$146,616
Medium HH solar system	0	0	$0.00
Total	**5,903**	**113**	**$390,976**

Source: African Solar Designs analysis

The following considerations should also be taken into account when analyzing this data:

- The large percentage of the population that is off-grid means that households across all but the lowest income quintile could demand various OGS products on a cash basis. The introduction of finance increases demand further.
- 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

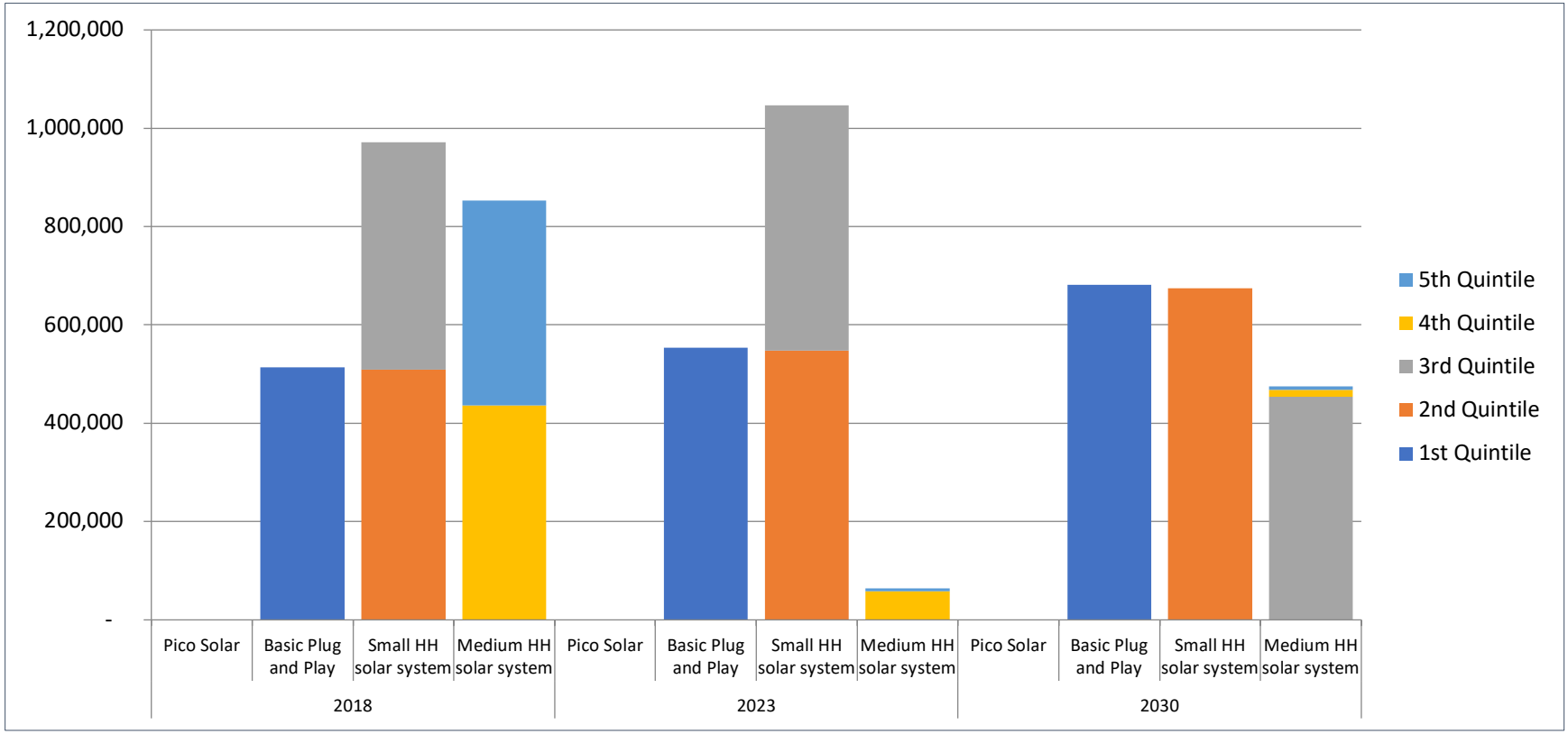
- **Financial Model**

In order to portray the effects of finance, a simple model was prepared that provides OGS system finance with a 34.8% p.a. interest rate92 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 service 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.

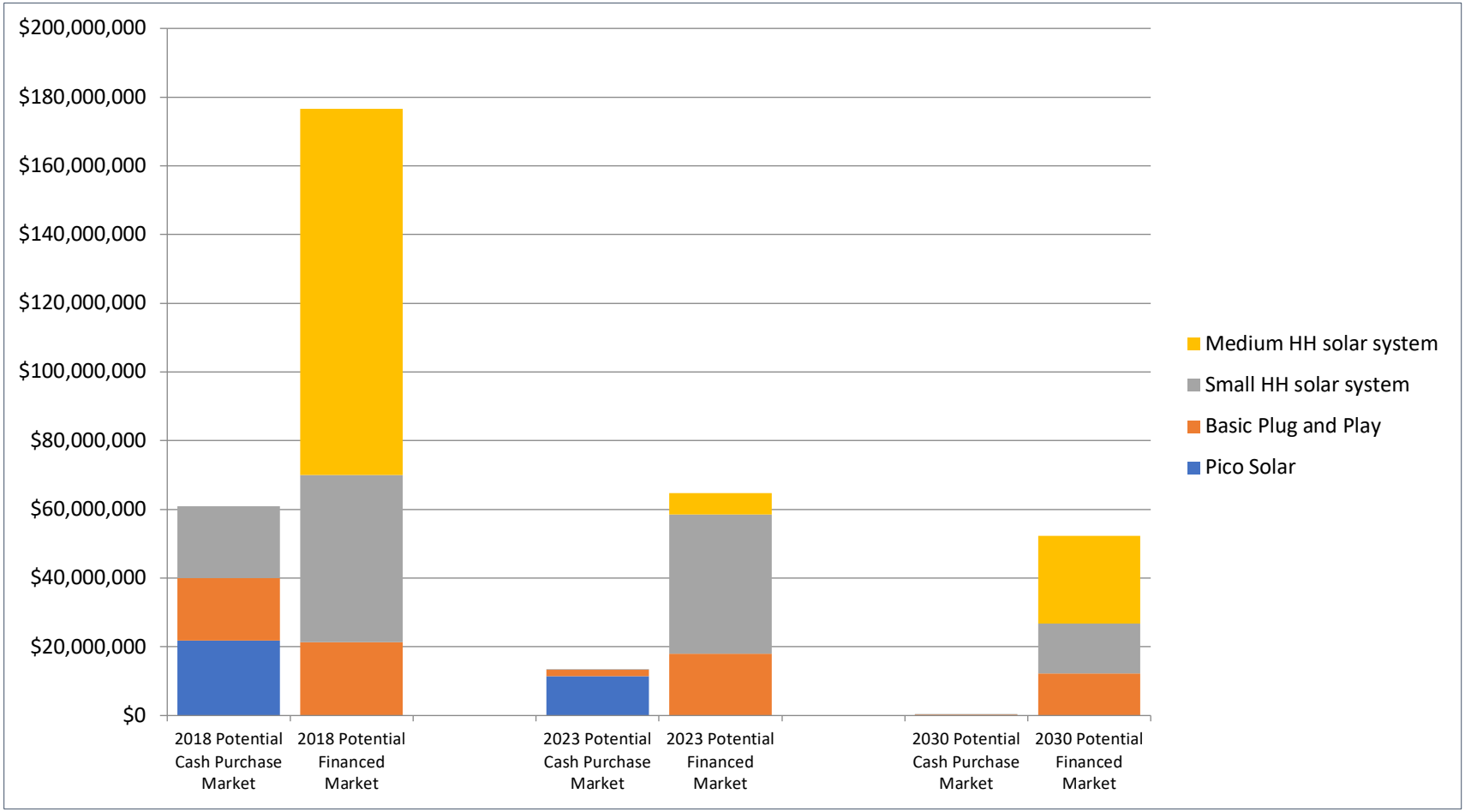
[92] http://www.theafricareport.com/West-Africa/cameroon-what-business-wants.html.
It is assumed that as a CEMAC country, interest rates in Chad are similar to Cameroon rates.

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



Source: African Solar Designs analysis

Figure 23: Estimated Off-Grid Solar Cash and Financed Market Potential for Household Sector by System Type



Source: African Solar Designs analysis

In 2018, without financing, 1,823,965 households (78% of households without access) in the country could afford an OGS system. However, with financing, 2,337,758 households (100% of households without access) could afford an OGS system as the 513,793 households without access in the lowest income quintile are enabled to acquire at least one OGS system. Consequently, the annualized potential market size increases from USD 60,854,487 to USD 176,573,492 mainly due to the fact that the households are enabled to purchase larger systems (**Figure 23**).

The least-cost electrification 2023 scenario calculates that 922,464 households could be electrified by stand-alone systems. Under this scenario, all the households without access have the ability to acquire at least one OGS system, however, financing enables them to acquire the larger systems. The annualized potential market size increases from USD 21,074,245 to USD 46,026,264 (**Figure 23**).

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 761,921. Under this scenario as well, all the households without access have the ability to acquire at least one OGS system, however, financing enables them to acquire the larger systems. The annualized potential market size therefore increases from USD 13,087,614 to USD 37,924,924 (**Figure 23**).

Table 15 presents the estimated annualized financed market potential for off-grid solar product sales in the country's household sector.

Table 15: 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	171,264	1,713	$21,408,037
Small HH solar system	194,214	9,711	$48,553,429
Medium HH solar system	170,579	42,645	$106,612,026
Total	**536,057**	**54,068**	**$176,573,492**
2023 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	184,613	1,846	$17,920,990
Small HH solar system	209,351	10,468	$40,644,806
Medium HH solar system	12,824	3,206	$6,224,403
Total	**406,788**	**15,520**	**$64,790,199**
2030 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	227,050	2,271	$12,217,999
Small HH solar system	134,868	6,743	$14,514,983
Medium HH solar system	94,954	23,738	$25,548,136
Total	**456,872**	**32,752**	**$52,281,118**

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**

  - 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 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 sizes the market potential for off-grid solar products for institutional users in Chad. 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 16 shows the estimated annualized cash market potential for institutional users in Chad. 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. There was insufficient GIS data available to properly estimate the market size; as a result, per capita comparisons were made with similar countries to analyze certain sectors as described below.[93]

Table 16: Estimated Total Cash Market Potential for Institutional Sector[94]

Institutional Sector		Units	kW Equivalent	Cash Value (USD)
Water supply	Low power pumping system	1,004	1,506	$3,765,750
	Medium power pumping system	704	2,817	$7,042,000
	High power pumping system	226	2,258	$5,645,000
	Subtotal	1,934	6,581	$16,452,750
Healthcare	Health post (HC1)	959	240	$599,625
	Basic healthcare facility (HC2)	120	180	$449,625
	Enhanced healthcare facility (HC3)	26	111	$277,200
	Subtotal	1,105	531	$1,326,450
Education	Primary schools	559	280	$838,125
	Secondary schools	64	123	$306,000
	Subtotal	623	403	$1,144,125
Public lighting	Public lighting (excluding street lighting)	356	178	$533,925
TOTAL		**4,018**	**7,693**	**$19,457,250**

Source: African Solar Designs analysis

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

[94] 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 17: 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.

As GIS data was not available to conduct the analysis, a per capita comparison made using data from Guinea[95] identified off-grid potable water points such as boreholes and wells that could be electrified by stand-alone systems. Based on these assumptions, the estimated annualized cash market potential for the water supply sector is presented in **Table 18**. The distribution of off-grid water points is illustrated in **Figure 24**.

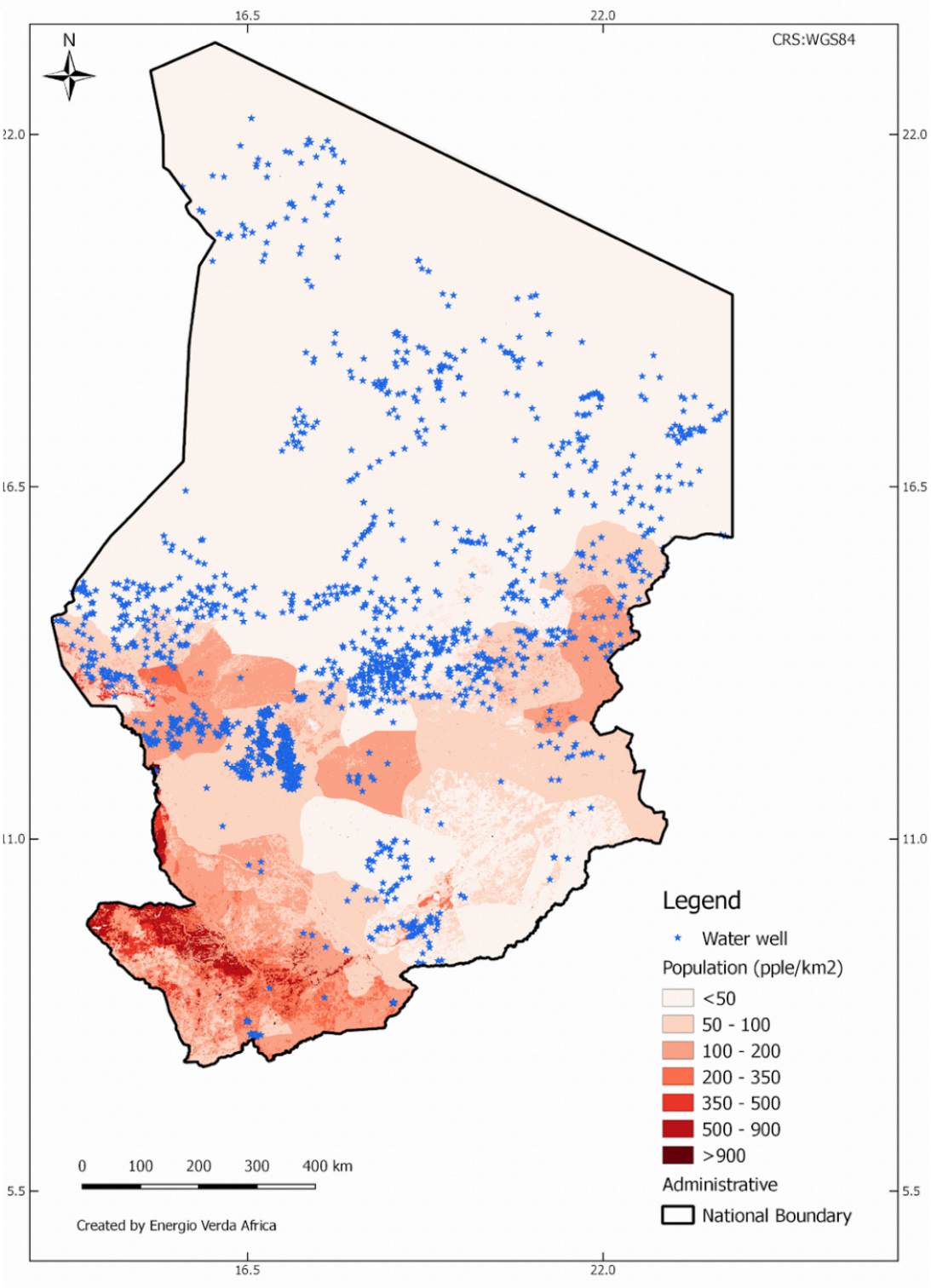
Table 18: Estimated Cash Market Potential for Water Supply[96]

Pump Type	Units	kW Equivalent	Cash Value (USD)
Low power	1,004	1,506	$3,765,750
Medium power	704	2,817	$7,042,000
High power	226	2,258	$5,645,000
Total	**1,934**	**6,581**	**$16,452,750**

Source: African Solar Designs analysis

[95] Guinea was grouped in the same category as Chad; See **Annex 2** for more details.
[96] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

Figure 24: Distribution of Off-Grid Water Points and Population Density[97]



Source: Energio Verda Africa GIS analysis

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

- **Healthcare**

Table 19: 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)	A per-capita comparison identified 7,723 off-grid healthcare facilities 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.

As GIS data was not available to conduct the analysis, a per capita comparison made using data from Guinea[98] identified off-grid healthcare facilities categorized according to their size (HC1, HC2, and HC3)[99] that could be electrified by stand-alone systems. 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 20**). The assumptions of system size below are based on the services offered at each of these facilities.

Table 20: Healthcare Facility Categorization and Electricity Demand[100]

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

[98] Guinea was grouped in the same category as Chad; See **Annex 2** for more details.
[99] NOTE: This represents a small subset of the overall health infrastructure in the country; See **Annex 1** for more details.
[100] "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 21**. The distribution of potential off-grid health facilities is shown in **Figure 8** in **Section 1.2.2.4**.

Table 21: Estimated Cash Market Potential for Healthcare Facilities[101]

Type of Facility	Units	kW Equivalent	Cash value (USD)
Health post (HC1)	959	240	$599,625
Basic healthcare facility (HC2)	120	180	$449,625
Enhanced healthcare facility (HC3)	26	111	$277,200
Total	**1,105**	**531**	**$1,326,450**

Source: African Solar Designs analysis

- **Education**

Table 22: Key Assumptions for Education Sector Analysis[102]

Sector	System Sizes	Key Assumptions
Education	• Elementary schools (500 W) • Secondary schools (1,920 W)	A per-capita comparison identified 11,175 off-grid primary schools and 1,275 off-grid secondary schools that could be electrified by stand-alone systems

The education sector analysis considered the electricity needs of off-grid primary and secondary schools.[103] 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.

As GIS data was not available to conduct the analysis, a per capita comparison made using data from Niger[104] 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 23**).

[101] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[102] 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**).
[103] 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.
[104] Niger was grouped in the same category as Chad; See **Annex 2** for more details.

Table 23: Education Center Categorization and Electricity Demand[105]

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 24**. The distribution of potential off-grid primary and secondary schools is shown in **Figure 25**.

Table 24: Estimated Cash Market Potential for Primary and Secondary Schools[106]

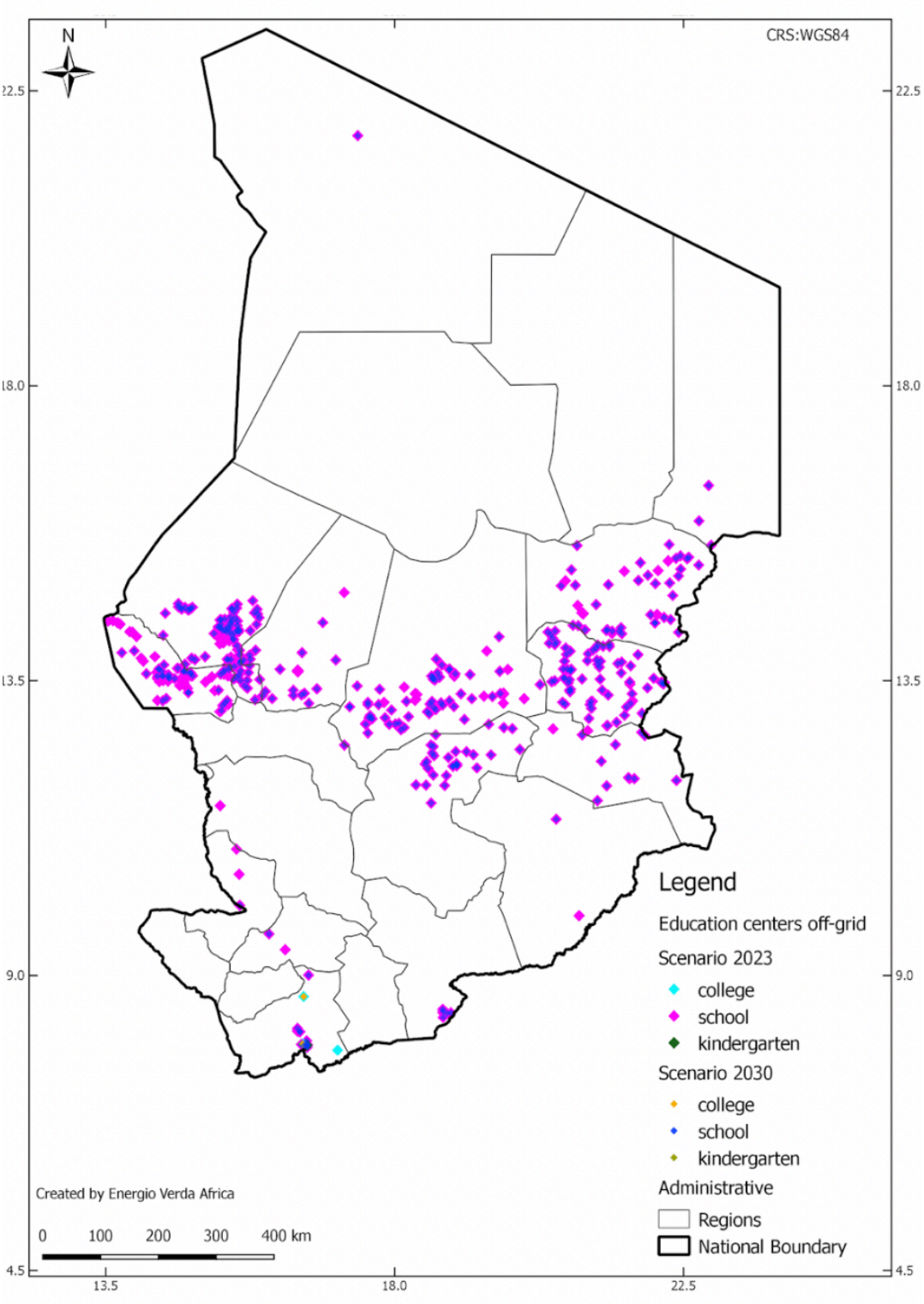
Type of Facility	Units	kW Equivalent	Cash value (USD)
Primary school	559	280	$838,125
Secondary school	64	123	$306,000
Total	**623**	**403**	**$1,144,125**

Source: African Solar Designs analysis

[105] "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

[106] 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 Potential Off-Grid Primary and Secondary Schools, 2023 and 2030[107]



Source: Energio Verda Africa GIS analysis

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

- **Public Lighting**

Table 25: Key Assumptions for Public Lighting Sector Analysis

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 26**.

Table 26: Estimated Cash Market Potential for Public Lighting[108]

Public Lighting Network	Units	kW Equivalent	Cash value (USD)
Village lighting (excluding street lighting)	356	178	$533,925

Source: African Solar Designs analysis

2.2.3 Ability to Pay and Access to Finance

Financing for institutional off-grid systems in Chad 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.[109]

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.

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

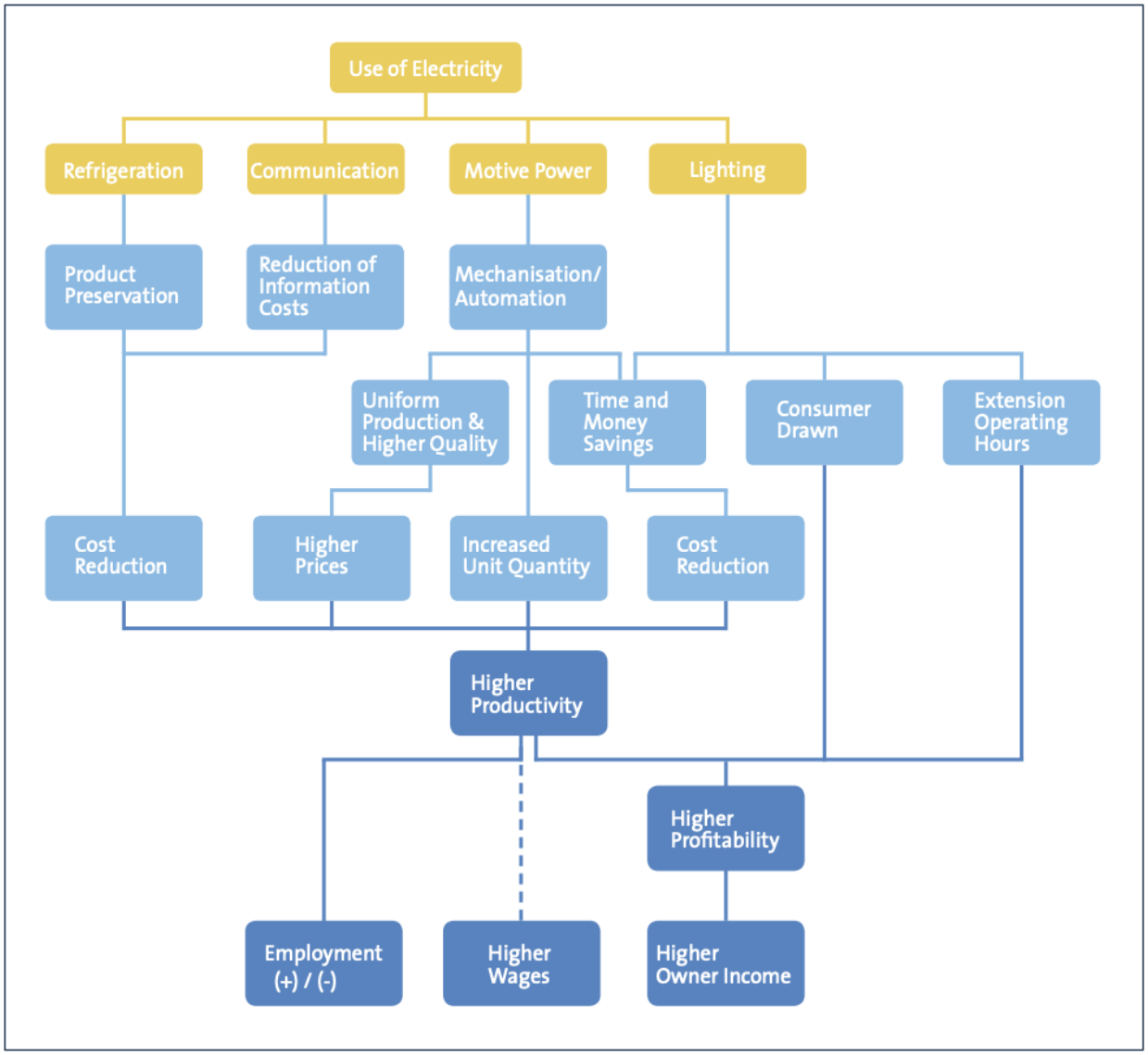
The calculation of the estimated off-grid solar market for SMEs focused only on barbering and tailoring appliances, which comprises a small portion of overall SME sector demand. These two microenterprises are indicative of the service-based SME off-grid solar market, as they benefit significantly from 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.

Aside from low agricultural productivity, weak infrastructure, particularly in transport and electricity sectors, have impeded the growth of Chad's industries and private sector development. 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 26**).

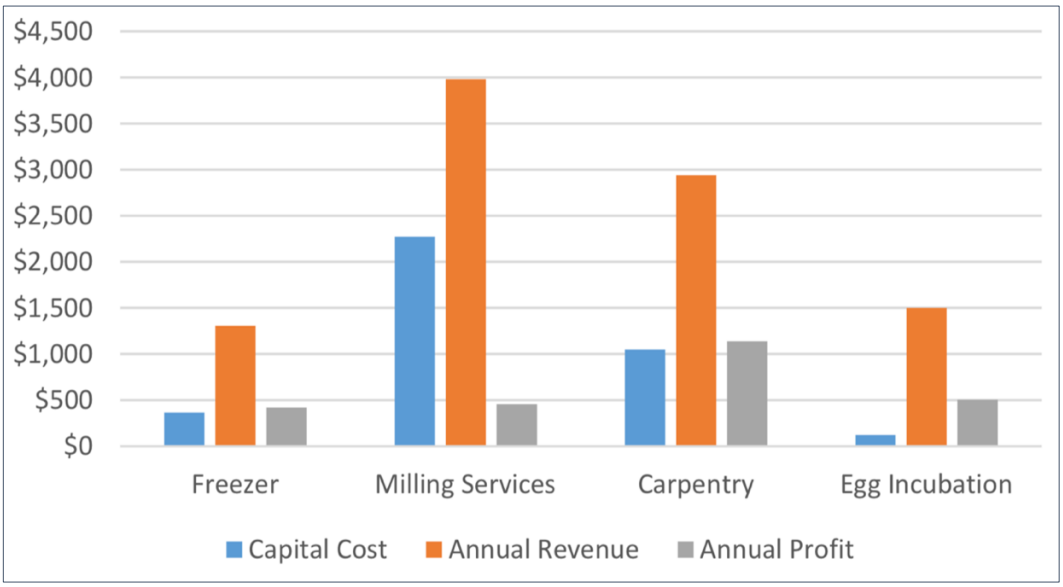
Figure 26: Pathways from Electricity to Income Generation[110]



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

[110] 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 27: Analysis of Cost, Revenue and Profit for Various Off-Grid Productive Use Applications[111]



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 27**).

Table 27: 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.

[111] "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**

Based on the focus group discussions, most PUE sector activities will take place in rural off-grid areas in Chad, particularly in the densely populated southern and central regions of the country, including the Lake Chad Basin.

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 28** presents the estimated annualized cash market potential for off-grid solar productive use applications.

Table 28: Indicative Total Cash Market Potential for Productive Use Sector[112]

Productive Use Sector		Units	kW Equivalent	Cash Value (USD)
SME Applications for Village Businesses	Microenterprises	202	51	$126,375
Value-added Applications	Irrigation	46,528	5,583	$30,243,056
	Milling	129	840	$2,098,804
	Refrigeration	356	1,958	$4,894,313
	Subtotal	47,013	8,381	$37,236,173
Connectivity Applications	Phone Charging	9,641	3,857	$8,310,940
TOTAL		**56,856**	**12,289**	**$45,673,488**

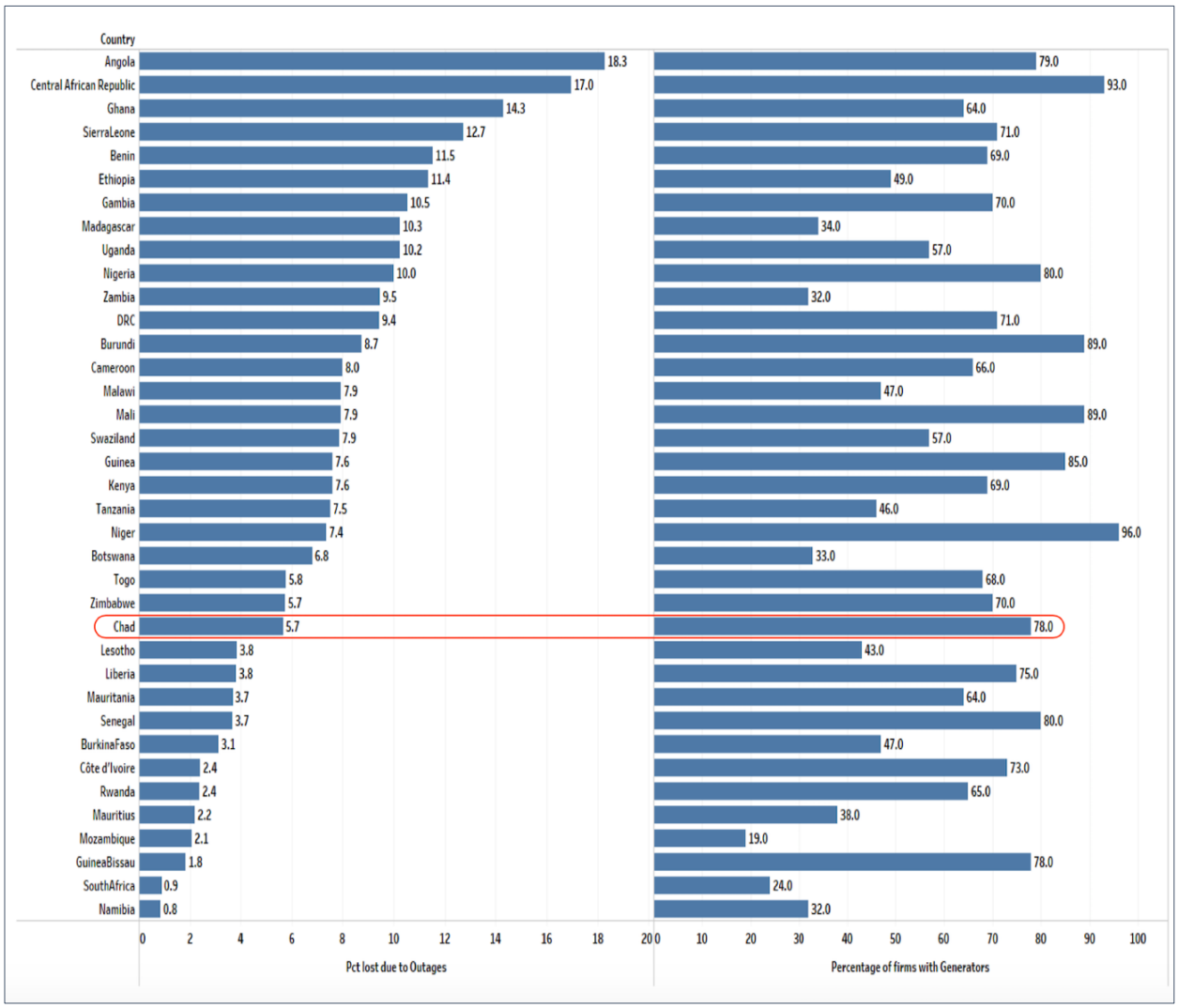
Source: Food and Agriculture Organization, GIZ and GSMA; African Solar Designs analysis

- **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.[113] This practice is extremely common in Chad, where power outages have accounted for nearly 6% of annual sales lost and where 78% of firms own generators **(Figure 28)**. Therefore off-grid solar solutions could play an important role in addressing the challenges of power quality for Chadian firms.

[112] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[113] 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

Figure 28: Percentage of Sales Lost due to Power Outages and Percentage of Firms with Generator [114]



Source: Center for Global Development

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

[114] Ramachandran, V., Shah, M. K., Moss, T., "How Do African Firms Respond to Unreliable Power? Exploring Firm Heterogeneity Using K-Means Clustering," Center for Global Development, (August 2018): https://www.cgdev.org/sites/default/files/how-do-african-firms-respond-unreliable-power-exploring-firm-heterogeneity-using-k-means.pdf

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.[115]

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 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 126,375 (**Table 29**).

Table 29: Estimated Market Potential for SMEs – Barbers and Tailors[116]

No. of SMEs with Constrained Access to Finance[117]	Units	kW Equivalent	Cash Value (USD)
1,011	202	51	$126,375

Source: World Bank; African Solar Design analysis

- **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. Focus group participants noted that milling of crops, irrigation, and poultry production are productive applications that would benefit from solar powered appliances and are well suited to bolster the Chadian agricultural value chain. Donor led initiatives are working with the GoC to improve access to water for agriculture to enhance the volume and value of agricultural production, given its importance to GDP and export revenue.[118]

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

[115] 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

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

[117] "MSME Finance Gap," SME Finance Forum: https://www.smefinanceforum.org/data-sites/msme-finance-gap

[118] "Lake Chad Basin Crisis Response Strategy," FAO: http://www.fao.org/3/a-i7078e.pdf

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. In Chad, donor-supported projects have done much to further the awareness and availability of solar powered irrigation systems.[119] 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.[120] GIS analysis demonstrated that access to the water table and surface water is not a major determinant of the costing of applicable solar irrigation systems, as most farming settlements in Chad are within close proximity to either surface water or relatively easily extractable sources of water (**Figure 29**).

It is important to note that in Chad, land is governed under formal and customary land tenure frameworks, both of which apply to agricultural and pastoral land. Laws Nos. 23, 24, and 25 of 1967, among other legislation, permits the registration of land rights, but do not provide adequate support for the decentralized administration of land.[121] In addition to increasing land scarcity, this has led to increased competition amongst various stakeholders over land and has made investments in irrigation schemes, especially those carried out by the state, contentious.

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 30 presents the estimated annualized off-grid solar cash market potential for smallholder value-added solar irrigation applications in Chad, which has an estimated cash value of USD 30.2M (see **Annex 2** for more details).

Table 30: Estimated Cash Market Potential for Value-Added Applications – Irrigation[122]

Estimated No. of Smallholder Farms Suitable for OGS Pumping for Irrigation	Units	kW Equivalent	Cash Value (USD)
279,167	46,528	5,583	$30,243,056

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

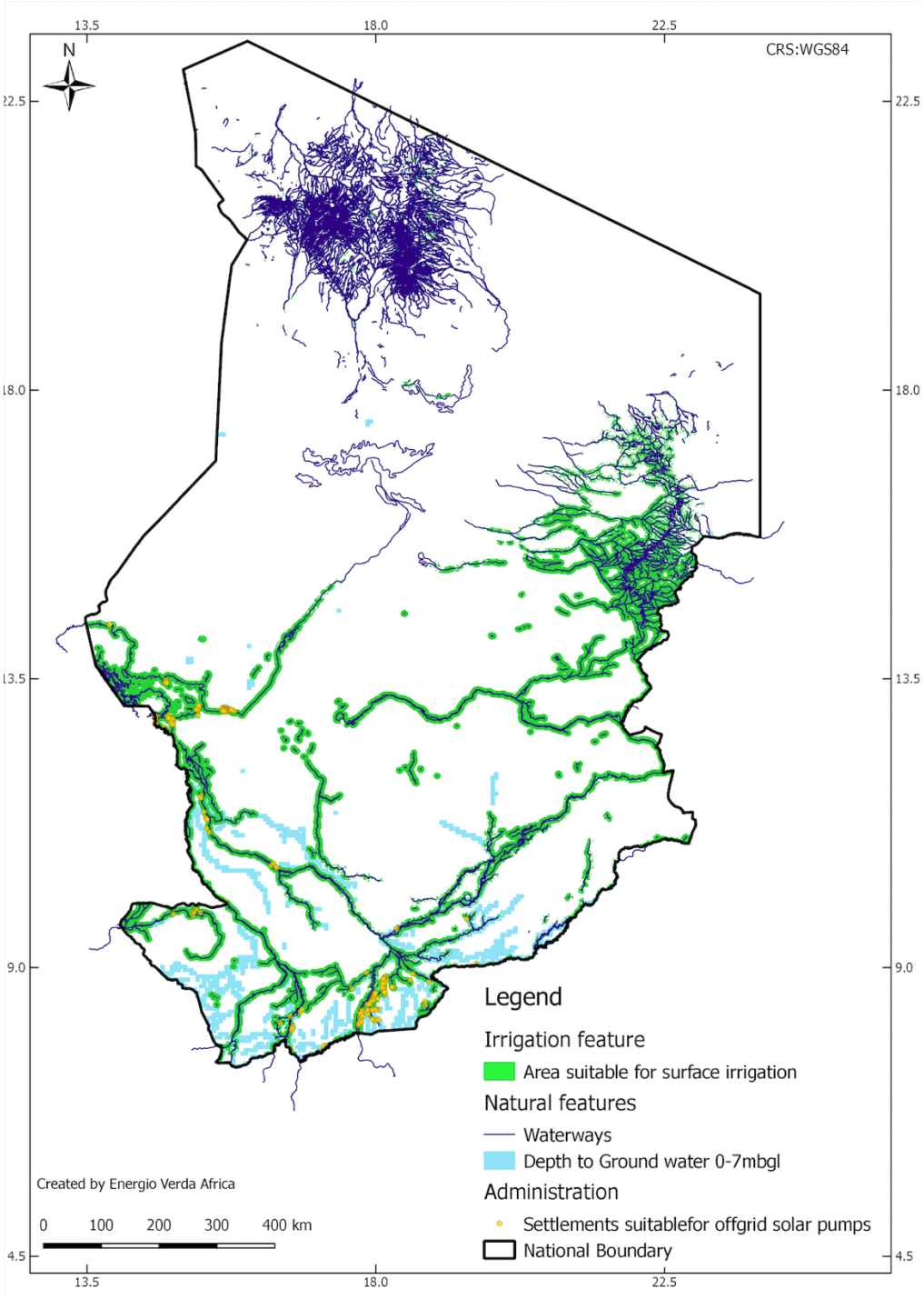
[119] "Building Resilience for food security and nutrition in Chad's rural community: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Project-related-Procurement/EOI_%E2%80%93_Chad_-_Building_Resilience_for_food_security_and_nutrition_in_Chad%E2%80%99s_rural_communities_%E2%80%93_10_2015.pdf

[120] *See* GIZ Powering Agriculture Toolbox on Solar Powered Irrigation Systems: https://energypedia.info/wiki/Toolbox_on_SPIS

[121] "Land Links: Chad" https://www.land-links.org/country-profile/chad/#land

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

Figure 29: 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; Open Street Map; Energio Verda Africa GIS analysis[123]

[123] 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 by Open Street Map 2018

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

Table 31: Estimated Cash Market Potential for Value-Added Applications – Milling[124]

Estimated No. of Solar Mills	Units	kW Equivalent	Cash Value (USD)
2,583	129	840	$2,098,804

Source: Food and Agriculture Organization; African Solar Designs analysis

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 32 presents the estimated annualized off-grid solar market potential for smallholder value-added solar refrigeration applications in Chad, which has an estimated cash value of USD 4.9 million (see **Annex 2** for more details).

Table 32: Estimated Cash Market Potential for Value-Added Applications – Refrigeration[125]

Off-Grid Market Centers	Units	kW Equivalent	Cash Value (USD)
7,119	356	1,958	$4,894,313

Source: Solar-Powered Cold Hubs, Nigeria; 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.

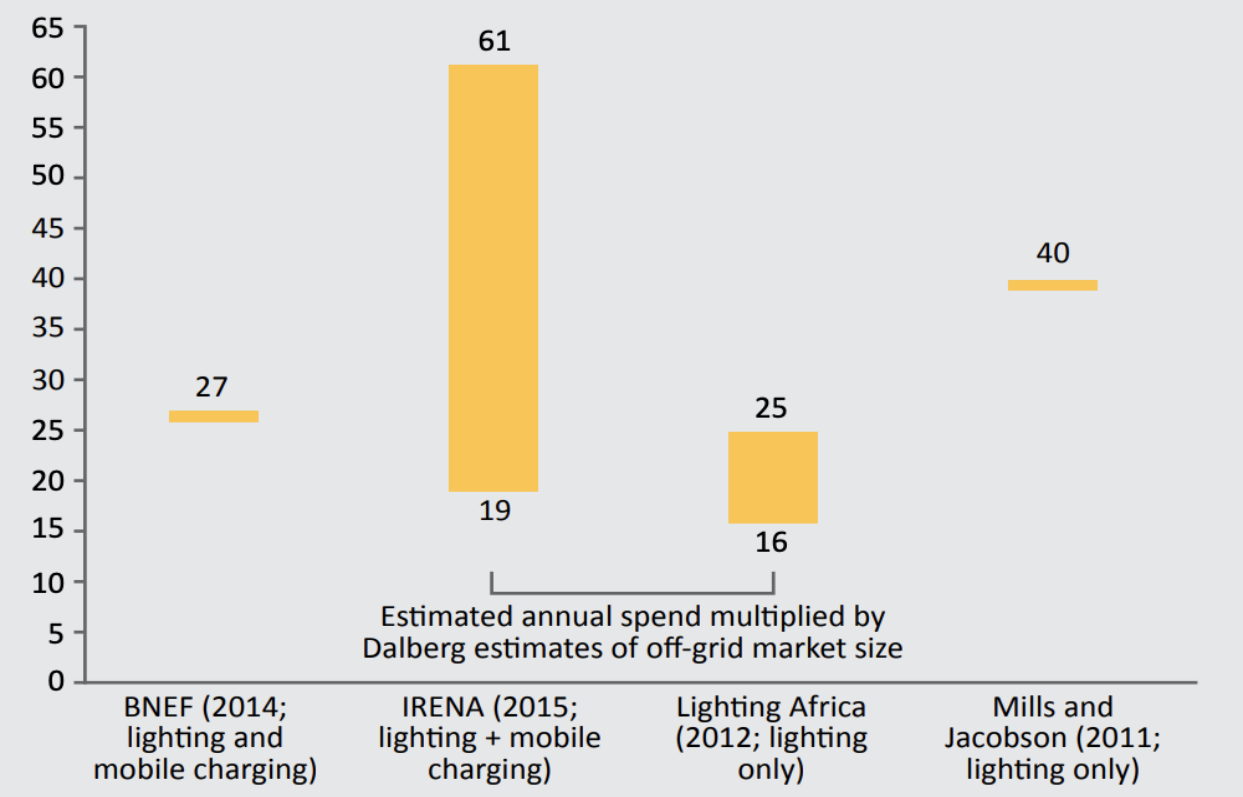
- **Connectivity Applications**

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 30**). Increasingly, off-grid solar devices, such as lighting devices, also include phone-charging capabilities that enable owners to engage in mobile-phone charging businesses.

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

Although mobile penetration has grown from 140,000 unique subscribers in 2006 to over four million in 2016, Chad's high taxes and fees for mobile services such as SIM activation limit mobile connectivity for the over eight million Chadians who remain unconnected. Mobile consumers and operators are required to pay up to 13 sector specific fees and taxes – more so than any other country in Africa. A reduction in these taxes may serve to increase mobile connections and improve sector wide growth significantly.[126]

Figure 30: Estimated Annual Off-Grid Household Expenditure on Lighting and Mobile Phone Charging[127]



NOTE: Figures in Billion USD

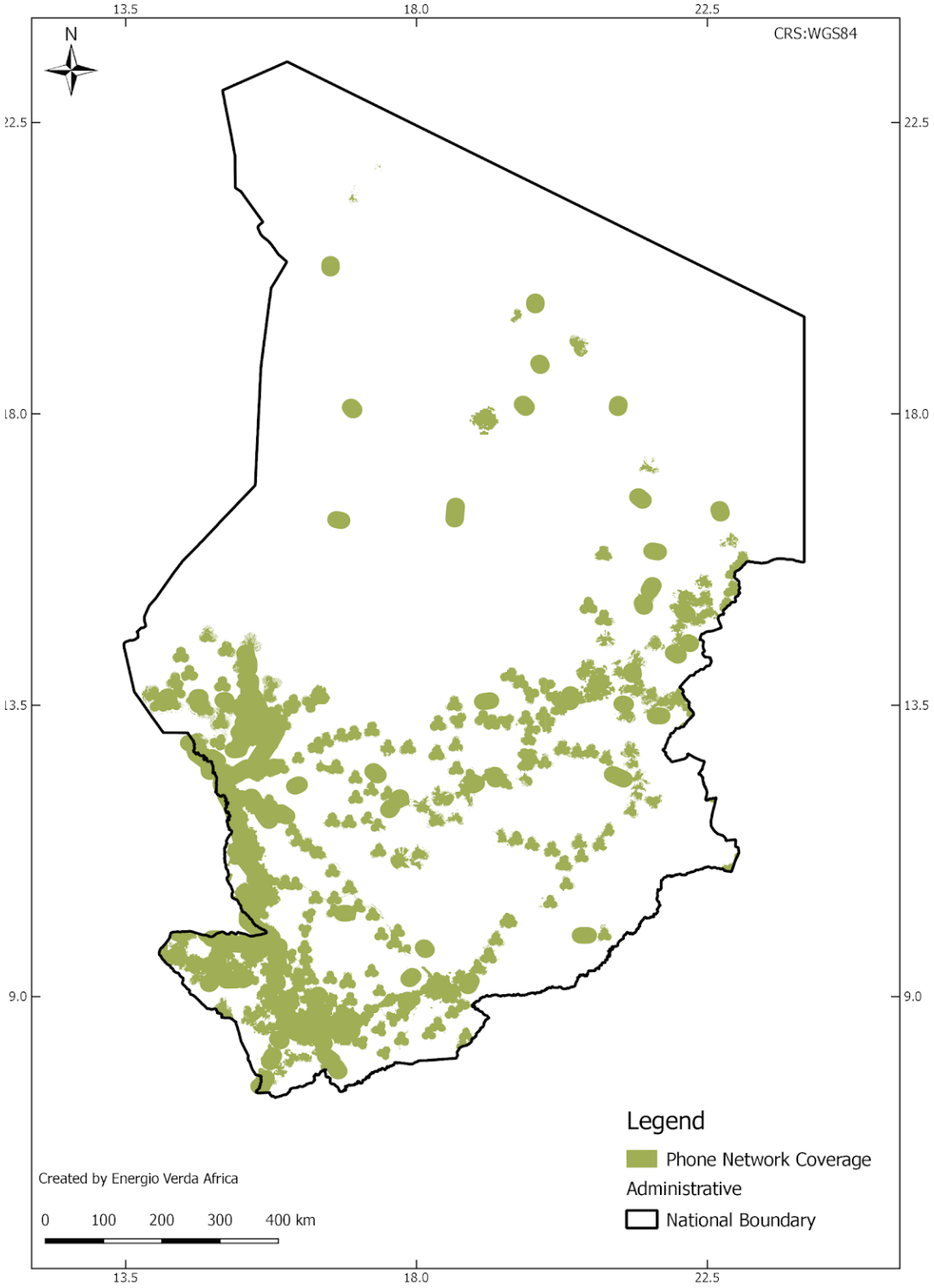
Source: Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP, 2018

Figure 31 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.

[126] "Digital Inclusion and Mobile Sector Taxation in Chad," Deloitte and GSMA, (November 2016): https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/01/Digital-Inclusion-and-Mobile-Sector-Taxation-in-Chad_English_report.pdf

[127] "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 31: Mobile Phone Network Geographic Coverage[128]



Source: GSMA

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

Table 33 presents the estimated annualized cash market potential for off-grid solar mobile phone charging enterprises in Chad, which has an estimated cash value of USD 8.3 million (see **Annex 2** for more details).

Table 33: Estimated Cash Market Potential for Mobile Phone Charging Enterprises[129]

Mobile Subscribers[130]	Rural Population (%)[131]	Units	kW Equivalent	Cash Value (USD)
6,231,009	77.40%	9,641	3,857	$8,310,940

Source: GSMA

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 Chad. 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). Providing solar-kits through subsidized micro-credit schemes can lead to productive uses and boost household income. The focus group discussion 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.
- Capacity development and training for installers and technicians is a dire need for current solar users who worry about the maintenance of their purchase. Training skilled solar technicians may encourage more users to purchase solar kits.
- 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. Another solution, e.g. a partial credit guarantee scheme recently introduced by the IFC would cover up to 50% of the risk of loans to SMEs that are investing in smart climate equipment including solar appliances.[132]
- Solar products prices remain high and vary throughout the country due to inadequate regulation. A potential solution to this would be to revise customs and import duties on solar products.
- 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.

[129] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[130] "The Mobile Economy: Sub-Saharan Africa," GSMA, (2017): https://www.gsmaintelligence.com/research/?file=7bf3592e6d750144e58d9dcfac6adfab&download
[131] World Bank: Rural Population (% of total population) https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS
[132] Press Release: "IFC Invests in Bank of Africa to Expand SME Lending in Eight Countries," (June 4, 2018): https://ifcextapps.ifc.org/ifcext/pressroom/ifcpressroom.nsf/0/947B76E4C106A246852582A200440E1C?OpenDocument

2.4 Supply Chain

This section reviews the off-grid solar supply chain in Chad, 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 34**.

Table 34: 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

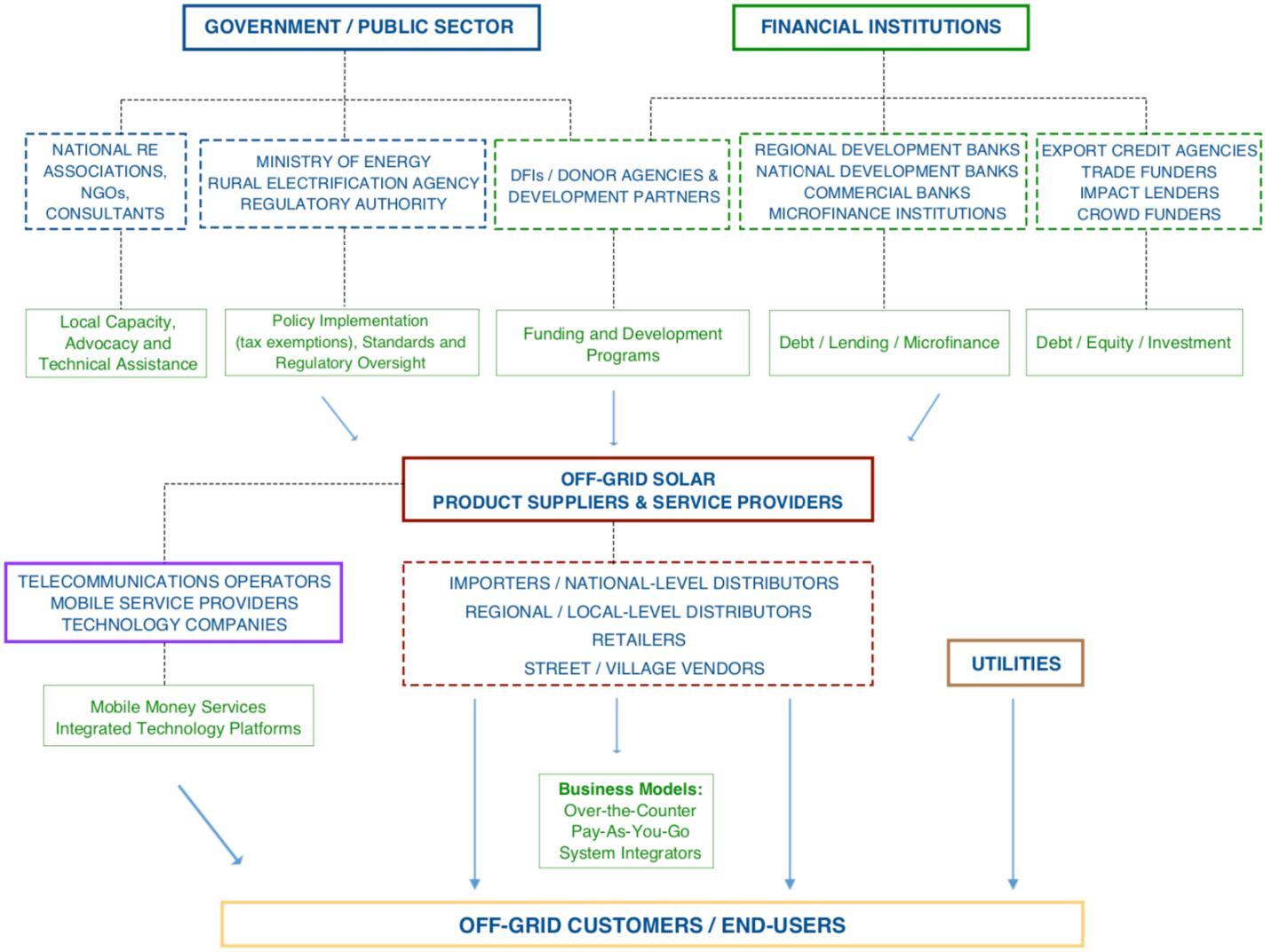
2.4.1 Overview of Commercial Market for Solar PV Equipment

The off-grid solar supply chain in Chad is made up of a wide range of stakeholders – importers, distributors, wholesalers, retailers, NGOs, and end-users (**Figure 32**). Chad has a relatively small solar market, as the country's overall market environment and opportunity for solar companies remains limited (**Figure 11**). The GoC has been working to address this through establishment of the Renewable Energy Agency (ADER), as well as through promotion of a number of pilot projects. These include the installation of 13 mini-solar plants (10 kW) for institutional use, the development of solar public lighting projects, solar kit distribution in the cities of Djarmaya, Moundou and Koundoul, a pilot project in agriculture led by women, and a study launched in 2016 on priority off-grid rural areas.

A variety of solar products and systems are offered by companies in the market (by both the formal and informal sector), and there are a number of business models currently 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. Nevertheless, 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, power supply in urban areas is often not sufficient, continuous, or reliable (**Figure 3**), further supporting expanded use of solar PV equipment by this consumer segment.

Local solar companies almost exclusively deploy the cash/over-the-counter sales business model. Focus group participants indicated that solar kits are the most widely used and preferred off-grid solar devices in the country. While large companies selling certified products play a central role in the market, the informal sector remains a key factor. Surveys of local industry stakeholders noted that a regulatory framework was necessary to address the widespread sale of low-quality, uncertified products in the market.

Figure 32: 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.[133] 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.

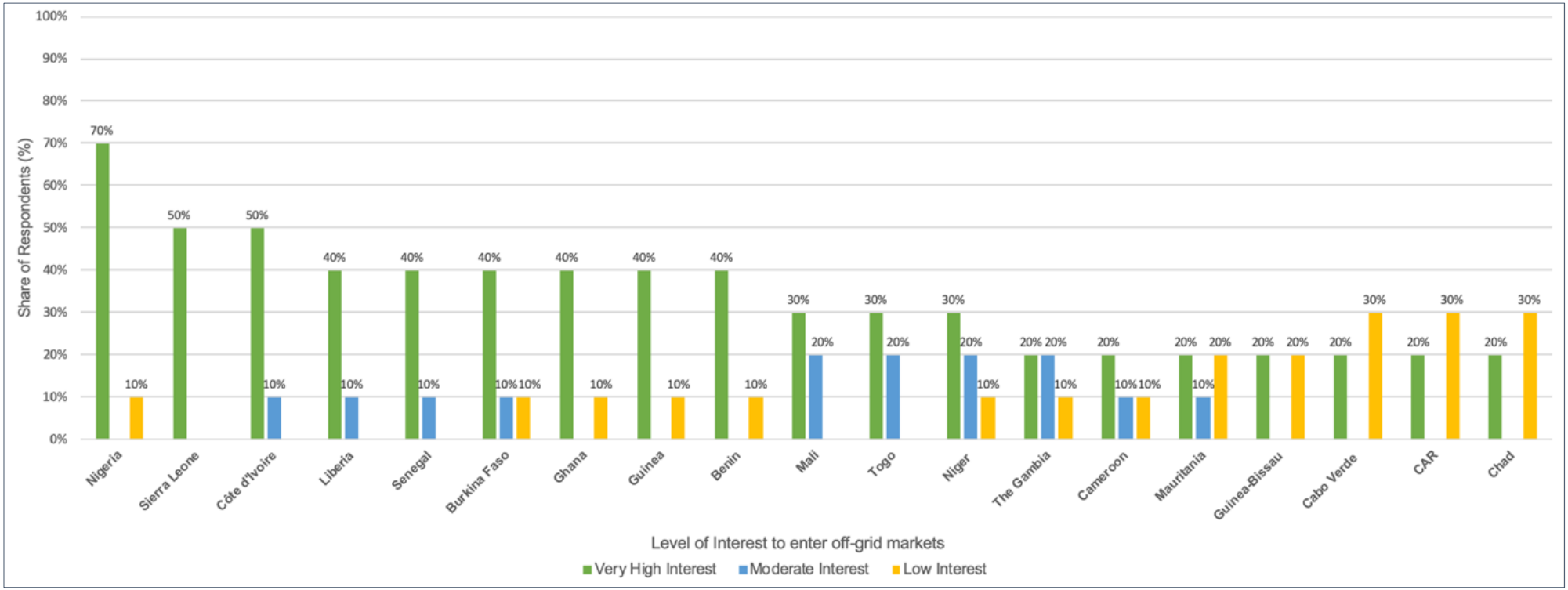
Market entry into Africa began in East Africa for a majority of the leading companies, a trend that can be attributed to advancements in mobile money transfer systems such as M-Pesa that have facilitated the PAYG off-grid business model. As the East African market becomes more crowded and mobile money 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.[134]

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.[135]

A survey of large international solar companies that assessed *inter alia* their level of interest in entering the off-grid markets in West Africa and the Sahel is presented in **Figure 33**. 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.

[133] "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
[134] Ibid.
[135] "Insights from Interviews with Off-Grid Energy Companies," ECREEE, (June 2018).

Figure 33: Level of Interest in Off-Grid Markets of ROGEP Countries among Major Suppliers[136]



Source: Stakeholder interviews; GreenMax Capital Advisors analysis

[136] 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 Chad

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 30 companies operating in Chad'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 in Chad were Tier 1 companies, with only three firms identified as Tier 2 companies (Bureau Africain de Recherche et d'Études, FESCMT-Chad and Tchad Énergie), while none have reached the Tier 3 level.[137]

Although most companies are local, three international companies were also identified – African Energy, Alternaprod, and Solar 23. African Energy and Solar 23 are noted to be the only two major manufacturer representatives and distributors of international brands, also acting as major wholesalers of off-grid products in Chad. African Energy is a US-based company that has formed over 10 partnerships with international manufacturers and operates from its USA-warehouse to distribute solar equipment in nine depots across Africa. Solar 23 is a German-based company also operating across Africa, including in N'Djamena. It is a solar equipment wholesaler, offering all major international brands, as well as technical and customer care services (design, sizing, installation, delivery, customer care).

Feedback from focus group discussions in Chad indicated that off-grid solar suppliers have a very small geographic coverage to reach rural customers, and a relatively poor supply chain and distribution network. While the country's larger Tier 2 companies (e.g. Bureau Africain de Recherche et d'Études, FESCMT-Chad and Tchad Énergie) acquired longstanding industry experience locally, they are not off-grid solar specialists and rather operate in the entire energy sector. While, there is no manufacturer or local assembler of solar products based in Chad, Africa Energy and Solar 23 are the country's two main international distributors and wholesalers that have formed partnerships with local companies.

There are four major retailers in the market – Tchad Solaire, ERDEP, Promosol and Alternaprod. Alternatprod is a subsidiary of US-French E-Longlife company. The company – which offers a wide range of products for various customers (households, SMEs and institutions) – had formed a partnership with the Renewable Energy Agency ADER and signed a rural electrification convention with the GoC (Ministry of Petroleum and Energy) to supply off-grid solar systems to primary and secondary school. Other companies include a variety of non-specialized retailers, buying their products from a number of different sources. Local solar companies typically sell a wide range of products, including pico solar lighting kits, multiple module and very large solar systems (e.g. 3ACE Commerce Énergies et Étude, 3A Energy Group).

- **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. Most local solar market players in the country are also not Lighting Global and Global Off-Grid Lighting Association (GOGLA) affiliated members; hence, relevant sales volumes and revenue are not available for Chad.

[137] "Insights from Interviews with Tier 3 Off-Grid Energy Companies," ECREEE, (June 2018).

➢ Main Solar Products and Components

Table 35 lists the brands of common solar products and components in Chad. The list does not include non-certified brands that are also common in the country's grey market.[138]

Table 35: Off-Grid Solar Products and Components in Chad

Systems	Companies
Distributors of Pico solar & plug and play system	Tchad Solaire, ERDEP, Promosol, Alternaprod, BOK, Mymoca, Sacis
Single module distributors	Alternaprod, Tchad Solaire, Promosol, BOK, Mymoca, Sacis
Multi module system distributors	ERDEP, 3A Énergie Group, 3A Commerce Énergie & Étude, Noor Solar Energy, Omnium Service Gr. SNEF
Very large system supplier	ERDEP, 3A Énergie Group, 3A Commerce Énergie & Étude, Noor Solar Energy, Omnium Service Gr. SNEF
Products/Components	**Brands**
Pico/plug & play system	Jinko, Trina Solar, Yingli Solar, Solar World (China, Germany, France)
Solar module	Risen, Flex, Qcells, Sunpower, Jinko, Suntec (China, Germany, France)
Inverter	Flex, Schneider, Delta, ABB, SMA, Solar Edge, Jinko (China, Germany, USA)
Lead Acid Battery	Powervault, Samsung SDI, Sonnen batteries Eco, Enphase, Solaris, Jinko (China, Germany, USA)

Source: Stakeholder interviews

➢ Market Prices

Table 36 presents average prices for off-grid systems and components in Chad's solar market. Prices for certified solar equipment remain higher compared to more mature solar markets.

Table 36: Estimated Price of Solar Systems and Components in Chad

Off-Grid System / Component	Price range (USD / per unit)
Pico solar lighting (10 Wp)	$25
Solar kit / plug-and-play SHS (150 Wp)[139]	$430
Solar Module (150 Wp - 250 Wp)	$300-320
Inverter (3 kW)	$520
Lead Acid Battery (220Ah)	$385

Source: Stakeholder interviews

➢ Importation Clearance Processes

Two government agencies are involved in the importation of solar products in Chad: The Ministry of Economy and the Ministry of Trade and Tourism. There is no tax, duty or VAT exemption for solar equipment in Chad. The country applies the CEMAC Common External Tariff (CET).[140] Like other CEMAC countries, Chad applies community charges that amount to 1.45%: The Community Integration Levy (TCI), the Organization for the Harmonization of Business Laws in Africa (L'Organisation pour

[138] 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.
[139] Solar system includes module, inverter and battery.
[140] "Chad - Import Tariffs", US Department of Commerce's International Trade Administration", (July 2017): https://www.export.gov/Contact-Us

l'Harmonisation en Afrique du Droit des Affaires, OHADA) and the Community Integration Contribution (CCI). Products imported from countries outside of the CEMAC zone are applied the following tariff rates: 10% for primary material and equipment, 20% for intermediate goods and 30% for consumer goods (e.g. electronics). In addition, supplementary taxes are applied, notably excise taxes of 20% on luxury products (including home appliances), an 18% VAT to all imported goods and a 2% statistical tax to all goods entering Chad. It takes about three months after initial order for the products to arrive in Chad, two weeks for customs clearance procedures to complete and an additional 90 days to get GoC agency's approval (if involved in the importation process).

2.4.4 Overview of Business Models

- **Company Approach to Market**

Historically, solar activities in Chad have developed as a side project of energy and construction companies, with solar companies only recently entering the market within the last decade (e.g. Alternaprod, Ets Ouma Solaire Agence). While companies offer different products, they mostly sell plug-and-play SHS and solar kits – easy to use for customers and do not require any technical capacity or maintenance – while relatively few enterprises offer multiple module or larger systems. Solar companies in Chad typically have a wide range of customers (households, SMEs, NGOs and public institutions). Companies utilize up-front cash over-the-counter business models, but do not offer consumer financing (e.g. PAYG) options to their customers.

- **Business Models**

There are three primary business models utilized in the market (**Table 37**), although in reality solar companies utilize a number of business models to reach a variety of clients:

- **Over-the-counter cash sales** include both informal and formal components. Many resellers 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/procurement** business model is utilized by larger companies in the market, working on larger systems and projects. They design, procure and install systems which range from high-end residential sites, to larger institutional systems. Local integrators represent international solar, inverter and battery brands with whom they partner with on projects. These companies include ERDEP, Noor Solar Energy, Omnium Service, Solar 23, 3A Énergie Group, 3Ace Commerce Énergie et Étude.
- **PAYG** is still an emerging business model in Chad's OGS market. While a few companies indicated that they rarely offered credit terms / consumer financing to their customers, other external sources of consumer finance are also limited. Local industry stakeholders indicated that while microfinance is sometimes accessible to their customers, MFIs require collateral and other conditions that are often difficult to meet especially for the population in rural areas.

Table 37: Overview of Off-Grid Solar Business Models

Business Model	Strategy and Customer Base	State of Development
Over-the-counter solar market	**Formal:** Retailers in Chad are mostly small scale, while there are very few distributors and wholesalers. Retailers are mainly located in large cities (N'Djamena and Moundou). They sell mostly solar kits lighting/electrical products, including Pico systems and large panels. **Informal:** Kiosks, street vendors form a key pico solar 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.	Early stage commercial market Early stage commercial development
System integrator/Procurement system	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 larger electricity users in the market and participate in procurement tenders to supply and install larger systems.	Early stage commercial market
Consumer finance (PAYG)	Consumer finance refers to the variety of credit term options availed to customers either directly by solar companies (installers) to customers they trust or by external stakeholders (MFIs). In Chad, a minority of companies offer financing directly to customers, in the absence of any guarantee for their customers to repay them. Lease and hire-purchase to buy solar products and PAYG repayment are not yet utilized in the market.	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. As distribution channels are really poor in Chad, suppliers require significant working capital to purchase equipment, renew inventory, transport equipment and cover field costs. Distributors of international OGS products receive basic trade finance and marketing support options, though typically limited. Most of the firms surveyed in Chad are self-financed with cash flow covered by shareholders and founders and from on-going business transaction. Some few of players have access to local bank financing or family finance but these resources are limited for most.

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 Chad 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 foreign exchange (FX) 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 FX 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**

Developing new models in Chad will require partnerships between developers, solar distributors, telco companies, commercial finance and the retail sector. One of the results of the FGD discussions was a list of potential partnerships that can be explored to enhance existing and new business models (**Table 38)**.

Table 38: 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 Chad 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 off-grid solar 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 GoC 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 GoC or formal projects.

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

Chad'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 Chad, surveyed stakeholders expressed concerns with regards to overall quality and reliability of equipment in the market, as quality control remains a main challenge facing companies. They expressed that high variability of quality destroys customer confidence in the product and tend to encourage customers to look for cheaper alternative products. Feedback from focus group meetings also indicated that there was a high level of customer complaints related to product quality and system operation and maintenance.

2.4.7 Local Capacity to Manage Business Development, Installation and Maintenance

Chad's nascent solar market is poised to grow if requisite 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:

- There is currently no import duty exemption. Such an exemption could be applied to all OGS products based on a specific regulation, and not only granted to importers on a case-by-case basis by ADER.
- 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 possessed by 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.
- Consumer awareness is low, particularly in rural areas outside of N'Djamena and Moundou. Campaigns led by the GoC / ADER are critical to raising awareness and growing the market.

Table 39 presents various areas of support and associated capacity building for the OGS supply chain in Chad. Attention should be given to the following:

- **Importers/Suppliers**: Reduce 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 the regulations and quality/standards to ensure product quality could significantly boost market growth.

Table 39: Capacity Buildings and Technical Assistance for the OGS Supply Chain in Chad[141]

Area of Support	Description	Rationale
Tax exemptions on solar technology	• Implementation of VAT and import duties exemption on all solar products (not exceptionally granted through ADER	• Costs of solar products are inflated by import duties; costs are passed on to customers, making solar less affordable.
Quality control/certification center	• Suppliers are able to effectively monitor the quality of products imported in Chad • Ensure that imported products are suitable/relevant to the local context (local standards) in Chad	• 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 and effect loss sharing agreements to cover irrecoverable inventory loans	• De-risking encourages private sector lending to solar sector • Initial security until the proof case of 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 • Incubation and acceleration of early-stage businesses • 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 suppliers in rural areas • Help Government institutions improve follow up and maintenance capacity on pilot projects (SHS and solar kits) • Include participatory methods to involve relevant local communities (e.g. for the distribution of solar kits)	• Make the business environment more conducive and profitable • Strengthen the overall ecosystem surrounding the solar market • Strengthen capacity across the sector (vs having capacity centralized in the capital only) • Ensure knowledge transfer from abroad for faster, more cost-efficient progress

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

[141] 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 Chad, 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 40 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** above for an overview of the gaps in the country's off-grid policy and regulatory framework.

Table 40: Key Barriers to Off-Grid Solar Market Growth in Chad

Market Barrier	Description
Demand[142]	
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 counterfeit over-the-counter lighting products. 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

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

	provide trade financing while commercial financiers in Chad, including banks and MFIs, are currently not positioned to service the financing requirements of solar distributors.
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
Lack of policy support for PAYG business model and mobile technology platforms	• In order to expand PAYG options for suppliers to utilize in the market, the GoC must first reform its taxation policy of the mobile sector, which has drastically limited the use of mobile services in the country and is a significant barrier to off-grid solar market growth (see **Section 1.3.4.5**).

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

2.5.2 Drivers of Off-Grid Solar Market Growth

Table 41 is a summary of the key drivers of OGS market growth in the country.

Table 41: Key Drivers of Off-Grid Solar Market Growth in Chad

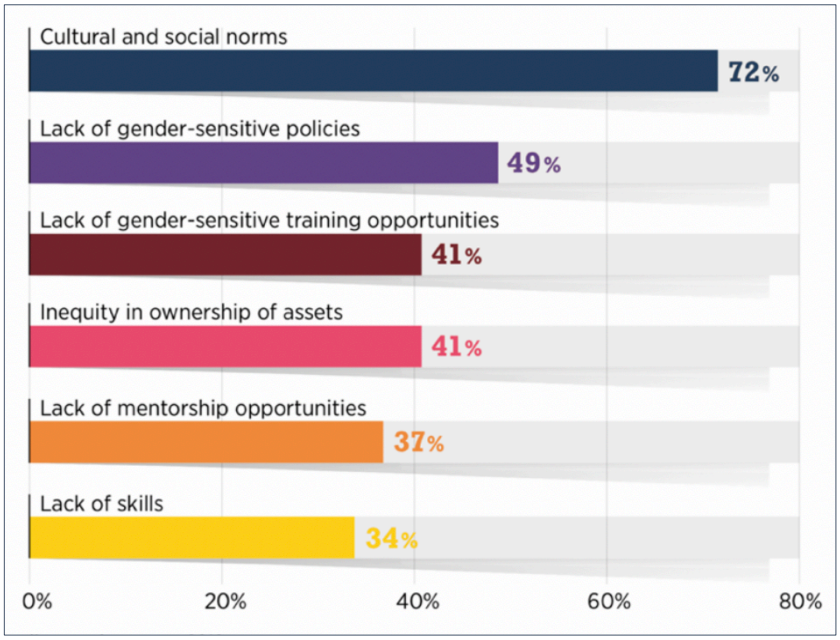
Market Driver	Description
Strong off-grid electricity demand	• Consumers from every market segment are aware of the high costs associated with energy access and consumption and are willing to take on quality, cost-effective alternatives
Willing government to support the industry	• The Government is viewed 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
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

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

2.5.3 Inclusive Participation[143]

Given that the off-grid market is only beginning to emerge in Chad, 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 34**). 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.[144]

Figure 34: 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.[145] 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.[146]

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,

[143] See **Annex 4** for more details.
[144] "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
[145] "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
[146] "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.[147] 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.[148]

The gender analysis undertaken in Chad 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)[149]
- 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

In an effort to address some of these challenges and improve the rate of participation among women in Chad's energy and off-grid sectors, the GoC adopted the National Gender Policy in 2011, which includes a series of objectives and includes a supportive framework to promote gender equality and women's empowerment in the country.

[147] "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

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

[149] 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.**

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 microenterprises 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 Euro 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.[150]

- **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.[151]

[150] 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 mid-2019.

[151] 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 Central African Economic and Monetary Community (Communauté Economique et Monétaire de l'Afrique Centrale, CEMAC), Chad shares a currency with six other countries in the economic community, the Central African CFA Franc, which is pegged to the euro. FIs in the country are regulated by the Bank of Central African States (Banque des États de l'Afrique Centrale, BEAC) and supervised by the Central African Banking Commission (Commission Bancaire de l'Afrique Centrale, COBAC). Within this macroeconomic environment, Chad has experienced relatively low rates of inflation and low interest rates.[152]

Chad has one of the smallest financial markets in the CEMAC zone and in Sub-Saharan Africa. The country's banking sector remains largely underdeveloped, contributing marginally to economic growth and faces a range of regulatory, governance and institutional challenges.[153]

The banking sector is highly concentrated, with nine active commercial banks and 197 microfinance institutions licensed by COBAC. As of August 2017, the nine licensed commercial banks operating in Chad were Banque Agricole et Commerciale (BAC), Banque Commerciale du Chari (BCC), Banque Sahélo-Saharienne pour l'Investissement et le Commerce au Tchad (BSIC-Tchad), Commercial Bank Tchad (CBT), Ecobank Tchad, Findev Microfinance Bank Tchad, Orabank Tchad, Société Générale Tchad, United Bank of Africa Tchad (UBA-Tchad).[154]

Of these banks, six are foreign-owned – three based in Togo (Ecobank, FINADEV Microfinance Bank and Orabank), one from Nigeria (UBA-Tchad), one from Libya (BSIC-Tchad), and one from France (Société Général Tchad). The Government of Chad has shares in four of these banks, including a majority stake in CBT, a 50%-stake in BAC and BCC, and a minority stake in Société Générale Tchad (**Table 42**).

[152] "Central African Economic and Monetary Community (CEMAC): IMF Country Report No. 19/1," International Monetary Fund, (January 2019): https://www.imf.org/en/Publications/CR/Issues/2019/01/03/Central-African-Economic-and-Monetary-Community-CEMAC-Common-Policies-of-Member-Countries-46501

[153] "Chad: IMF Country Report No. 19/25," International Monetary Fund, (January 2019): https://www.imf.org/en/Publications/CR/Issues/2019/01/24/Chad-Third-Review-Under-the-Extended-Credit-Facility-Arrangement-Request-for-Waiver-of-46545

[154] "Situation du système bancaire de la CEMAC," COBAC, (2017): http://www.sgcobac.org/upload/docs/application/pdf/2017-12/situation_du_systeme_bancaire.pdf

Table 42: Licensed Commercial Banks in Chad, 2017[155]

Name	Ownership	Date of Incorporation
Banque Agricole et Commerciale (BAC)	Chad State (50%) Sudanese State (50%)	-
Banque Commerciale du Chari (BCC)	Libyan Arab Foreign Bank (50%), Chad State (50%)	2001
Banque Sahélo-Saharienne pour l'Investissement et le Commerce au Tchad (BSIC-Tchad)	BSIC, Libya (100%)	2003
Commercial Bank Tchad (CBT)	Chad State (50.84%), Fotso Group (18.0%), CNPS (12.4%), Star National (9.73%), Others (7.28%)	1963
Ecobank Tchad	Ecobank Transnational Incorporated (ETI), Togo, (100%)	2001
FINADEV Microfinance Bank Tchad	Orabank Group, Togo (81%)	2003
Orabank Tchad	Orabank Group, Togo (100%)	1992
Société Générale Tchad	Société Général, France (40%), Société Générale de Banque, Belgium (26%), Chad State (20%), Private shareholders (14%)	1963
United Bank for Africa - Tchad	UBA, Nigeria (100%)	2008

Source: COBAC and BEAC

According to COBAC, in 2016, the total balance sheet of commercial banks stood at FCFA 851 billion (USD 1.4 billion), net credit and deposits at FCFA 617 billion (USD 992 million) and FCFA 721 billion (USD 1.16 billion), respectively (**Figure 35**). Chad represents less than 8% of the banking sector total balance sheet in the CEMAC zone (**Figure 36**).[156]

Microfinance institutions in Chad have a less prominent role in the country's financial market, as their geographic coverage is mainly limited to the capital N'Djamena.[157] As of 2017, the country's 197 licensed MFIs had a total balance sheet of about FCFA 10.7 billion (USD 17.2 million), which represented less than 2% of the commercial banking sector's balance sheet of FCFA 851 billion (USD 1.37 billion) in the same year.[158]

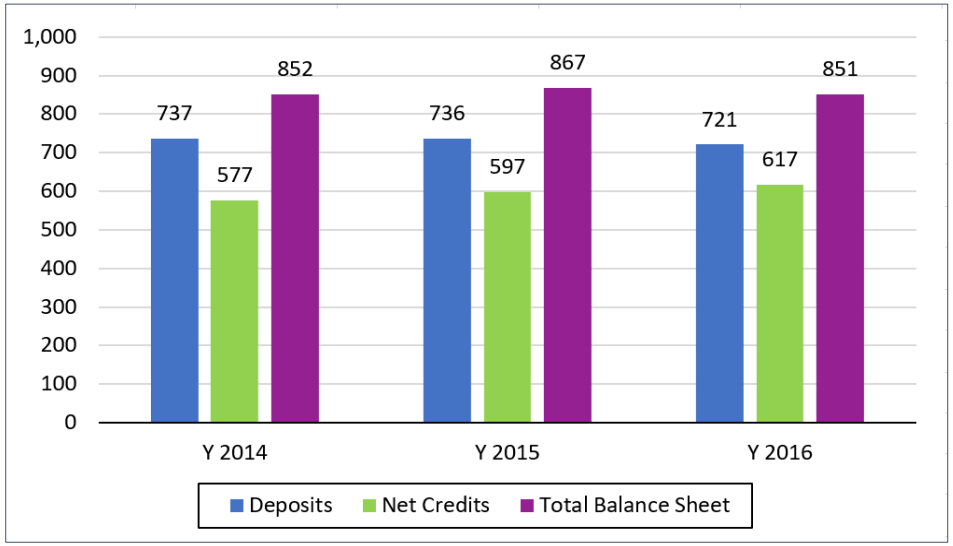
[155] "Lexique des Établissements," COBAC, (2017): http://www.sgcobac.org/jcms/ess_7498/fr/banques#refresh-0; and "Liste des banques agréées de la RCA au 28 octobre 2014," BEAC, (2014): https://www.beac.int/wp-content/uploads/2016/10/Liste_Banques_-RCA-_28oct14.pdf

[156] "Bulletin n°19 de la Commission Bancaire de l'Afrique Centrale," COBAC, (2016): http://www.sgcobac.org/jcms/ess_5064/en/internet-cobac-page-d-accueil?cids=ess_5422&jsp=front%2Fquery.jsp

[157] "Chad: IMF Country Report No. 16/275," International Monetary Fund, (August 2016): https://www.imf.org/external/pubs/ft/scr/2016/cr16275.pdf

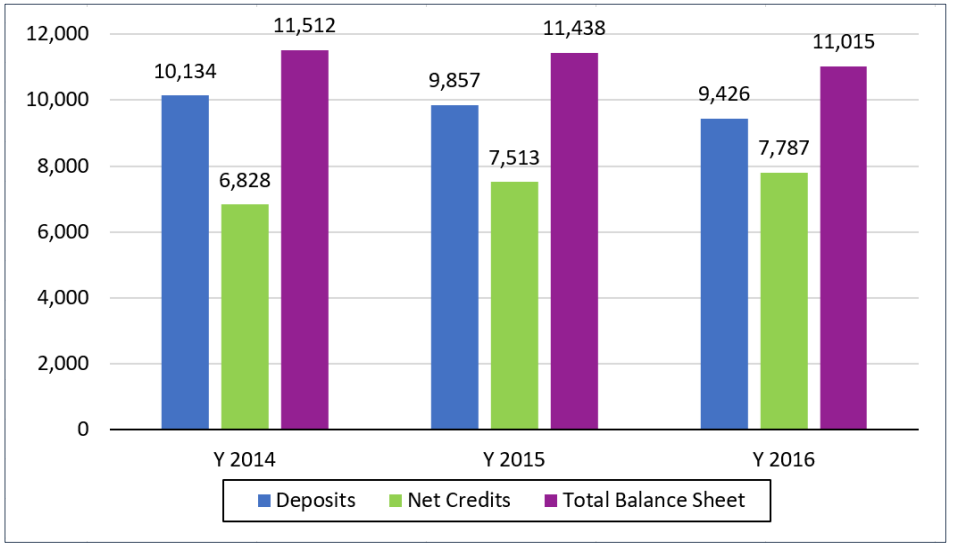
[158] "Situation du secteur de la microfinance de la CEMAC," COBAC, (June 2017): http://www.sgcobac.org/upload/docs/application/pdf/2017-12/situation_du_secteur_de_la_microfinance_au_30_juin_2017.pdf

Figure 35: Chad Banking Sector Financial Indicators (FCFA billion)



Source: COBAC

Figure 36: CEMAC Banking Sector Financial Indicators (FCFA billion)



Source: COBAC

- **Banking Industry Financial Soundness Indicators**

Table 43 provides a summary of commercial bank financial indicators in Chad.

Table 43: Summary of Commercial Bank Financial Indicators[159]

Indicator	2014	2015	2016	2017
Balance Sheet and Revenue				
Total Assets (USD million)	1,725	1,465	1,435	-
Net Credit (USD million)	1,492	1,245	1,215	-
Customer Deposits (USD million)	1,168	1,010	1,040	-
Net Banking Income (USD million)	-	140	142	-
Net Profit (USD million)	-	13.2	15.8	-
Asset Quality				
Nonperforming loans / total loans (%)	-	-	-	28
Gross credit in arrears / Gross banking loans (%)	11.7	17.0	20.9	-
Provisions / Credit in arrears (%)	68.3	56.1	52.4	-
Net credit in arrears / Gross banking loans (%)	3.7	7.3	-	-
Liquidity				
Liquidity of assets / Total assets (%)	30.8	26.0	23.1	27.5
Liquidity of assets / Short-term liabilities (%)	152.9	142.1	155.0	188.9
Capital Adequacy				
Regulatory capital / Risk-weighted assets (%)	13.4	14.7	13.2	18.0
Profitability and Revenue				
ROA - Return on assets, net income to average assets (%)	2.1	1.6	1.4	1.1
ROE - Return on equity, net income to average capital (%)	19.4	15.2	14.6	9.0

Source: COBAC and International Monetary Fund

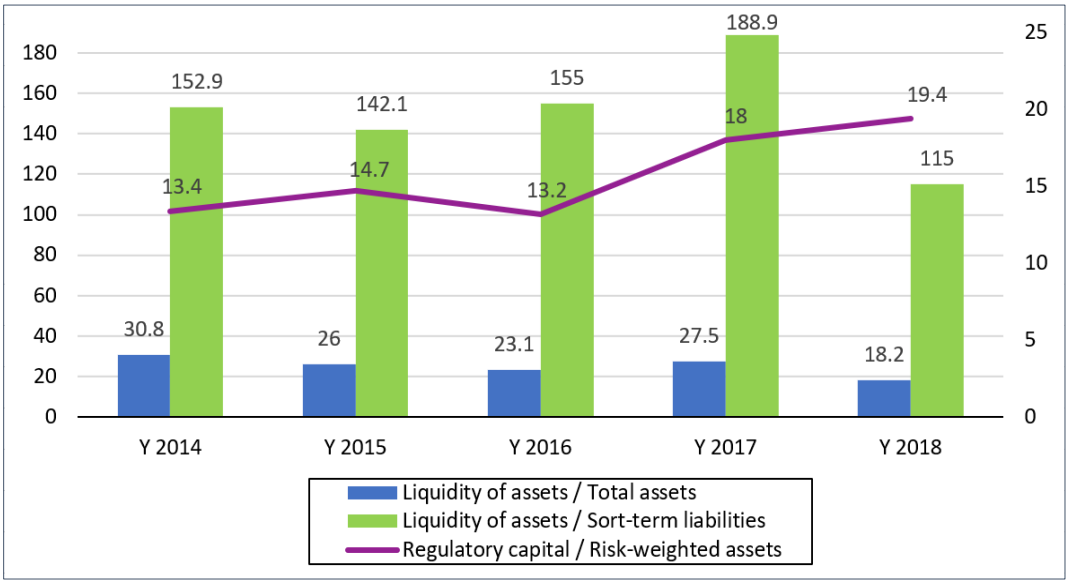
Asset-Based Indicators: In 2017, the banking sector's ratio of non-performing loans (NPLs) accounted for 28% of total gross loans, as asset quality deteriorated significantly over the period 2014-2018 – a prolonged period of low oil prices (**Table 43**). The country's high share of NPLs are due in part to accumulation of arrears by the Government; new regional standards adopted by the BEAC aim to address this and improve the market's overall financial soundness.

Liquidity Indicators: The banking sector's liquidity ratio decreased from 30.8% of total assets in 2014 to 27.5% in 2017, while the liquidity of assets to short term liabilities increased from 152.9% to 188.9% over the same period (**Table 43 and Figure 37**). While the sector's overall liquidity has slightly improved, vulnerabilities remain high as domestic commercial banks are exposed to government debt and the private sector also relies heavily on government procurement/funds. In 2018, the BEAC interim emergency liquidity facility helped to address this. As of June 2018, however, three of the country's nine commercial banks were not in compliance with CEMAC zone minimum regulatory liquidity ratios.

Capital-Based Indicators: Between 2014 and 2018, the banking sector's average capital adequacy ratio (CAR) increased by 6% (**Figure 38**). This increase helped banks remain adequately capitalized despite their difficult liquidity situation.

[159] IMF Country Report No. 19/25, 2019; and
"Chad: IMF Country Report No. 18/108," International Monetary Fund, (April 2018): https://www.imf.org/en/Publications/CR/Issues/2018/04/27/Chad-First-Review-Under-the-Extended-Credit-Facility-Arrangement-and-Request-for-a-Waiver-of-45817

Figure 37: Banking Sector Liquidity and Capital Adequacy Indicators (%)[160]



Source: COBAC

Income and Expense-Based Indicators: Key income and expense-based indicators for the commercial banking sector are shown in **Table 44**. As of 2016, Chad's net banking income was FCFA 84.2 billion (USD 135.4 million), representing about 9% of the CEMAC banking industry's net banking income of FCFA 914.8 billion (USD 1.5 billion).

Table 44: Banking Sector Income and Expense Indicators[161]

Indicator	2013	2014	2015	2016	2017
Net banking income (FCFA million)	-	-	82,867	84,160	-
Net result (FCFA million)	-	-	7, 808	9,351	-
ROA: Return on assets (net income to average assets, %)	2.8	2.1	1.6	1.4	1.1
ROE: Return on equity (net income to average capital, %)	21.1	19.4	15.2	14.6	9.0

Source: COBAC

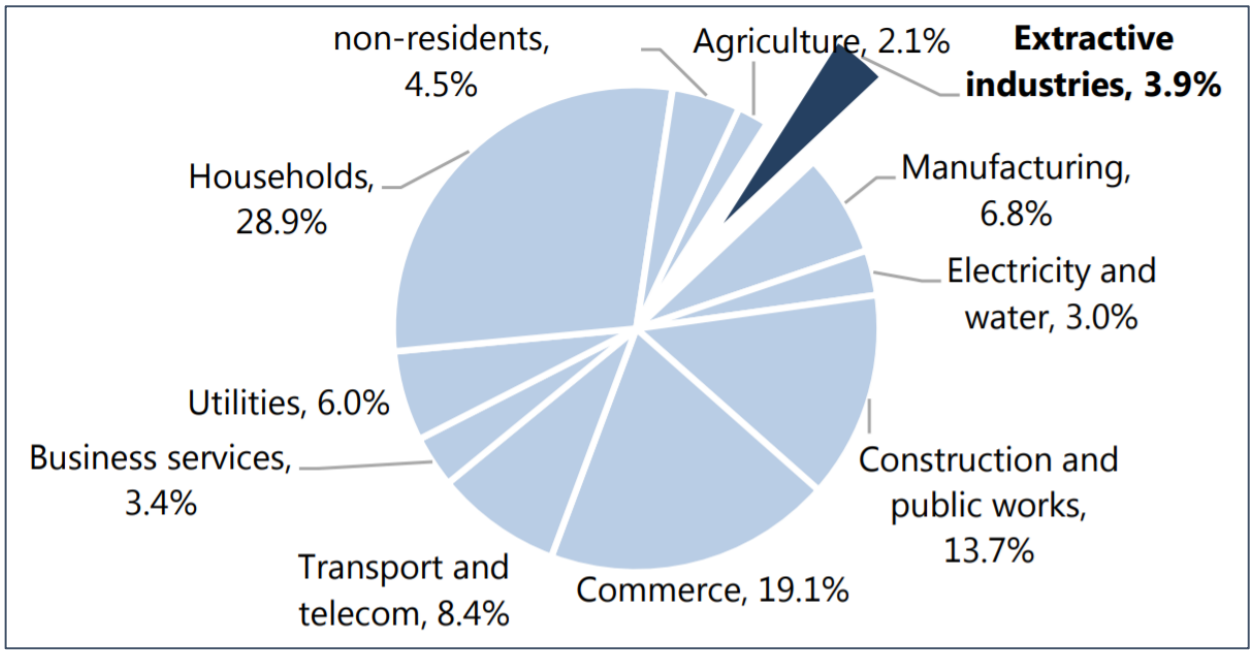
- **Distribution of Credit by Sector**

Bank distribution of credit by sector in 2016 is shown in **Figure 38**. Between 2016 and 2018, the banking sector's total credit to the economy remained consistently around FCFA 620 billion (USD 1 billion).[162] In general, banking sector credit plays a relatively limited role in supporting the economy, as it represented less than 9% of nominal GDP in 2017.[163] Commercial banks in Chad are exposed to a significant amount of sovereign risk. The Government accounted for nearly 60% of Chad's domestic assets, while credit to the economy represented the balance.

[160] IMF Country Report No. 19/25, 2019.
[161] Ibid.
[162] "Rapport de politique Monétaire de la CEMAC," CEMAC, (December 2018): https://www.beac.int/wp-content/uploads/2018/11/Rapport-politique-mone%CC%81taire_Decembre-2018.pdf
[163] IMF Country Report No. 19/25, 2019.

Chad ranked 181st out of 190 countries in the World Bank's Doing Business 2019 report. The study identified low levels of access to financing for businesses as a key barrier development, as most local SMEs are unable to access credit, especially the mid-term and long-term credit needed for investment.[164]

Figure 38: Banking Sector Loan Portfolio, 2016[165]



Source: COBAC

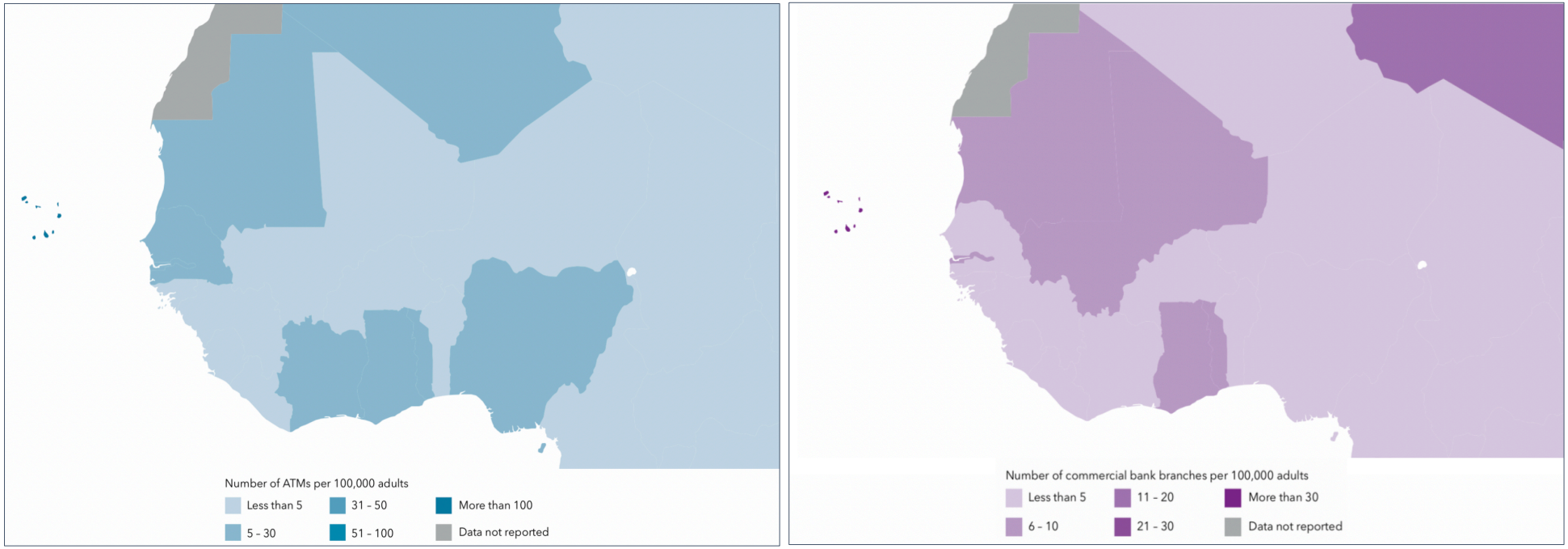
3.2.2 Financial Inclusion

- **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 39**).[166] 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%.[167] Many countries across the region have also seen a sharp increase in mobile money account ownership (**Figure 40**) and transaction volume (**Figure 41**).

[164] "Ease of Doing Business: Chad," World Bank Doing Business, (2019): http://documents.worldbank.org/curated/en/409011541067625646/pdf/WP-DB2019-PUBLIC-Chad.pdf
[165] IMF Country Report No. 16/275, 2016.
[166] "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
[167] 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 39: ATMs and Branches of Commercial Banks per 100,000 Adults in West Africa and the Sahel, 2017[168]

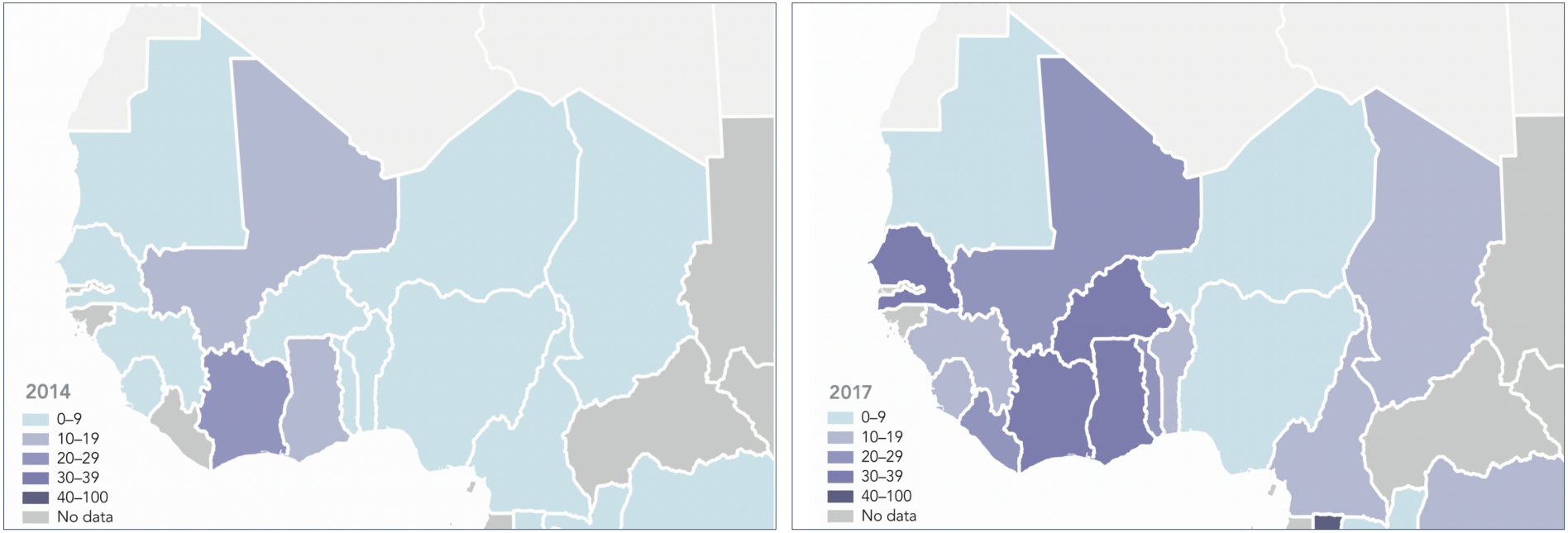


Source: International Monetary Fund

Figure 39 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.

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

Figure 40: Share of Adults with a Mobile Money Account in West Africa and the Sahel (%), 2014 and 2017[169]



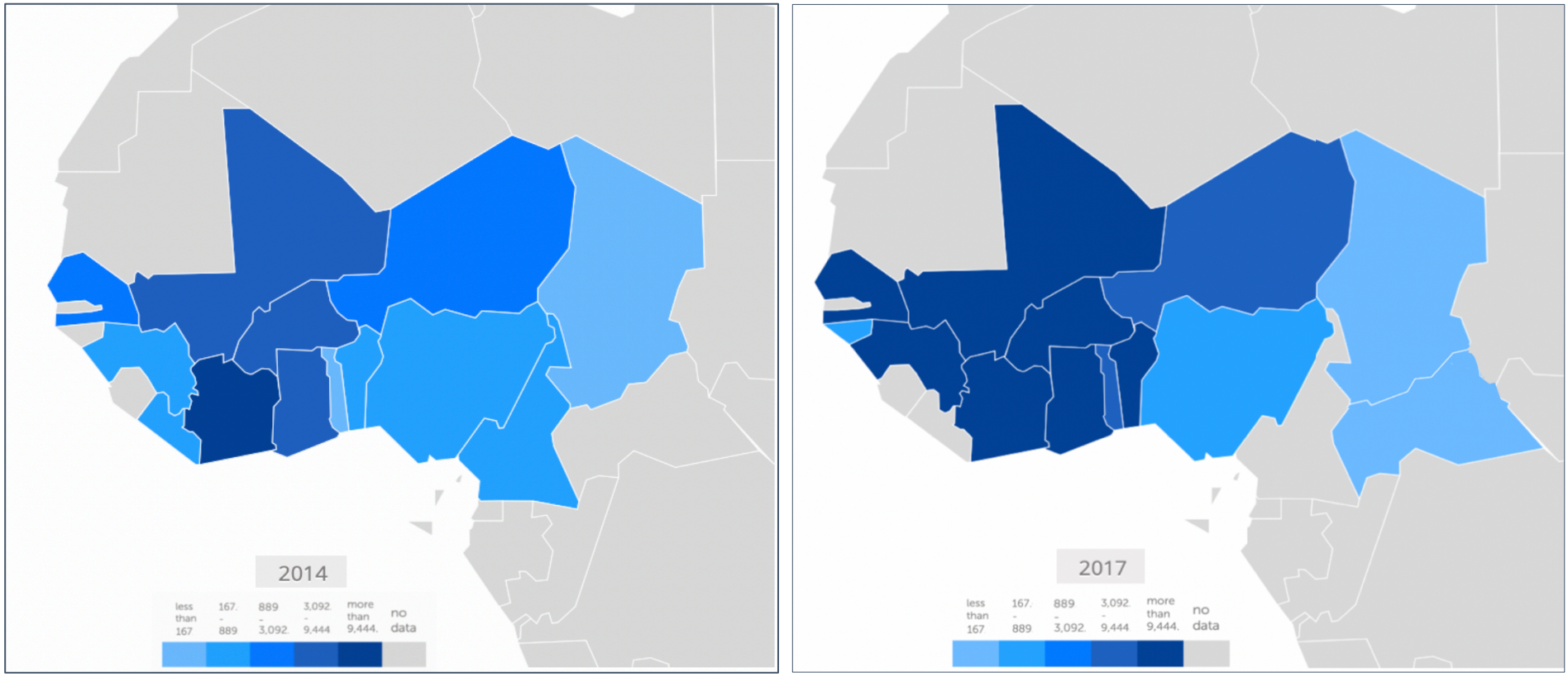
NOTE: Maps exclude Cabo Verde (no data)

Source: World Bank Global Findex Database

Figure 40 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 in Benin, Cameroon, **Chad**, Guinea, Mali, Sierra Leone and Togo, while growth in account ownership was slower in Niger, Nigeria and Mauritania. There was either no data or insufficient data available to assess account ownership in Cabo Verde, Central African Republic, The Gambia, Guinea-Bissau, and Liberia.

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

Figure 41: Mobile Money Transactions per 1,000 Adults in West Africa and the Sahel, 2014 and 2017[170]



NOTE: Maps exclude Cabo Verde (no data)

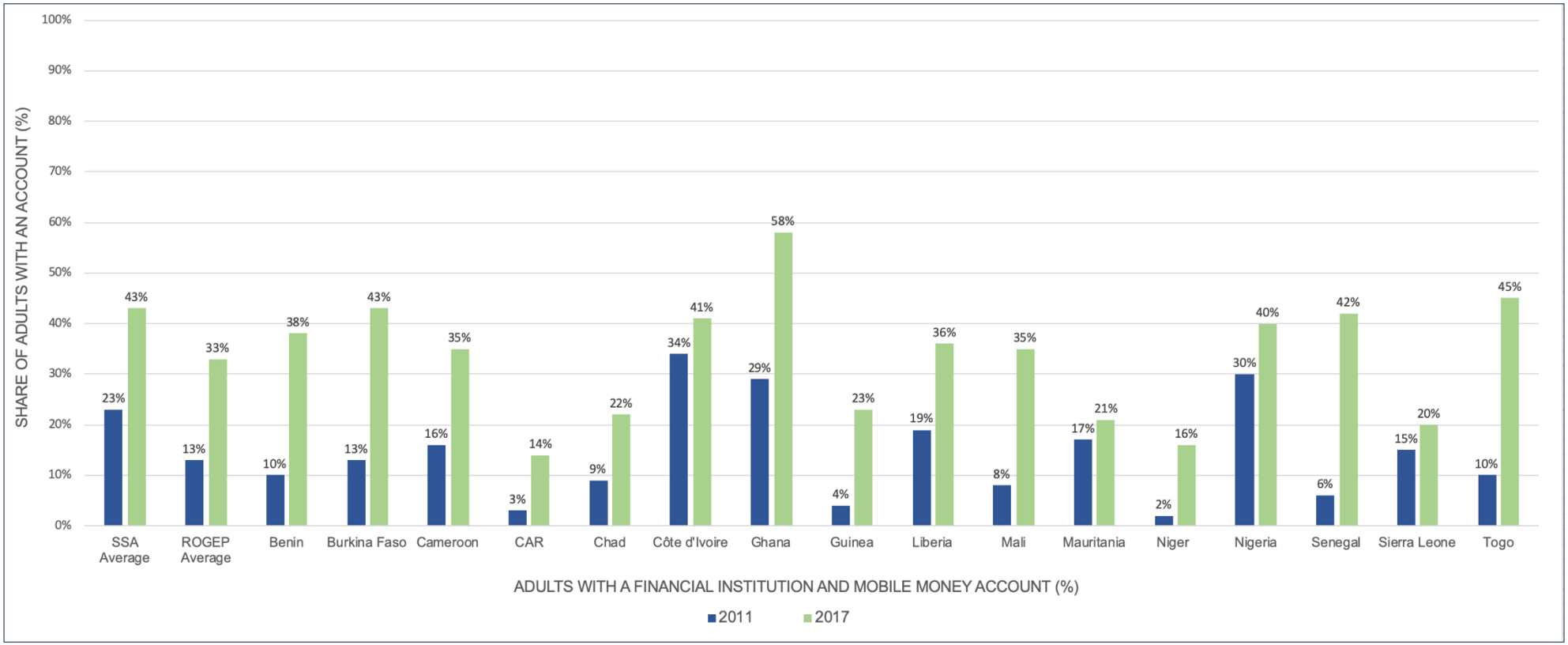
Source: International Monetary Fund

Figure 41 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, while growth in transaction volume was slower in Nigeria and **Chad**. There was either no data or insufficient data available to assess transaction volume in Cabo Verde, Cameroon, Central African Republic, The Gambia, Guinea-Bissau, Liberia, Mauritania and Sierra Leone.

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

In 2017, 22% of Chad's adult population had an account at a financial institution or with a mobile money service provider, up from 9% in 2011. In 2017, the country had one of the lowest rates of financial inclusion in West Africa and the Sahel, 11% below the region's average and 21% below the average for Sub-Saharan Africa (**Figure 42**).

Figure 42: Share of Adults with Access to Financial Services in West Africa and the Sahel (%), 2011 and 2017[171]



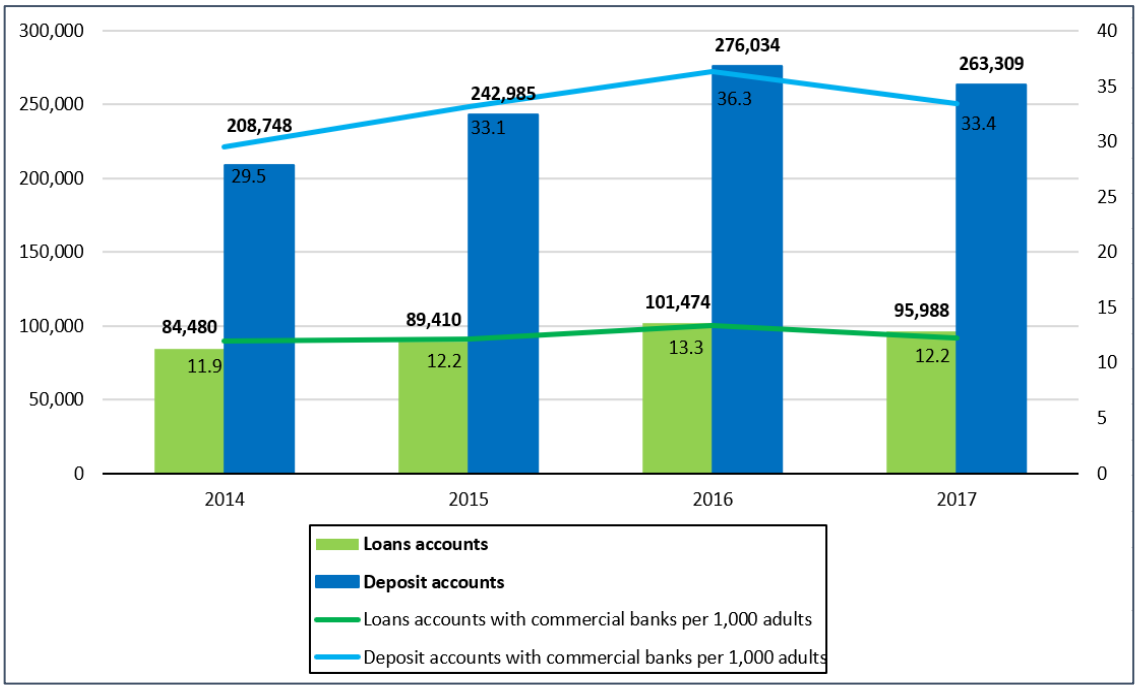
NOTE: Cabo Verde, Guinea-Bissau and The Gambia excluded (no data); data for Côte d'Ivoire is from 2014 and 2017

Source: World Bank Global Findex Database

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

Access to financial services remains an ongoing challenge in Chad. In 2017, the total number of loan accounts amounted to 95,988, while the total number of deposit accounts was 263,309 – equivalent to 12.2 loan accounts and 33.4 deposit accounts per 1,000 adults, respectively (**Figure 43**).

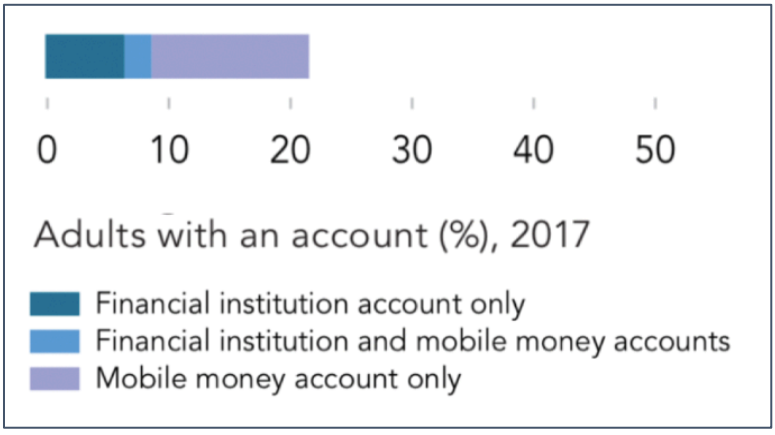
Figure 43: Loan and Deposit Accounts at Commercial Banks in Chad[172]



Source: International Monetary Fund

The country's modest improvements in financial inclusion between 2011 and 2017 (**Figure 42**) were driven primarily by the proliferation of mobile money services. By 2017, more adults in the country had an account with a mobile money service provider than at a financial institution (**Figure 44**).

Figure 44: Financial Institution Account Ownership, 2017[173]



Source: World Bank Global Findex Database

[172] IMF Financial Access Survey: http://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C&sId=1460054136937
[173] Demirguc-Kunt et al., 2017.

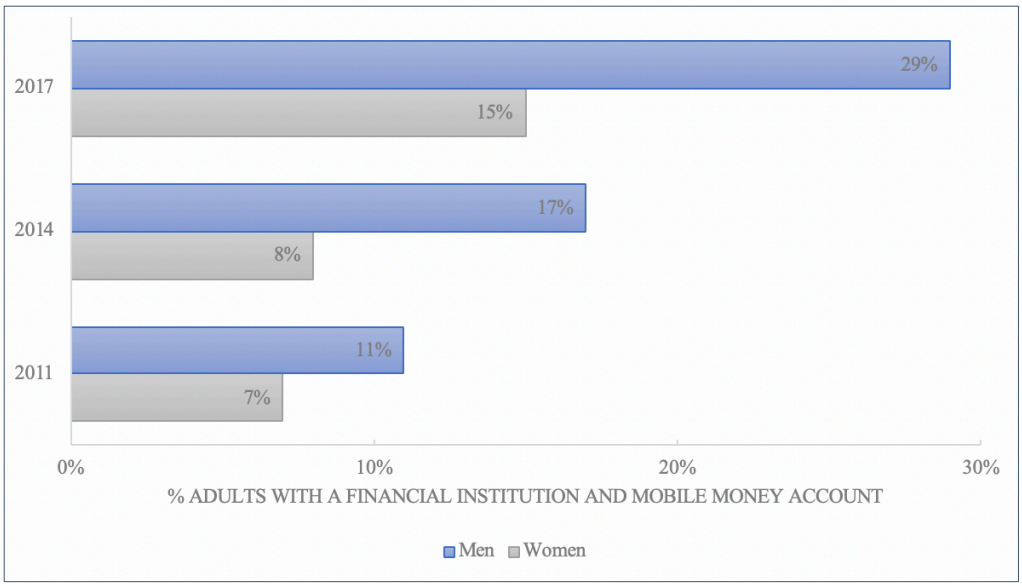
As of 2017, three banks in Chad were offering mobile money services – Ecobank in partnership with Airtel (Airtel Money), Orabank in partnership with Tigo (Tigo Cash), and UBA in partnership with VISA (UBA Africard).[174] Development of the mobile money sector has been hampered by the country's low levels of mobile phone penetration, limited mobile network geographic coverage (**Figure 31**) and internet usage as well as the Government's regressive tax policies (see **Section 1.3.4.5**).[175]

The microfinance sector's contribution to financial inclusion remains limited, largely due to poor management and financial performance.[176] The sector is also hindered by its reduced geographic reach, as most of its branches are located in urban centers. In 2017, there were 68 branches and 50,986 deposit accounts at MFIs in Chad, which represented about 20% of the commercial banking sector (**Figure 41**).[177]

➢ 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 Chad, the gender gap is slightly higher than the regional average, with 15% of women compared to 29% of men holding an account (**Figure 45**). Women in Chad experience financial exclusion mainly due to low or irregular sources of income and limited access to land and credit. The country's elevated levels of poverty, social and cultural norms, and lower levels of education and rates of literacy make it difficult for women to access and use financial services.

Figure 45: Financial Inclusion Gender Gap in Chad[178]



Source: World Bank Global Findex Database

[174] "Etat des systèmes de paiement par monnaie électronique dans la CEMAC," BEAC, (September 2017) : https://docplayer.fr/88945930-Etat-des-systemes-de-paiement-par-monnaie-electronique-dans-la-cemac.html
[175] "Digital Inclusion and Mobile Sector Taxation in Chad," Deloitte and GSMA, (November 2016): https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/01/Digital-Inclusion-and-Mobile-Sector-Taxation-in-Chad_English_report.pdf
[176] IMF Country Report No. 16/275, 2016.
[177] "Situation du secteur de la microfinance de la CEMAC," COBAC, (June 2017): http://www.sgcobac.org/upload/docs/application/pdf/2017-12/situation_du_secteur_de_la_microfinance_au_30_juin_2017.pdf
[178] 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 programs, policies and regulations are therefore critical to overcoming the barriers that women face and driving overall progress towards financial inclusion.[179] The expansion of digital financial services, especially mobile money, has also created new opportunities to better serve women, the lower-income population and other groups that are traditionally excluded from the formal financial system.

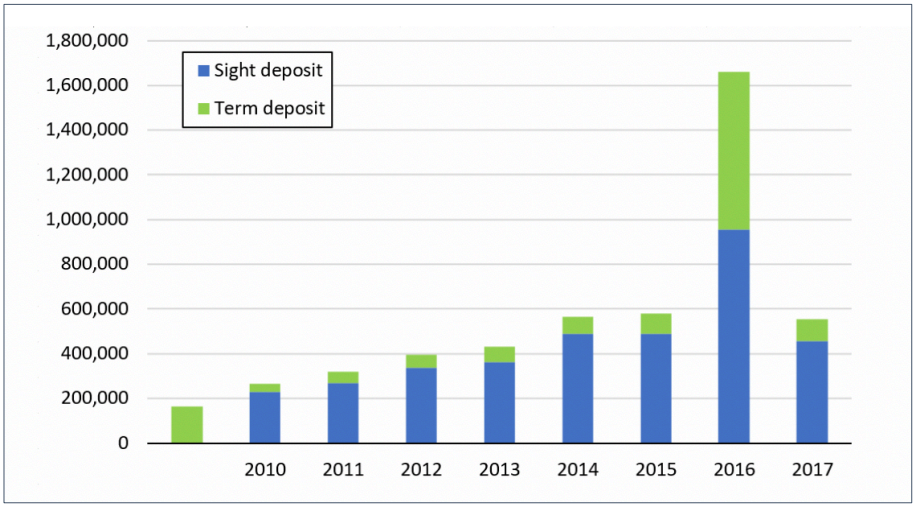
To address this issue, the Government of Chad intends to build on financial inclusion policies being pursued at the regional level. In December 2016, CEMAC heads of state adopted a regional strategy that included a focus on increasing the stability of and inclusion within the financial sector to spur economic growth, avert a financial crisis, and preserve the current exchange rate peg. The implementation of the strategy includes long-term, structural reforms to strengthen CEMAC regional and national institutions' capacity to manage public finance and to create a business-friendly environment in support of economic growth. In 2018, the World Bank committed $35 million to support the overall regional strategy.[180]

3.2.3 Commercial Lending Environment

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

Over the period 2009-2017, deposit liabilities for the banking sector in Chad were dominated by short-term deposits, which represented 82.51% of total deposits in 2017, the highest share in the CEMAC zone (**Figure 46** and **Table 45**). Structural short-term liabilities in Chad oblige banks to maintain high levels of liquidity to mitigate risks.[181] In 2018, the excess reserves to required reserves ratio for Chadian banks stood at 286.5%.[182]

Figure 46: Maturity Structure of Bank Deposits (FCFA million)



Source: BEAC

[179] 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

[180] "Strengthening the Capacity of Regional Financial Institutions in the CEMAC Region (P161368)," The World Bank, (27 March 2018): http://documents.worldbank.org/curated/en/390661522173803460/text/Project-Information-Document-Integrated-Safeguards-Data-Sheet-Strengthening-the-Capacity-of-Regional-Financial-Institutions-in-the-CEMAC-Region-P161368.txt

[181] IMF Country Report No. 16/275, 2016.

[182] "Rapport sur la politique monétaire," BEAC, (December 2018): https://www.beac.int/wp-content/uploads/2018/11/Rapport-politique-mone%CC%81taire_Decembre-2018.pdf

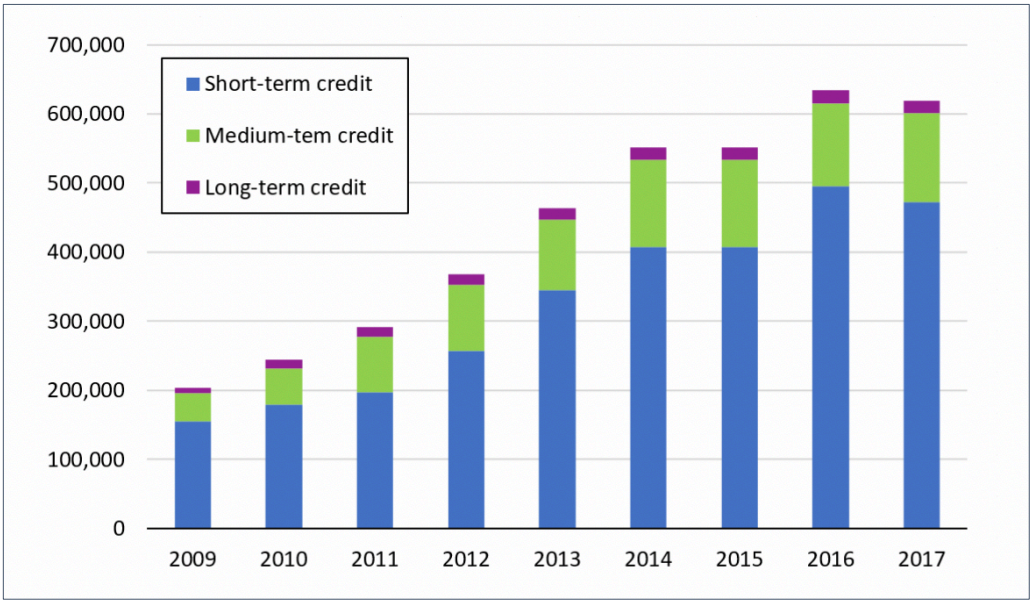
Table 45: Maturity Structure of Bank Deposits[183]

Indicator	2009	2010	2011	2012	2013	2014	2015	2016	2017
Sight deposits	83.13%	86.72%	84.11%	85.38%	84.10%	86.42%	84.41%	57.63%	82.51%
Term deposits	16.87%	13.28%	15.89%	14.62%	15.90%	13.58%	15.59%	42.37%	17.49%

Source: BEAC

With the majority of bank deposits being short-term, banks are also constrained in their ability to create long-term assets; consequently, most of the credit available in the Chadian market is also short-term. Between 2009 and 2017, the maturity structure of bank credit remained relatively stable, with short-term credit accounting for about three-quarters of total credit during this period (**Figure 47** and **Table 46**).

Figure 47: Maturity Structure of Bank Credit (FCFA million)



Source: BEAC

Table 46: Maturity Structure of Bank Credit (%)

Indicator	2009	2010	2011	2012	2013	2014	2015	2016	2017
Short-term credit	75.91%	73.69%	67.91%	69.98%	74.40%	73.74%	73.74%	78.05%	76.28%
Medium-term credit	20.06%	21.36%	27.29%	26.09%	22.04%	22.88%	22.88%	19.01%	20.70%
Long-term credit	5.31%	6.73%	7.06%	5.62%	4.79%	4.58%	4.58%	3.77%	3.96%

Source: BEAC

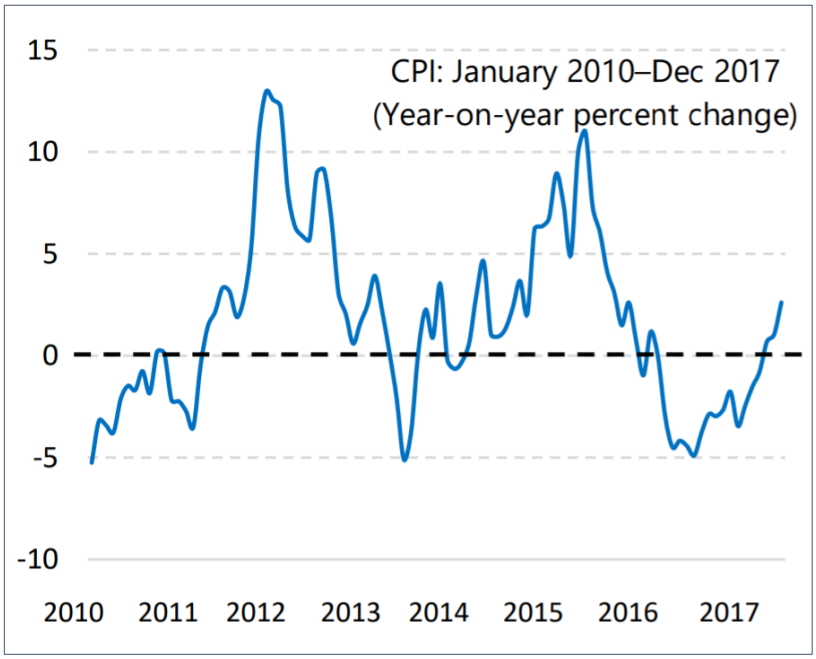
- **Interest Rates**

In the wake of security concerns (affecting cross-trade border in particular), weak global demand, and fluctuations in oil prices, Chad experienced volatility in its inflation rate over the period 2010-2017 (**Figure 48**). In 2018, Chad had the third highest inflation rate (2.5%), behind Central African Republic (3.0%) and

[183] "Statistiques monétaires du Tchad à fin novembre," BCEAC, (November 2018): https://www.beac.int/economie-stats/statistiques-monetaires/

Equatorial Guinea (4.0%). Despite an inflation rate above the CEMAC zone average (1.7%), it remained below the BEAC threshold of 3.0%.[184]

Figure 48: Inflation Rate (%)[185]



Source: International Monetary Fund

Lending interest rates by commercial banks in Chad are also above average interest rates in the CEMAC zone (**Table 47**).

[184] IMF Country Report No. 19/1, 2019.
[185] IMF Country Report No. 18/108, 2018.

Table 47: Commercial Bank Lending Rates (%), 2017[186]

	H1 2017				H2 2017			
	Chad		CEMAC***		Chad		CEMAC	
	AEIG*	NIR**	AEIG	NIR	AEIG	NIR	AEIG	NIR
Consumer Credit								
Consumer loan	31.02	11.51	17.33	12.90	43.87	9.22	19.02	11.82
Overdrafts	20.89	15.39	16.12	14.75	14.26	11.39	16.25	13.98
Medium-term credit	17.66	13.17	14.93	12.30	18.67	13.38	15.71	12.30
Long-term credit	15.92	12.40	11.75	8.42	14.31	7.88	13.90	10.65
Guarantees	6.07	4.00	5.44	3.70	-	-	4.50	4.00
SMEs								
Cash loans	12.39	9.68	9.04	8.15	19.55	8.35	10.74	8.12
Overdrafts	12.47	12.11	11.78	10.47	12.80	12.21	10.51	9.81
Medium-term credit	13.57	10.93	9.05	8.06	12.57	10.27	8.73	7.60
Long-term credit	13.87	10.67	14.04	10.24	7.33	6.33	8.42	6.85
Guarantees	2.85	1.89	3.99	2.27	3.99	3.32	2.27%	2.49
Large Companies								
Cash loans	9.68	7.69	5.62	4.43	8.36	8.10	5.67	5.16
Overdrafts	9.29	9.19	7.66	6.49	10.33	10.17	8.15	6.87
Medium-term credit	10.61	8.94	9.02	6.12	9.20	8.21	7.31	6.14
Long-term credit	11.73	7.97	10.38	7.29	9.44	8.00	8.84	7.50
Guarantees	3.54	3.38	2.85	2.54	1.36	1.17	1.42	1.18
Public Administration								
Cash loans	8.13	6.62	6.88	5.93	8.02	6.53	6.30	5.54
Overdrafts	11.50	10.00	7.00	6.85	0.34	0.33	11.23	10.00
Other Entities								
Overdrafts	16.48	12.86	11.90	11.70	15.00	14.00	10.06	9.41
Guarantees	-	-	1.26	0.25	2.49	2.35	2.49	2.35
Medium-term credit	17.15	15.00	4.33	4.00	-	-	7.07	6.50
Long-term credit	10.07	10.00	10.07	10.00	-	-	-	-

NOTE: H1/H2 = First/Second half of year
* Average Effective Interest Rates
** Nominal Interest Rates
*** CEMAC data excludes Gabon

Source: BEAC

- **Foreign Exchange Market**

As a member state of CEMAC, Chad's currency, the CFA franc, is pegged to the euro. The BEAC 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 African countries.[187]

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. This provides stability and credibility to the currency. The common currency also expedites trade by removing foreign exchange between the six

[186] "Taux débiteurs moyens pratiqués par les banques dans la CEMAC, au 2nd semestre 2017," BEAC, (2018): https://www.beac.int/economie-stats/statistiques-marche-monetaire/
[187] 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/

countries in CEMAC as well as the eight member states of the West Africa Economic and Monetary Union (WAEMU).[188]

Monetary stabilization across the CEMAC zone reflects a reduction in the regional payment balance deficit. This can largely be attributed to reductions in public expenditures as well as tightening of BEAC's monetary policy (including foreign exchange allocation to commercial banks) and additional foreign exchange reserves under IMF budget support programs (in Cameroon, CAR, Chad and Gabon).[189]

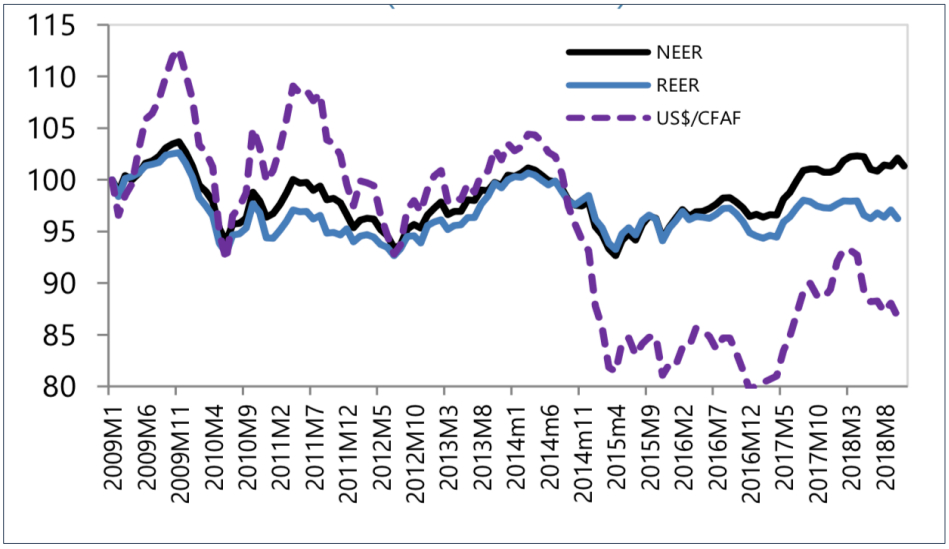
Table 48: Official Exchange Rate, (FCFA-USD)[190]

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

Table 48 shows the exchange rate of the US dollar against the Central African franc between 2013 and 2018. The real effective exchange rate in CEMAC was relatively stable between 2000 and 2013, before depreciating due to corresponding higher inflation (**Figure 49**). This shift can largely be attributed to the increase in political instability across the region and a concurrent decline in oil export revenue.

Figure 49: Real and Nominal Effective Exchange Rates in CEMAC[191]



Source: BEAC and International Monetary Fund

[188] 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

[189] "La situation monétaire se stabilise en zone CEMAC," French Treasury, (June 2018): https://www.tresor.economie.gouv.fr/Articles/7ea7eee8-10e9-4e65-ba55-91ec38ae3dab/files/1060fafb-660a-4db4-aafd-0cbbfdbb78b5

[190] IMF – International Financial Statistics: http://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B

[191] "Central African Economic and Monetary Community (CEMAC): IMF Country Report No. 19/1," International Monetary Fund, (January 2019): https://www.imf.org/en/Publications/CR/Issues/2019/01/03/Central-African-Economic-and-Monetary-Community-CEMAC-Common-Policies-of-Member-Countries-46501

- **Collateral Requirements**

The collateral system (guarantees, sureties and mortgages) in Chad is governed by the Organization for the Harmonization of Business's Law in Africa (L'Organisation pour l'Harmonisation en Afrique du Droit des Affaires, OHADA). A common problem in the Central African Economic and Monetary Community is poor judicial processes regarding collateral registry and recovery, as well as a lack of available credit information about the borrower. Hence, most banks require high amounts of collateral in order to mitigate consumer credit risk. Commercial banks in Chad are particularly risk-averse and have very high collateral requirements. As a result, the 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.

- **Banking Supervision**

Banking sector supervision in Chad is organized at the regional level through COBAC, which has been assigned a role that is more typical of regulatory authorities at the national level. COBAC shares responsibility with national ministries of finance for the licensing of new banks, and it has the authority to sanction credit institutions, to revoke banking licenses and to decide on liquidation of banks. Although a legal hierarchy has been established wherein COBAC's provisions override national legal frameworks, in practice, COBAC has to rely on cooperation from respective national authorities to enforce its decisions. With support from BEAC, COBAC interventions have successfully overcome a number of banking sector crises across the region, which has strengthened the legitimacy of the institution's regulatory mandate.

Under its 2019-2021 strategic plan, COBAC has committed to strengthening the CEMAC monetary policy, progressively adopting a risk-based banking supervision process. In response to shortfalls of regional foreign reserves, the BEAC has tightened its monetary policy and modernized its monetary policy framework. The overall objective is to develop an interbank market through the reduction of excess liquidity and to enforce prudential regulations through improved cooperation between COBAC and the BEAC.[192]

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 Chad's off-grid solar market, 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.

3.2.5 Key Barriers to Off-Grid Solar Lending

- **Low Rates of Access to Financial Services**

As indicated in **3.2.1** and **3.2.2**, the development of the banking sector is extremely limited in Chad. In 2017, only 22% of the population had an account at a financial institution or with a mobile money service provider (**Figure 44**).

- **Challenging Security and Business Environment**

The political, social and security environment in Chad remains highly unstable. This instability has made the country's business environment unfavorable, as Chad is among the lowest-ranked countries in the World

[192] IMF Country Report No. 19/1, 2019.

Bank Doing Business assessment (181st out of 190 countries) in 2019).[193] The development of the off-grid sector, which relies heavily on the private sector, is therefore severely constrained.

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

Much like other African markets, local FIs in Chad 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. There remains a significant gap in overall local FI capacity, as most of the interviewed FIs stressed that technical assistance would be necessary to facilitate off-grid solar lending.

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

As described in **Section 3.2.3**, the sizable share of short-term deposits (83% of total) 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, Pay-As-You-Go (PAYG) and Energy-as-a-Service payment and business models reduce entry barriers for consumers by allowing for small, incremental payments, which are more affordable, rather than demanding a high up-front cost for installation and service.

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

As described in **Section 3.2.3**, consumers in Chad face very strict collateral requirements. Many consumers also lack basic financial literacy and knowledge about the terms and conditions of financial products and therefore struggle to obtain loans. 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 off-grid sector.

[193] "Ease of Doing Business: Chad," World Bank Doing Business, (2019): http://documents.worldbank.org/curated/en/409011541067625646/pdf/WP-DB2019-PUBLIC-Chad.pdf

3.3 Financial Institutions[194]

3.1.1 Development Finance Institutions

Several DFIs are active in Chad, including AfDB, AFD/Proparco, IFC, and KFW/DEG, and US Overseas Private Investment Corporation (OPIC) among others; however, there has been little funding made available to support development of the off-grid solar sector to date. The identified DFI programs relevant to this sector are described below.

- **African Development Bank: Sustainable Energy Fund for Africa / Facility for Energy Inclusion**

The **Sustainable Energy Fund for Africa (SEFA)** is a USD 60 million multi-donor trust fund administered by the African Development Bank with the objective of supporting sustainable private sector led economic growth in African countries through the efficient utilization of clean energy resources and support small- and medium-scale renewable energy project development.[195]

The **Facility for Energy Inclusion (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 independent power producers and mini-grid developers. The FEI Off-Grid Energy Access Fund (OGEF), structured by Lion's Head in partnership with the Nordic Development Fund, 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.[196]

The launch of the FEI in 2016 led to a significant increase in AfDB financing for distributed renewable energy throughout Sub-Saharan Africa.[197] The FEI OGEF, which launched in 2018, will initially focus on East Africa, Côte d'Ivoire, Ghana and Nigeria.[198]

- **US Overseas Private Investment Corporation**

In 2019, U.S. OPIC committed a USD 10 million loan to FinLux Ellen to support the introduction of off-grid solar kits and appliances in Chad.[199] This marked the first time OPIC had committed financing to a project in the country. The solar kits and appliances distributed by FinLux utilize a battery produced in the United States. The total project cost is estimated at USD 15.4 million, with the remaining investment coming from various sources, including AfDB's SEFA.[200]

[194] Excluding commercial banks, which are reviewed in detail in **Section 3.2**.
[195] "Sustainable Energy Fund for Africa," African Development Bank, (2018): https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/sustainable-energy-fund-for-africa/
[196] Facility for Energy Inclusion – Off-Grid Energy Access Fund: https://www.ogefafrica.com
[197] Lee, A. Doukas, A. and DeAngelis, K., "The African Development Bank and Energy Access Finance in Sub-Saharan Africa: Trends and Insights from Recent Data," Oil Change International and Friends of the Earth U.S., (November 2018): http://priceofoil.org/content/uploads/2018/11/AfDB-Energy-Access-Finance-report-high-quality.pdf
[198] "African Development Bank, Nordic Development Fund and Partners launch Off-Grid Energy Access Fund with US$ 58 million," African Development Bank Group, (August 27, 2018): https://www.afdb.org/en/news-and-events/african-development-bank-nordic-development-fund-and-partners-launch-off-grid-energy-access-fund-with-us-58-million-18432/
[199] "OPIC Advances First Financing Project in Chad," OPIC, (March 2019): https://www.opic.gov/press-releases/2019/opic-advances-first-financing-project-chad
[200] "Public Information Summary," OPIC, (March 2019): https://www.opic.gov/sites/default/files/files/9000083215.pdf

3.1.2 Microfinance Institutions

The development of the microfinance sector in Chad has been limited. While there are many semi-formal MFIs that operate in the country, only 24 MFIs were licensed by COBAC as of 2016. MFIs typically operate in the capital N'Djamena and have a relatively limited presence in rural areas.

Licensed MFIs are typically either savings and credit cooperatives or NGO. Many MFIs which members of the country's MFI Association (Association Professionnelle Tchadienne des Établissements de Microfinance, APT-EMF). Founding members of the APT-EMF include Union Régionale des Coopératives d'Epargne et de Crédit de N'Djaména (URCOOPEC), Union des Clubs d'Épargne et de Crédit (UCEC), Projet d'Appui au Réseau de Coopératives d'Épargne et de Crédit (PARCEC), Volunteers in Technical Assistance in Chad (VITA), Association pour le Développement de l'Épargne et du Crédit (ASDEC), and Centre d'Études pour la Promotion et la Rentabilisation des Initiatives Communautaires (CEPRIC).[201]

The microfinance sector has been regulated by the CEMAC since 2002, with the adoption of COBAC legal framework and prudential standards for the sector. At the national level, a Technical Unit in charge of MFI Management was established under the Directorate of Monetary and Financial Affairs of the Ministry of Finance and Budget in 2002. The Technical Unit is responsible for mediating between COBAC and MFIs in Chad, in addition to reviewing license agreements prior to submitting them to COBAC for approval.

Between 2010 and 2014, the MFI sector in Chad benefitted from the Support Program for Financial Inclusion in Chad (Programme d'Appui à la Finance Inclusive, PAFIT), which provided targeted financial support to women and micro-entrepreneurs in the country.[202]

3.1.3 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.[203] 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.[204]

Much like other African states, informal financial services are widely available in Chad (**Figure 50**). 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 overall lack of geographic coverage by FIs in rural areas of the country means that a significant portion of the rural population either relies exclusively on informal sources of finance at the community level or utilizes a combination of informal and formal credit and savings methods.

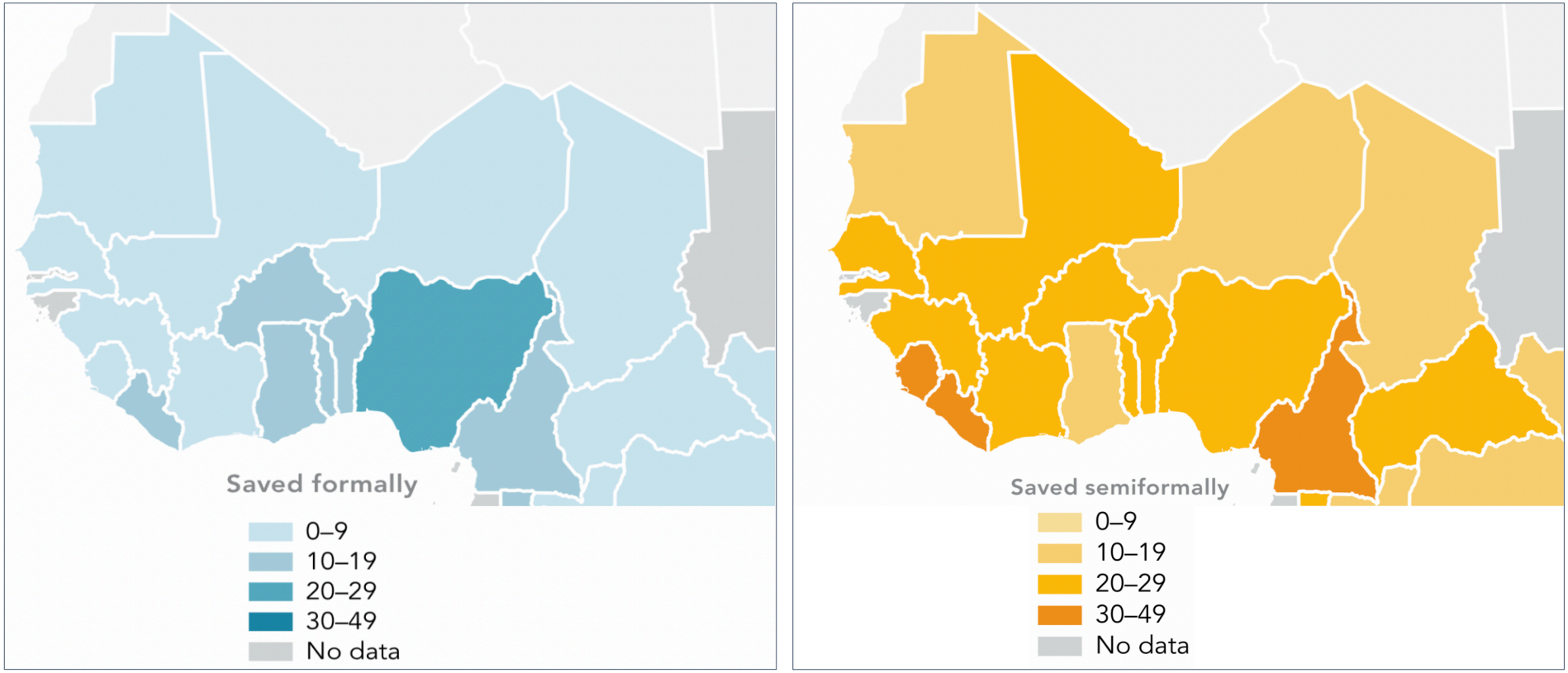
[201] "Cadre institutionnel et juridique des EMF au Tchad," CGAP, (2008): http://www.findevgateway.org/sites/default/files/mfg-fr-etudes-de-cas-cadre-institutionnel-et-juridique-des-emf-tchad-09-2008.pdf

[202] "Programme d'Appui à la Finance Inclusive, (PAFIT): Programme de Développement Conjoint," UNDP, UNCDF, (July 2010): http://www.findevgateway.org/sites/default/files/mfg-fr-etudes-de-cas-programme-appui-finance-inclusive-au-tchad-07-2010.pdf ; and "Microfinance Project in Chad," Islamic Development Bank: www.isdb.org/projects?field_sector_target_id=331&field_status_target_id=All&country_titles=24

[203] "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

[204] 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 50: Share of Adults Saving in the Past Year (%), 2017[205]



NOTE: Maps exclude Cabo Verde (no data)

Source: World Bank Global Findex Database

Figure 50 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 Chad.

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

3.4 Summary of Findings

- **Opportunity for ROGEP Credit Lines**: Banks in Chad 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.

- **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 Chad, 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 Chad are extremely high (120%+), particularly for SMEs. 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, 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.

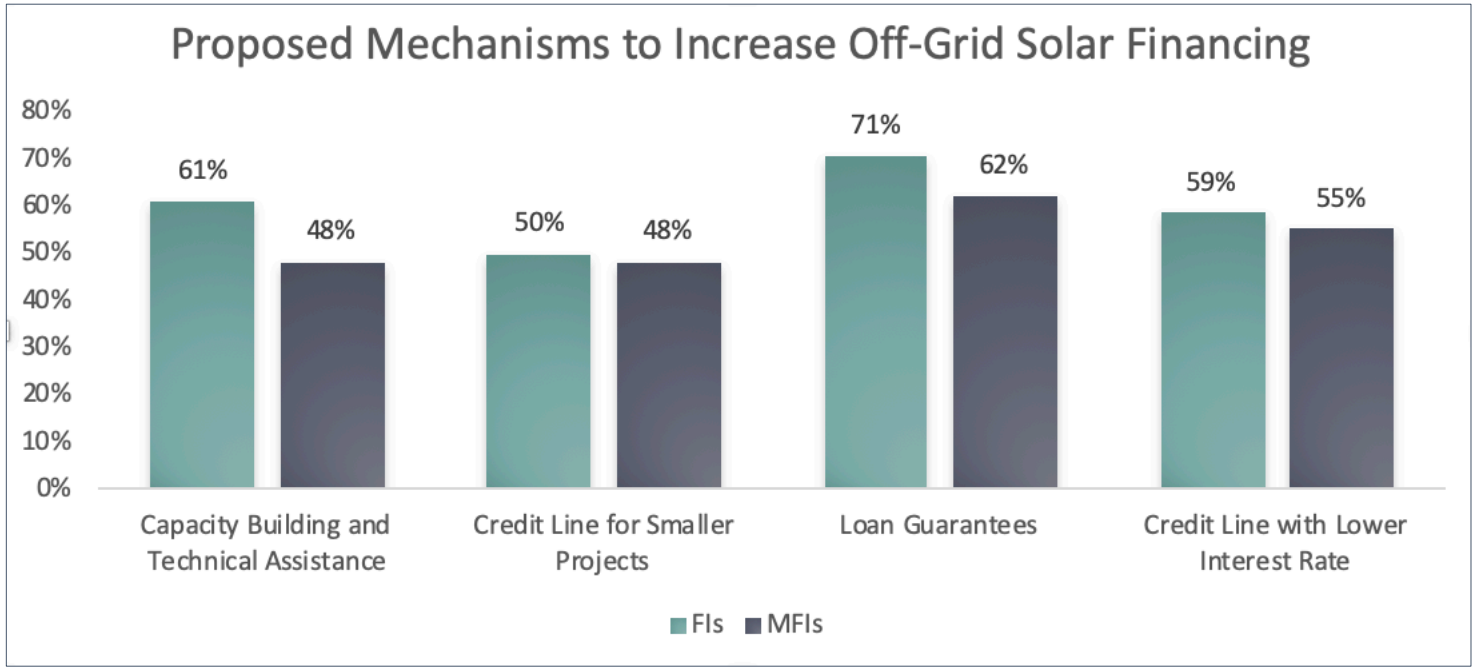
- **Risk Perception of New Lenders**: In order to attract additional lenders into the off-grid solar market segment, there is need for strong, reasonably priced credit enhancement mechanisms. In order to cover "market entry" risks for lenders unwilling to enter this market, guarantee instruments that 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. 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.

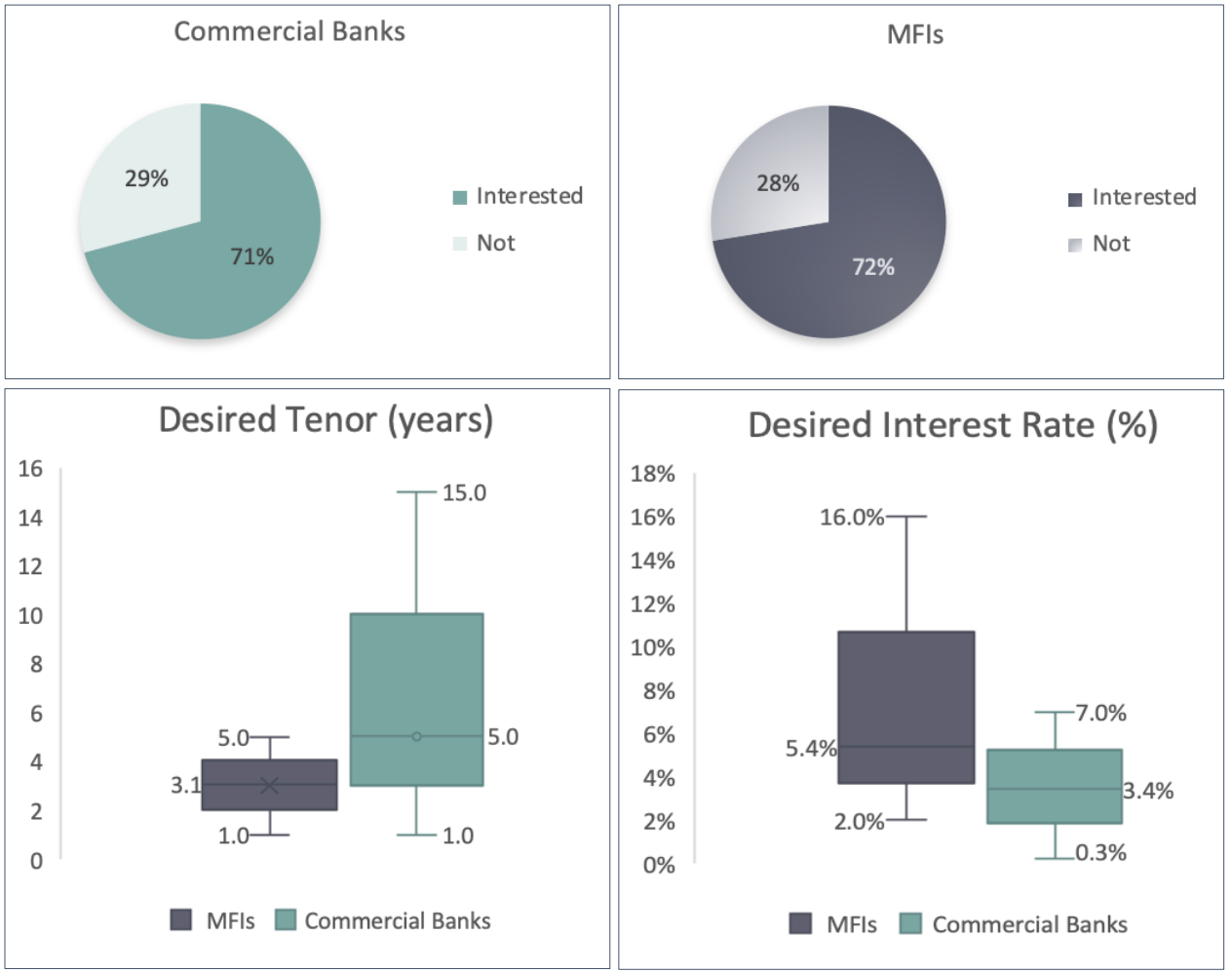
- **Digital Financial Services**: The advent of digital financial services and mobile money is one of the most important developments in off-grid solar market development to date, as it has allowed new and innovative business models to emerge that are now driving unprecedented growth in the sector. Mobile 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 modify the current taxation regime that is currently in place, as it is significant barrier to development of the mobile money sector (see **Section 1.3.4.5**). The GoC should also 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.

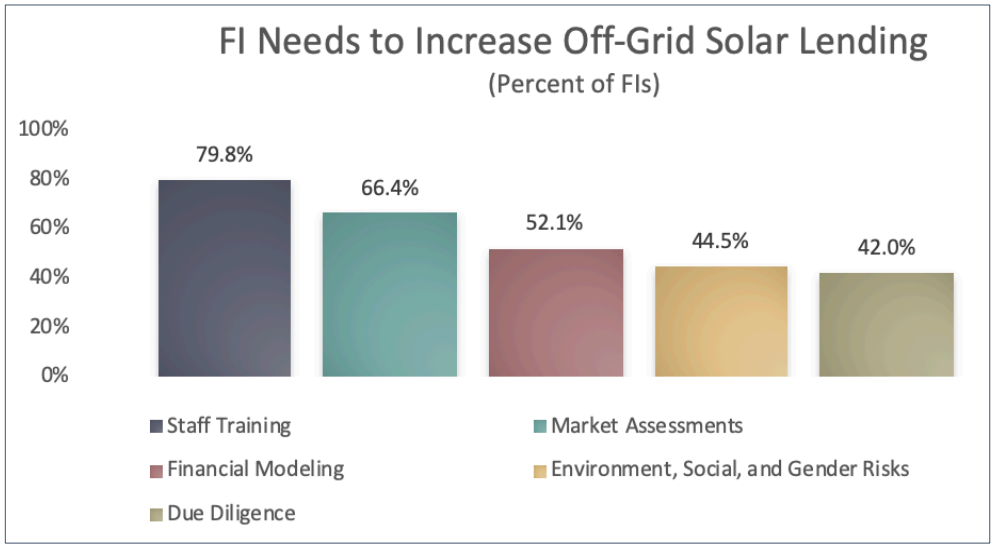
Key findings from the Task 3 FI survey activity are presented below. The results are based on feedback from a total of 121 FIs (including commercial banks, microfinance institutions and other non-bank FIs) that were interviewed across the 19 ROGEP countries. This summary only focuses on responses from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



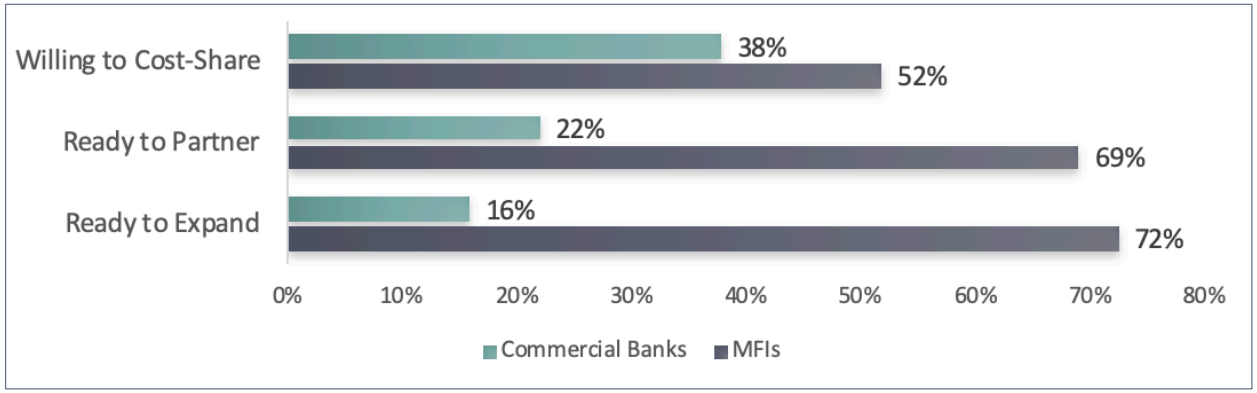
According to the survey, there is strong financial-sector interest across ROGEP countries to finance renewable energy projects, especially in off-grid solar. Commercial banks and MFIs identified loan guarantees as the most important measure that could improve their capacity to lend to the renewable energy 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[206] (according to WAPP densification plans).[207] Distribution lines (MV lines) are concentrated within the capital N'Djamena only and were not available for the analysis. This had no effect on the output due to the 5 km buffer distance and Voronoi polygon used for the analysis.

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)[208]
- Are located within areas that have a population density of more than 350 people per km^2 (as defined by Eurostat for rural areas)[209], plus an additional 50 people per km^2 for greater feasibility of mini-grids[210] and are within 1 km[211] of a social facility (education center or health facility).

1.1.3. *Electrification by off-grid stand-alone systems* – 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

[206] NOTE: Low-voltage distribution lines were not considered in this analysis (data was unavailable)
[207] No information for Chad was given on the distance for densification; the WAPP densification plans were used instead.
[208] 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
[209] http://ec.europa.eu/eurostat/web/rural-development/methodology
[210] Identified in discussions with different international mini-grid developer.
[211] Preferred maximum distance for mini-grids from discussions with different international developer.

Africa) or within 5 km of planned future line extensions[212]

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 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.[213]

1.2.3. *Electrification by off-grid stand-alone systems* – 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)
- According to the analysis, there are no un-electrified settlements within grid areas.

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 analysis had to revert to other studies of population distribution – such as 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."[214]

A Voronoi polygon analysis[215] was used to create boundaries for each settlement. These boundaries were then used in combination with a population density layer to estimate total settlement population of the given year. The current annual national population growth rate of 3.0%[216] was applied to the geospatial analysis to project populations for the scenario 2023 and 2030 analyses.

[212] NOTE: Low-voltage distribution lines were not considered in this analysis (data was unavailable)
[213] 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.
[214] https://www.worldpop.org
[215] To learn more about Voronoi polygons, see wikidot: http://djjr-courses.wikidot.com/soc128:qgis-voronoi-polygons
[216] https://data.worldbank.org/indicator/SP.POP.GROW?locations=TD

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 lines); MV lines exist in N'Djamena only and are covered by the buffer zone	≤ 5km distance	≥ 5km distance	≥ 5km distance	≤ 15km distance	≥ 15km distance	≥ 15km distance	ECOWREX, 2018 & AfDB, 2017[217]
Electricity grid network (planned)	Future network planned to be built (HV lines)	Not considered	Not considered	Not considered	≤ 5km distance	≥ 5km distance	≥ 5km distance	ECOWREX, 2018 & AfDB, 2017[218]
Mini-grids	No mini-grids are existing in 2018; potential mini-grids from the scenario 2023 analysis were used in the scenario 2030 analysis to establish potential growth of mini-grids.	--	--	--	Not considered	≤ 1km distance from all identified mini-grids in Scenario 2023	≥ 1km distance from all identified mini-grids in Scenario 2023	GIS analysis, Scenario 2023
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 [219]	≥ 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 Chad (cities, towns, villages, hamlets)	Used	Used	Used	Used	Used	Used	OpenStreetMap (OSM), 2018

[217] http://www.ecowrex.org/mapView/index.php?lang=eng; AfDB, Environmental and Social Impact Assessment (ESIA) Summary, Project: Chad-Cameroon 225 kV electrical grid interconnection project, page 5, May 2017; digitized by EVA

[218] Ibid.

[219] 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

Social facility: education centers	Kindergarten, school, college; Indicator of active local economy	Not considered	≤ 1km distance[220]	≥ 1km distance	Not considered	Not considered	Not considered	OSM & Humanitarian Data Exchange (HDX), 2018[221]
Social facility: health centers	Hospitals and health centers; Indicator of active local economy	Not considered	≤ 1km distance[222]	≥ 1km distance	Not considered	Not considered	Not considered	HDX, 2018[223]
Growth center: airport, urban areas	Economic growth centers for the analysis up to 2030; Regional capitals are defined as urban areas	Not used	Not used	Not used	Not considered	≤ 15km distance	≥ 15km distance	airports: Humanitarian Data Exchange (HDX), 2017 urban areas: GeoNames, 2018[224]

[220] Preferred maximum distance for mini-grids from discussions with different international developer.
[221] It is a compilation of data coming from different sources, such as government, cluster education, WFP (school feeding)
[222] Preferred maximum distance for mini-grids from discussions with different international developer.
[223] Extracted from Prime Minister / Ministry of Public Health and National Malaria Control Program (with OCHA contributions)
[224] http://www.geonames.org/

ANNEX 2: TASK 2 METHODOLOGY

OFF-GRID SOLAR PV MARKET ASSESSMENT METHODOLOGY

Focus Group Discussions (FGDs) were held in N'Djamena and Moundou in June-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,[225] multiplied by electricity access rates from the International Energy Agency (IEA),[226] 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 e.g. 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.

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

[226] 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 TV	-	-	1	-
Small Generator	-	-	-	1

- Numbers of units of torch lights/lanterns, cell phones, dc radio, dc TV 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 Chad, 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%	81%
Fourth 20%	85%
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."[227] Other research has shown household energy spending between 6-12% for low income segments in sub-Saharan Africa.[228] 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:

[227] 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).
[228] 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 DC TV powered by lead acid battery recharged once per week.
- **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 Chad, 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 estimated to be 34.8% p.a., based on information available on the typical interest rate charged by Microfinance Institutions in Cameroon. It is assumed that as both countries belong to CEMAC, interest rates in Chad would be within the same range as Cameroon rates.[229]

2023 and 2030 Household Demand Scenario: Assumptions

1. The GIS analysis[230] estimated that by 2023, 11.5% of the population will be grid connected, 28.4% will be connected by mini-grids while 60.1% of the population will be connected by off-grid stand-alone solutions. By 2030, the GIS analysis estimated that 16.2% of the population will be grid connected, 30.0% will be connected by mini-grids while only 53.7% of the population will be connected by off-grid stand-alone solutions. Based on these dynamics in the 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 data), the households in the quintiles with the highest income will be given

[229] http://www.theafricareport.com/West-Africa/cameroon-what-business-wants.html
[230] See Annex 1 for GIS methodology

priority due to their relatively higher power demand and ability to pay for power consumption. Hence, the highest quintile was assumed to have only 1% off-grid households, while the second highest quintile was assumed to have 11% off-grid households. The percentages of off-grid households in the bottom three quintiles remain unchanged. These assumptions have been made such that the total number of off-grid households assumed is 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 three quintiles were assumed to have only 1%, 2%, 67%, off-grid households respectively, while the percentages of off-grid households in the bottom two quintiles remain unchanged. These assumptions have been made such that the total number of off-grid households assumed is equal to the GIS data 2030 estimate.

Quintile	% Off-Grid (2023)	% Off-Grid (2030)
Highest 20%	1%	1%
Fourth 20%	11%	2%
Third 20%	90%	67%
Second 20%	99%	99%
Lowest 20%	100%	100%

2. Inflation rates for Chad: According to the IMF World Economic Outlook data, inflation in Chad is estimated to be at 3% 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 1.03.

3. Based on a 3% population growth rate from the World Bank[231] and the population density dataset used in the study, the estimated total population will be 16,061,307 in 2023 and 19,753,382 in 203

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 39.9% in 2023 and 46.3% in 2030.

5. To estimate GDP, it was assumed that the current annual GDP growth rate of 3.14%, will be maintained through 2023 and 2030:

Parameter	2023	2030
Population	16,061,307 (GIS estimate)	19,753,382 (GIS estimate)
GDP (constant 2010 USD)	$10,131,695,929	$ 8,103,887,442

6. According to the Lighting Global Off-Grid Solar Market Trends Report 2018,[232] the price of solar pico products is expected to fall to USD 10.6 in 2020 and USD 10.1 in 2022 down from USD 10.9 in 2016. Using these 2020 and 2022 data points, the average annual fall in prices from 2020 was estimated at 2.36%, and it was assumed that the annual price decrease will be maintained at this rate through 2030. (Annual cost reduction factor of 0.98)

7. Similarly, according to the same report, the price of small SHS components is expected to fall to USD 60.4 in 2020 and USD 47.4 in 2022, down from USD77.8 in 2016. Based on these 2020 and

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

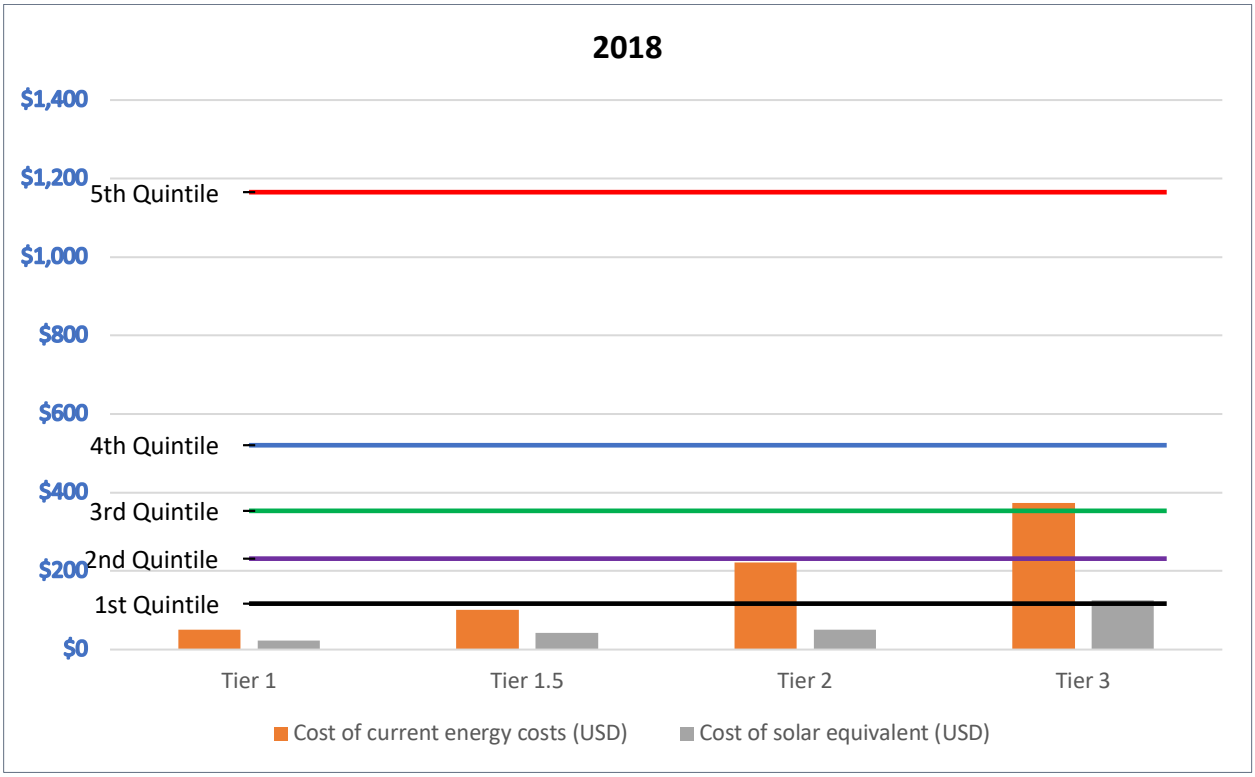
[232] "Off-Grid Solar Market Trends Report 2018," Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf

2022 data points, the average annual fall 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)

8. It was assumed the interest rates in Chad will stagnate at the current rate of 34.8% 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 analysis was also completed for the 2023 and 2030 scenarios.

- 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.

- These costs were compared against a 10% monthly energy budget for households of different income quintiles. This analysis did not assess affordability for 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:

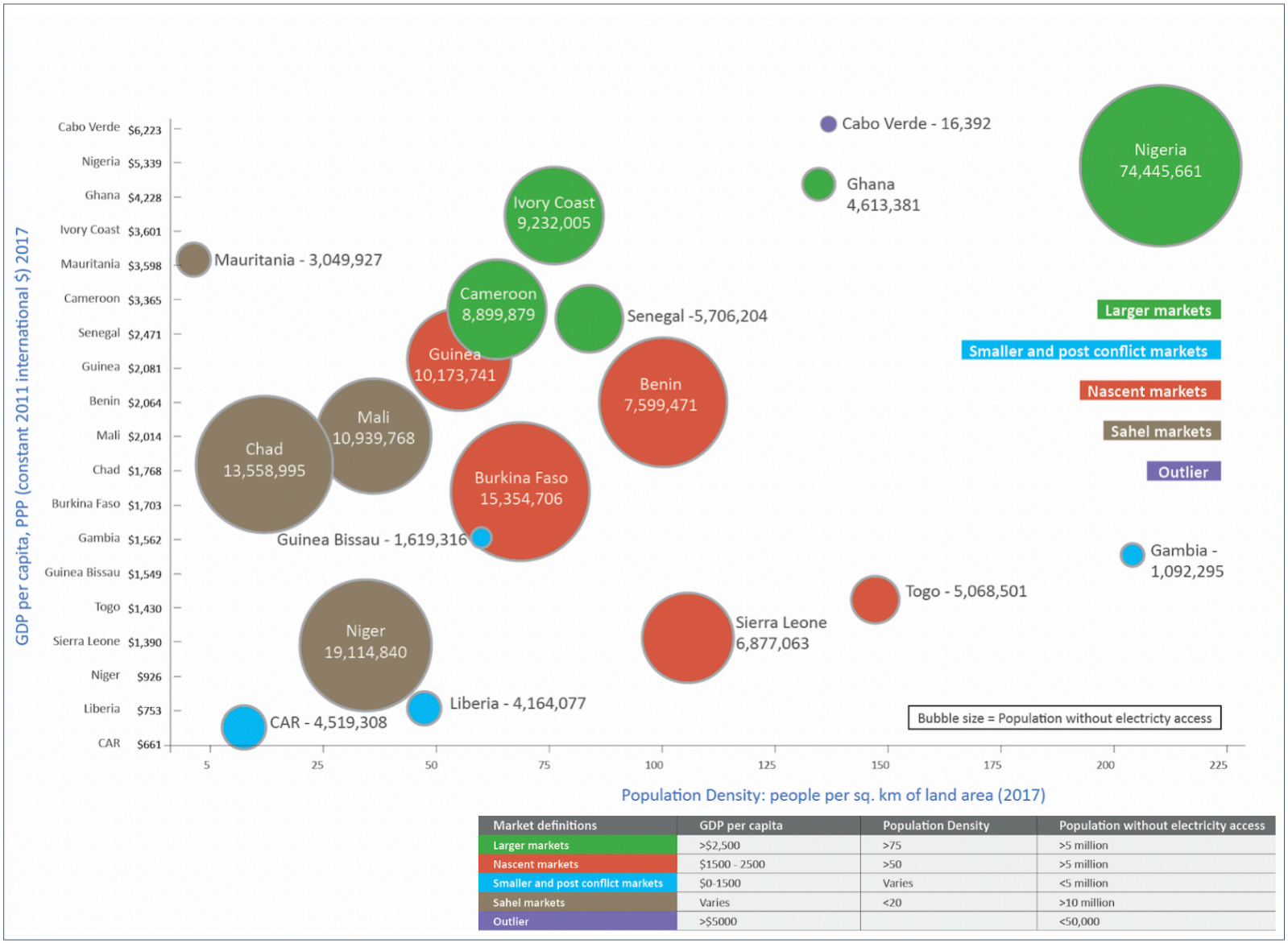
Country Categorization by Income and Population Density			
Category 1: Low-income / low population density	**Category 2:** Low-income / high population density	**Category 3:** High-income/ low population density	**Category 4:** High-income / high population density
Niger	Benin	Cameroon	Nigeria
Burkina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

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.[233] The solar PV sizing factor is based on the peak sun hours available across most of Africa.

[233] "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: The electricity needs of a given town/market center (assuming two [2] public lighting points per market center)

2.3 Institutional Market Sizing Calculations

Household systems, cost and price per watt:

System Type	Tier Rating	USD/Watt[234]	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

[234] 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	X		X		=	Estimated Annualized Off-Grid Solar Market Potential for Healthcare Sector
HC 1		Cost per tier 3 system ($625)		Divided by system lifetime of 5 years		
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	X		X		=	Estimated Annualized Off-Grid Solar Market Potential for Education Sector
Primary		Size of solar system in Watts (500W)		Cost per watt ($3) divided by system lifetime of 20 years		
Secondary		Size of solar system in Watts (1920W)		Cost per watt ($2.50) divided by system lifetime of 20 years		

Public Lighting						
# of off-grid market centers	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

CHAD			
Water Supply	**Healthcare**	**Education**	**Public Lighting**
Per capita assumption	Per capita assumption	Per capita assumption	Per capita assumption

Data was collected on the total number of off-grid institutions by institutional market segment for Chad 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 GIS 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:[235]

- **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.

[235] 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[236]	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)[237]	X 25%	=	Smallholder Irrigation Potential (hectare)[238]	Divided by 0.3[239]	=	Estimated No. of Smallholder Farms Suitable for Solar Irrigation	X	$650 (cost of solar pumping kit)[240]	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[241] adjacent to permanent surface water sources. As identified by experts in a study in Zambia[242] and based on other expert consultations, beyond a 5 km distance from surface water, the returns are not economically feasible. **Figure 29** is a map of the cropland within a 5 km distance from permanent surface water.

[236] "MSME Finance Gap," SME Finance Forum: https://www.smefinanceforum.org/data-sites/msme-finance-gap
[237] AQUASTAT – Food and Agriculture Organization: http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en
[238] 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
[239] 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/
[240] 120W solar pumping kit: https://futurepump.com/futures-bright-farmers-kenya/
[241] "Prototype Land Cover Map over Africa at 20m Released," Esa, (February 2018): https://www.esa-landcover-cci.org/?q=node/187
[242] "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)[243]	X	70%[244]	X	50%[245]	=	Smallholder Milling Potential (tons)	Divided by 2 tons per day X 70% capacity factor[246]	=	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[247]	X	5,500 W[248]	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[249]	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

[243] Food and Agriculture Organization: http://www.fao.org/faostat/en/#data/RF
[244] Assumption that 70% of crops are milled
[245] Assumption that 50% of milled crops are processed at smallholder farmer level
[246] 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/
[247] https://www.citypopulation.de
[248] 5.5kW solar powered refrigeration system – *See*: https://www.deutschland.de/en/solar-powered-coldhubs-nigeria
[249] "The Mobile Economy, Sub-Saharan Africa," GSMA Intelligence, (2017): https://www.gsmaintelligence.com/research/?file=7bf3592e6d750144e58d9dcfac6adfab&download

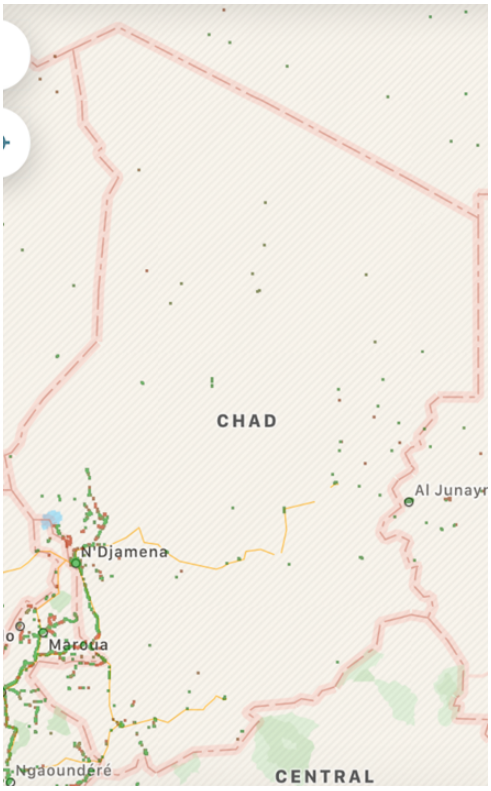
* Indicative Costs for Phone Charging Appliances[250]

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 31)**. 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

[250] "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 N'Djamena and Moundou in June-July 2018
- Survey of 3 locally-based solar companies/suppliers in the country
- Survey of 10 larger international solar product suppliers
- ECREEE supplier database
- 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 Chad is included below:

1	AAREDA
2	African Energy
3	Alternaprod Tchad
4	Bakargue Corporation
5	BINGO
6	BOK
7	Bureau Africain De Recherches D'etudes Et De Strategies
8	CEDOF
9	ERDEP
10	FESCMT-CHAD
11	Innovent
12	Mymoca
13	Noor Solar Energy
14	Omnium Service Gr. Snef
15	Ouma Solair
16	Promosol (Center for The Promotion of Solar Energy)
17	SACIS
18	Sauvagine
19	Seter
20	Solar TCHAD
21	Solar 23
22	Tchad Energie
23	Tchad Solaire
24	3A ENERGIE GROUP 3A
25	3Ace Commerce Energie & Etude
26	UFLCDS
27	Vergnet

Source: ECREEE, Focus Group Discussions; Stakeholder interviews

ANNEX 3: TASK 3 METHODOLOGY

FINANCIAL INSTITUTION ASSESSMENT

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 Chad. 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.[251]

The questionnaire that was administered to FIs in the country and across the ROGEP region is included below.[252] 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?
- Is the bank interested to explore a credit line with ROGEP? What size of credit line would the bank be

[251] The results of this assessment and corresponding recommendations were prepared for ECREEE in a separate, confidential report.
[252] The survey was adapted based on the type of FI that was being interviewed (commercial banks, MFIs, Regional Development Banks)

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.[253] 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.[254]

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.[255] 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.[256] 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.[257]

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).[258] 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).

[253] "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

[254] 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

[255] "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

[256] Ibid.

[257] "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/

[258] "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 N'Djaména and Moundou in June-July 2018 to share their insights and inform the overall market study. A gender questionnaire was also distributed to key stakeholders in Chad 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[259] (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 Chad

Structural inequalities and gender discrimination against women and girls persist in Chad, 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 are still widespread 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 (HDI) on Gender Inequality, where Chad performs extremely poorly, ranking 186 out of 189 countries in the index.[260]

2.2 Gender and Poverty

Poverty remains widespread in Chad, affecting an about half of the population. Poverty rates are higher in rural areas where a large share of the country's poor population lives. The country also faces huge challenges with refugees from Sudan, CAR and Nigeria. According to UNDP statistics, 65.5% of the labor force is considered working poor at PPP USD 3.10/day.[261] 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

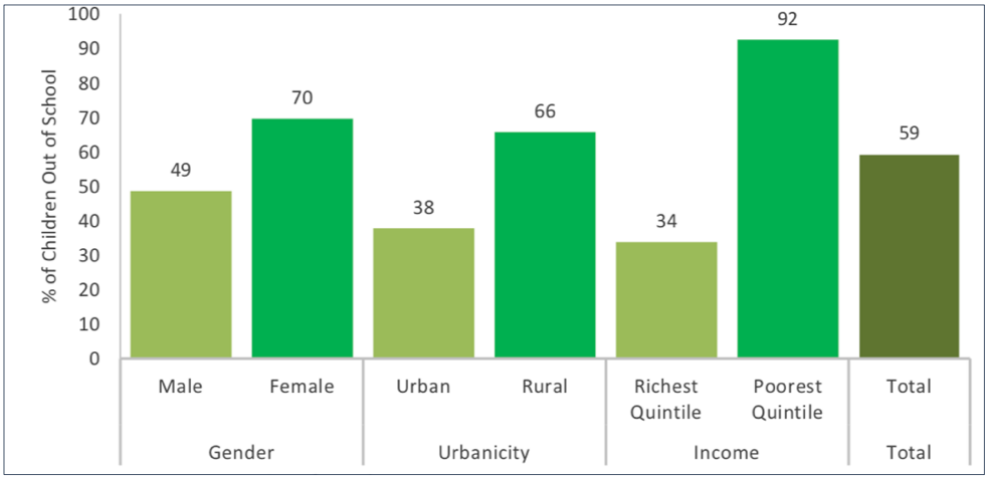
2.3.1 Education, Skills Development and Training

While Chad has made some progress in gender parity in rates of access to primary education, there are many troubling signs in the primary and secondary education sector as well as persistent gaps between men and women in higher education (see **Figure 10**). Only 1.7% of adult women in the country have attained some level of secondary education compared to 10% of men.[262]

[259] **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.
[260] "UN Human Development Reports: Gender Inequality Index (GII)," UN Development Programme, (2018): http://hdr.undp.org/en/composite/GII
[261] "UN Human Development Indicators: Chad," UN Development Programme, (2018): http://hdr.undp.org/en/countries/profiles/TCD
[262] Ibid.

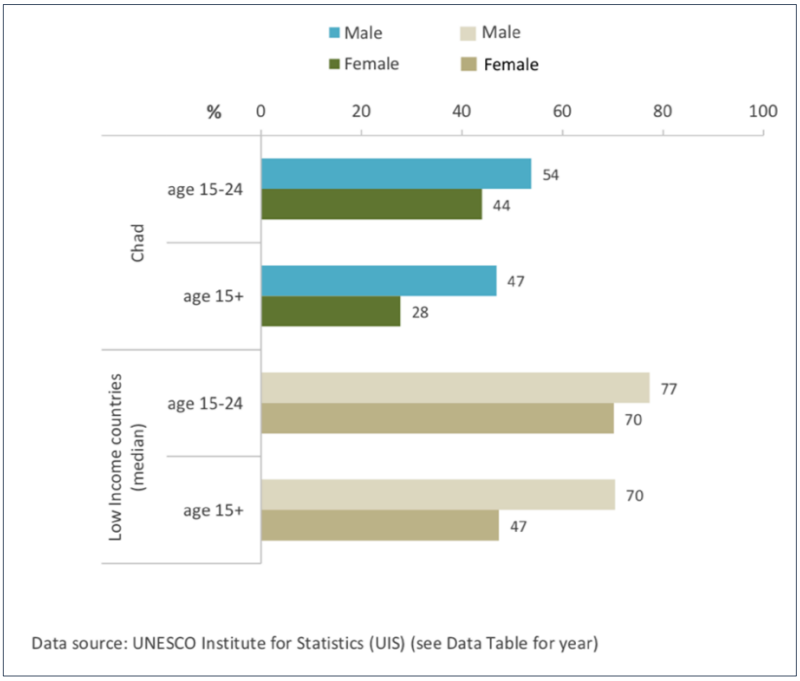
An estimated 49% of boys of secondary school age are out of school compared to 70% of girls of the same age.[263] Across the entire sector, there are huge disparities between the poorest and the richest youth in terms of access to education. This trend remains consistent in literacy rates among the country's youth and adult populations, as just 28% of the country's female adult population is literate, compared to 47% of the adult male population.[264]

Percentage of Children of Secondary School Age (12-18) Out of School



Source: UNESCO Institute for Statistics

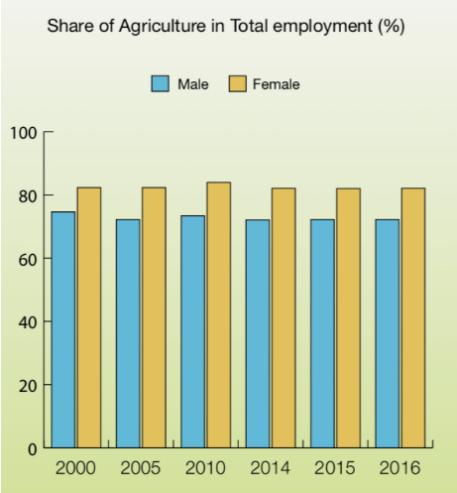
Literacy Rates Among Youth and Adult Populations



Source: UNESCO Institute for Statistics

[263] "Chad: National Education Profile, 2014 Update," Education Policy and Data Center, (2014): https://www.epdc.org/sites/default/files/documents/EPDC%20NEP_Chad.pdf
[264] Ibid.

According to the UN, as of 2017, only 14.9% of women in Chad had an account at a financial institution or with a mobile money service provider.[265] 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, which disproportionately employs women.[266]



Source: African Development Bank

2.3.2 Fertility Rates and Reproductive Health

As of 2017, the fertility rate in Chad remained very high, at 6.6 children per woman. The country also has an extremely high maternal mortality rate; for every 100,000 live births, 856 women die from pregnancy related causes. An estimated 22.9% of women have an unmet need for family planning.[267]

2.3.3 Participation and Decision-Making

Socio-cultural perspectives in Chad 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 64.8% compared to 77.6% for men.[268] As of 2017, women held only 12.8% of the country's seats in parliament.[269] The gender assessment found that progress has been made in recent years. In 2010, Marie-Thérèse Fatimé Mbailemdana became the first female mayor of N'Djamena by a presidential decree. In 2018, HadjéIttir Deby Itno became the second female Mayor of the city.

[265] "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
[266] "Indicators on Gender, Poverty the Environment and Progress toward the Sustainable Development Goals in African Countries," African Development Bank, (2017): https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/GENDER_Poverty_and_Environmental_Indicators_on_African_Countries-2017.pdf
[267] "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
[268] "UN Human Development Indicators: Chad," UN Development Programme, (2018): http://hdr.undp.org/en/countries/profiles/TCD
[269] Ibid.

2.4 Gender Policy, Institutional and Legal Framework in Chad

2.4.1 Gender Mainstreaming initiatives by the Government

Gender equality gained widespread support in post-civil war Chad's development. As a result, the GoC adopted gender mainstreaming as a pathway to achieve not only equality between the sexes, but also to address poverty reduction, economic growth, sustainable development and the improved well-being of its citizenry. Chad's policy framework for promoting gender equality and women's empowerment is guided mainly by its the National Gender Policy published in 2011 that sets ambitious objectives but in fact, the process of formal adoption of implementation has been significantly delayed.

The country's Constitution (1996) provides equal rights for all citizens. Specifically, men and women are equal under the law and the State has a duty to see to the elimination of all forms of gender discrimination. To date, the Government has enacted several laws to ensure the protection and promotion of the rights of women and children under the National growth strategy for poverty reduction (Stratégie Nationale de croissance pour la réduction de la pauvreté). General coordination of gender-related interventions is carried out by the Ministry of Planning, Economy and International cooperation in close collaboration with the Ministry of Social Action, National Solidarity and the Family (Ministère de l'Action Sociale, de la Solidarité Nationale et de la Famille).

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. Chad's legal system consists of both civil, customary and religious laws, leading to contradictions and inconsistencies when dealing with gender-relate issues.

At the international level, Chad should ratify the Protocol to the African Charter on Human and Peoples' Rights on the Rights of Women in Africa (Maputo Protocol), as it is currently a signatory to the Charter but has yet to formally ratify it.[270]

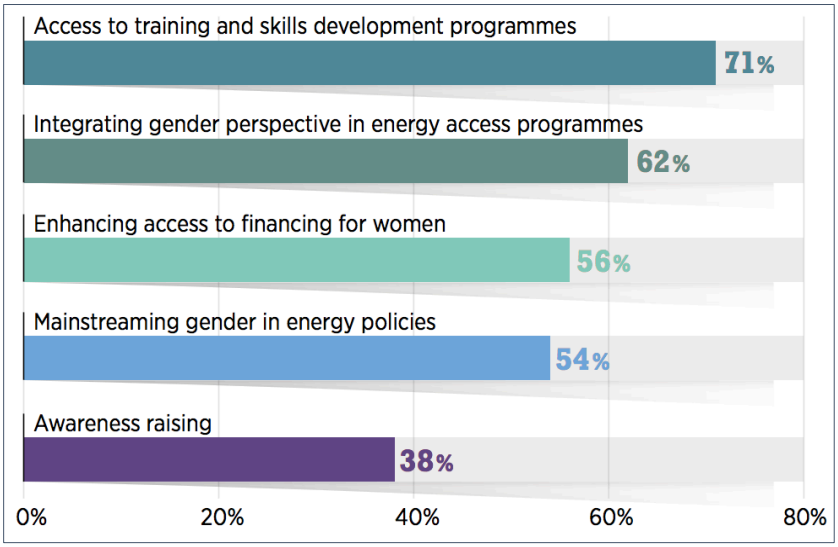
2.5 Summary of Recommendations

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.[271]

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.[272]

[270] http://www.achpr.org/instruments/women-protocol/ratification/
[271] "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
[272] 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 Chad's energy sector:[273]

- 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.[274]

[273] 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

[274] "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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