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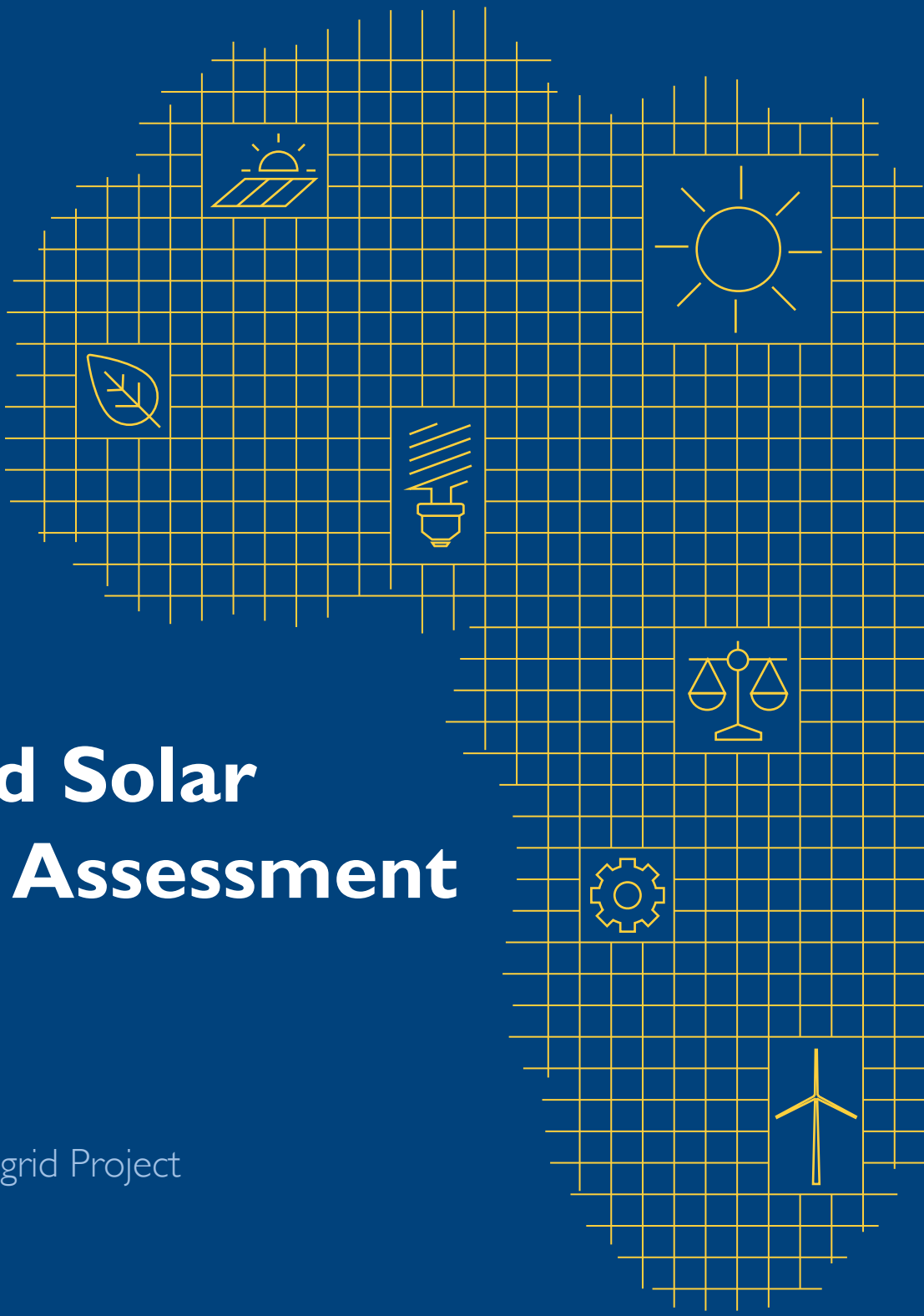

OCTOBER 2019

Off-Grid Solar Market Assessment

Niger

Power Africa Off-grid Project

ABOUT POWER AFRICA

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

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

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Abbreviations and Acronyms

ACEP	Agency for Private Enterprise Credit (Agence de Credit pour Entreprise Privée)
ADC	Austrian Development Agency
ADFD	Abu Dhabi Fund for Development
AECF	Africa Enterprise Challenge Fund
AECID	Spanish Agency for International Development Cooperation (Agencia Española de Cooperación Internacional para el Desarrollo)
AFD	Agence Française de Développement (French Development Agency)
AfDB	African Development Bank Group
AGRA	Alliance for a Green Revolution in Africa
ANERSOL	National Agency of Solar Energy (Agence Nationale d'Energie Solaire)
ANPER	Nigerien Rural Electrification Promotion Agency (Agence Nigérienne de Promotion de l'Electrification en milieu Rural)
ANSI	National Agency for Information Society (Agence Nationale pour la Société de l'Informacion)
APE-Solaire	National Association of Solar Professionals (Association des Professionals d l'Energie Solaire)
ARCEP	Regulatory Authority for Electronic Communications and Posts (Autorité de Régulation des Communications Électroniques et des Postes)
ARESS	African Renewable Energy System and Solution
ARSE	Regulatory Authority of the Energy Sector (Autorité de Regulation du Secteur de l'Energie)
BAGRI Niger	Agricultural Bank of Niger (Banque Agricole du Niger)
BCEAO	The Central Bank of West African States (Banque Centrale des États de l'Afrique de l'Ouest)
BCN	Commercial Bank of Niger (Banque Commerciale du Niger)
BEEEI	Office of Environmental Assessment and Impact Studies (Bureau d'Evaluation Environnementale et des Etudes d'Impacts)

BIA Niger	Agency for Private Enterprise Credit (Agence de Credit pour Entreprise Privée)
BIN	Austrian Development Agency
BMZ	Abu Dhabi Fund for Development
BNIF-AFUWA	Africa Enterprise Challenge Fund
BOAD	Spanish Agency for International Development Cooperation (Agencia Española de Cooperación Internacional para el Desarrollo)
BSIC	Agence Française de Développement (French Development Agency)
C&I	African Development Bank Group
CAGR	Alliance for a Green Revolution in Africa
CAIMA	National Agency of Solar Energy (Agence Nationale d'Energie Solaire)
CBAO	Nigerien Rural Electrification Promotion Agency (Agence Nigérienne de Promotion de l'Electrification en milieu Rural)
CEDEAO	National Agency for Information Society (Agence Nationale pour la Société de l'Informacion)
CINAC	National Association of Solar Professionals (Association des Professionals d l'Energie Solaire)
CIPMEN	Regulatory Authority for Electronic Communications and Posts (Autorité de Régulation des Communications Électroniques et des Postes)
CNES	African Renewable Energy System and Solution
Conseil de l''Etante	Regulatory Authority of the Energy Sector (Autorité de Regulation du Secteur de l'Energie)
CPP	Agricultural Bank of Niger (Banque Agricole du Niger)
CSI	The Central Bank of West African States (Banque Centrale des États de l'Afrique de l'Ouest)
DEG	Commercial Bank of Niger (Banque Commerciale du Niger)
DESCO	Office of Environmental Assessment and Impact Studies (Bureau d'Evaluation Environnementale et des Etudes d'Impacts)
DGIS	Directorate-General for International Cooperation
DIV	Development Innovation Ventures

DPNE	National Electricity Policy Document (Document de Politique Nationale sur l'Électricité)
ECOWAS	Economic Community of West African States
ECOW-GEN	ECOWAS Programme on Gender Mainstreaming in Energy Access
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EFSD	European Fund for Sustainable Development
ElectriFI	Electrification Financing Initiative
EMIG	College of the Mining Industry and Geology (L'Ecole des Mines et de la Géologie)
e-money	electronic money
EXIM	Export-Import
FCFA	Franc of the African Financial Community (Franc Communauté Financière Africaine)
FEI OGEF	Facility for Energy Inclusion Off-Grid Energy Access Fund
FISAN	Investment Fund for Food Security in Niger (Fonds d'Investissement pour la Sécurité Alimentaire au Niger)
GDP	gross domestic product
GIMAFOR	Group of Engineering, Management, Formation, and Research (Groupe d'Ingénierie, de Management, de Formacion, et de Recherche)
GIZ	German Society for International Cooperation (Deutsche Gasellschaft für Internationale Zusammenarbeit)
GMG	green mini-grid
GOGLA	Global Off-Grid Lighting Association
GON	Government of the Republic of Niger
GSMA	Global System for Mobile Communications Association (Groupe Spécial Mobile Association)
GWh	gigawatt-hour
IDA	International Development Association
IFC	International Finance Corporation
IPP	independent power producer
IRENA	International Renewable Energy Agency

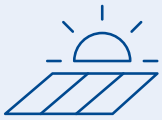
JVE	Young Volunteers for the Environment (Jeunes Volontaires pour l'Environement)
KANF ELECTRONICS SARLU	KANF ELECTRONICS Unipersonal Limited Liability Company (Société à Responsabilité Limitée Unipersonnelle)
KfW	Credit Institute for Reconstruction (Kreditanstalt für Wiederaufbau)
km	kilometer
KOSAP	Kenya Off-Grid Solar Access Project
kV	kilovolt
kWh	Kilowatt-hour
KWp	Kilowatt-peak
LPG	Liquified petroleum gas
LSMS	Living Standards Measurements Survey
MFI	microfinance institution
MoE	Ministry of Energy
MW	megawatt
NEFCO	Nordic Environment Finance Corporation
NELACEP	Niger Electricity Access Expansion Project
NES	National Electrification Strategy
NESAP	Niger Solar Electricity Access Project
NGO	non-governmental organization
NIGELEC	Nigerien Electricity Company (Société Nigérienne d'Electricité)
Niger	Republic of Niger
NITA	Niger Money Transfer (Niger Transfert d'Argent)
OCA	Open Capital Advisors
ONERSOL	Solar Energy Office (Office de l'Energie Solaire)
OPEC	Organization of the Petroleum Exporting Countries
OPIC	Overseas Private Investment Corporation
PAOP	Power Africa Off-grid Project

PAYGO	pay as you go
PERAN	Autonomous Rural Electrification Projects in Niger (Projets d'Electrification Rurale Autonome au Niger)
PNDS	Nigerien Party for Democracy and Socialism (Parti Nigérien pour la Démocratie et le Socialisme)
PPP	public–private partnership
PRASE/Safo	Rural Program for Access to Energy Services in Safo (Programme Rural d'Accés aux Services Energétiques de Safo)
PTFM	Multifunctional Platforms Project (Projet Plates-Formes Multifonctionnelles)
PV	photovoltaic
REACT	Renewable Energy and Adaptation to Climate Technologies
RECA	Network of Chambers of Agriculture (Réseau des Chambres d'Agriculture)
REEEP	Renewable Energy and Energy Efficiency Partnership
ROGEP	Regional Off-Grid Electrification Project
SAE	African Equipment Company (Société Africaine d'Equipement)
SAPPP	Public Partnership Support Structure (Structure d'Appui au Partenariat Public)
SEEN	Water Exploitation Company of Niger (Societe d'Exploitation des Eaux du Niger)
SEFA	Sustainable Energy Fund for Africa
SGE	Sahelian Electrical Engineering (Sahélienne de Génie Électrique)
SHS	solar home system
Sida	Swedish International Development Cooperation Agency
SIDI	Solidarity for Development and Investment (Solidarité Internationale pour le Développement et l'Investissement)
SIMA	Social Investment Managers and Advisors
SINERGI	Investment Management Company and Initiatives (Société d'Investissement de Gestion et d'Initiatives)
SOMINA	Mining Company of Azelik SA (Société des Mines d'Azelik SA)
SONIBANK	Nigerien Bank Corporation (Société Nigérienne de Banque)
SONICHAR	Nigerien Coal Company of Anou Araren (Société Nigérienne du Charbon d'Anou Araren)

SORAZ	Zinder Refinery Company (Société de Raffinage de Zinder)
SUNREF	Sustainable Use of Natural Resources and Energy Finance
T&D	transmission and distribution
TCN	Transmission Company of Nigeria
UEMOA	West African Economic and Monetary Union (Union Economique et Monétaire Ouest Africaine)
UGEAP	Universal Green Energy Access Program
UNDP	United Nations Development Programme
USAID	U.S. Agency for International Development
VAT	value-added tax
VSLA	village savings and loan associations
W	watt
WAEMU	West African Economic and Monetary Union
WAPP	West African Power Pool
XOF	West African CFA franc

INTRODUCTION

This report by Power Africa Off-grid Project's (PAOP) provides insights into the opportunities and risks associated with Niger's off-grid solar energy market and gives companies, investors, governments, and other stakeholders a deeper understanding of the market. While other stakeholders (i.e., development partners) have conducted market assessments, Power Africa has identified market information gaps and seeks to bridge those gaps in the following ways:



This report provides a comprehensive and detailed review of solar home systems (SHSs), mini-grids, productive use of energy, and other aspects of the off-grid solar value chain. Additionally, this report includes details on policy and regulatory issues, the structure and historical context of the energy sector, and gender mainstreaming.

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

Insights in this report help Power Africa Off-grid Project (PAOP) plan and prioritize activities across work streams of policy and regulations, market intelligence, business performance, access to finance, and cross-sectoral integration throughout sub-Saharan Africa.

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

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

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

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

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

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

1 EXECUTIVE SUMMARY

Republic of Niger overview. The Republic of Niger (Niger) is a nation of nearly 21.5 million people in West Africa (Table ES-1). The population of Niger is predominantly rural and reliant on subsistence agriculture; 96 percent of the population is clustered in the southernmost regions of Dosso, Maradi, Tahoua, Tillabéri, and Zinder, which represent only 35 percent of the land area. This concentration is the result of the more hospitable climate of the southernmost regions and the proximity to Nigeria, a key economic partner.

TABLE ES-1. KEY ECONOMIC AND SOCIAL INDICATORS FOR NIGER

Population	21,477,348 (49.85% male residents and 50.2% female residents)
Population growth rate (annual)	3.9%
Urban and rural populations	Urban: 16.4% (3,522,285); rural: 83.6% (17,955,063)
Population density	17 people per square kilometer
Rate of urbanization	4.27% annually (2015–2020 estimate)a
Gross Domestic Product (GDP) per capita	$378.06 (2017)
GDP growth rate (annual)	4.9% (2017)
Poverty headcount (at $3.20 per day, 2011 purchasing power parity)	76.9% of population (2014)
Electricity access rates	Overall: 10%; urban: 46%; rural: 3%; Niamey: 72%

Source: CIA Factbook and World Bank

An estimated 177 megawatts (MW) of grid-connected generation capacity, 98 percent of which is fossil fuel generation, provides electricity to 360,000 customers. The Nigerien Electricity Company (Société Nigérienne d'Electricité [NIGELEC]) owns all grid infrastructure and operates 110 diesel-powered mini-grids to expand rural electrification. NIGELEC also imports a significant amount of electricity from Nigeria to supplement in-country generation capacity.

Electricity access rate estimates for Niger are between 10% (Table ES-1) and 19% (Power Africa Geospatial Analysis). Of these households without electricity, 27 percent are located within 5 kilometers (km) of the grid, making them potentially low-cost targets for on-grid electrification. An additional 33 percent of households without electricity are located within 20 km of the grid, and 40 percent without electricity are greater than 20 km from the grid. Per capita consumption in 2014 was 51.4 kilowatt hours (kWh), which is well below the average of 480 kWh for sub-Saharan Africa.[1] From 2005 to 2015, electricity consumption grew at a compound annual growth rate (CAGR) of 16 percent. From 2015 to 2027, NIGELEC forecasts that consumption will grow at a CAGR of 32 percent, partly because of planned investments in updating and expanding the grid, as well as planned capacity expansion.

[1] IEA, "IEA Statistics: Niger."

Niger's goal is to electrify 60 percent of the population by 2027 and achieve universal electrification by 2035. Niger is developing a National Electrification Strategy (NES) with three key electrification strategies: grid expansion, installation of mini-grids for isolated communities, and distribution of solar home systems (SHSs) in remote areas with low-density populations.

Off-grid solar is expected to play a significant role in electrification in Niger. As the primary initiative in off-grid energy by the Government of the Republic of Niger (GON), the Niger Solar Electricity Access Project (NESAP) focuses on developing off-grid solar in Niger. NESAP consists of the following four components: market development of stand-alone solar systems; rural electrification through mini-grid development; solar PV hybridization of and expansion of access to existing thermal mini-grids; and implementation support and technical assistance. Table ES-2 lists the major players in off-grid solar.

TABLE ES-2. SELECT SOLAR COMPANIES ACTIVE IN NIGER BY PRODUCT TYPE

COMPANY	PICO-SOLAR AND SHSS	MINI-GRIDS	PRODUCTIVE USE AND AGRICULTURE
Benalya/Benafsol	●	○	●
Oolu Solar	●		
Bren-Tronics/Alternaprod	●	○	
Sahelian Electrical Engineering	●		●
Consultations Plus	●		●
Jimafor	●		
YANDALUX	●	○	
Elhyfros	●		●
Continental InvestinAfrica Corporation (CINAC)	●		●
African Renewable Energy System and Solution (ARESS)	●	○	
Awango by Total	●		
NIGELEC		●	
Phanes Group		●	
Ennera		○	
Access Energie		○	
Prosolia Africa		○	
KANF Electronics			●
SES Niger			●

a Filled circles indicate that the company is actively marketing products in the category. Empty circles indicate that the company is preparing to or considering entering the category.
Source: Power Africa Technical Advisors

Many electrification initiatives in Niger are funded by and implemented with support from international donors. Some of the donors include the World Bank, the Islamic Development Bank, the French Development Agency (Agence Française de Développement [AFD]), the U.S. Agency for International Development (USAID), the Economic Community of West African States (ECOWAS), and the African

Development Bank Group (AfDB). Additional donors include the Abu Dhabi Fund for Development, Export-Import (EXIM) Bank India, the Directorate-General for International Cooperation (DGIS), theCouncil of the Entente (Conseil de l'Etante), the West African Economic and Monetary Union (WAEMU), and the West African Development Bank (Banque Ouest Africaine de Développement [BOAD]). The two largest initiatives ongoing in Niger are NESAP and the Niger Electricity Access Expansion Project (NELACEP), which focuses on grid expansion. Both initiatives are partnerships between GON and the World Bank.

Institutional Landscape. The Ministry of Energy (MoE) is responsible for coordinating and implementing energy policy in Niger, which takes place across a variety of agencies and government entities. The Regulatory Authority of the Energy Sector (Autorité de Regulation du Secteur de l'Energie [ARSE]) regulates the electricity sector and advises the legislature regarding the development of laws and regulations. The National Association of Solar Professionals (Association des Professionals d l'Energie Solaire [APE-Solaire]) is the solar industry association in Niger.

The Nigerian Rural Electrification Promotion Agency (Agence Nigérienne de Promotion de l'Electrification en milieu Rural [ANPER]) is responsible for developing and implementing strategies for expanding electrification in rural portions of the country. Four universities in Niger already offer degree programs and classes that provide relevant training for the energy sector, including renewable energy. Niger also has both public and private trade schools that provide training for solar technicians. Finally, APE-Solaire facilitates apprenticeships for solar technicians with solar companies in Niger.

Pico-solar and SHS sector overview. Both pico-solar and SHSs are important for rural electrification in communities where grid expansion or mini-grids are not an economically viable approach.

Most active pico-solar deployments still follow a donor- and government-driven approach, typically involving subsidies to keep equipment prices low. Early efforts to develop a private pico-solar market have met mixed results. Although the formation of APE-Solaire has brought together the off-grid industry in Niger, the business cases and economic environment are challenging for private SHS companies. In fact, the Global Off-Grid Lighting Association (GOGLA) reports that less than 7,500 quality-certified products were sold from January 2018 through June 2019.

ANPER is implementing SHS projects with financial support from several development partners. These projects are targeting 352 villages for SHS distribution. ANPER is keen to engage local authorities to maintain the systems, which will include training and partnership with the system suppliers. Another major project is the Regional Off-Grid Electrification Project (ROGEP), which is funded by the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE). ROGEP, which is a multi-national program that aims to foster a regional market for SHSs, has selected Niger to pilot innovative models of health post electrification. The first pilot includes 25 health posts.

Since mid-2018, the NESAP has helped to drive progress in the government to address key barriers to pico-solar market development. First, the government instructed the National Agency of Solar Energy (Agence Nationale d'Energie Solaire [ANERSOL]) to develop and implement quality standards for solar products, which will be implemented by customs authorities under the Ministry of Finance. Second, NESAP has established credit lines with banks, including the Nigerien Bank Corporation (Société Nigérienne de Banque [SONIBANK]), the Sahara Bank Group for Investment and Trade (Banque Sahélo Saharienne pour l'Investissement et le Commerce [BSIC]) and one microfinance institution, Capital Finance, for pico-solar and SHS companies. Third, as of September 13, 2018, pico-solar systems are exempt from both general import duties and value-added tax (VAT). In parallel, solar companies have worked with wireless service providers to support payments over mobile, making it easier for consumers to pay for products.

Mini-grid sector overview. Geographically and demographically, Niger is particularly well-suited to mini-grids due to the dispersed nature of its population. Approximately 27 percent of Nigeriens live in communities with fewer than 500 people, and 42 percent live in communities with between 500 and 2,000 people. Extending grid infrastructure to such small communities is often not financially viable if they are not close to existing infrastructure. Until recently, NIGELEC was the only mini-grid developer in Niger. However, private-sector investment is growing. For instance, the Phanes Group has one mini-grid operation in Boki, Niger, and more in the planning stages, Benalya and YANDALUX are also taking steps to enter the market and international donors are funding mini-grid development and feasibility studies covering more than 500 potential mini-grid sites..

The current policy and regulatory environment in Niger is supportive of private companies entering the mini-grid market, but areas of uncertainty that must be addressed to accelerate growth in the market include private ownership, tariff structures, import restrictions, tax regimes, compensation for grid takeover, and quality control. Notable progress has been made by allowing mini-grid developers to set cost-reflective tariffs. However, there are no regulations or policies regarding how a mini-grid operator will be compensated if the grid enters its territory. The most important policy development regarding mini-grids in Niger is a forthcoming decree that will establish clearer regulatory frameworks and business models for mini-grid development and operation. The decree will establish a range of business models for mini-grids.

Other barriers include labor force shortages, no tax subsidies or exemptions for mini-grid development; low purchasing power of consumers; and low population densities.

Productive use solar sector overview. Nationally, approximately 80 percent of all households grow crops. The majority of small-holder famers rely on rainfed irrigation, despite the vast and untapped groundwater resources throughout Niger. Given the potential crop yield increases and land use implications of groundwater access, solar-powered water pumps could be a boom for Niger's agricultural sector. Crops that require processing (e.g., millet, peanut, sesame) offer another opportunity for increased economic productivity from off-grid solar.

However, because the market for agriculture and productive-use solar systems is still nascent in Niger, business models and financing have not matured to offer a diversity of options. Currently, all but one company operating in the agriculture and productive-use space offer only cash sales.

The primary government program that supports the adoption of agriculture and productive use solar technology is the Investment Fund for Food Security in Niger (Fonds d'Investissement pour la Sécurité Alimentaire au Niger [FISAN]), which supports farmers adopting technology for agricultural economic development.

Eligible projects include cold rooms, rural roads, irrigation schemes, and water pumping stations, including solar-powered water pumps. The only regulations directly relevant to the productive use solar sector in Niger is that solar pumps are exempt from import duties and VAT.

2 NIGER ENERGY SECTOR OVERVIEW

2.1 COUNTRY INTRODUCTION

The Republic of Niger (Niger) is a developing nation of nearly 21.5 million people in West Africa. The population of Niger is predominantly rural and reliant on subsistence agriculture, although much of the land in Niger is not arable, and the entire country experiences frequent droughts, which is typical for the region. Niger is divided into seven regions; 96 percent of the population is clustered in the southernmost regions of Tillabéri, Dosso, Tahoua, Maradi, and Zinder, which represent only 35 percent of the land area. This concentration is the result of the more hospitable climate of the southernmost regions and the proximity to Nigeria, a key economic partner.

The Gross Domestic Product (GDP) per capita of Niger was $378.06 in 2017. While Niger may be one of the poorest countries in the world, Niger's economy has been in expansion since 2010 with annual growth rates between 2.3% up to 11.8%. (Table 1).

l'Investissement et le Commerce [BSIC]) and one microfinance institution, Capital Finance, for pico-solar and SHS companies. Third, as of September 13, 2018, pico-solar systems are exempt from both general import duties and value-added tax (VAT). In parallel, solar companies have worked with wireless service providers to support payments over mobile, making it easier for consumers to pay for products.

TABLE 1. NIGER SOCIO-ECONOMIC INDICATORS SUMMARY

SOCIO-ECONOMIC INDICATORS	SUMMARY
Population	21,477,348 (49.85% male residents, 50.2% female residents)
Population growth rate	3.8%
Urban and rural populations	16.4% urban (3,522,285) 83.6% rural (17,955,063)
Population density	17 people per square kilometer
Rate of urbanization	4.27% annually (2015–2020 estimate)
GDP per capita	$378.06 ($8.12 billion overall) (2017)
GDP growth rate	4.8%
Poverty headcount (at $3.20/day, 2011 public–private partnership [PPP])	76.9% of population (2014)
Life expectancy at birth	60.4 years
Languages spoken	French (official); Hausa; Djerma; Songhai; Tamasheq; Peul/Fulfulde; Kanuri; Arabic dialectal; Toubou
Main exports	Cowpeas, livestock, onions, and uranium

Source: CIA Factbook and World Bank

Agriculture accounts for approximately 40 percent of the GDP and employs 76 percent of the labor force in Niger, according to the World Bank. Most agriculture is for subsistence, but after uranium and livestock, crops are Niger's largest exports.[2] Despite having export markets for some agricultural products, crippling droughts mean that Niger is a net food importer and heavily reliant on other countries to meet its caloric needs. Most crops in Niger are dependent on rainfall. As of 2011, only 0.2 percent of total agricultural land was irrigated.

2.2 ELECTRICITY SECTOR

2.2.1 GRID INFRASTRUCTURE AND GENERATION

The Nigerien Electricity Company (Société Nigérienne d'Electricité [NIGELEC]) is a semi-public company that is 95 percent owned by the Government of the Republic of Niger (GON). As of 2017, NIGELEC had provided service to 362,954 customers. Niger's electricity grid infrastructure is heavily concentrated in the most populous regions of the country, along the southern border with Nigeria.

The grid is divided into six zones, which are listed in Table 2. Currently, each zone is an island, with little or no transmission infrastructure to connect the grid and allow for better management of growing demand, particularly in urban areas.

TABLE 2. TRANSMISSION AND DISTRIBUTION ZONES IN NIGER

ZONE	DESCRIPTION	ESTIMATED POPULATION
River Zone	The transmission and distribution (T&D) infrastructure across the Tillabéri and Dosso Regions is served by a 132 kilovolt (kV) interconnection from Birnin Kebbi, Nigeria, and a 120 megawatt (MW) power contract.	4.02 million
Niger Central East Zone	The T&D infrastructure primarily serves the towns of Tahoua, Maradi, and Zinder, as well as surrounding areas. The zone is supplied by a 132-kV interconnection and a 60-MW power contract from Katsina, Nigeria.	7.1 million
North Zone	North Zone infrastructure connects the population centers of Agadez, Arlit, and Tchirozerine in the remote northern region of Agadez. Power is supplied by the Nigerien Coal Company of Anou Araren's (Société Nigérienne du Charbon d'Anou Araren's [SONICHAR's]) coal plant and a NIGELEC-owned thermal diesel generator with a combined capacity of 37 MW. Private mining companies are also significant consumers of electricity in this zone, although they are primarily self-supplied.	548,799
Eastern Zone (Diffa Zone)	This zone serves the city of Diffa and surrounding areas. Power is supplied over a 33-kV line from Damasak, Nigeria, and a 5-MW power contract. There is also a 2.3-MW NIGELEC-owned diesel generator in the Niger Central East Zone.	156,906
Gaya/Malanville Zone	Distribution lines in the City of Gaya in southwestern Niger are supplied by a 33-kV line and a 7-MW power contract from Kamba, Nigeria. The planned transmission infrastructure would effectively merge this zone with the River Zone.	234,638
Isolated Zone	This zone consists of 110 isolated mini-grids that NIGELEC powers with diesel generators.	472,921

Source: Sadou Mounkaila, Niger Clean Energy Expert
Note: The population estimates reflect the populations in the regions that each zone covers. The authors do not intend to imply that the existing infrastructure in each zone makes electricity accessible to the full population listed.

[2] CIA, "Africa :: Niger — CIA World Factbook."

GENERATION CAPACITY

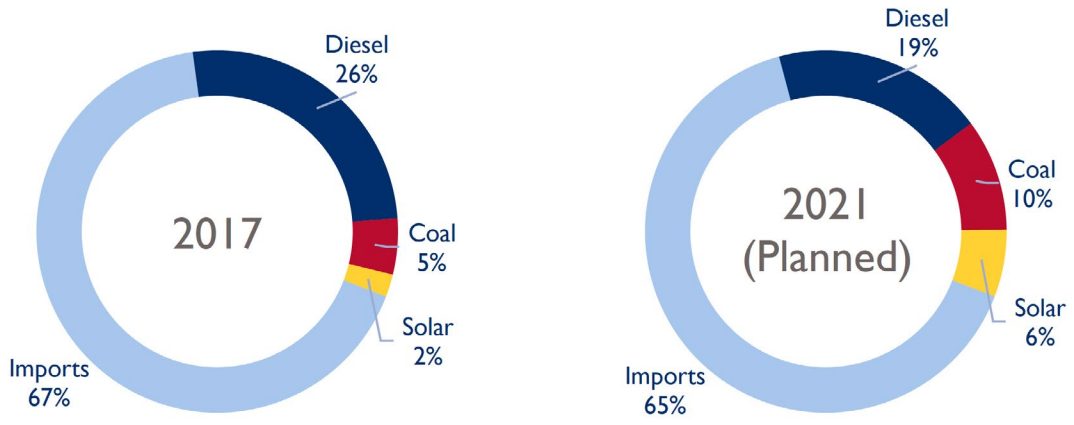
The electricity grid in Niger currently has approximately 177 megawatts (MW) of installed capacity, 98 percent of which is fossil fuel generation (Table 3). In addition to the grid, NIGELEC operates 110 diesel-powered mini-grids to expand rural electrification. NIGELEC owns and operates approximately 50 percent of the current installed capacity; the other 50 percent is owned by four independent power producers (IPPs). Industry (especially mining) uses approximately half of installed capacity, meaning that the capacity to serve consumers is constrained, which increases reliance on imports from Nigeria.

TABLE 3. INSTALLED GENERATION CAPACITY IN NIGER

DESCRIPTION	OWNER	INSTALLED CAPACITY (IN MW)	FUEL TYPE
State-owned diesel oil–fired power station (western grid)	NIGELEC	80	Diesel oil
More than 100 state-owned diesel-powered mini-grids	NIGELEC	4	Diesel oil
IPP (northern grid, mostly for servicing the mining industry and associated urban centers)	Nigerien Coal Company of Anou Araren (Société Nigérienne du Charbon d'Anou Araren [SONICHAR])	36	Coal
IPP (refinery company that sells surplus to NIGELEC)	Zinder Refinery Company (Société de Raffinage de Zinder [SORAZ])	23	Diesel oil
IPP	Aggreko	15	Diesel oil
IPP (uranium mining company that sells surplus to NIGELEC)	Mining Company of Azelik SA (Société des Mines d'Azelik SA [SOMINA])	15	Coal
Other stand-alone and mini-grid (includes households, community installations, telecommunication towers, and others)	Other (off-grid producers)	4	Solar photovoltaic
Total	--	177 MW	--

The installed capacity is not enough to meet demand, and this means that 67 percent of electricity was imported in 2017 with that percent expected to increase in the coming years, primarily from Nigeria. NIGELEC forecasts in its 2017–2027 Business Plan that the Transmission Company of Nigeria's (TCN's) imports will continue to increase as new transmission and distribution (T&D) infrastructure between the two countries comes online (See Figure 1).

FIGURE 1. ELECTRICITY GENERATION MIX



Source: Sadou Mounkaila, Niger Clean Energy Expert

COST OF GENERATION

NIGELEC thermal production is the most expensive means of delivering energy to customers for the utility. The Nigerien Coal Company of Anou Araren (Société Nigérienne du Charbon d'Anou Araren [SONICHAR]) coal-fired production has been, on average, over 60 percent cheaper than NIGELEC's own thermal production, but TCN imports from Nigeria are cheaper still, averaging 90 percent lower than NIGELEC production, according to the 2016 NIGELEC report.

For the forecasted costs of production through 2027, TCN's imports still represent the cheapest option for purchasing electricity, but that price is now matched by the forecasted cost of generating power at the Kandadji Hydroelectric Plant, which is expected to start producing power in 2023. The next cheapest source of production is solar PV, which is forecasted to cost 50 XOF (Franc of the African Financial Community [Franc Communauté Financière Africaine]) per kilowatt hour (kWh) on average.

The large gap in prices between thermal production and TCN's imports has several implications for the expansion of electricity access and for off-grid electrification. First, in power zones where interconnections with Nigeria exist, there is a significant price incentive to expand capacity to import power rather than build new capacity of any kind. Second, in areas where imported power is not available—for example, in the North Zone and isolated NIGELEC mini-grids—the business case is strong for deploying solar PV to replace thermal production and add new generation capacity in constrained areas. Focusing solar deployment on the North Zone and isolated mini-grids does not address capacity expansion in the southern zones, where demand growth is strongest, but it does address what may be the loss-leading regions of service for NIGELEC.

GRID EXPANSION PLANS

Grid expansion is one of the three pillars of Niger's electrification strategy. In 2016, NIGELEC's 2016–2027 Business Plan outlined 562 MW of planned capacity expansion. In 2017, NIGELEC received funding from the French Development Agency (Agence Française de Développement [AFD]) to extend the grid network, increase rural electricity access, and interconnect existing grid zones. Niger's participation in the West African Power Pool (WAPP) is also a driving factor in capacity expansion plans.

Grid expansion efforts focus on the following three objectives:

- Maintain and upgrade existing infrastructure, which is congested and aging.
- Densify distribution networks in urban areas where some grid infrastructure exists but does not reach all the local residents.
- Interconnect the stand-alone infrastructure zones (see Table 2). Interconnections will allow NIGELEC to move electricity from oversupplied zones to undersupplied zones and may increase imports from Nigeria, which is currently the cheapest source of electricity for Niger.

2.2.2 ELECTRICITY ACCESS AND CONSUMPTION

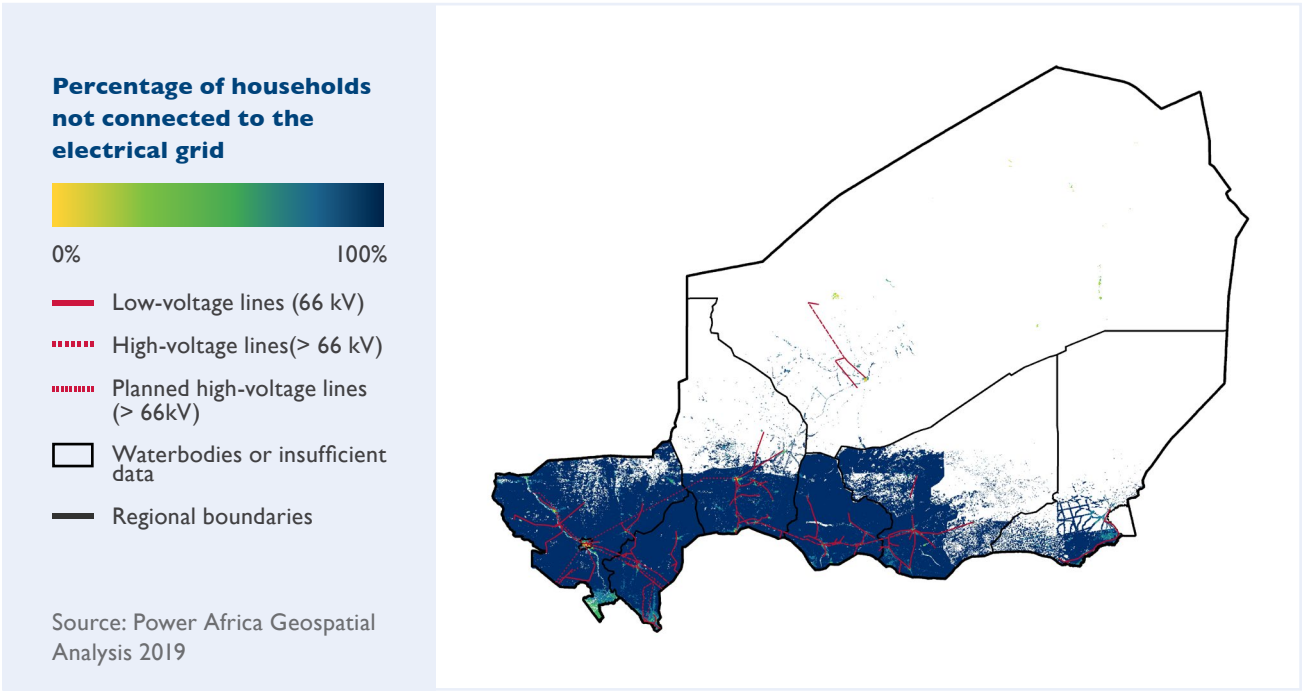
Estimates of electricity access uses survey data from the Niger 2014 Living Standards Measurements Survey (LSMS), population data from LandScan, and raw and modelled satellite imagery.[3] A data dictionary that defines indicators used in the analysis can be found in Annex A and B provides a full description of the methodology used in the analysis.

[3] World Bank, "National Survey on Household Living Conditions and Agriculture - Living Standards Measurement Study"; East View Information Services, "LandScan Global Population Database."

Niger has low levels of electrification across the country. In 2015, approximately 90 percent of households in the country were not connected to the electrical grid. Lack of electrification is much more pronounced in rural areas, where approximately 97 percent of households, compared with 54 percent of households in urban areas, are not connected to the electrical grid. In Niamey, the most populous city, 72 percent of households are connected to the electrical grid, whereas in Zinder, the second most populous city, only 23 percent of households are connected.

In Figure 2, Power Africa estimated the percentages and numbers of households not connected to the electrical grid in 1 kilometer (km) × 1-km grids across Niger.

FIGURE 2. GEOSPATIAL ANALYSIS OF HOUSEHOLDS WITH ELECTRICAL GRID ACCESS



Based on findings of a geospatial analysis conducted for this report (Table 4. Households Not Connected to the National Electrical Grid), out of nearly 3.1 million households in Niger, nearly 2.4 million are estimated to lack access to electricity.[4] Of these households, 27 percent (644,000) are located within 5 km of the grid, making them potentially low-cost targets for on-grid electrification. An additional 33 percent (763,000) of households are located within 5–20 km of the grid, and 40 percent (954,000) are located farther 20 km from the grid. Niger has low population density, despite most of the population being concentrated in the southern regions of the country. Approximately 69 percent of the population live in communities with fewer than 2,000 people, further complicating the economics of connecting such small communities to grid power.

[4] This differs from the official access rate of 10%, as access in the geospatial analysis is estimated using a proprietary machine learning algorithm and leverages a multitude of geocoded datasets.

TABLE 4. HOUSEHOLDS NOT CONNECTED TO THE NATIONAL ELECTRICAL GRID

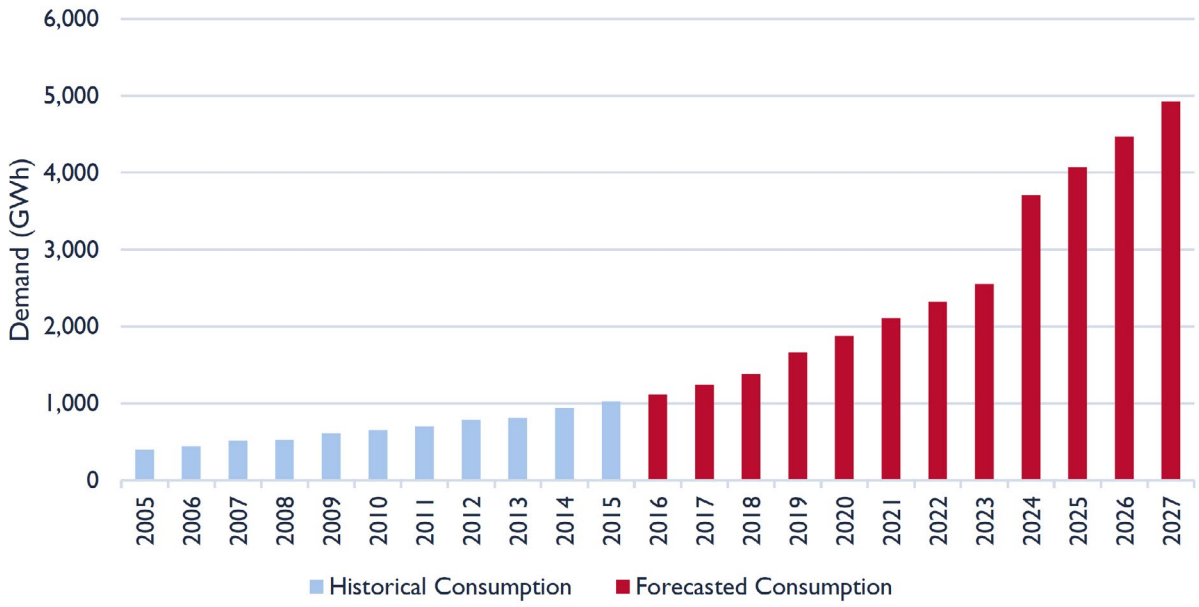
REGIONS	TOTAL HOUSEHOLDS NOT CONNECTED TO THE ELECTRICAL GRID	<5 KM OF GRID		5–10 KM FROM GRID		10–20 KM FROM GRID		>20 KM FROM GRID	
		NUMBER OF HOUSHOLDS A	PERCENTAGE OF ALL HOUSEHOLDS NOT CONNECTED TO THE ELECTRICAL GRID B	NUMBER OF HOUSEHOLDS A	PERCENTAGE OF ALL HOUSEHOLDS NOT CONNECTED TO THE ELECTRICAL GRID B	NUMBER OF HOUSEHOLDS A	PERCENTAGE OF ALL HOUSEHOLDS NOT CONNECTED TO THE ELECTRI-CAL GRIDB	NUMBER OF HOUSEHOLDS A	PERCENTAGE OF ALL HOUSEHOLDS NOT CONNECTED TO THE ELECTRI-CAL GRID B
		6,000	16%	3,000	8%	1,000	3%	28,000	76%
Diffa	81,000	21,000	26%	7,000	9%	7,000	9%	46,000	57%
Dosso	301,000	73,000	24%	48,000	16%	59,000	20%	122,000	41%
Maradi	515,000	163,000	32%	73,000	14%	118,000	23%	161,000	31%
Niamey	38,000	34,000	89%	4,000	11%	—	0%	—	0%
Tahoua	464,000	138,000	30%	68,000	15%	88,000	19%	170,000	37%
Tillabéri	404,000	78,000	19%	59,000	15%	80,000	20%	188,000	47%
Zinder	517,000	131,000	25%	61,000	12%	87,000	17%	239,000	46%
Total	2,357,000	644,000	27%	323,000	14%	440,000	19%	954,000	40%

Source: Power Africa Geospatial Analysis 2019

[a] The number of households includes only those not connected to the electrical grid.
[b] The percentage columns refer to households that are not connected to the electrical grid within the specific distance from mapped voltage lines out of all households not connected to the electrical grid within that region.

In 2014, per capita consumption was 51.4 kWh, which is well below the average of 480 kWh for sub-Saharan Africa.[5] From 2005 to 2015, electricity consumption grew at a compound annual growth rate (CAGR) of 16 percent. From 2015 to 2027, NIGELEC forecasts that consumption will grow at a CAGR of 32 percent, partly because of planned investments in updating and expanding the grid, as well as planned capacity expansion. Figure 3. Historical and Forecasted Electricity Consumption in Niger, 2005–2027 shows historical and forecasted consumption from NIGELEC's 2016–2027 Business Plan. For the most part, electricity consumption rises steadily, but in 2024, NIGELEC forecasts that electricity consumption will increase 45 percent after major grid expansion investments funded by AFD and the Word Bank have been completed.

FIGURE 3. HISTORICAL AND FORECASTED ELECTRICITY CONSUMPTION IN NIGER, 2005–2027



Source: NIGELEC Activity Reports

NIGELEC's customer base of approximately 363,000 accounts is divided into the following four customer classes: private individuals, industrial customers, commercial customers, and the government. In 2015, 65 percent of the sales volume was from private individuals, 11 percent was from each of the industrial and commercial customers, and 14 percent were from the government (Table 5). It is important to note that some industrial customers own and operate their own generation assets, which are not reflected in NIGELEC's reporting.

TABLE 5. CONSUMPTION BY SECTOR, 2012–2015

YEAR	CHARACTERISTIC	PRIVATE INDIVIDUALS	INDUSTRY CUSTOMERS	COMMERCIAL CUSTOMERS	GOVERNMENT
2012	Quantity (in GWh)	392.48	75.19	76.65	98.69
	Sector share	61%	12%	12%	15%
	Percentage change over previous year	4.14%	8.45%	8.49%	4.14%

[5] IEA, "IEA Statistics: Niger."

TABLE 5. CONSUMPTION BY SECTOR, 2012–2015					
YEAR	CHARACTERISTIC	PRIVATE INDIVIDUALS	INDUSTRY CUSTOMERS	COMMERCIAL CUSTOMERS	GOVERNMENT
2013	Quantity (in GWh)	426.02	71.52	72.91	97.07
	Sector share	64%	11%	11%	15%
	Percentage change over previous year	9%	-5%	-5%	-2%
2014	Quantity (in GWh)	495.11	78.96	80.49	103.72
	Sector share	65%	10%	11%	14%
	Percentage change over previous year	16%	10%	10%	7%
2015	Quantity (in GWh)	530.92	87.11	88.8	115.79
	Sector share	65%	11%	11%	14%
	Percentage change over previous year	7%	10%	10%	12%

Source: NIGELEC Activity Reports

Table 6 presents the average tariff rate paid by customer class from 2012 to 2015. In general, industrial and government customers enjoy the lowest average tariffs. In 2012, NIGELEC introduced a social tariff for low-income and low-consumption private individuals that may have contributed to the slight downward trend in prices that individuals faced from 2012 to 2014. This trend reversed, however, in 2015. Among customer classes in 2015, the average price paid was 82.62 XOF/kWh, or $0.14/kWh.

TABLE 6. AVERAGE TARIFF RATE BY CUSTOMER CLASS, 2012–2015					
YEAR	CHARACTERISTIC	PRIVATE INDIVIDUALS	INDUSTRY CUSTOMERS	COMMERCIAL CUSTOMERS	GOVERNMENT
2012	Quantity (in GWh)	392.48	75.19	76.65	98.69
	Value (XOF billion)	32.31	5.16	6.19	7.01
	Average price (XOF/kWh)	82.32	68.63	80.76	71.03
2013	Quantity (in GWh)	426.02	71.52	72.91	97.07
	Value (XOF billion)	34.68	5.16	6.19	7.65
	Average price (XOF/kWh)	81.40	72.15	84.90	78.81
2014	Quantity (in GWh)	495.11	78.96	80.49	103.72
	Value (XOF billion)	40.25	6.04	7.24	8.45
	Average price (XOF/kWh)	81.30	76.49	89.95	81.47
2015	Quantity (in GWh)	531	87	89	116
	Value (XOF billion)	44	7	8	9
	Average price (XOF/kWh)	82.86	80.46	89.89	77.59

Source: NIGELEC Activity Reports

In October 2017, GON issued a decree to set forth new electricity tariffs based on a cost-reflective approach—the first time national tariffs have been adjusted since 1994. The new tariffs became effective in January 2018 and represent an overall increase of 20 percent. The tariff change is intended to ensure that NIGELEC can continue to invest in the generation, transmission, and distribution of assets to improve electricity access across the country. Tariffs are blended based on both capacity of connection and monthly consumption. Low voltage tariffs are divided into the

following three categories: a social tariff, a general tariff (segmented for 3-kW, 6-kW, 12-kW, 18-kW, and 20-kW connections), and a public lighting tariff. Medium voltage tariffs are divided into the following two categories: a general tariff and a hydropower-agricultural development tariff. See Annex C for detailed tariff structure information.

QUALITY OF GRID SERVICE

Quality of service is a significant challenge for the electricity infrastructure in Niger. Load shedding is common, especially in highly congested urban areas, where demand growth has outstripped aging T&D infrastructure. The five T&D zones described in Table 2 are isolated from one another, which caused the following issues:

- NIGELEC is limited in its ability to move electricity around between regions, which would increase flexibility and make it easier to balance the grid.
- The ability to import power is constrained by the interconnections available in each zone, thereby limiting the country's ability to meet growing demand without building new in-country capacity.
- In addition to challenges stemming from infrastructure in Niger, quality of service is affected by the reliability of the electrical grid in Nigeria.

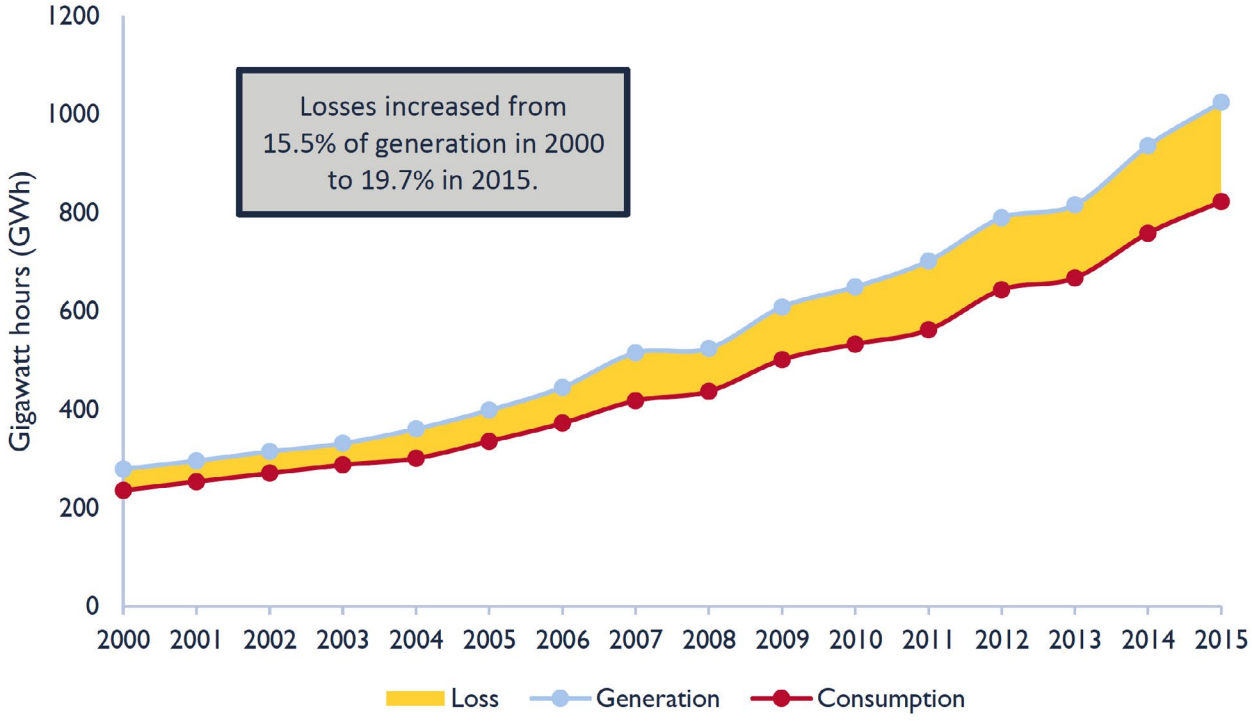
In 2016, NIGELEC recorded 564 power outages totaling 365 hours of service interruption (NIGELEC 2016b). It is difficult to compare this measure to other countries because NIGELEC does not use international standards to report outages.[6] Instead, NIGELEC agents record the outages by manually compiling the triggers.

Another measure of quality of service is the gap between electricity generation and electricity consumption. Figure 4 shows consumption and demand in Niger from 2000 to 2015. The gap between the two lines indicates energy losses. Annual losses rose from 15.5 percent in 2000 to 19.7 percent in 2015. Given the two trends are divergent but approximately parallel, it is likely that most losses are technical (e.g., line loss to natural dissipation in grid components) versus non-technical (e.g., electricity theft, non-payment, errors in accounting).[7] For comparison, electricity grids in developed nations typically experience technical T&D losses of between 5 percent and 7 percent. Energy losses of nearly 20 percent represent a significant loss of revenue for NIGELEC, which struggles to cover its basic operating costs and relies on donor organizations to finance infrastructure expansion projects.

[6] System Average Interruption Duration Index (SAIDI)

[7] Antmann, "Reducing Technical and Non-Technical Losses in the Power Sector."

FIGURE 4. ELECTRICITY GENERATION VERSUS CONSUMPTION IN NIGER, 2000–2015



Source: NIGELEC

Unreliable service has driven people and companies to look for off-grid solutions, most commonly diesel generators. In addition, outages damage the perceived benefits of electricity access, which may discourage unconnected individuals or communities from trying to acquire access to electricity. More information is available in Bacon and Kojima (2016), which provides a detailed analysis of more than 200 studies that investigate the linkage between energy and economic growth.[9]

2.2.3 FUTURE ELECTRIFICATION TARGETS

Niger's overarching target is to electrify 60 percent of the population by 2027 and achieve universal electrification by 2035. Additionally, with support from the World Bank and the International Development Association (IDA), the GON has developed a cohesive National Electrification Strategy (NES) with targets expected to be achieved by 2021.[9] The NES includes the following key deployment strategies:

- Grid extension in southern regions of the country
- Mini-grids for isolated villages
- Distribution of solar kits for remote areas with a widely dispersed population.

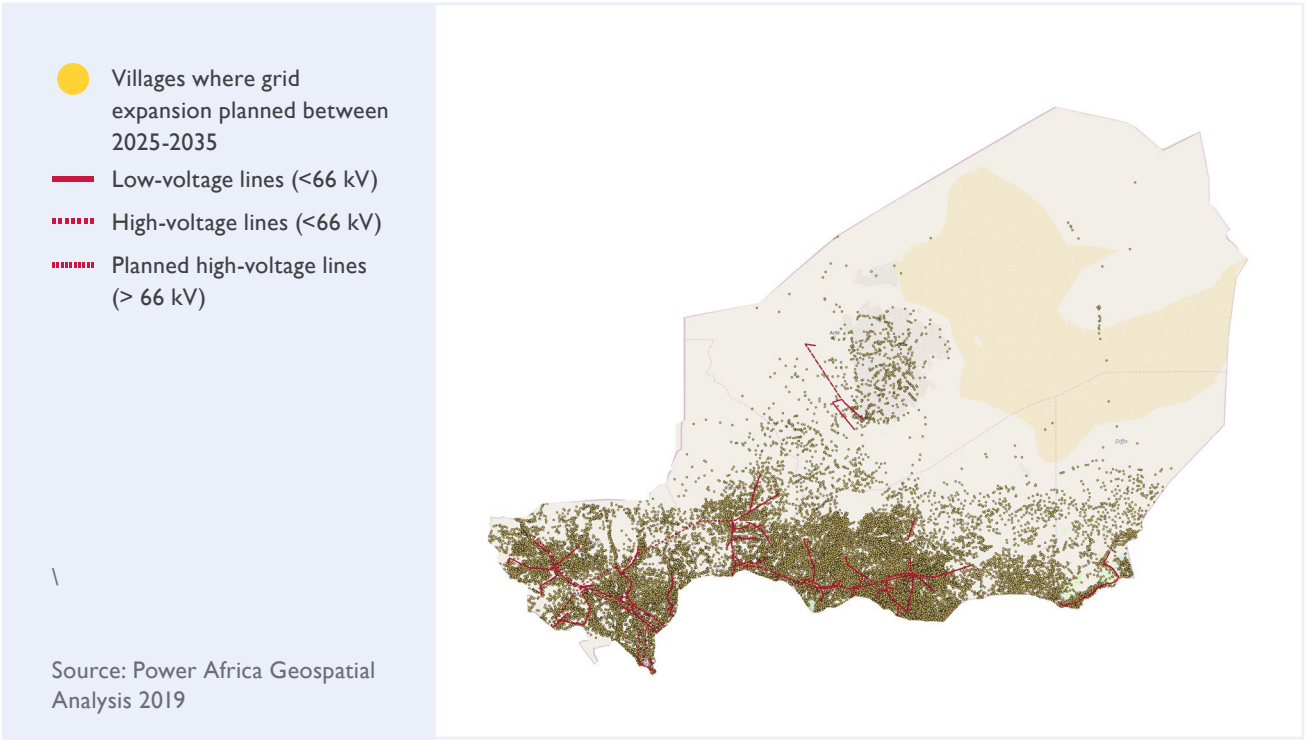
[8] Bacon and Kojima, "Energy, Economic Growth, and Poverty Reduction."

[9] The NES was adopted by GON under decree number 2018-743/PRN/M/E (dated October 19, 2018)

The NES will also develop the regulatory and institutional frameworks required to support implementation of the strategy and tie together existing initiatives, ministries, and agencies that are actively working toward electrification in Niger.[10]

From the Power Africa geospatial analysis, an estimated 73 percent of households are located farther than 5 km from the grid, and 69 percent of the population lives in communities with fewer than 2,000 people. The high cost of both extending and maintaining grid infrastructure to such distant and dispersed populations suggests that off-grid electrification in rural areas will be especially important in helping Niger meet its electrification targets. Draft data from the NES identifies specific populations that will be targeted for one of the three interventions previously mentioned. Figure 5, Figure 6, and Figure 7 map these populations for the overall population, those to receive mini-grids, and those to receive SHS kits, respectively.

FIGURE 5. OVERALL POPULATION TARGETED FOR GRID EXTENSION BY 2035

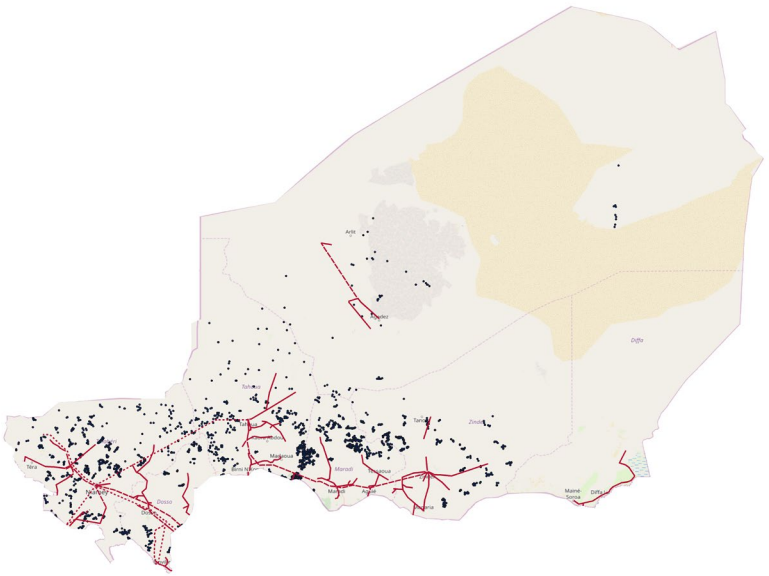


Source: Power Africa Geospatial Analysis 2019

[10] ANPER, "Atelier Régional D'électrification Hors Réseau (ROGEP)."

FIGURE 6. POPULATIONS TARGETED FOR ELECTRIFICATION BY USING MINI-GRIDS BY 2035

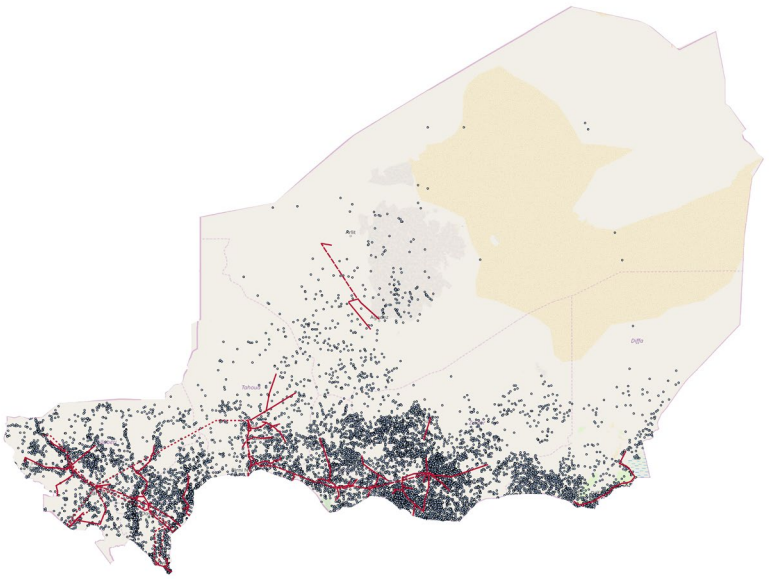
Villages to be targeted with mini-grids
Low-voltage lines (<66 kV)
High-voltage lines (<66 kV)
Planned high-voltage lines (> 66 kV)



Source: Power Africa Geospatial Analysis 2019

FIGURE 7. POPULATIONS TARGETED FOR ELECTRIFICATION USING SOLAR HOME SYSTEMS BY 2035

Villages to be targeted with solar home systems
Low-voltage lines (<66 kV)
High-voltage lines (<66 kV)
Planned high-voltage lines (> 66 kV)



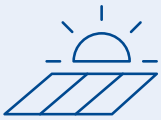
Source: Power Africa Geospatial Analysis 2019

2.2.4 RURAL ELECTRIFICATION STRATEGY

Niger has been targeting rural electrification since at least 2006 when the Ministry of Mines and Energy published the National Strategy of Access to Modern Energy Services, which set a goal of electrifying 50 percent of the population by 2015.[11] At the time, the focus of rural electrification efforts was on diesel generation sources, but early efforts were also underway to validate solar PV systems as a viable option for electrifying key public facilities in rural communities, including health, education, and communications facilities.

To accelerate rural electrification, ANPER was in 2013 by Law 2013-24 (dated May 6, 2013). ANPER is charged with designing, implementing, and monitoring rural electrification programs, and its goal is to achieve 30 percent rural electrification by 2030 through the deployment of off-grid systems. The largest electrification program guided by ANPER is the Solar Electricity Access Project (NESAP). Funded by the World Bank, NESAP is charged with market development for off-grid solar PV in rural parts of the country.

The other major electrification program is the Niger Electricity Access Expansion Project (NELACEP), which is implemented by NIGELEC. Funded by the World Bank, the aim of NELACEP is to expand the national Nigerien grid to create 330,000 new connections. Funding through NELACEP also supports the development of the NES, which is piloted by the Ministry of Energy (MoE). The extent to which NELACEP will electrify rural populations is unclear. While some rural communities are within reach of the electricity grid, it is likely that much of the rural population will be targeted for off-grid electrification (i.e., mini-grids and SHSs).



A key enabler of rural electrification in Niger is likely to be the deployment of mini-grids to serve small communities that are too far from NIGELEC's T&D infrastructure to be connected at a reasonable cost. The current rule of thumb is to consider mini-grids for localities farther than 15 km from the grid.

Private sector investment will be important to mini-grid development and SHS adoption in rural Niger. The National Electricity Policy Document (Document de Politique Nationale sur l'Électricité [DPNE]) calls for the formalization of efforts to encourage private sector investment in rural electrification. Part of this effort involves establishing a definition of off-grid populations and developing a regulatory framework to support private sector participation.

2.2.5 CURRENT STATE OF OFF-GRID SOLAR

Off-grid solar technologies are expected to play a significant role in electrification in Niger. Two out of the three pillars of the NES (see Section 2.2.3) focus on solar and solar-diesel hybrid mini-grid development and SHSs. As GON's primary initiative for off-grid electrification, NESAP is focused on developing off-grid solar in Niger. NESAP consists of the following four components:

- Market development of stand-alone solar systems ($7 million)
- Rural electrification through service-based solar hybrid mini-grids ($10 million)
- Solar PV hybridization of isolated thermal mini-grids and expansion of access ($25 million)
- Implementation support and technical assistance ($7.89 million).

Data regarding the current penetration of off-grid solar are unavailable, but most of the deployment of individual solar solutions have been conducted under the backing of donor programs or the penetration of low-quality panels and used batteries. Market assessment by the International Renewable Energy Agency

[11] Government of Niger, "Strategie Nationale D'acces Aux Services Energetiques Modernes Des Populations Nigeriennes."

(IRENA) and World Bank estimates PV installed capacity by 2014 at nearly 6 MW. However, the bulk of this calculation is based on a large telecommunications tower installation (2.8 MW) and solar pumps (0.9 MW). The market assessment does not report any significant residential installed PV capacity (less than 0.1 MW); therefore, this figure significantly underestimates the private supply of equipment.[12] For example, Comtrade statistics show that Niger recorded official imports of PV modules (under Harmonized System Code 854140) of nearly $6 million between 2013 and 2016 (which could imply at least a three times larger installed capacity). Furthermore, according to Power Africa Technical Advisors, the bulk of solar PV imports in Niger are not recorded.

According to somewhat dated national statistics from 2012, 84 percent of adults in rural households and 34 percent of urban households reported using dry-cell battery torch lights as their primary source of light, whereas 82 percent of adults in all households in Niger reported that they still use wood as the energy source for cooking.[13] More recent assessments conducted by organizations such as Open Capital Advisors (OCA) and Save the Children show findings that are approximately in line with the previously mentioned percentages.

In 2017, OCA estimated the potential off-grid solar market in Niger to be $204 million (see Table 7). The three largest potential segments are private household demand, small-scale irrigation, and water provision, with most of the market potential (64 percent) coming from solar-powered water pumps. However, this percentage should be assessed with some caution because the study did not conduct stress tests on groundwater to determine whether the water reservoirs could support high levels of pumping. Also, a key assumption driving OCA's market size estimates is that consumer financing is available to enable households and smallholder farms to be able to afford SHSs and solar pumping kits.

TABLE 7. ESTIMATED SOLAR MARKET SIZE BY SEGMENT

SEGMENT	ESTIMATED ANNUALIZED MARKET SIZE, $
Private households	56.5 million
Schools	1.6 million
Health centers	0.4 million
Public buildings	0.4 million
Large irrigation schemes	1.2 million
Small-scale irrigation	33.4 million
Crop processing	12.5 million
Water provision	96.6 million
Streetlights	1.0 million
Total	**203.6 million**

Source:[14]

Note: "Annualized market size" is defined as the maximum sales revenues achievable in any given year if all potential customers are accessible, interested, and there are no further barriers (e.g., affordability) preventing the transaction. "Annualized" refers to the average annual sales potential under consideration of product lifetimes. If, for example, 100 households want to buy a solar system and the solar system has an expected lifetime of 5 years, then the "annualized" sales volume is 20 units (100 units divided by 5 years).

[12] IRENA, "Niger Renewables Readiness Assessment 2013."

[13] Gaoh and Ali, "RAPPORT SUR LES CARACTERISTIQUES DE L'HABITAT ET LE CADRE DE VIE."

[14] Open Capital Advisors, "Off-Grid Solar Market Assessment in Niger & Design of Market-Based Solutions."

2.3 DEMAND FOR ELECTRICITY

2.3.1 HOUSEHOLD DEMAND FOR ELECTRICITY

This section provides a detailed profile of how households connected to the electrical grid are different from those that are not. The data and analysis presented here come from an assessment of latent demand as part of the Power Africa Geospatial analysis.

Nationally, approximately 80 percent of households in urban areas are connected to the electrical grid. In contrast, approximately 90 percent of households in rural areas are not connected to the electrical grid. Out of the 2.36 million households not connected to the electrical grid, only 235,000 are located in urban areas. Approximately 25 percent of these households in urban areas are in Niamey and Zinder, which are the two largest cities in Niger, according to the Power Africa geospatial analysis.

As described in Table 8, households not connected to the electrical grid reported owning fewer assets, their homes are made with lower quality materials, and the heads of household have lower levels of education than those in households connected to the electrical grid. However, households not connected to the grid reported high rates of ownership of mobile telephones (and, to a lesser extent, radios). In addition, 89 percent of the households reported owning agricultural land, which suggests a latent demand for electricity for irrigation.

TABLE 8. COMPARING CHARACTERISTICS OF HOUSEHOLDS ON AND OFF THE ELECTRICAL GRID

INDICATOR	HOUSEHOLDS CONNECTED TO THE ELECTRICAL GRID	HOUSEHOLDS NOT CONNECTED TO THE ELECTRICAL GRID
Urban	80%	10%
KEY ASSETS		
Mobile telephone	92%	58%
Radio	44%	30%
Television	75%	3%
Refrigerator	28%	<1%
Computer	9%	<1%
Generator	3%	1%
Car	11%	<1%
Bicycle	11%	3%
Agricultural land	34%	89%
HOUSING QUALITY		
Advanced finished floor	71%	7%
Advanced finished walls	40%	5%
Advanced finished roof	60%	7%

TABLE 8. COMPARING CHARACTERISTICS OF HOUSEHOLDS ON AND OFF THE ELECTRICAL GRID

INDICATOR	HOUSEHOLDS CONNECTED TO THE ELECTRICAL GRID	HOUSEHOLDS NOT CONNECTED TO THE ELECTRICAL GRID
EDUCATION OF HEAD OF HOUSEHOLD*		
Did not finish primary school	56%	91%
Finished primary school	33%	9%
Finished secondary school	2%	<1%
Some higher education	9%	<1%
OCCUPATION OF HEAD OF HOUSEHOLD*		
Total Employed	81%	89%
Agriculture	25%	87%
Sales	21%	4%
Manual labor	33%	7%
Professional	16%	1%

Source: Power Africa Geospatial Analysis 2019

* In some countries, only men are counted as heads of households. Recognizing this, it is relevant to mention that in Niger, the head of household includes both men and women. Both widows and women whose husbands are away for extended periods can be considered a head of household.

Among households not connected to the electrical grid, there are differences in housing quality, asset ownership, and a variety of socio-economic characteristics, underscoring a dynamic range of potential consumers for energy services.

To understand the potential market for different types of off-grid solutions, Power Africa and Fraym segmented households not connected to the electrical grid into three discrete categories based on housing quality and ownership of mid-range electrical assets (i.e., mobile telephones or radios) or high-range assets (i.e., televisions, refrigerators, computers, generators, or cars). The three categories are modest-consumption, medium-consumption, and large-consumption power households:

- Modest-consumption power households make up 51 percent of the total off-grid market potential. Households in this category own at least one mid-range electrical asset, but the homes are made from unfinished or partially finished components, such as dirt floors or mud walls. These households have demonstrated some ability to pay for electrical assets but still lack substantial spending power, as illustrated by their housing quality and lack of high-range assets.
- Medium-consumption power households make up 10 percent of the total off-grid market potential. Households in this category own a mobile telephone, and the homes have a roof, walls, or floor made with some advanced material, such as metal, wood, or covered brick. These households have a greater ability to pay, but they still have limited discretionary income, as illustrated by their lack of any high-range assets.

- Large-consumption power households make up 4 percent of the total off-grid market potential. Households in this category own at least one high-range asset. These high-range assets not only proxy well for wealth but they also illustrate a demand for energy because many of the assets are electric. Households in this category also report a high level of television ownership, suggesting some current demand for energy services.

For the Power Africa geospatial analysis, most (i.e., 65 percent) households not connected to the electrical grid were placed into one of these three groups.

The remaining 35 percent of households not connected to the electrical grid are assumed to have low-consumption power, as indicated by a lack of mid- or high-range assets and homes made entirely from less durable building materials.

To understand potential latent demand for electrification, Power Africa analyzed the discretionary spending patterns and asset ownership of large-consumption power households that are not connected to the electrical grid. The findings from this analysis illustrate the potential for high electronic asset ownership and energy demand once these large-consumption power households that are currently dependent on non-grid energy sources have access to reliable electricity.

Nationally, "annual discretionary spending," which is defined as annual expenditures on items unrelated to food, health, education, or housing, is approximately $560 among all households and $385 among households not connected to the electrical grid.

The annual discretionary spending of large-consumption power households is approximately twice as high as the national average. Large-consumption power households spend approximately $1,010 per year on discretionary items. Households connected to the grid own computers and refrigerators at higher rates than large-consumption power off-grid households, whereas television and generator ownership is higher for large-consumption power off-grid households. Annual non-utility electricity costs are significantly higher for large-consumption power households than for households with electricity from the national grid, suggesting some demand for electricity among large-consumption power households that is either unavailable from or inadequately fulfilled by electricity from the national grid.

With these data in mind, Power Africa concluded that large-consumption power households have significant latent demand for electrification, including to power electric appliances and assets (Table 9).

TABLE 9. COMPARING LARGE-CONSUMPTION POWER OFF-GRID HOUSEHOLDS WITH ON-GRID HOUSEHOLDS

INDICATOR	LARGE-CONSUMPTION POWER HOUSEHOLDS	HOUSEHOLDS WITH ELECTRICITY FROM THE NATIONAL GRID
Main source of light: national utility	0%	100%
Main source of light: batteries	48%	0%
Main source of light: generator	12%	0%
Main source of light: solar	2%	0%
Owns a generator	42%	3%
Owns a television	84%	75%
Owns a refrigerator	8%	28%
Owns a computer	2%	9%
Owns a car	10%	11%
Owns agricultural land	68%	34%
Lives in urban areas	66%	79%
Average annual electricity utility bill	$0	$195
Average annual non-utility electricity cost	$16	$2
Average annual energy spending	$120	$160
Average annual discretionary spending	$1,011	$1,647

Source: Power Africa Geospatial Analysis, 2019

2.3.2 EDUCATIONAL, HEALTH CARE, AND PUBLIC FACILITIES

In 2017, OCA, on behalf of Lighting Global, conducted a detailed market assessment for off-grid solar in Niger that included a market-sizing exercise for educational, health care, and public facilities.[16] Key conclusions and market size estimates from OCA are summarized in the remainder of this section of the report. More details are available in the full report. OCA collected data through consultations with government and businesses in Niger.

EDUCATIONAL FACILITIES

In its assessment, OCA considered four categories of educational facilities: nursery, primary, secondary, and tertiary. OCA found that in all cases, even when factoring in the cost of a grid connection, grid electricity would be less expensive than solar systems. However, given that the distribution of schools approximately maps to the geographic distribution of the population, a large percentage of schools currently do not have access to grid power.

When comparing solar with other energy sources (e.g., diesel generator, kerosene lamps, gas appliances), solar PV presents net-positive annual savings for schools. In total, OCA estimates the annualized market size for solar PV in educational facilities to be $1.6 million.[17]

HEALTH FACILITIES

OCA estimates the annualized market for solar in Nigerien health facilities to be $415,000. Cases de Santé are smaller health facilities that tend to have lower power needs but are also the largest group.

PUBLIC FACILITIES

Niger has approximately 1,100 public buildings, most of which are used for law enforcement and the justice system. OCA found the annualized market for solar in public buildings to be $408,619 (Open Capital Advisors 2017).

OCA's analysis across educational, healthcare, and other public facilities concludes that where buildings have access to grid electricity, the business case for solar is not favorable unless solar PV is being used as a back-up generation source in place of back-up diesel. However, OCA's analysis also assumes that schools, health care facilities, and public buildings are spread approximately in line with the distribution of the population. Given this assumption and what is known about grid access for households, it is likely that many of these facilities will not have access to grid power in the immediate future. Thus, solar systems present a strong alternative to diesel generators and other traditional forms of energy.

A key enabler of electrification efforts in schools, health care, and public buildings is collaboration among MoE, ANPER, and the Ministries of Education and Health. A mechanism for coordination would enable more effective planning of electrification efforts for education and health care buildings, including new facilities. Currently, no such mechanism for coordination exists and may be challenging to establish given the complex bureaucracies within each ministry.

2.4 OVERALL POLITICAL LANDSCAPE

At a local and regional level, Niger is a unitary country consisting of eight regions and 265 municipalities (52 urban and 213 rural). The 2011 National Policy on Decentralization aims to improve local basic public services provision. Local governments are responsible for economic development, education, social

[16] Open Capital Advisors.
[17] Open Capital Advisors.

services, and cultural development within their territory. Municipalities are in charge of primary health care provision and water provision (both potable and for agricultural purposes). Nigerien municipalities and regions receive a share of taxes raised nationally, and municipalities can raise local taxes and borrow for investment projects.[18] [19] Niger is a semi-presidential representative democratic republic, with a President, Prime Minister, and representatives for regions within Niger. Since 2011, the President has been Mr. Mahamadou Issoufou and the Prime Minister has been Mr. Brigi Rafini. The ruling Nigerien Party for Democracy and Socialism (Parti Nigérien pour la Démocratie et le Socialisme [PNDS]) has maintained power since a coup that occurred February 19, 2010. The last general election in Niger was in 2016, when President Issoufou secured his second term.

The next general election will be held in 2021, and the incumbent President has given all indications that he will abide by the two-term limit. The PNDS has chosen Mr. Mohamed Bazoum as its 2021 presidential candidate.[20] To promote a peaceful election process, the U.S. Agency for International Development (USAID) is launching a joint program with the current GON to promote peaceful dialogue among political candidates and support the government institutions responsible for conducting the elections.[21]

Despite the currently stable political environment, multiple regions in Niger have been in a state of emergency because of the rise of terrorist activities and drug trafficking. An insurgency of Boko Haram in the Diffa Region is confounded by an influx of Nigerian refugees fleeing Boko Haram in Nigeria. Regions of Niger that border Mali to the West, Libya to the North, and Nigeria to the South have realized a significant rise in kidnappings and terrorist attacks in recent years.[22] According to the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), attacks resulted in more than 100 deaths in 2018, and more than 150 thus far in 2019.[23] The security situation in the Diffa region is a substantial barrier to business and donor activities.

2.5 GOVERNMENT INSTITUTIONS

The MoE is responsible for coordinating and implementing energy policies in Niger that takes place across a variety of agencies and government entities. ARSE, which operates under the authority of the Prime Minister of Niger, regulates the electricity sector and advises the legislature regarding the development of laws and regulations.

In addition to the MoE and ARSE, Niger has dedicated organizations in place that focus on solar energy and rural electrification. The National Agency of Solar Energy (Agence Nationale d'Energie Solaire [ANERSOL]) is charged with conducting applied renewable energy research and offering training programs about managing renewable energy systems in Niger. Under NESAP, ANERSOL is responsible for developing and implementing standards and testing imported solar equipment. For context, ANERSOL was originally created in the 1960s as the Solar Energy Office (Office de l'Energie Solaire [ONERSOL]) and was one of the first organizations of its kind in Africa. ANERSOL was also called the National Center for Solar Energy (Centre National de l'Energie Solaire [CNES]) until November 2018, when it was renamed ANERSOL.[24]

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[18] OECD, "Niger Country Profile."

[19] Shared taxes include property tax, with 50% being retroceded to the local governments; business tax, with the total being given to municipalities and regions; personal income tax (30% to the local governments); business licenses tax (100%) and the mining and petroleum tax (15% of the mining and petroleum revenues of the state). See OECD 2016 for more information.

[20] AfricaNews, "Niger President Serves Quit Notice, Party Elects Candidate for 2021 Polls."

[21] USAID, "United States and Government of Niger Celebrate Opening of Program to Support 2021 Elections."

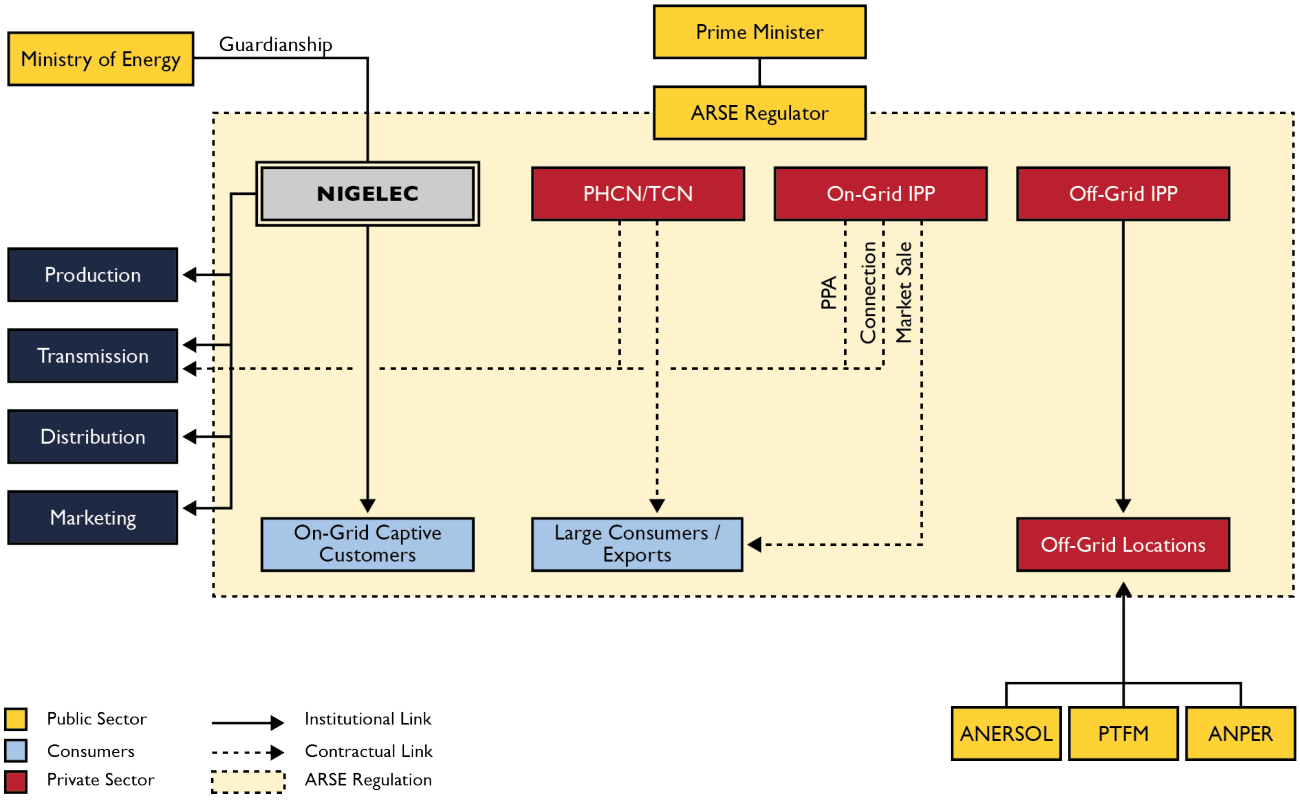
[22] U.S. Department of State, "Niger Travel Advisory."

[23] UN OCHA, "Niger."

[24] IRENA, "Niger Renewables Readiness Assessment 2013."

ANPER is responsible for developing and implementing strategies to expand electrification in rural portions of the country that are farther than 10 km from the grid infrastructure (Figure 8).

FIGURE 8. NIGER ELECTRICITY SECTOR INSTITUTIONAL FRAMEWORK



Source: Modified from Nodalis Conseil 2016

The government-owned utility in Niger is NIGELEC, which owns and maintains all of the T&D infrastructure and approximately 50 percent of the generating capacity in Niger. In addition, NIGELEC is responsible for imports of electricity from Nigeria and exports to Benin, as well as Niger's participation in the WAPP. Electricity imported from Nigeria is purchased from TCN. NIGELEC also transports electricity generated by IPPs. SONICHAR is a coal mining company, and the Zinder Refinery Company (Société de Raffinage de Zinder [SORAZ]) runs an oil refinery in Niger. Both companies operate generation capacity for their own consumptive needs and sell excess generation to NIGELEC. Table 10 summarizes the major public- and private-sector stakeholders in the electricity sector in Niger.

TABLE 10. KEY ENERGY SECTOR STAKEHOLDERS IN NIGER	
STAKEHOLDERS	**DESCRIPTIONS**
POLICIES AND REGULATIONS	
ANPER	Responsible for implementing rural electrification initiatives
ARSE	Responsible for regulations in the electricity sector and advises the legislature about the formation of energy policy and legislation
MoE	Coordinates and implements national energy policies
RESEARCH AND DEVELOPMENT	
ANERSOL	Charged with conducting applied renewable energy research, offering training programs about managing renewable energy systems, and developing standards for imported solar systems greater than 350 watts (W)
PRIVATE SECTOR	
NIGELEC	State-owned electricity utility; operates both generation and T&D infrastructure
SONICHAR	Nigerien coal-mining company that also sells excess electricity for NIGELEC's T&D grid
SORAZ	Nigerien oil-refining company that also sells excess electricity to NIGELEC's T&D grid
TCN	Electricity importer from Nigeria to Niger

A key relationship—and potential point of internal conflict—is between NIGELEC and ANPER. NIGELEC has its own rural electrification efforts, but these are mostly associated with grid extension and must be undertaken using NIGELEC funds; in contrast, ANPER focuses on off-grid electrification using GON budgeted funds. These two approaches to electrification can be complementary, but they are also a source of some institutional conflict because resources are scarce.

2.6 INTERNATIONAL DONORS

Several electrification initiatives in Niger are funded by and implemented with support from international donors. Table 11 outlines major international donors currently active in Niger.

TABLE 11. INTERNATIONAL DONOR ORGANIZATIONS	
ORGANIZATIONS	**DESCRIPTIONS OF ACTIVITIES**
World Bank	The World Bank is partnering with the GON on several initiatives, including NESAP and NELACEP. The World Bank also funds Lighting Africa, which works with manufacturers, distributors, governments, and other development partners to build and grow the modern off-grid solar energy market. The World Bank has also provided financing to build the Kandadji Hydroelectric Plant. The International Finance Corporation (IFC's) Scaling Solar program is evaluating the conditions for its support to large solar IPPs.
Islamic Development Bank	The Islamic Development Bank has launched a program to release $180 million in financing to six African countries for renewable energy projects as part of a broad strategy to deepen its involvement in the region, aimed at energy access for the poor. In Niger, the program focuses on mini-grids.

TABLE 11. INTERNATIONAL DONOR ORGANIZATIONS	
ORGANIZATIONS	**DESCRIPTIONS OF ACTIVITIES**
AFD	AFD supports and provides financing for the expansion of the distribution grid, with a focus on urban and peri-urban communities that are currently off-grid.a
USAID	USAID funds Power Africa, which operates in Niger and provides technical assistance and funding for electrification projects. Power Africa's transaction-centered approach focuses on facilitating energy project transactions while simultaneously driving policy reform.
ECOWAS	ECOWAS funds and manages ECREEE, which provides capacity building, market development for renewable energy, and grants for renewable energy projects. ECREEE implements the ECOWAS Programme on Gender Mainstreaming in Energy Access (ECOW-GEN). In 2015, ECOWAS member states adopted ECOW-GEN to address existing barriers that may hinder the equal participation of women and men in expanding energy access in West Africa. Currently, ECOW-GEN is undertaking a feasibility study of business opportunities for women in a changing energy value chain in West Africa.
Abu Dhabi Fundfor Development (ADFD)	ADFD has provided financing for the construction of the Kandadji Hydroelectric Plant. With the support of IRENA, a project focused on rural electrification for more than 150,000 people, using 2.1-MW solar PV micro-grids and SHSs, has been implemented; 100 schools will be electrified, and drinking water supplies will improve.
African Development Bank Group (AfDB)	AfDB is providing financing, technical assistance, and capacity building to extend and densify NIGELEC's grid infrastructure. The initial project description also lists the World Bank, European Union, the AFD, the West African Development Bank (Banque Ouest Africaine de Développement [BOAD]), and the Islamic Development Bank as technical and financial partners. Under the Sustainable Energy Fund for Africa (SEFA), AfDB has been supporting the mini-grid policy development program.
Export-Import (EXIM) Bank India	EXIM Bank India provided financing for upgrading on-grid power stations and power lines, as well as off-grid solar PV electrification of 50 villages.
Directorate-General for International Cooperation (DGIS) and the Government of Netherlands	The SNV Netherlands Development Organisation, with DGIS, has supported the training of mid-level technicians, establishing a professional association of solar entrepreneurs, and importing the first container load of quality pico-solar lamps with tax exemption. This partnership has also helped with gaining a tax exoneration for another 1,240,000 pico-solar devices; using the first imports to undertake market trials at pilot scale, undertaking widely recognized product and market studies, and staging the first professional marketing campaigns.
Council of the Entente (Conseil de l'Entente)	The Council of the Entente funded electrification of three communities through the distribution of 335 solar kits to communities of Sabongari Foga Barra, Nakigaza, and Angoual Gaja.
West African Economic and Monetary Union (WAEMU)	In partnership with ECREEE, WAEMU donated SHSs for the electrification of Tondigamey.
West African Development Bank (Banque Ouest Africaine de Développement [BOAD])	BOAD funded rural electrification by hybrid micropower plants in 47 communities in Niger, the Rural Electrification Emergency program in 2015–2016. BOAD also funded the construction of the final 20 MW of generating capacity at the Gorou-Banda Thermal Power Plant in Niger

Source: OCA and AFD

2.7 SOLAR AND RENEWABLE ENERGY ASSOCIATIONS

The National Association of Solar Professionals (Association des Professionals d l'Energie Solaire [APE-Solaire]) was founded in May 2013. Most solar companies in Niger are either members of or in the process of joining APE-Solaire. The goals of APE-Solaire are to

- Raise awareness of the benefits of solar energy
- Contribute to the professionalization of the sector by strengthening the capacities of the actors
- Facilitate networking of solar energy professionals
- Sensitize GON, local authorities, and financial institutions regarding the integrated and harmonious development of solar energy in Niger.

APE-Solaire's coordination activities are primarily driven by annual meetings of its members, which can be Nigerien solar companies, international corporations, donor organizations, financial institutions, and individuals with a personal interest in promoting solar energy in Niger. Between meetings, the initiatives of APE-Solaire are implemented by the full-time National Executive Office under the direction of the National Executive Board, which consists of representatives of active members.

APE-Solaire's primary activity is to participate as a stakeholder in GON's ongoing development of policy and regulation of solar energy in Niger. APE-Solaire also facilitates apprenticeship positions at solar companies to train new solar technicians. Annex D of this report lists the founding members of APE-Solaire.

2.8 TRAINING INSTITUTIONS, INCUBATORS, AND ACCELERATORS

There are three main pathways for training professionals in the solar industry in Niger: universities, secondary training and trade schools, and apprenticeships:

- Universities. Niger has two universities—the University of Niamey and the School of Mines and Geology (Ecole des Mines et de la Géologie [EMIG])—that offer training programs for technicians and engineers in the field of renewable energy with an emphasis on solar technologies. In close cooperation with universities from Western Africa, Abdou Moumouni University has established a master's degree program focusing on climate change and energy. The University of Maradi offers classes for electricity in general and for renewable energy. In 2014, GON approved opening four new universities and, notably, one in Agadez will focus on fossil fuel and renewable energy.[25] The Polytechnic School of Niamey (École Polytechnique de Niamey) offers degrees and training in renewable energies and information and communication technology specifically tailored to the needs of private companies.
- Secondary Training and Trade Schools. Both public and private trade schools provide training for solar technicians. Issa Béri is an example of a public trade school, and Wangari is an example of a private school.
- Apprenticeship. APE-Solaire facilitates apprenticeships for solar technicians with solar companies in Niger.

A centralized directory of trained solar technicians does not exist in Niger; however, the universities and the secondary training and trade schools previously mentioned could be an important starting point for an inventory of how many trained technicians are working in Niger.

[25] RECP, "Africa-EU Renewable Energy Cooperation Programme (RECP): Higher Education for Renewable Energy - Niger."

In addition to the training efforts mentioned, the Incubator Center for Small and Medium Enterprises in Niger (Centre d'Incubateur des Petites et Moyennes Entreprises du Niger [CIPMEN]) is a small business incubator that has been advising solar companies since 2014. Also, the Maison de l'Entreprise is a government-sponsored institution that fosters the emergence of competitive enterprises and a pro-private–sector business environment. In addition to offering facilities, Maison de l'Entreprise proposes services such as advice to set up businesses in Niger, including a single window for all processes associated with incorporating a company in Niger, as well as technical and financial support to early stage companies.

3 PICO-SOLAR AND SOLAR HOME SYSTEMS

3.1 COMMERCIAL OVERVIEW

Solar home systems are one of the three pillars of Niger's NES and will be especially important in rural electrification efforts in the country. Most active deployments in the field still follow a donor/government-driven approach, typically involving some level of subsidy to assets and an operator that aims to recover only some portion of the capital costs (either by invoicing per kilowatt hour or some fixed charge). Such programs typically enjoy duty exemptions; for a more detailed description of ongoing donor programs, see Table 11.

The most ambitious government and donor program attempted thus far is PRASE in the Safo municipality (also mentioned in Section 2.2.2), a $5.4 million joint European Union and UNDP effort that led to the electrification of 50 villages using SHSs for the following:

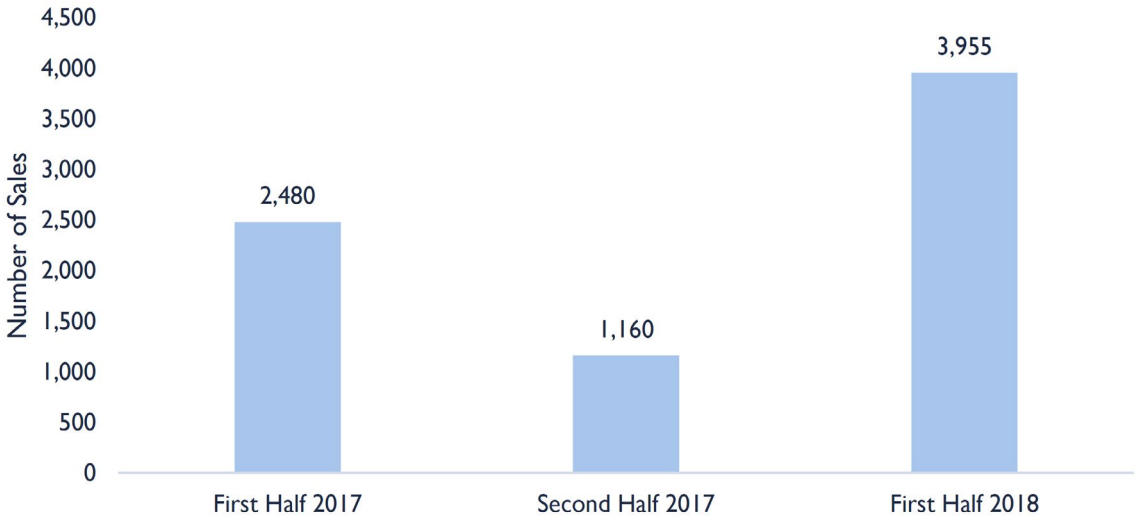
- Individual access
- Basic service in public facilities (schools and health centers)
- Productive uses (e.g., water pumps for agriculture) and water access.

PRASE was considered a success in terms of powering public facilities and productive uses, but the developer (Elhyfros at the time) could not mobilize funds to scale up the SHS component of the project.[26] Early efforts to develop a private pico-solar market also met with mixed results Although the formation of APE-Solaire through the efforts of the SNV Netherlands Development Organisation helped bring together the off-grid industry in Niger, the business cases and economic environment were challenging for private SHS companies. In fact, the first effort to sell SHS products commercially, led by Haske Solaire, collapsed, in part because of failure to secure tax exemptions at the border.

Most of the commercial sales of quality-certified solar lanterns have been by Awango, which is operated by Total (French oil company). Still, Total reports difficulties with selling the d.light lanterns in Niger at a 50 percent mark-up—owing to the tax wedge—compared with Burkina Faso, where Total experienced a duty-free environment.

[26] UNDP, "Integration of Greenhouse Gas Emission Reductions in Niger's Rural Energy Service Access Program."

FIGURE 9. SALES OF PICO-SOLAR AND SHS PRODUCTS IN NIGER



Source: GOGLA

Outside of Total, other projects have typically been non-governmental organization (NGO) driven with SNV Netherlands Development Organization, Save the Children, and Mercy Corps deploying pico-solar lanterns. In fact, the Global Off-Grid Lighting Association (GOGLA) reports fewer than 7,500 quality-certified products sold between January 2018 and June 2019, according to the most recent GOGLA sales and investment data. GOGLA does not report revenues, but most of these sales are pico-solar lanterns purchased with cash. Total system sales from pay-as-you-go (PAYGO) were a total of only a few hundred US dollars.

Despite low sales volumes—which are perhaps 20 percent to 25 percent of sales registered in Burkina Faso or Mali—there are good reasons to expect an acceleration in 2019 and particularly 2020. For instance, since mid-2018, NESAP has helped catalyze GON's effective response to the three key challenges that curtailed the emergence of a market-based offer of pico-solar solutions—GON instructed the ANERSOL and Customs to develop and implement standards; established credit lines with banks and microfinance institutions (MFIs); and implemented an import tax exemption for off-grid equipment. In parallel, both Orange Niger and Airtel Niger have worked out technical challenges related to accepting PAYGO payments for solar products. As of June 2019, Oolu Solar is integrated with Orange Niger, and Benalya/Benafsol with Airtel Niger. Both telecommunication companies strive to add more operators to their unstructured supplementary service data menus.

Since 2018, Niger has attracted investments from local and foreign companies. Some companies are now selling solar kits with financing. Benalya has imported approximately 2,000 units of pico-solar products (including pico-solar lanterns and SHSs) from Greenlight Planet, whereas Oolu Solar effectively began sales in April 2019 after receiving its first shipment of products.

The strategies of these two companies reflect the wide gap in business approach between domestic and international firms. Oolu Solar is deploying a standard agent-based model with targeted areas of deployment, where a sales agent goes out into communities to sell direct to the customer. Whereas Benalya is working with CIPMEN to establish a network of local distributors throughout the country.

The gap is further reinforced by the difference in product offerings, which reveals different views of how to attain profitability and achieve impacts in this market. Oolu Solar offers a fairly focused product range of three-light and charger systems and a larger unit with a television. Clients make a down-payment and select one of three payment plan options.

The other company that has begun conducting pilot efforts in Niger is E-Longlife by Bren-Tronics. This company is already active in Chad and wrapping up financing for scaling operations in Niger. E-Longlife is looking to deploy units of different power ranges in a service offering that includes all types of appliances. E-Longlife's standard offer centers on a lighting standard and a SHS that is large enough for unlimited television use, fans, refrigeration, and other basic direct current appliances.

At least two other international companies coming from Benin are conducting advanced market exploration—African Renewable Energy System and Solution (ARESS) and the Continental Invest-in-Africa Corporation (CINAC). ARESS currently operates in northern Benin and Burkina Faso and targets market entry by the fourth quarter of 2019.

As of April 2019, NESAP has trained five local companies for technical assistance (carried out by CIPMEN) with a goal of working toward full adoption of PAYGO and development of routes to market. The companies include YANDALUX, Consultations Plus, Benafsol, Elhyfros, and the Sahelian Energy Company (Compagnie Sahelienne d'Énergie). YANDALUX has a strong track record as a mini-grid developer. Another company, d.light, is conducting talks with local groups to better design its market entry strategy.

3.1.1 SOLAR HOME SYSTEMS SALES SUMMARY

Power Africa obtained data from GOGLA and its members on the off-grid solar sector in Niger. Data are limited, but from the second half of 2017 to the first half of 2018, sales of SHSs in Niger increased by 241 percent.[27] Sales in Niger are lower than for most other Power Africa countries, but we expect that data access is also an ongoing challenge; thus, it is not clear how representative the available data are of actual sales in Niger.

3.1.2 COMPANIES SELLING PICO-SOLAR AND SOLAR HOME SYSTEMS

Table 12 provides a summary of the companies selling pico-solar and SHSs in Niger. Table 13 provides details of financing for SHSs in Niger.

TABLE 12. COMPANIES SELLING PICO-SOLAR AND SOLAR HOME SYSTEMS IN NIGER

Company Name and Logo	Years of Operation	Product Range	Sales to Date, Areas of Operation	Financing Raised
Groupe BENALYA La force d'un réseau intelligent Benalya/Benafsol	The company was founded in 2011.	PAYGO (Angaza) and cash Pico-solar with GreenLight Planet (GLP) and 19-inch television Large kits locally designed and assembled (Victron batteries)	100 units per month	Uses own funds and has strong relationship with banks; MFI partnerships in place

[27] Calculation based on data provided by GOGLA in 2019.

TABLE CONTINUED FROM PREVIOUS PAGE

TABLE 12. COMPANIES SELLING PICO-SOLAR AND SOLAR HOME SYSTEMS IN NIGER

Company Name and Logo	Years of Operation	Product Range	Sales to Date, Areas of Operation	Financing Raised
Oolu Solar	Effective operations in Niger began in January 2019, but the company has been in business since 2015.	PAYGO (Angaza), with large payment flexibility Manufacturer is Amped Innovations Two offers: Basic: SHSs (5 lights and phone charger) 5 lights and 19-inch television	200 units per month	Financing secured on the basis of operations outside Niger
Bren-Tronics/ Alternaprod	Bren-Tronics/ Alternaprod was founded in 2012.	Proprietary products and remote-control solution (for perpetual lease model) Units ranging from lanterns to kilowatt per cycle range Bren-Tronics also offers paired appliances	Pilot completed; company is scaling in Chad	Financing secured with the Electrification Financing Initiative (ElectriFI) and the Overseas Private Investment Corporation (OPIC)
La Sahelienne de Genie Electrique (SGE)	SGE was established in 2009.	PAYGO (Angaza) Lanterns, charging stations, and SHSs with Lagazel	First pilot completed	None specific; beneficiary of support from GIZ
Consultation Plus	The company was founded in 2009.	Defining an offer for pico-solar kits Working with Lorentz pumps, Victron batteries, and Steca refrigerators	Developing PAYGO SHS offer	Uses own funds and has a strong relationship with banks; MFI partnerships in place
Yandalux	The company has been operating in Niger for almost 6 years.	Developing PAYGO SHS offer. NIWA modular products; offers entry-level kit and a kit with 24-inch television on a cash basis	First pilots with NIWA; strictly cash distributor	None specific

TABLE CONTINUED FROM PREVIOUS PAGE

TABLE 12. COMPANIES SELLING PICO-SOLAR AND SOLAR HOME SYSTEMS IN NIGER

Company Name and Logo	Years of Operation	Product Range	Sales to Date, Areas of Operation	Financing Raised
Elhyfross	Founded in 2001	—Mini-grid operator and PAYGO SHS in perspectives	—	Beneficiary of PRASE program of the UNDP and the European Union
CINAC	The company was founded in 2015.	—	Has not begun operational deployment	Financing secured on the basis of operations outside Niger
ARESS	Not applicable	PAYGO and cash Pico-solar with LGP and televisions Large kits locally designed and assembled (Victron batteries)	Has not begun operational deployment	Financing secured on the basis of operations outside Niger
Total (Awango)	Launched in 2012	d.light lanterns and Awango SHSs	—	Internal funds

Source: Power Africa Technical Advisors

TABLE 13. FINANCING RAISED TO DATE IN NIGER FOR SOLAR HOME SYSTEMS

TYPE	AMOUNTS AND DATES
Debt	A local bank has issued 200,000 loans at an 11 percent annual interest rate and two-year term
Equity	No equity raised. ARESS is raising round A and Oolu Solar round B for regional operations.
Grants	To date, no specific grant has been awarded to support local companies.
FINANCE TO BE RAISED DURING THE NEXT 24 MONTHS	
Debt	$2 million to $3 million by five companies.
Equity	Unlikely to be a top priority of local groups.
Grants	$750,000 (but no specific window has been announced).

Source: Discussions with in-country stakeholders and experts

3.1.3 BARRIERS TO MARKET GROWTH

In Table 14 barriers to market growth and potential solutions for SHSs are summarized from in-country stakeholder interviews. The main barriers are importation costs, access to finance, duties and taxes, ability to pay, distribution challenges, and local staffing issues. Many of the barriers can be reduced or alleviated with the support of GON in collaboration with donors and investors.

TABLE 14. BARRIERS TO MARKET GROWTH FOR SOLAR HOME SYSTEMS

BARRIER	DETAILS	POTENTIAL SOLUTION
Importation costs	Landlocked country means additional transport costs for products sourced in China.	Improving the supply chain from port-of-entry countries in order to reduce the transportation costs to Niger.
Access to finance	SHS companies and consumers alike require capital in order to participate in the market. Access to finance is critical for an expansion of buyers and sellers in the nascent industry.	Improving financial literacy as well as financial inclusion of consumers. More finance options for SHS companies.
Duties and taxes	Value-added tax is still applied despite NESAP agreement to eliminate this tax.	ANPER will address this issue with the Ministry of Finance.
Ability to pay	Low incomes, combined with underdeveloped financing mechanisms mean that a substantial portion of the Nigerien population may not be in the position to purchase pico-solar or SHS equipment.	The market can grow substantially at current prices over the next two to three years and await a trend of falling prices to expand the market over the medium term. More robust financing offerings will help. ANPER is considering launching a Results-Based Financing Scheme.
Distribution challenges	Transport is available only for deliveries along main routes.	Companies will have to ensure the means and processes for stock transfers.
Local staffing issues	Niamey is not a site for startup businesses. Finding and retaining talent can be challenging.	Support to attract startup companies (e.g. incubators), as well as training centers to create a pool of skilled technicians.
OTHER CAPACITY ISSUES		
Mobile money penetration and transaction fees	Mobile money is used by fewer than 9 percent of the adult population. Transaction fees are high but in line with Senegal and other countries in the region.	SHS companies should propose work in partnership with telecommunication companies to expand the network, accept cash, and promote work with MFIs. Telecommunication companies need to see the business in the volume of transactions rather than unit transaction fees.
Mobile network stability	Companies experienced difficulties with reaching agents and clients in specific rural areas because of inconsistent service.	Expansion of the cell tower network.

Source: Power Africa Technical Advisors

3.2 RELEVANT GOVERNMENT AND DONOR PICO-SOLAR PROGRAMS

Under the NES, which was adopted in 2018, GON estimates that 10 percent of the population of Niger will be targeted for electrification with pico-solar products. In addition, making SHSs more accessible is a key strategy of the NES. Both pico-solar and SHSs are relevant technologies for rural electrification in communities that do not have the population, proximity, and/or density required to make grid expansion or mini-grids an economically viable approach.

3.2.1 EXISTING PICO-SOLAR PROGRAMS

ANPER is currently implementing six SHS projects with financial support from many development partners (see Table 15). These projects will supply SHSs to 352 villages previously identified by GON. The business model is not yet clear, but ANPER is keen to engage local authorities regarding the maintenance of the systems, including training and partnership with the system suppliers.

TABLE 15. DONOR ORGANIZATIONS FUNDING ANPER SOLAR HOME SYSTEM PROJECTS

FUNDING INSTITUTION	NUMBER OF LOCALITIES TARGETED
Islamic Development Bank	40
IRENA/Abu Dhabi Fund for Development (ADFD) facility	45
Council of the Entente (Conseil de l'Entente)	4
Export-Import (EXIM) Bank India	40
Economic Community of West African States (Communauté Économique des Etats de l'Afrique de l'Ouest [CEDEAO])	100
G5 Sahel	123
Total	**352**

With respect to financing for SHSs and developing an ecosystem of suppliers, Component 1 under NESAP provides to SHS companies a credit line of more than $10.5 million to fund 100,000 certified-quality solar products, provide technical assistance to 10 pico-solar companies, and provide solar pumps to 1,000 farmers. NESAP has partnered with two banks—the Nigerien Bank Corporation (Société Nigérienne de Banque [SONIBANK]) and the Sahara Bank Group for Investment and Trade (Banque Sahélo Saharienne pour l'Investissement et le Commerce [BSIC])—and an MFI—Capital Finance—to disburse money from this line of credit.

The Regional Off-Grid Electrification Project (ROGEP), funded by ECREEE, is a multinational program that aims to foster a regional market for SHSs and enable access to SHSs for households, industries, and public institutions in 19 countries, including Niger. Out of $225 million committed by the World Bank, it is not yet clear how much will be dedicated to Niger. ROGEP, however, selected Niger to pilot innovative models of health post electrification.

GON also recently started discussing a pilot project called Smart Villages with the World Bank and other stakeholders. Smart Villages uses connectivity and off-grid electrification technologies to improve local development of services (e.g., energy, health, clean water, education, e payment, e platform for trade of local products, e government) based on increased collaboration among public institutions. Smart Villages is being developed under President Issoufou and is Niger's contribution under the SMART Africa Alliance,

which is headquartered in Kigali, Rwanda. The World Bank has committed $100 million to the project, and the Project Director of Smart Villages is pursuing an additional $100 million to $150 million during discussions with the African Development Bank Group (AfDB), AFD, and private companies.[28]

3.3 PICO-SOLAR AND SHS–RELEVANT REGULATIONS

In Niger, ARSE is the agency charged with regulating the electricity sector; however, ARSE does not regulate SHSs. The pico-solar market is free in Niger, and GON does not intend to make concessions for SHSs. Nevertheless, discussions have occurred about regulating service fees for larger systems leased to consumers over longer periods without the intention to transfer ownership, but no decision has been made to date.

To incorporate in Niger, an SHS company must write its constitution. It is advisable that these startups work with a local lawyer, who will draft all necessary documents and assist with formalities at the Maison de l'Entreprise. For companies interested in participating in rural electrification programs, ANPER is the primary point of engagement.

RELEVANT TAXES

Importation codes for pico-solar systems are those adopted by the Harmonized ECOWAS Customs Codes. In addition, as of September 13, 2018, pico-solar systems are exempt from both general import duties and value-added tax (VAT). The exemption is in line with Schedule 69 of the Electricity Act (Law Number 2016-05 [signed May 17, 2019]). The list of exempt products is intended to be updated annually by both the Ministry of Energy and the Ministry of Finance

Pico-solar products are exempt from most fees, but they are still subject to a statistic fee, an ECOWAS levy, and a solidarity ECOWAS levy, which are due at Customs upon importation.

QUALITY CONTROL

ANERSOL is responsible for ensuring quality and conformity control, building capacity, and providing training about solar equipment. GON has adopted the Lighting Global certification as the standard for SHSs with capacity less than 350 Wp.[29] Companies supplying systems with capacity greater than 350 Wp must consult with ANERSOL for compliance. Under NESAP (Component 1), ANERSOL has established a list of pre-approved equipment as eligible to the NESAP credit line but has kept the door open for equipment not listed. ROGEP is attempting to develop regional standards at the ECOWAS level for plug-and-play solar and stand-alone solar systems.

Niger has adopted the Lighting Global certification for pico-solar systems below 350 Wp. For systems greater than 350 Wp, ANERSOL has developed specifications that guarantee the quality of equipment to be sold in Niger. ANERSOL is entitled to test all equipment that is not Lighting Global certified before they can be sold in Niger. Individual components of a stand-alone solar system must adhere to international standards. Under NESAP, ANERSOL has established a list of brands per equipment but does not preclude locally assembled systems. Companies assembling locally should use standardized components and provide a two-year or GOGLA-equivalent warranty.

E-WASTE

No government agency in Niger is specifically responsible for processing electronic waste (e-waste) from pico-solar systems. MoE, ANERSOL, and the Office of Environmental Assessment and Impact Studies (Bureau d'Evaluation Environnementale et des Etudes d'Impacts [BEEEI]), an office within the Ministry of Environment, are working toward formalizing regulations with respect to the processing of e waste.

[28] World Bank, "Projects : Niger: Smart Villages for Rural Growth and Digital Inclusion | The World Bank."

[29] Lighting Global, "Our Standards | Lighting Global."

3.4 PICO-SOLAR AND SHS FINANCING OVERVIEW

Access to finance is a substantial barrier for the growth of the SHS market in Niger, both for SHS companies and for consumers. The following two subsections highlight the current state of company and consumer finance in the SHS sector of Niger.

3.4.1 COMPANY FINANCE

COMMERCIAL FINANCE

According to the General Secretariat of the (Union Economique et Monétaire Ouest Africaine [UEMOA]) Banking Commission, in 2017, Niger had 15 approved credit institutions (i.e., 12 banks and 3 branches of foreign institutions; see Table 16). Based on the size of the balance sheet, only three of the credit institutions are classified as large (greater than 200 billion XOF) and three are classified as average (between 100 and 200 billion XOF).

TABLE 16. APPROVED FINANCIAL INSTITUTIONS IN NIGER

NAME	TYPE
Bank of Africa Niger	Bank
Atlantic Bank Niger (Banque Atlantique Niger)	Bank
Commercial Bank of Niger (Banque Commerciale du Niger [BCN])	Bank
International Bank for Africa in Niger (Banque Internationale pour l'Afrique au Niger)	Bank
Ecobank Niger	Bank
Nigerien Bank Corporation (Société Nigérienne de Banque [SONIBANK])	Bank
Sahara Bank Group for Investment and Trade (Banque Sahélo Saharienne pour l'Investissement et le Commerce [BSIC])	Bank
Agricultural Bank of Niger (Banque Agricole du Niger [BAGRI Niger])	Bank
Islamic Bank of Niger (Banque Islamique du Niger [BIN])	Bank
Sahelian Financing Society (Société Sahélienne de Financement)	Bank
National Office of Financial Intermediation (Bureau National d'Intermédiation Financière [BNIF-AFU-WA])	Bank
AL IZZA International Money Transfer (AL IZZA Transfert d'Argent International)	Bank
Orabank Côte d'Ivoire, Niger Branch (Orabank Côte d'Ivoire, Succursale du Niger)	Branch
West African Banking Company, Niger Branch (Compagnie Bancaire Ouest Africaine [CBAO], Succursale du Niger)	Branch
Regional Bank of Markets, Niger Branch (Banque Régionale des Marchés, Succursale du Niger)	Branch

Source: Power Africa Technical Advisors

In Niger, banks are generally not located in rural areas. The banks with the largest footprints are:

- Agricultural Bank of Niger (Banque Agricole du Niger [BAGRI Niger]) has 23 agencies including one in each of the 8 regions' capital city and at least one departmental head per region.
- Ecobank Niger has 15 agencies, including 7 in Niger.
- SONIBANK has 12 agencies, including 5 in Niger
- BSIC has eight agencies, including seven in Niger.

SONIBANK and BSIC are the most active banks that finance solar energy companies through a subsidiary line of financing for granting one or more secondary business loans. Both banks were selected to serve as participating financial institutions for implementing Component 1 of NESAP (Off-Grid Solar Equipment Market Development), which aims to develop the commercial market for autonomous off-grid solar systems with a line of credit of $7 million.

As previously discussed, SONIBANK and BSIC have partnered with NESAP to lend to solar systems providers and small and medium enterprises, whereas Capital Finance has been targeting households and very small enterprises. Since 2014, SONIBANK, the largest bank of Niger, has provided approximately €16.4 million in loans to companies for green energy projects. BSIC, the sixth largest bank in Niger, with an 8.5 percent share of the market, has provided approximately €360,000 in loans to Benalya for solar irrigation and energy projects. Loan categories from the NESAP credit line are described in Table 17, with credit lines amount expressed in both the euro (€) and the West African CFA franc (XOF).

TABLE 17. LOAN CATEGORIES UNDER THE NESAP CREDIT LINE INITIATIVE

FINANCIAL INSTITUTIONS	AMOUNT PER LOAN	TENURE	TARGET
SONIBANK and BSIC	Up to XOF 240,000,000 (€360,000)	24 months + 4 months grace period	Solar systems providers
	Up to XOF 5,000,000 (€7,500)	36 months + 3 months grace period	Stand-alone systems users
	Up to XOF 7,500,000 (€11,600)	60 months + 6 months grace period	Small and medium enterprises
Capital Finance	Up to XOF 250,000	18 months	Households
	Up to XOF 500,000	24 months	Households
	Up to XOF 10,000,000	24 months	Small and medium enterprises

The process for applying requires SHS providers to apply for a loan and provide a business plan and the desired loan amount directly to SONIBANK or BSIC. The Credit Committee assesses each application, considering technical advice from ANERSOL. Upon a positive evaluation, the Credit Committee requests the NESAP team to validate the loan before disbursement. The interest rate is a maximum of 11 percent, depending on the risk taken by the bank. In addition, borrowers owe a commitment fee of 1.5 percent of the loan amount.

Out of the 11.5 million bank accounts in the UEMOA zone, Niger has the second lowest number with 629,943. In 2017, Niger had the lowest banking market share in the zone (4.4 percent). At the end of 2017,

Niger's banking rate was 6.5 percent, or 93.5 percent of the population of Niger was unbanked.[30] In early 2019, GON decided to launch an effort to connect all civil servants with banking services, which should help to reduce the number of those unbanked.

Female entrepreneurs are under no explicit restrictions regarding access to commercial finance. In fact, both private companies and government organizations employ women in prominent positions. For example, Oolu Solar and ANERSOL are headed by women. Benalya also employs female workers in high positions.

INVESTORS

Incorporated in Niger, the Investment Management Company and Initiatives (Société d'Investissement de Gestion et d'Initiatives [SINERGI]) offers equity, quasi-equity, and bridge capital to small and medium enterprises. SINERGI's investments range from €30,000 to €150,000, typically in the form of 25 percent equity and 75 percent loans, for a period of four to five years. SINERGI is interested in funding pico-solar companies and is supported by Investisseurs & Partenaires, a French investment company with several well-known shareholders. Some of those shareholders are the International Solidarity for Development and Investment (Solidarité Internationale pour le Développement et l'Investissement [SIDI]), the Bank of Africa Niger, Orano Mines of Niger, Water Exploitation Company of Niger (Societe d'Exploitation des Eaux du Niger [SEEN]), the Insurance and Reinsurance Company of Niger (Compagnie d'Assurances et de Reassurances du Niger), and Veolia Niger, as well as several individual investors.

The crowdfunding platforms Lendahand and Trine and investment funds such as the Electrification Financing Initiative (ElectriFI) and Oikocredit have stated interest and have funds that allow them to invest in off-grid companies in Niger.

Annex E is a detailed list of pan-African lenders and investors, most of which are active in Niger.

3.4.2 CONSUMER FINANCE

Access to finance is a key factor in making pico-solar and SHS affordable to consumers, particularly in rural parts of Niger where households on average have lower purchasing power. Key to consumers accessing finance are microfinance institutions as well as the mobile money banking system.

MICROFINANCE INSTITUTIONS

There are 42 MFIs operating in Niger. Their main loans are for agriculture and livestock development. Only Capital Finance, a participating financial institution in NESAP, provides loans for pico-solar systems. ACEP has stated interest in participating in NESAP and is developing products and partnerships with actors in the sector, notably Benafsol.

MFIs are increasingly an actor in the distribution of pico-solar products. Starting in 2017, ASUSU SA, one of the largest MFIs in Niger, had explored early partnerships to begin issuing loan top-ups to prompt existing customers to purchase pico-solar products, but discussions with operators stalled. In early 2019, Capital Finance was selected as the MFI under NESAP and will offer loans for the purchase of pico-solar as well as kits for productive uses. In Niger, the Agency for Private Enterprise Credit (Agence de Credit pour l'Entreprise Privée [ACEP]) is actively following the same path.

To date, there are no records of actual sales channeled through MFIs, primarily because of MFIs have struggled to secure financing in Niger. Both Capital Finance and ACEP await access to funds from NESAP so they can roll out new products. Both companies are also discussing with Kiva to access even softer credit lines than NESAP and could use such lines to offer credit to existing customers.

Currently, no MFIs are specifically targeting female entrepreneurs. Outside of formalized MFIs, since 1991, CARE International has been organizing women in rural Niger into village savings and loan associations (VSLAs) called Mata Masu Dubara. Women pool their savings and use it to build businesses, pay health costs, and cover children's school fees. VSLAs could also provide a platform for financing to help women buy pico-solar systems or start businesses that supply pico-solar systems to their communities. Additional training would likely be important for supporting female entrepreneurs in starting pico-solar based businesses in Niger.

By 2016, the number of women active in the VSLA groups in Niger was 663,056. The total number in West Africa was 3,113,936.[31] CARE, with the support of local organizations, was able to set up and supervise 21,000 women's groups. In addition, other partners such as World Vision, CRS, Plan International, Mercy Corps, PRODAF have launched similar efforts. Taken together, Niger has a total of 33,000 groups or 800,000 women members across the country.

MOBILE MONEY

As in many other countries in the sub-region, the daily life of the average Nigerien—especially in rural portions of the country where banks are absent—has been completely revolutionized by the ability to transfer money using one's mobile telephone. In 2017, the World Bank estimated that 9.5 percent of adults had a mobile money account and 13.5 percent had made a digital payment in the past year.

Mobile money services are an important offset to the very low banking rate in Niger. Mobile money introduces greater traceability of payments and significantly reduces the physical effort and time required to send money to someone who may live far away.

To encourage the creation and use of electronic money (e-money) accounts, mobile operators apply almost zero account creation and management costs and even give users bonuses for bill payments if they use this method. This incentive attracts consumers to sign up and fund their accounts.

One result of the widespread adoption of mobile money is that mobile network operators now have valuable data about users that could be used to develop risk profiles and credit scores, which could help financial institutions de-risk financing for pico-solar products and SHSs. Mobile network operators could even extend lines of credit, making it easier and more affordable for Nigeriens to afford solar lanterns, SHSs, and higher capacity stand-alone systems.

One payment model that has been implemented is PAYGO, which allows consumers to purchase solar products over time rather than up front. Two mobile money operators in the country (i.e., Airtel Niger and Orange Niger) are already supporting the two pico-solar companies (i.e., Benafsol and Oolu Solar) in using PAYGO through mobile money to purchase solar equipment. Transfer fees remain high at between 2 percent and 5 percent, which may become barrier to scaling the industry in Niger.

3.5 PICO-SOLAR AND SHS DISTRIBUTION PARTNERS

Many organizations support pico-solar companies through training, business services, and connecting with customers. Central Supply of Inputs and Agricultural Materials (Centrale d'Approvisionnement en Intrants et Matériels Agricoles [CAIMA]) is an agricultural products distributor with a presence in all 265 communes in Niger. Because CAIMA is an established distribution channel with a national reach, the company can provide easier access to consumers in rural portions of the country.

[31] CARE International, "Women on the Move in West Africa: 2017 Annual Report."

Also, in the agriculture sector, the Network of Chambers of Agriculture (Réseau des Chambres d'Agriculture [RECA]) is a useful channel for disseminating information about pico-solar systems to farmers and stakeholders involved in the agricultural value chain.

CIPMEN is a business incubator and accelerator with a focus on renewable energy, environment, agribusiness, and new technology. Although CIPMEN does not facilitate the distribution of products, it provides marketing strategy, management, and accounting training for new small businesses.

Money transfer companies, such as AL IZZA International Money Transfer (AL IZZA Transfert d'Argent International) and Niger Money Transfer (Niger Transfert d'Argent [NITA]), are potentially valuable connection points between companies and customers because they can collect payments and channel them to pico-solar companies. AL IZZA International Money Transfer, for example, has more than 300 offices in Niger and plans to open 19 new offices in 2019.

The network of the Young Volunteers for the Environment (Jeunes Volontaires pour l'Environement [JVE]) has representatives in 40 communes of Niger and is eager to support the distribution of SHSs and pico-solar lanterns. The JVE network conducted several pilot distributions of stoves and other products targeted to low-income populations in rural areas.

Total, the energy company, offers import logistics, stockholding, and deliveries to the gas stations.

4 MINI-GRIDS

4.1 MINI-GRID COMMERCIAL OVERVIEW AND APPLICABILITY TO THE COUNTRY

The use of mini-grids is one of the three core strategies for electrification in Niger's NES. Mini-grids have been in use for some time by NIGELEC, which already maintains and operates 130 diesel-fueled mini-grids in isolated service zones, of which 11 will be hybridized with solar PV under NESAP (Component 3).

Distance from the grid is a major factor that discourages extending grid access. Table 18 provides estimates of the distribution of households without electricity, based on their distance from the NIGELEC grid. OCA estimates that for households within 5 km of the grid, it would cost $1,100 per household to build out the infrastructure necessary to connect them. This estimate rises dramatically with distance—beyond 10 km, the findings from the OCA study estimate a cost of $6,000 per household. [32]

TABLE 18. COST OF EXTENDING GRID ACCESS BY DISTANCE FROM GRID

PROXIMITY TO GRID	NUMBER OF OFF-GRID	PERCENTAGE OF OFF-GRID HOUSEHOLDS	COST OF GRID CONNECTION (U.S. DOLLARS PER HOUSEHOLD)
HOUSEHOLDS	630,000	27%	$1,100
5–10 km from grid	317,000	13%	$2,900
10–20 km from grid	430,000	18%	$6,000
>20 km from grid	980,000	42%	Not applicable
Total	**2,357,000**	**100%**	—

Source:[33]

Although NIGELEC already uses mini-grids widely, one of the challenges the utility has experienced is profitability. Historically, diesel mini-grids have been loss leaders for NIGELEC because of the higher operation and maintenance costs, which have not been defrayed with higher tariffs that are cost reflective. The losses associated with mini-grids are one reason NIGELEC has difficulty self-financing infrastructure maintenance and expansion. With GON support, NIGELEC has been able to absorb losses to ensure electricity access in these areas, but private developers will not undertake projects that do not have a clear payback period and profitable business case.

According to a 2018 study of the mini-grid market in Niger conducted by Carbon Trust, the current market size is estimated at $51 million, with a market size of $47 million accounting for planned grid extensions.

The analysis estimates that mini-grid solutions would at best serve 4,328,074 people, or 23 percent of the population.[34]

[32] Open Capital Advisors, "Off-Grid Solar Market Assessment in Niger & Design of Market-Based Solutions."

[33] Source: Open Capital Advisors.

[34] Carbon Trust, "Mini-Grid Market Opportunity Assessment: Niger, Green Mini-Grid Market Development Programme: SE4ALL Africa Hub, AfDB, Carbon Trust, and SNV."

4.1.1 STATE OF THE MINI-GRID MARKET IN NIGER

Until recently, NIGELEC's investment in providing electricity in Isolated Zones (see Table 2) was the primary source of mini-grid development in Niger. As the industry grows, four known mini-grid developers, including NIGELEC, currently operate in Niger (Table 19). Two groups—Benalya and YANDALUX—are in the process of entering the market and do not have any active projects under development or in operation. Phanes Group, an international solar developer based in Abu Dhabi, is active across sub-Saharan Africa and operates a satellite office in Nigeria where the company currently has utility-scale solar installations totaling 227.5 MW over the Sokoto, Jigawa, and Kebbi States in Nigeria.[35] In Niger, Phanes Group also has one operating mini-grid in Boki and is planning approximately 100 more projects in the country. Many other companies are also considering entering the mini-grid market in Niger, notably Ennera, ACCESS Energie, Prosolia Africa, ARESS, and Bren-Tronics/Alternaprod.

Niger is geographically well-suited to attracting investment in mini-grids in part because the country shares borders with Nigeria, Benin, and Burkina Faso, in which the leading mini-grid developers in sub-Saharan Africa are already investing. Investors' trekking North depends only on Niger's adoption of the necessary policies.

TABLE 19. MINI-GRID DEVELOPERS ACTIVE IN NIGER

Company Name and Logo	Years of Operation	Sales to Date, Areas of Operation
NIGELEC	N/A	Operates 110 mini-grids in Niger and is developing at least 5 in partnership with donor agencies (see Table 11 and Table 21)
Phanes Group	Founded 2012	Operates 1 mini-grid in Boki, Niger (31 kWp with storage), powering 110 homes
Benalya/Benafsol	Founded 2011	Has built 1 mini-grid for the Nigerien Army, as well as a water pump and streetlights for a refugee camp; currently evaluating a larger investment in the mini-grid sector in Niger
Yandalux	Launched in 2012	—

Source: Power Africa Technical Advisors

[35] Phanes Group, "Phanes Group: What We Do."

Table 20 details the existing mini-grid feasibility studies and development projects underway in Niger.

TABLE 20. PIPELINE OF MINI-GRID FEASIBILITY STUDIES AND PROJECTS IN DEVELOPMENT

PROJECT LEAD	FUNDING SOURCES	PROJECT TYPE	NUMBER OF MINI-GRIDS	NOTES
GON and ANPER	BOAD, Islamic Development Bank, IRENA and the Abu Dhabi Fund for Development (ADFD), and Export-Import (EXIM) Bank India	Development	360	Project to electrify 360 villages
NIGELEC	World Bank through NESAP Component 2	Development	5	Project to electrify 12 villages
Power Africa	Power Africa	Feasibility study	69	Study using mobile phone towers as anchor off-takers
ANPER	AFD	Feasibility study	250	Early stage talks occurred and AFD funding was committed; next step is to validate Terms of Reference to recruit consultants
Phanes Group	Phanes Group	Development	100	Operating 1 mini-grid in Boki and planning 100 more
YANDALUX	ECREEE and Plan International	Development	1	Gorou 1 mini-grid (27.6 kWp) commissioned in 2016

4.1.2 SITING CONSIDERATIONS

Identifying promising mini-grid locations that ensure financial viability involves the consideration of many factors, including:

- Grid extension planning. To recoup the initial capital investment, mini-grids often involve long payback periods, which lead developers to avoid areas that may be candidates for grid extension.
- Population density. Communities with low population density may not be suitable candidates for mini-grid deployment. Developers look for localities with a sufficient number of potential customers to sustain the business model and prefer denser communities that minimize the distribution infrastructure requirements.
- Purchasing power of target customers. Project viability depends on identifying customers with sufficient resources to purchase the power generated and pay for connection fees.
- Availability of commercial or industrial off-takers. One approach for ensuring the financial viability of a project is to identify a major off-taker in the form of a commercial, industrial, or government facility that can act as an anchor consumer of electricity generated from a project. Mobile network operators are a common anchor because their infrastructure is co-located with other users and because they have consistent, predictable electricity needs.

4.1.3 BARRIERS TO MINI-GRID DEVELOPMENT

The most common barriers to mini-grid development are the uncertainties regarding grid extension plans

and the ability to secure cost-reflective tariffs. In Niger, NIGELEC has publicized its planned grid extension. However, uncertainty will remain until construction is underway. Additionally, Niger does not have any explicit regulations or policies in place about how mini-grid operators will be compensated if the grid enters their territories.

Rigid tariff structures are also an issue in some parts of sub-Saharan Africa, where tariffs are held to a national standard that does not incorporate the higher operating costs associated with mini-grids.

However, in Niger, there are no restrictions against mini-grid developers setting their own cost-reflective tariffs.

Labor force shortages are and will continue to be a problem for some time as the development of mini-grid projects—particularly using solar energy—starts to accelerate. Section 2.8 details existing efforts in Niger to address training needs.

Other barriers to mini-grid development include the following:

- No incentives, such as subsidies or tax exemptions, apply directly to mini-grid development.
- The standardized concession system for electricity production does not account for differences in generation capacities or technologies installed.
- Households with a low-income level constrain consumers' ability to pay cost-reflective tariffs.
- Most rural areas in Niger have a low population density; therefore, providing service to these customers may not be financially viable.

The forthcoming decree to establish a regulatory framework for mini-grids may provide some clarity with respect to incentives, grid takeover, and business models that would help de-risk large investments in mini-grid development in Niger.

4.2 RELEVANT GOVERNMENT AND DONOR MINI-GRID PROGRAMS

ANPER is responsible for engaging the private sector and providing leadership regarding planning the development of new mini-grids in Niger. However, NIGELEC is still the largest mini-grid operator in the country, and the utility has a monopoly over electrification within 10 km of the grid. Although there are no specific ongoing mini-grid development efforts within NIGELEC, the utility is likely to continue to play a large role in mini-grid development in Niger. Grid-connected mini-grids could be a promising strategy for reaching localities on the edge of NIGELEC's territory and increasing the resilience of the grid.

AfDB and the Sustainable Energy Fund for Africa (SEFA) have established a green mini-grid (GMG) policy and regulatory framework with technical norms, quality control, and institutional arrangements. The aim of this initiative is to create an enabling environment for private-sector engagement in GMGs operationalized through GON institutions. One objective of this initiative is to provide targeted support to GMG developers, including capacity building and financing for feasibility studies. The GMG initiative will also engage with operators, banks, investors, and donors to create appropriate stimulation measures to demonstrate bankability of GMGs and prepare for GMG scale-up.

4.3 POLICY AND REGULATORY ENVIRONMENT FOR MINI-GRIDS

The current policy and regulatory environment in Niger is supportive of private companies entering the mini-grid market, but the following key areas of uncertainty still must be addressed to accelerate growth in the market:

Private ownership. Private companies are allowed to fully own and operate mini-grids in Niger. However, formalized frameworks have yet to be created for public–private partnerships (PPPs), which may be critical to the success of the mini-grid market.

Tariff structures. A standardized tariff methodology has not been established for mini-grids in Niger. The current principle in Niger is to apply cost-reflective tariffs, but GON intends to design financial support schemes that account for the need to ensure the commercial viability of service providers while also protecting customers from high tariffs. Historically, ANPER has approved mini-grid tariffs, but that responsibility will fall to ARSE, the electricity sector regulator, when the National Strategy for Access to Electricity (Stratégie Nationale d'Accès à l'Electricité) has been implemented.

Import restrictions. Import restrictions do not exist, other than those imposed by quality control and standards. However, the mini-grid components that are not considered to be renewable energy (e.g. batteries) are currently subject to import duties and VAT.

Tax regimes. No tax advantages are currently extended specifically to mini-grid developers. However, GON has eliminated taxes and import duties for renewable energy equipment. Most mini-grids under development use solar and energy storage, though hybrid systems continue to use diesel-fuel generation as well.

Compensation for grid takeover. Currently, no regulations specifically state how mini-grid operators may be compensated if the NIGELEC grid enters their service territory. A clear policy on this matter would significantly de-risk the prospect of developing a mini-grid near the electricity grid in some of the more densely populated regions of Niger.

Quality control and standards. Quality standards have not been specifically defined for mini-grids in Niger. However, GON has established that mini-grid operators are expected to comply with international standards for system design, operation standards, safety, allowable voltage, and frequency variations.

Also, some requirements are stated in the service agreements that mini-grid operators enter into with GON. The requirements include power quality standards, maintenance response times, and some operating procedures regarding billing, collection, and claims handling. Finally, mini-grid operators must be prepared to interconnect with Niger's electricity grid if the grid overlaps the mini-grid's service territory.

Mobile money. Mobile money acts to reduce the transaction costs for mini-grid operators because customers can pay their bills directly by using their mobile phone. Two institutions govern MFIs in Niger—the Regulatory Agency of the Microfinance Sector and the Microfinance Sector Regulatory Commission.

4.3.1 REGULATIONS UNDER DEVELOPMENT

The most important policy development regarding mini-grids in Niger is the forthcoming decree on the Autonomous Rural Electrification Projects in Niger (Projets d'Electrification Rurale Autonome au Niger [PERAN]), which will establish clearer regulatory frameworks for mini-grid development and operation. ANPER hopes that the PERAN Decree will be adopted soon because the tendering of mini-grids under NESAP is awaiting its adoption. The draft version of the PERAN Decree discusses the following three models of mini-grid financing and site allocations:

- **Public model.** Regarding this model, GON funds the infrastructure and enters into an agreement with a service provider to operate the mini-grids for a maximum of 10 years.

- **PPP model.** Regarding this model, ANPER selects sites and tenders them to the private companies after seeking approval from MoE, the Ministry of Finance, ARSE, and Structure d'Appui au Partenariat Public – Privé (SAPPP[36]). Mini-grid projects under PPP must not exceed a capital expenditure of 250 million Central African CFA francs or $500,000, according to Article 3 of the Law number 2018-765/PRN/MF.
- **Private-sector model,** whereby a private company selects sites independently and applies to ANPER for authorization to develop, build, and operate a mini-grid on these sites. Upon acknowledging receipt of the application, ANPER will seek clearance from MoE, Ministry of Finance, ARSE, and SAPPP. Based on these clearances, the Prime Minister authorizes an ad hoc committee to negotiate the PPP agreement with the project developer. Mini-grid developers are protected in Niger because a second proposal cannot be accepted for a site under the negotiation process.

The draft version of the PERAN Decree also authorizes ANPER to subsidize off-grid mini-grid projects and lend money to electricity service providers. The level of subsidy will depend on the cumulative investment, operating costs, and expected revenues from electricity sales.

Additional foundational regulations that impact the development and operation of mini-grids in Niger include the following:

- Law number 2015-58 (dated December 2, 2015) for the creation, assignation, and operation of ARSE
- The Electricity Act – Law number 2016-05 (dated 17 May, 2016)
- Law number 2013-24 (dated May 6, 2013) for the creation of ANPER and the setting of its duties and obligations
- Decree number 2016-514/PRN/ME/P (dated September 16, 2016) stating the modalities and conditions for agreement and licensing of operators of public electricity services
- Law number 2018-40 (dated June 5, 2018) defining PPP agreements
- Decree number 2018-765/PRN/MF (dated November 2, 2018) stating the modalities for implementing Law number 2018-40 (dated June 5, 2018)
- Decree number 2016-519/PRN/ME/P (dated September 28, 2016) stating the service agreement between electricity service operators and their customers
- Final PERAN Decree (TBD).

[6] SAPPP is the public entity that supports public private partnership within the Government

5 AGRICULTURAL AND PRODUCTIVE USE SOLAR

5.1 AGRICULTURAL AND PRODUCTIVE USE SOLAR COMMERCIAL OVERVIEW

Nationally, approximately 80 percent of all households in Niger grow crops. Out of the households connected to the electrical grid, 32 percent grow at least one crop, compared with approximately 88 percent of the households not connected to the electrical grid.

Among the households not connected to the electrical grid, 89 percent own land suitable for agriculture, and 87 percent of the individuals aged 15 years or older who live in these households are employed in agriculture. Approximately 85 percent of the farming households not connected to the electrical grid grow the major crop of millet. Among the same farming households, 76 percent grow cowpeas, 62 percent grow sorghum, 14 percent grow peanuts, and 12 percent grow sesame.

Households that are involved with growing agricultural products that require some amount of processing, such as millet, peanuts, and sesame, may increase their productivity by using solar systems that provide electricity for home processing equipment.

In addition to solar-powered processing equipment, solar-powered water pumping stations are an opportunity to improve yields on existing farmland through irrigation or convert previously unusable land through irrigation. Currently, 98 percent of farming households in Niger use rainwater as the main source of water for at least some of their crops. Only approximately 2 percent irrigate at least one of their crops using something other than rainwater.[37] Of these 47,000 farming households nationwide, approximately 81 percent use motor pumps to aid in water harvesting and irrigation.

The remaining 2.3 million farming households that only utilize rainwater to water crops or do use use motor pumps could benefit from irrigation schemes powered by solar energy. As shown in Table 21, the majority of solar companies operating in Niger focus on the solar pump subsector. Howeer opportunities exist beyond solar pumps (i.e., solar refrigerators, solar-powered mills, etc.)

TABLE 21. AGRICULTURAL AND PRODUCTIVE USE SOLAR COMPANIES

COMPANY NAME AND LOGO	AREAS OF OPERATIONS
KANF Electronics	Solar pumps, stand-alone solar systems, and solar streetlights
Consultation Plus	Solar pumps; PAYGO solar pumps introduced in April 2019
SES Niger	Solar refrigerators sold to households and health centers; solar pumps Interest in offering stand-alone solar systems to money transfer offices throughout rural Niger, solar refrigerators for milk producers, and cooled storage facilities to reduce the losses from onions and potatoes stored for one to two months
Benalya	Solar pumps, solar refrigerators, and solar fans
Sahelienne de Génie Electrique	Solar pumps
ELHYFROS	Solar pumps
YANDALUX	Solar pumps and solar lighting

[37] Other sources for water for crops include wells, dammed, or diverted waterbodies, as well as bored or drilled holes.

5.2 BUSINESS MODELS FOR AGRICULTURAL AND PRODUCTIVE-USE PRODUCTS

Because the market for agricultural and productive-use solar systems is still nascent in Niger, business and financing models are still evolving. Currently, all companies operating in the agricultural and productive-use space offer only cash sales. Consultations Plus now offers Lorentz pumps through PAYGO to potential clients, but this option is new to the market and has been offered for less than 3 months as of August 2019.

5.3 RELEVANT GOVERNMENT AND DONOR AGRICULTURAL AND PRO DUCTIVE-USE PROGRAMS

The primary GON program that supports the adoption of agricultural and productive-use solar technology is the Investment Fund for Food Security in Niger (Fonds d'Investissement pour la Sécurité Alimentaire au Niger [FISAN]). FISAN supports projects for individual farmers or groups of farmers to adopt technology for agricultural economic development.

Approved projects receive 40 percent of funding from grants and up to 50 percent from commercial bank loans.[38] Eligible projects include those that involve cold rooms, rural roads, irrigation schemes, and water pumping stations, including solar-powered water pumps. FISAN also provides a 50 percent guarantee on loans. Companies selling productive-use technologies cannot apply directly but are encouraged to work with farmers' organizations to identify and structure the needs of farmers and help them prepare and submit applications to FISAN.

5.4 AGRICULTURAL AND PRODUCTIVE USE–RELEVANT REGULATIONS

The only regulation that directly addresses agricultural and productive use solar products relates to import duties and taxes. The Minister of Finance has exempted import duties and VAT on solar pumps in Letter number 00028/ME/ANPER (dated January 4, 2019) to the Minister of Energy.

5.5 AGRICULTURAL AND PRODUCTIVE-USE DISTRIBUTION PARTNERS

CAIMA, the agricultural products distributor, has a presence in all 266 communes in Niger. Because CAIMA is an established distribution channel with a national reach, the company can provide easier access to consumers in rural portions of the country.

Also, in the agriculture sector, RECA is a useful channel for disseminating information about productive-use solar systems among farmers and stakeholders involved in the agricultural value chain.

[33] BAGRI Niger is the only current lender under FISAN

6 PRIORITY SECTOR SUPPORT ACTIVITIES

Niger's NES has three main pillars: pico-solar and SHSs, grid extension, and mini-grids.

Strategies to expand SHS adoption and mini-grid development align well with the Power Africa's Off-Grid Project (PAOP) directive, but potential support opportunities are also available by engaging with NIGELEC and their efforts to expand the electricity grid. Table 22 lists priority sector support activities that should be considered in Niger.

TABLE 22. PRIORITY SECTOR SUPPORT ACTIVITIES

SUPPORT ACTIVITY	NES PILLAR	DETAIL
Digital payment technology	Grid extension, mini-grids, and pico-solar/SHSs	Support continued expansion of digital payments infrastructure, including standards (e.g., data privacy)
Gender mainstreaming	Grid extension, mini-grids, and pico-solar/SHSs	Support the development of standards or goals for employing women in the energy sector; no formal programs in place to bring more women into this field
Institutional capacity building	Grid extension, mini-grids, and pico-solar/SHSs	Support the establishment of a coordination mechanism between electrification stakeholders and Ministries of Education and Health
Institutional capacity building	Grid extension and mini-grids	Support strengthening of planning coordination between private mini-grid developers and NIGELEC
Municipal government and development planning	Pico-solar/SHSs and mini-grids	Support ANPER with a dedicated budget to mainstream off-grid electrification in the municipal development plan
Planning	Mini-grids and grid extension	Explore opportunities to partner with NIGELEC in grid-connected mini-grid development to fill gaps in the grid, increase resilience, and reach remote areas in NIGELEC's territory
Private-sector support and market intelligence	Mini-grids and pico-solar/SHSs	Provide tools, analysis, and support for mini-grid developers and SHS companies to identify promising markets
Productive-use resource assessment	Pico-solar/SHS	Support mapping study of groundwater resources in Niger to better understand where the water supply can support extensive adoption of water pumping with solar water pumps
Regulation and de-risking	Mini-grids	Clarify compensation requirements for grid takeover of a mini-grid
Training	Pico-solar/SHSs and mini-grids	Support training needs within Niger, particularly in remote areas (Areas of focus include determining whether access to training is adequate and whether the current training institutions in Niger are producing an adequate stream of qualified workers to meet workforce needs.)

ANNEX A DEFINITIONS FOR GEOSPATIAL ANALYSIS

Table A-1 below provides key definitions used by Power Africa for the geospatial analysis conducted for this market assessment.

TABLE A-1. DEFINITIONS USED FOR GEOSPATIAL ANALYSIS

VARIABLE	DESCRIPTION
Households without access to electricity	Households that responded "no" to the survey question: "Does your household have access to electricity?"
CONSUMER GROUPS*	
Large-consumption power households	Households without electricity that had at least one high-cost asset out of the following: car, computer, television, or refrigerator.
Medium-consumption power households	Households without electricity that own a mobile telephone and have at least one type of high-quality housing material for the roof, floor, or walls.
Modest-consumption power households	Households without electricity that own at least a radio or mobile telephone and that do not fall into the large- or medium-consumption power household categories.
HOUSEHOLD ASSET OWNERSHIP	
Computer	Household reports owning a computer.
Television	Household reports owning a television.
Refrigerator	Household reports owning a refrigerator.
Mobile phone	Household reports owning a mobile telephone.
Car	Household reports owning a car.
Radio	Household reports owning a radio.
Agricultural land	Household reports owning land used for agriculture.
Livestock	Household reports owning at least one type of livestock, including sheep, goats, cows, horses, pigs, or chickens.
Bank account	Household reports having at least one bank account, without specifying how it is used.
HOUSEHOLD CHARACTERISTICS	
Household size	Household reports the number of people living in the household.
Advanced finished floor	Household floors are made out of cement, vinyl, tile, or carpet.
Advanced finished walls	Household walls are made out of cement, brick, cinderblocks, tiles, covered adobe, or limestone.

TABLE CONTINUED FROM PREVIOUS PAGE

TABLE A-1. DEFINITIONS USED FOR GEOSPATIAL ANALYSIS

VARIABLE	DESCRIPTION
Advanced finished roof	Household roof is made out of cement or metal.
Advanced finished house	Household floor, walls, and roof are all made of advanced finished materials.
Advanced cooking fuel	Household reports using electricity or gas for cooking.
Flush toilet	Household reports having any type of flush toilet.
MEDIA CONSUMPTION	
Regular television watcher	An individual is defined as a regular television watcher if he or she watches television at least once per week. Only individuals aged 15–49 years are included.
Regular radio listener	An individual is defined as a regular radio listener if he or she listens to the radio at least once per week. Only individuals aged 15–49 years are included.
HEAD OF HOUSEHOLD EDUCATION	
Did not finish primary school	Head of household has received no schooling or has not finished primary school.
Finished primary school	Head of household has completed primary school and may have attended, but not completed, secondary school.
Finished secondary school	Head of household has completed secondary school and may have attended some higher education.

*Groups are mutually exclusive, with each household being classified into the highest tier for which it is eligible

ANNEX B GEOSPATIAL ANALYSIS DATA AND METHODS

The Fraym database used in the geospatial analysis combines satellite imagery and existing household surveys that are harmonized and re-weighted based on population data from third-party sources such as multilateral and bilateral development actors, thereby ensuring that indicators are comparable across countries and over time.

For this study, indicators at the individual and household levels were sourced from the Niger 2014 Living Standards Measurements Survey (LSMS) conducted by the National Institute of Statistics with technical and financial assistance from the World Bank.[39] These surveys are meant to be nationally representative and use a stratified two-stage sample design. LSMS data were enumerated in 2014 with a total sample size of 3,671 households.

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

Data regarding financial inclusion and behaviors come from the 2017 Niger Global Findex data set designed by the Development Research Group, Finance and Private-Sector Development Unit, of the World Bank.

When exhaustive data about the national grid were unavailable, data regarding mapped existing electric lines were obtained from the World Bank data set Africa—Electricity Transmission and Distribution, which provides the most up-to-date and credible map of electric power lines in Niger.

Spatial Prediction

To create spatial layers of households not connected to the electrical grid, machine learning was used to combine survey coverage data at the cluster level with satellite imagery to identify spatial linkages and predict patterns at a hyper-local scale. In particular, the analysis relied on a survey question that asked: "Is this household connected to the electrical network of the Nigerien Electricity Company (Société Nigérienne d'Electricité [NIGELEC])?"

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

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

[39] World Bank, "National Survey on Household Living Conditions and Agriculture - Living Standards Measurement Study."

› Gething, P., A. Tatem, T. Bird, and C.R. Burgert-Brucker. 2015. Creating Spatial Interpolation Surfaces with DHS Data DHS Spatial Analysis. Reports No. 11. Rockville, MD: ICF International. Available at http://dhsprogram.com/publications/publication-SAR11-Spatial-Analysis-Reports.cfm#sthash.U4CPy69y.dpuf

› Engstrom, R., J.S. Hersh, and D.L. Newhouse. 2017. Poverty from Space: Using High-Resolution Satellite Imagery for Estimating Economic Well-being. World Bank Policy Research Working Paper WPS 8284. Available at http://documents.worldbank.org/curated/en/610771513691888412/Poverty-from-space-using-high-resolution-satellite-imageryfor-estimating-economic-well-being

ANNEX C NIGELEC TARIFF TABLES

TABLE C-1. LOW VOLTAGE TARIFFS

SOCIAL TARIFF	**SOCIAL TARIFF**	**UNIT**	**PRICE (IN US DOLLARS [$])***
	Fixed charge	$ per subscriber per month	0.43
	ENERGY PRICE		
	0–50 kWh	$ per kWh	0.10
GENERAL TARIFF	**GENERAL TARIFF 3 KW**	**UNIT**	**PRICE (IN $)***
	Fixed charge	$ per subscriber per month	2.21
	ENERGY PRICE		
	0–150 kWh	$ per kWh	0.12
	151–300 kWh	$ per kWh	0.15
	>300 kWh	$ per kWh	0.22
	GENERAL TARIFF 6 KW	**UNIT**	**PRICE (IN $)***
	Fixed charge	$ per subscriber per month	4.43
	ENERGY PRICE		
	0–150 kWh	$ per kWh	0.12
	151–300 kWh	$ per kWh	0.15
	>300 kWh	$ per kWh	0.22
	GENERAL TARIFF 12 KW	**UNIT**	**PRICE (IN $)***
	Fixed charge	$ per subscriber per month	8.85
	ENERGY PRICE		
	0–500 kWh	$ per kWh	0.17
	>500 kWh	$ per kWh	0.24
	GENERAL TARIFF 18 KW	**UNIT**	**PRICE (IN $)***
	Fixed charge	$ per subscriber per month	13.27
	ENERGY PRICE		
	0–500kWh	$ per kWh	0.17
	>500kWh	$ per kWh	0.24
	GENERAL TARIFF 30 KW	**UNIT**	**PRICE (IN $)***
	Fixed charge	$ per subscriber per month	22.12

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TABLE C-1. LOW VOLTAGE TARIFFS

	SOCIAL TARIFF	UNIT	PRICE (IN US DOLLARS [$])*
	ENERGY PRICE		
	0–500 kWh	$ per kWh	0.17
	>500 kWh	$ per kWh	0.24
PUBLIC LIGHTING TARIFF	**PUBLIC LIGHTING**	**UNIT**	**PRICE (IN $)***
	Fixed charge	$ per subscriber per month	0
	Energy price	$ per kWh	0.10

* Exchange rate as of November 2018: $1 = 577 XOF.

Source: Mini-Grid Market Opportunity Assessment: Niger, Green Mini-Grid Market Development Programme: SE4ALL Africa Hub & African Development Bank. Carbon Trust and SNV, November 2018

TABLE C-2. MEDIUM VOLTAGE TARIFFS

GENERAL TARIFF	UNIT	PRICE (IN US DOLLARS [$])*
FIXED CHARGE	$ per subscriber per month	10.65
ENERGY PRICE		
Peak hour	$ per kWh	0.15
Off-peak hour	$ per kWh	0.097
HYDROPOWER-AGRICULTURE DEVELOPMENT TARIFF	**UNIT**	**PRICE (IN $)***
FIXED CHARGE	$ per subscriber per month	0.87
ENERGY PRICE		
Peak hour	$ per kWh	0.11
Off-peak hour	$ per kWh	0.088

* Exchange rate as of November 2018: $1 = 577 XOF.

Source: Mini-Grid Market Opportunity Assessment: Niger, Green Mini-Grid Market Development Programme:

SE4ALL Africa Hub & African Development Bank. Carbon Trust and SNV, November 2018

ANNEX D GOGLA DATA TABLES

TABLE D-1. GOGLA SALES DATA IN NIGER BY PRODUCT CATEGORY

SALES PERIODS IN NIGER	0–1.5 WP	1.5–3 WP	3–10 WP	11–20 WP	21–49 WP	50–100 WP	100+ WP	UNKNOWN CATEGORY	TOTAL
January through June 2017	—	—	—	—	—	—	—	2,480	2,480
July through December 2017	—	255	—	—	—	—	—	905	1,160
January through June 2018	—	795	—	—	—	—	—	3,160	3,955
July through December 2018	—	—	—	—	—	—	—	0	—
Total	—	1,050	—	—	—	—	—	6,545	7,595

Source:[40]

TABLE D-2. GOGLA SALES VOLUME IN NIGER BY BUSINESS MODEL

SALES VOLUMES IN NIGER	CASH + PAYGO	CASH ONLY	PAYGO ONLY
January through June 2017	2,480	—	—
July through December 2017	1,160	—	—
January through June 2018	3,955	—	—
Total	7,595	—	—

Source:[41]

[40] GOGLA, "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data."
[41] GOGLA.

TABLE D-3. GOGLA-ESTIMATED IMPACT IN NIGER FROM 2016 THROUGH DECEMBER 2018

METRICS									
PEOPLE WITH IMPROVED ENERGY ACCESS (CUMULATIVELY	PEOPLE WITH IMPROVED ENERGY ACCESS (CURRENTLY)	PEOPLE WITH ACCESS TO TIER 1 ENERGY SERVICES (CURRENTLY)	PEOPLE WITH ACCESS TO TIER 2 ENERGY SERVICES (CURRENTLY)	PEOPLE WHO HAVE STARTED A NEW JOB (CUMULATIVELY)	ADDITIONAL INCOME (CUMULATIVELY)	CHANGE IN LIGHT HOURS USED (CUMULATIVELY)	CHANGE IN ENERGY SPENDING (CUMULATIVELY)	CHANGE IN ENERGY SPENDING—HOUSEHOLD	GREENHOUSE GAS EMISSIONS AVOIDED (CUMULATIVELY)
96,840	79,380	52,122	—	994	$2,502,978	18,325,062	$2,507,184	$726	19,370

Source:[42]

TABLE D-4. GOGLA BREAKDOWN OF WEST AFRICA REGION FUNDING TYPES, TRANSACTIONS, BUSINESS MODELS, USE OF FUNDING, AND FUNDING FLOW BY INVESTOR TYPE

WEST AFRICA	ITEM	2012	2013	2014	2015	2016	2017	2018
	Grant	$0	$0	$656,000	$0	$300,000	$0	$210,000
	Equity–Common shares	$0	$0	$0	$3,320,000	$55,300,000	$8,700,000	$61,095,984
	Equity–Preferred shares	$0	$0	$0	$0	$0	$1,000,000	$0
	Debt–Note or bond	$0	$0	$0	$0	$0	$0	$0
	Debt–Bank or financial institution loan	$0	$0	$0	$15,000,000	$1,750,000	$8,250,000	$4,000,000
	Debt–Crowdfunding	$0	$0	$0	$0	$35,422	$0	$2,353,155
	Debt–Securitization or factoring	$0	$0	$0	$0	$50,000,000	$0	$0
	Other	$0	$0	$0	$0	$0	$0	$0
TYPE OF INVESTMENT	Total	$0	$0	$656,000	$18,320,000	$107,385,422	$17,950,000	$67,659,139
	Number of transactions	0	0	2	3	9	5	24
	Average transaction size	–	–	328,000	6,106,667	11,931,714	3,590,000	2,819,131
TRANSACTIONS	Median transaction size	–	–	328,000	3,200,000	1,500,000	3,200,000	143,558
	PAYGO	$0	$0	$656,000	$18,320,000	$107,350,000	$17,950,000	$65,704,261
	Non-PAYGO	$0	$0	$0	$0	$35,422	$0	$1,954,878
BUSINESS MODEL	Total	$0	$0	$656,000	$18,320,000	$107,385,422	$17,950,000	$67,659,139
	Uncertain	$0	$0	$0	$0	$0	$0	$0
	Business plan development, corporate setup, and proof of concept	$0	$0	$0	$0	$4,335,422	$3,200,000	$0
	Introduction of product to the market or product refinement	$0	$0	$656,000	$18,200,000	$1,650,000	$5,500,000	$0
	Scale up business and reach critical mass of customers	$0	$0	$0	$0	$40,150,000	$1,000,000	$1,305,984

TABLE CONTINUED FROM PREVIOUS PAGE

WEST AFRICA	ITEM	2012	2013	2014	2015	2016	2017	2018
	Geographic expansion, add new products, or make acquisition	$0	$0	$0	$120,000	$11,000,000	$8,000,000	$60,121,776
	Bridge working capital needs, including extended financing of consumer loans	$0	$0	$0	$0	$50,250,000	$250,000	$6,231,379
	Refinancing existing liabilities	$0	$0	$0	$0	$0	$0	$0
	Other	$0	$0	$0	$0	$0	$0	$0
USE OF FUNDING	Total	$0	$0	$656,000	$18,320,000	$107,385,422	$17,950,000	$67,659,139
	Crowdfunding	$0	$0	$0	$0	$35,422	$0	$2,353,155

Source:[43]

[42] GOGLA.
[42] GOGLA.

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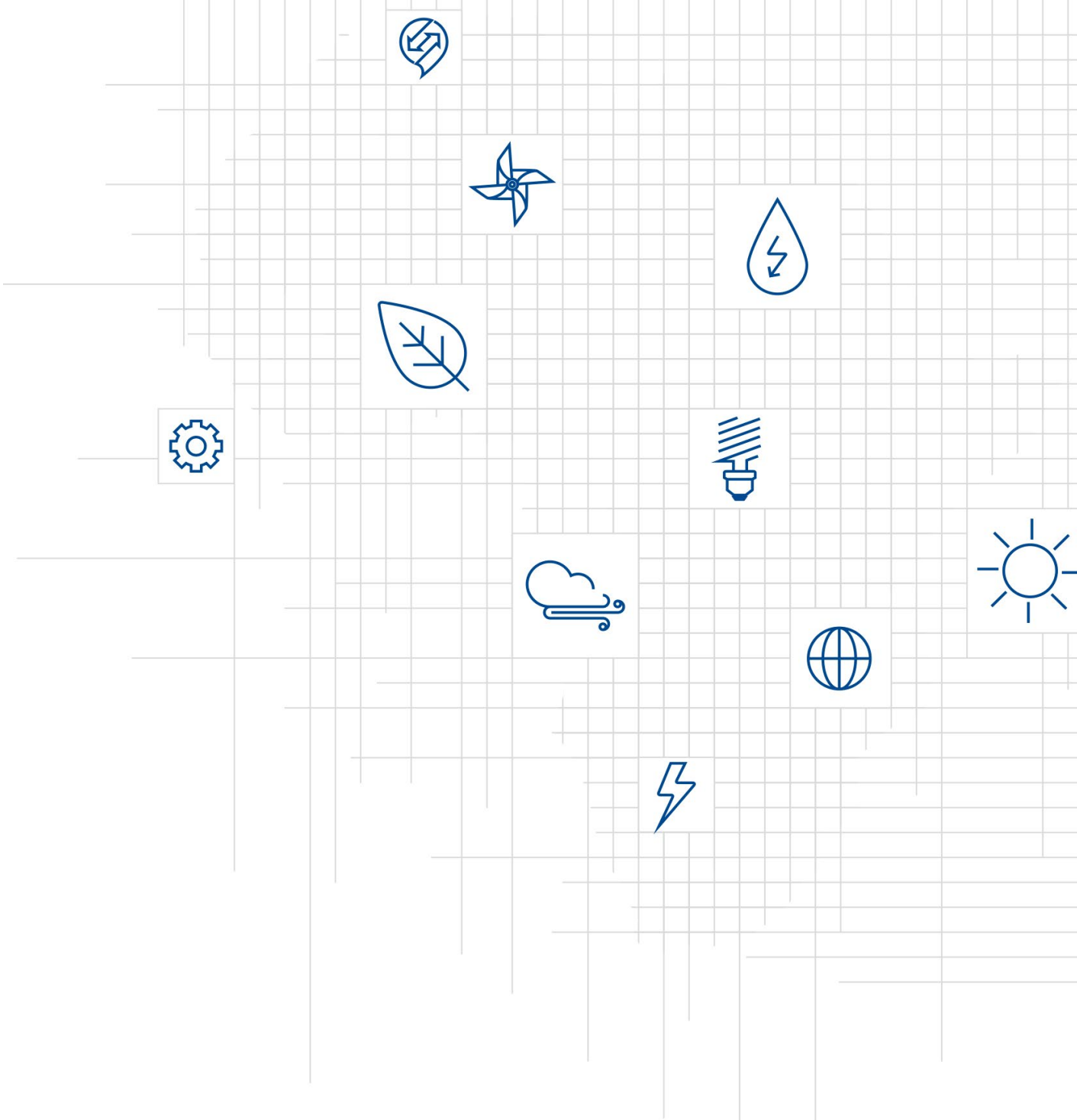

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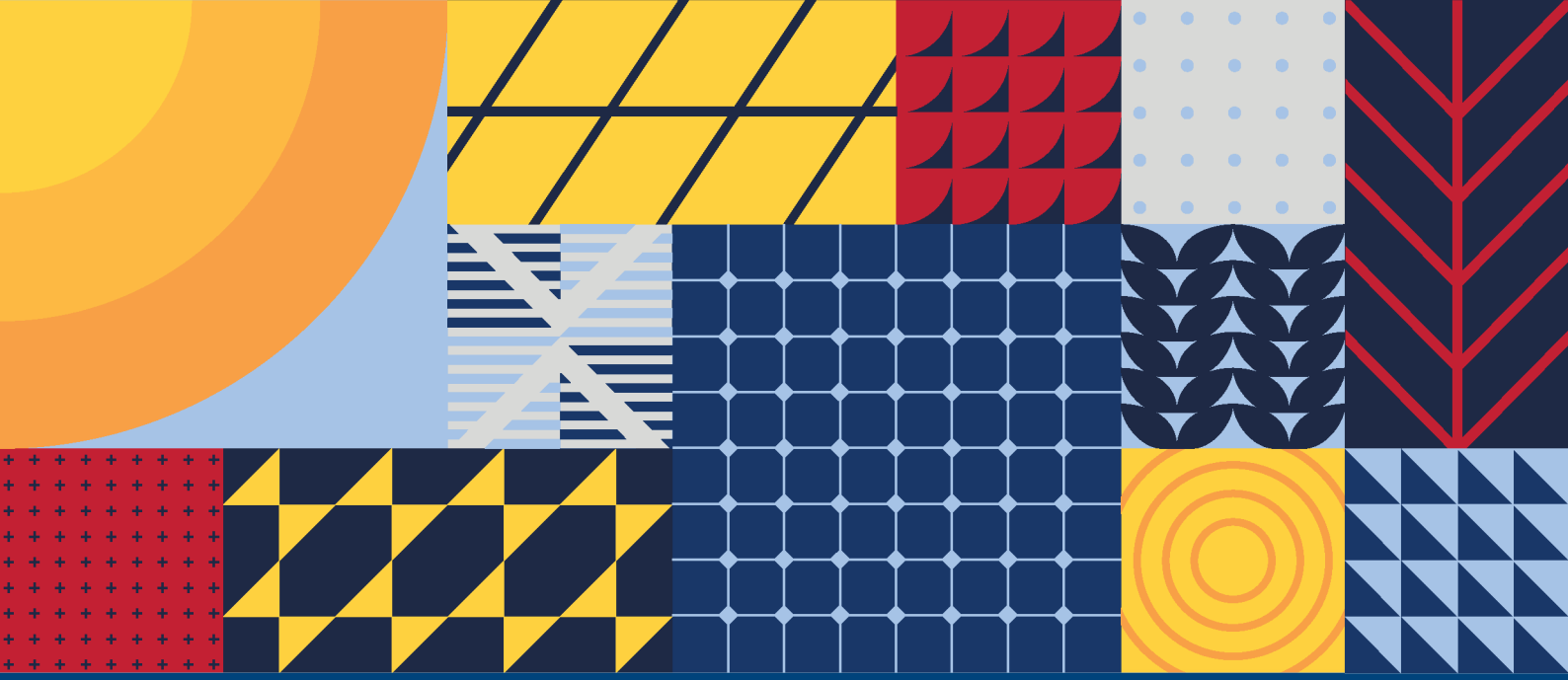

Power Africa aims to achieve 30,000 megawatts of new generated power, create 60 million new connections, and reach 300 million Africans by 2030.