March 2021

ProGREEN Senegal Renewable Energy Assessment

Consolidated Report

START

Québec

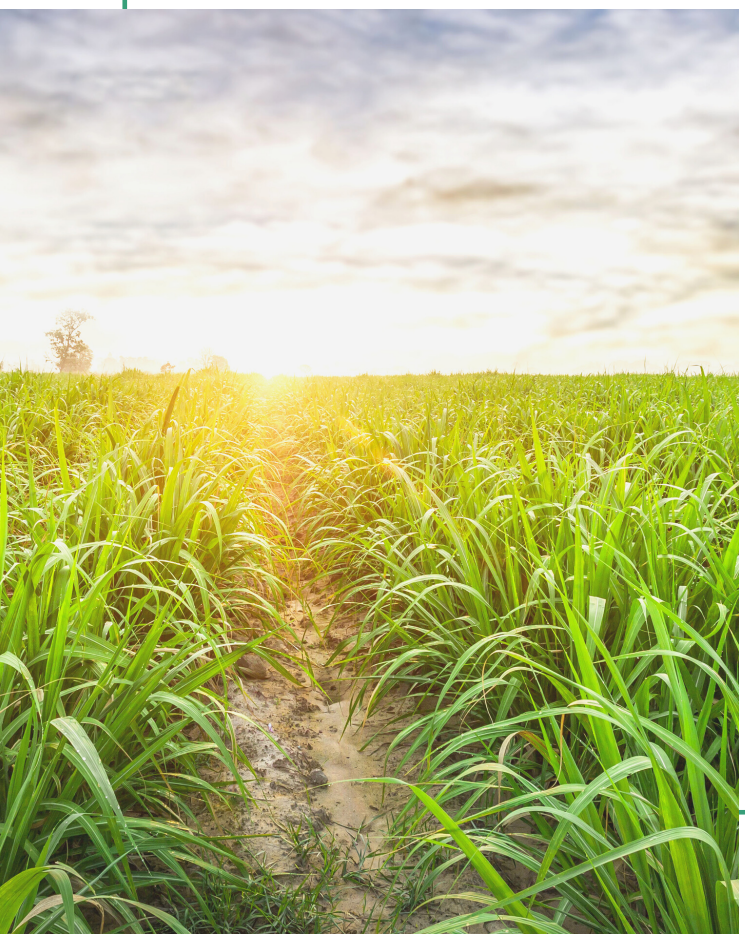
Fonds de recherche – Nature et technologies
Fonds de recherche – Santé
Fonds de recherche – Société et culture

About ProGREEN

START with financial support from the Research Fund of Quebec (FRQ) is implementing a multi-year effort in Burkina Faso and Senegal to strengthen understandings of transitions to renewable energy and the impacts of these transitions upon development, especially as related to food and water security and the well-being of the population. Specifically, the "Promoting Gains in Renewable Energy (ProGREEN) – West Africa" project is aiming to answer the question: "How can small-scale renewable energy systems contribute to a broader energy transition in West Africa?". In this study ProGREEN seek to identify:

- The main constraining and enabling factors regarding the development of renewable energy in West Africa;
- The main impacts of renewable energy access on development in West Africa and related challenges.

This assessment report will serve as a decision-making tool for policy makers making strategic choices about renewable energy policies in Senegal and Burkina Faso, for technical and financial partners, investors, and development and research organizations working in the renewable energy space.



Executive Summary

Like a number of West African countries, Senegal relies heavily on fossil fuels to meet its energy needs. This is in spite of the enormous potential for renewable energy in the country, especially with regard to solar energy. Recently, the country has been making concerted efforts at diversifying its energy supply, however despite greater emphasis being placed on the promotion of renewable energies, the sector still faces many persistent challenges. Barriers to the expansion of renewable energy include insufficient regulatory frameworks and quality control, limited coordination between actors, inadequate funding and low levels of technically skilled people to ensure sustainability and success of installations. Further, the benefits derived from these sources of energy have been, up to this point, either unknown to the general public or poorly leveraged.

The Senegal ProGREEN assessment team undertook an intensive documentary review of Renewable Energy (RE) projects followed by interviews with project promoters, focus groups and beneficiary populations across 21 sites in 10 regions of the country. Collected data was analyzed using the SWOT tool which identifies the strengths, weaknesses, opportunities and threats for each type of renewable energy while taking into account the environmental, institutional and socio-economic context.

Field data collected during site visits to renewable energy installations in Senegal and interviews with project beneficiaries and managers have revealed that small-scale renewable energy projects have, in general, contributed to improved living conditions in communities, income generating activities, increased access to basic social services, increased access to information and communication technologies, access to financial services and improved water management. Recognizing the great potential for renewable energy to bolster these benefits, the Senegal assessment team gives the following overall recommendations:

- Strengthen legislative and regulatory frameworks for renewable energy sectors,
- Set up consultation frameworks to ensure synergy between the actions of different actors, but also to encourage sharing of experiences and a better structuring of the sector,
- Promote research and development, capacity building and start-up incubators for better management of maintenance-related bottlenecks and to promote employment of local people,
- Decrease/subsidize the price of equipment and installation,
- Develop financial support schemes to meet needs in terms of acquisition of equipment and installation of systems for the benefit of diverse users (households and dealers).

ProGREEN Senegal Team

The Senegal ProGREEN assessment team is made up of 16 junior and senior members (six women and 10 men) from research, the private and public sectors, and civil society with diverse expertise in renewable energy (solar, biomass and hydropower) linked to water, food and agriculture, land use, health, socio-economics, Small and Medium Enterprise development (SME), and gender and youth empowerment.

Left to right from top: Ibrahima Ly; Yvonne Faye; Abdou Diop; Khoudia Kane; Kader Diop; Bassirou Sarr; Aissatou Diallo; Saboury Ndiaye; Ousmane Fall Sarr; Mame Satou Senghor; Antoine Faye; Abdou Ndour; Seynabou Diouf Niasse; Abdou Aziz Diedhiou; Adiara Kaba Diakhate; Salif Sow.

Acronyms	English Translation
AEME	Agency for the Economy and Energy Management
AGR	Income Generating Activity
ANER	National Agency for Renewable Energies
ASER	Senegalese Agency for Rural Electrification
BAD	African development bank
CI	Investments Code
CGI	Tax Code
CDN	National Determined Contribution
CTP	Case des Tout-petits (preschool nursery & kindergarten)
CEDEAO	Economic Community of West African States, ECOWAS
CSS	Senegalese Sugar Company
CNB	National Biofuels Committee
CNH	National Hydrocarbons Committee
CCNUCC	United Nations Framework Convention on Climate Change
DH	Hydrocarbons Directorate
ER	Renewable energy
EnDEV	Energising Developpement
ERSEN	Renewable Energy Senegal
ECREEE	ECOWAS Center for Renewable Energy and Energy Efficiency
EREI	Ecowas Renewable Energy Investment and Business Incitative
EP	Public lights
EPT	Thiès Polytechnic School
FA	Improved Stove
FAER	African Renewable Energy Fund
FASEN	Improved Stoves in Senegal
FER	Rural Electrification Fund
FEM	Global Environmental Fund
FONGIP	Public Investment Guarantee Fund
FVC	Green Climate Fund
GIE	Economic interest group
GES	Greenhouse gas
GIZ/PNEB	German Development Cooperation Agency
HPV	High Photovoltaic Permeability
IDE	Foreign Direct Investment
IPP	Private independent producers
MDP	Clean Development Mechanism
MEDD	Ministry of the Environment and Sustainable Development
ODD	Sustainable Development Goals
ONG	Non-Governmental Organization
OP	Private Operator
PER	Rural Electrification Program
PME	Small and medium-sized enterprise
PNB-SN	National Program Biogas - Senegal
PTFM	Solar milk storage platform
PV	Photovoltaic
PRODERE	Renewable Energy Development and Energy Efficiency Program in West African Economic and Monetary Union (WAEMU) Area
PROGRES-LAIT	Regional Solar Energy and Milk Value Chain Program
SE4ALL	Sustainable Energy four ALL
SEFA	Sustainable Energy Fund for Africa
SENELEC	National Electricity Company (National Utility)
SWOT	Strengths, Weaknesses, Opportunities, Threats

ASSESSMENT METHODS

- **Document collection and review**: The country team collected and reviewed sub-regional, national and sectoral policy documents, project documents, evaluation reports and other pertinent literature relevant to understanding the energy sector in general and small-scale renewable energy in Senegal in particular.

- **Meeting institutional actors**: Meetings were held with institutional actors including Technical and Financial Partners (TFPs) and project managers. The purpose of these meetings was to learn more about implementation strategies and progress of small-scale renewable energy projects in order to be better able to evaluate them. Further, a number of relevant documents to the analysis were also collected (e.g. previous evaluations, minutes of meetings, etc.) during this phase.

- **Field data collection**: Site visits were conducted for a sub-set of projects in order to collect baseline data and information from diverse actors including system operators/managers, unit operators/managers, beneficiaries of energy services (users), traditional authorities (village chiefs), and more. Data collection was carried out mainly through semi-structured interviews with individuals, focus group discussions, direct observations and documentary review. During the field data collection 21 renewable energy sites including eleven (11) solar photovoltaic projects and ten (10) bioenergy projects were visited. See Figure 1.

- **Data Analysis**: Collected data on each type of renewable energy was analyzed using the SWOT (Strengths - Weaknesses - Opportunities - Threats) tool, which takes the environmental, institutional and socio-economic context into account. It is mainly a qualitative analysis, punctuated by some quantitative data from a selection of renewable energy promotion projects.

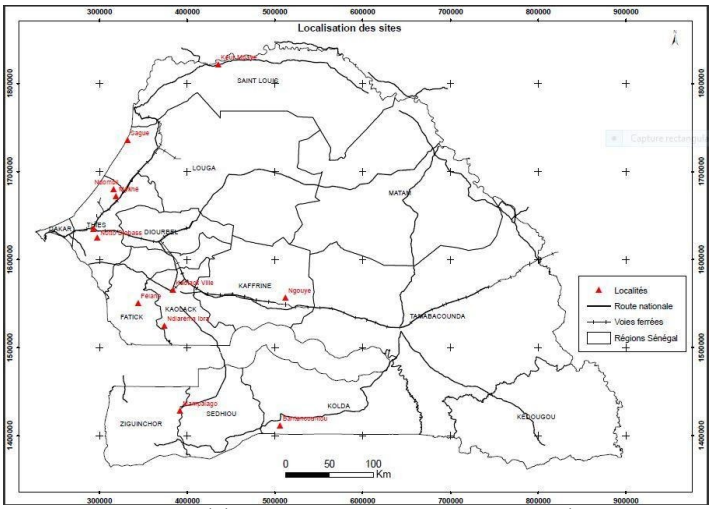


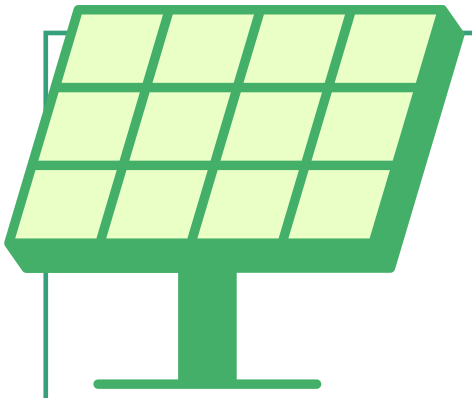
Figure 1: Renewable Energy Project Sites Visited

Renewable Energy Context

West African countries face numerous challenges relating to inadequate energy supply and access. Although, its energy access rate is estimated at 64% (IRENA, 2013) Senegal, like other countries in the region, experiences difficulties with increasing that rate and translating gains into economic growth. The country relies heavily on imported fossil fuels, accounting for over 80% of energy production, and is therefore exposed to fluctuations in world oil market prices. Electricity access is also unevenly distributed, – 75% in urban areas against 17% rural areas. Rural areas primarily rely on biomass for cooking and lighting and this accounts for more than 50% of the country's energy consumption. This heavy use of biomass depletes the country's forest stocks, and contributes to significant land degradation and release of greenhouse gases. In 2011, the country encountered a serious energy crisis, linked to oil market inflation, that caused serious social difficulties and significant negative impacts on the various sectors of the economy.

Though persistent challenges remain, the country is endowed with a large potential for renewable energy resources including, solar irradiation above 2,000 kWh /m2/year, wind speeds above 6 m/s, potential hydropower measured at 1,400 MW, large stocks of agricultural byproducts (approximately 3.3 million dry tons of agricultural residues) and opportunities for agribusiness (rice, husk, bagasse, peanut shells, cotton, stalks, etc.)) (IRENA, 2013). The government is now steadily working to advance the renewable energy sector in order to provide a reliable, affordable and sustainable energy supply that will help overcome certain socio-economic challenges. In accordance with guidelines from the international community and directives from the Economic Community of West African States (ECOWAS), strong efforts are being made to increase the share of renewable energy in the national energy balance. In this direction, Senegal has set an objective to gradually increase the share of renewable energy from 2% to 15% and 30% respectively in 2010, 2020 and 2030 (Senegal Plan d'Actions National des Energies Renouvelables, PANER 2015 - 2020/2030) alongside work on the social and economic development goals set out in the "Plan Sénégal Emergent (PSE) 2035".

To translate this vision into reality, the government has implemented proactive measures that include the improvement of its institutional and regulatory frameworks, increased investment in small-scale renewable energy to strengthen energy transitions and to improve well-being and security of vulnerable communities. However, understanding how small-scale renewable energy installations, especially in more remote areas, can collectively contribute to achieving broader development goals remains unknown.



Current Energy Production and Renewable Energy Potential

Senegal is highly dependent on fossil fuels for its energy supply. The country spends up to 40% of its revenue on oil supplies, leaving fewer resources for social programs and contributing to greater environmental degradation. In 2017, the mean domestic power capacity stood at roughly 550MW. To meet increasing national energy demands, the country has turned to new coal and diesel generation. For example, a 52MW diesel plant was built in mid-2016, followed by construction of a 125 MW coal-fired power plant in Sendou in 2018.

Senegal is now aiming for more universal energy coverage with a goal of at least 90% connection of rural households by 2025, along with diversifying its energy mix by having renewable sources (excluding biomass) account for 15% of primary energy (Report Energy sector Senegal, 2017). In this context, to reduce the chronic electricity production gap that is being exacerbated by growing demand for electricity, renewable on grid systems have been developed including the Manantali and Félou hydroelectric dams which generate 320MW (Report Energy sector Senegal, 2017), five solar plants that opened in 2019 (Senergy (30MW), Ten Merina (30MW), Malicounda (22MW) and two 20MW capacity plants operated by Engie), and more recently, the Taiba NDiaye wind farm which is the largest wind farm in West Africa with 46 wind turbines generating 158 megawatts of electricity. The wind farm produces up to 15% of electricity for the national utility (SENELEC). In addition, several decentralized initiatives are planned or in progress throughout the country to reach more remote locations.

These increasing renewable energy initiatives point to the huge underexploited renewable energy potential in Senegal. Below, a more detailed overview of this potential is presented, categorized by energy type.

- **Solar Power Potential**: The country has significant solar energy resources. The horizontal global irradiation in most parts of the country is above 2,000 kWh/m2 /year, with a daily global irradiation averaging 5.43 kWh/m2. In addition, falling prices of photovoltaic panels and system components make solar energy an attractive solution for moving away from fossil fuel dependency. However, due to the relatively high cost of initial investments, coupled with the low purchasing power of a large portion of the population (especially rural populations) solar Photovoltaic (PV) remains quite inaccessible for many people. Though the private sector engages the rural electrification market to a limited degree, in general, most installed capacity belongs to government and NGO-led projects.

Current Energy Production and Renewable Energy Potential

- **Wind Power Potential**: With 531 km of exposure on the Atlantic Ocean, the coastal zone of Senegal offers a large untapped wind potential (Figure 2), estimated by the Senegalese Meteorological Service to hold speeds of 5.7 to 6.1 m/s in the 50 km coastal strip between Dakar and Saint-Louis. One 150 MW wind power project is being implemented already, with 50 MW injected into the national utility grid. Another pilot project with a solar-wind-diesel hybrid system was installed in the village of Sine Moussa Abdou (Tivaouane department, Thies region), by the PERACOD/GIZ program.

- **Hydroelectric Potential**: Senegal's total potential for large hydropower plants on the Senegal (1,200 MW) and Gambia Rivers is estimated at about 1,400 MW, of which only 260 MW are currently being exploited via the Manantali plant which supplies countries of the Organization for the Development of the Senegal River (OMVS). Similarly, the Gambia River, overseen by the Organization for the Development of the Gambia River (OMVG) has a significant potential that, so far, has not been exploited. Sambangalou dam located in Senegal 930 km upstream from the mouth of the Gambia River and about 25 km south of Kédougou is currently being constructed and will generate 128 MW when completed with potential estimated at 400 GWh. In addition to energy production, the dam will support agriculture and fisheries through irrigation and flood control. However, debates are still ongoing regarding the potential impacts to ecosystem services.

- **Biomass and biofuel potential**: Solid biomass in the form of agricultural by-products and liquid biofuels also has promising potential in some parts of Senegal. Biomass resources, such as agricultural waste (estimated at about 3.3 million dry tons of agricultural residues) and agro-industrial by-products (rice husks, bagasse, peanut shells, cotton stalks, etc.) have potential uses in on- and off-grid power generation. A promising collaboration is also underway with THECOGAZ, in collaboration with the Senegalese Slaughterhouse Management Company (SOGAS), for producing energy and bio-fertilizer from organic materials used in the slaughterhouse operations.

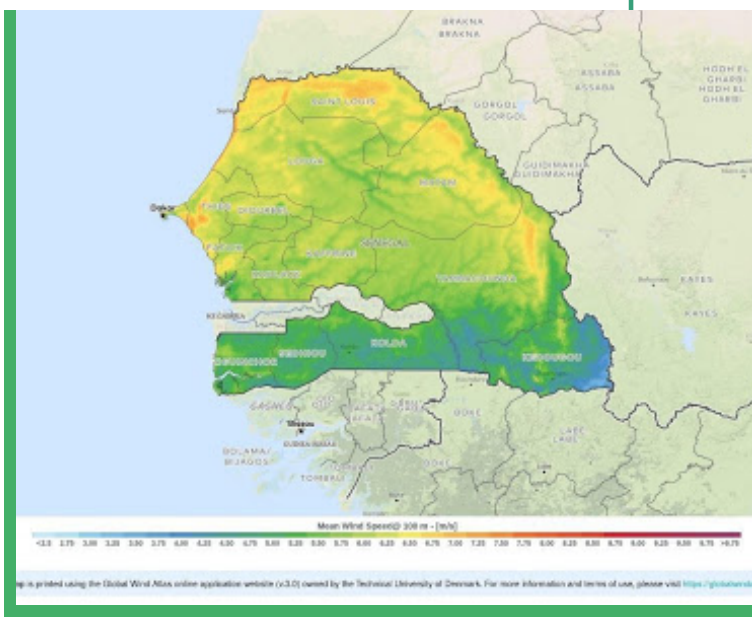


Figure 2 : Average wind speed at a height of 100m (source : Global Solar Atlas/ World Bank)

Major Regulatory Frameworks

Senegal is investing in efforts to promote renewable energy, energy efficiency and access, in part by updating its regulatory framework for energy. This is materialized by the promulgation of new laws and adoption of implementing decrees that will enable and increase involvement of broader energy stakeholders. Among the updates we have:

Law N°98-29 of April 14, 1998 - defines the orientation of the electricity sub-sector;

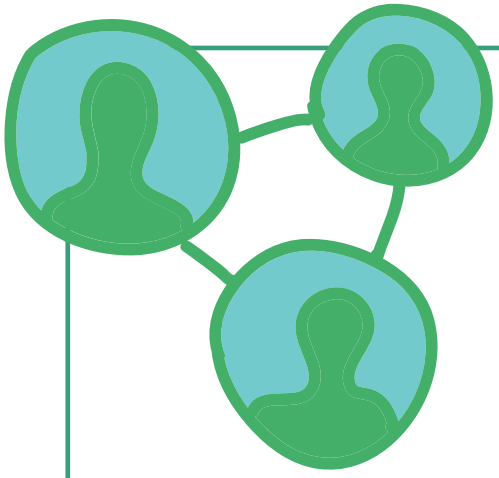
Law n°2010 of 20 December 2010 - promotes the development of renewable energies across the whole of Senegal;

Law no 2010-22of 15 December 2010 - aims to increase favorable conditions for the development of the biofuel sector;

Decree n°2013-684 - on the creation, organization, and operation of the National Agency for Renewable Energies (ANER) placed under the technical supervision of the Minister in charge of Energy and under the financial supervision of the Minister in charge of Finance;

The Energy Sector Development Policy Letter (LPDSE) - adopted in October 2012, has been integrated into the Emerging Senegal Plan with ambitious objectives for improving the sector's performance in the medium to long term. Overall, the objective of the policy is to improve the reliability and affordability of access to modern electricity services in a sustainable manner by: (i) Ensuring energy security and increasing energy access for all; (ii) developing an energy mix combining thermal generation, bio-energy, and renewables and taking advantage of opportunities flowing from regional interconnections to access low-cost hydropower; (iii) continuing and accelerating the liberalization of the energy sector by encouraging independent production and sector institutional reform; (iv) improving the competitiveness of the sector, to lower the cost of energy and reduce sector subsidies; and (v) strengthening sector regulation.

Tax Law No. 2012-32 of December 31, 2012 - that provides facilities to support private actors to strengthen their business with tax exoneration.



Key Institutional Actors

The Senegalese renewable energy sub-sector has several departments working under the direction of the ministry in charge of energy, presented as follows:

The Ministry of Petroleum and Energy is responsible for implementing policies defined by the Government and coordinating collaboration with stakeholders. The Ministry is also in charge of granting licenses and concessions for the private sector.

The National Electricity Company (SENELEC) controls distribution operations and is working with on-grid private actors to increase the share of renewable energy in national electricity production in order to provide a more competitive supply.

The Senegalese Rural Electrification Agency (ASER) under the supervision of the Ministry of Energy, administers rural electrification policies and provides technical and financial assistance to support rural electrification initiatives.

The National Agency for Renewable Energies (ANER) is in charge of (i) Contributing to the development of an attractive legislative and regulatory framework for the development of renewable energies; (ii) Identifying, evaluating and exploiting the potential of available and economically promising renewable energy resources in the different regions of the country; (iii) Popularizing the use of equipment for the production of electricity from renewable sources; and (iv) Carrying out prospective and strategic studies for the development of renewable energies.

The Electricity Sector Regulatory Commission (CRSE) is an independent body within the Ministry of Energy with responsibility for regulating the generation, transmission, distribution and sale of electricity. The commission has a pivotal role in rural electrification by harmonizing the price of energy bought from Rural Electrification Concessions (RECs) and Local Initiatives for Rural Electrification (ERILs).

Non-institutional actors include numerous institutions (e.g. NGOs, private companies, multinational corporations, Development Partners, Banks and financial institutions, Academia (universities, training centers, others), and independent power producers) collaborating closely with public institutions to promote the development of RE.

Technical and Financial Mechanisms and Opportunities

With the universal access objective set for 2030, Senegal is committed to working with technical and financial partners on developing the most appropriate financial mechanisms to boost development of renewable energy. International collaborations are often motivated by the desire to participate in the collective response to global challenges, combined with a drive for securing promising markets that well-informed investors see as profitable and inviting. In Senegal, technical and financial mechanisms used to provide a clean and affordable energy supply based on sustainable solutions are:

The endogenous approach: Direct or indirect tax benefits and incentive measures. For the incentive measures, the government, through the General Tax Code (CGI) and the Investment Code (CI) offers incentive schemes to private organizations in the field of rural electrification in the form of direct and indirect tax benefits to reduce costs and increase their competitiveness. These tax incentives for private rural electrification investments can equal an income tax exemption of up to 30%. Law n° 2010-21 of December 20, 2010 also promoted subsidies on renewable energy equipment. In late 2018, the government harmonized the price of energy bought from Rural Electrification Concessions (RECs) and Local Initiatives for Rural Electrification (ERILs). Prior to this harmonization, the prices for energy from RECs and ERILs were higher than those of the national utility. Other endogenous mechanisms include guaranteed credit funds like FONGIP and grants through ASER to support investments in renewable energy (e.g. solar pumping systems in Niaye, and support for ERILs and RECs).

The exogenous approach: Identified mechanisms and opportunities that are defined as being able to attract private investments and make the country's motivation and orientation in the field of renewable energies more sustainable. Mainly based on collaborations with sub-regional and regional institutions, international organizations, and bi & multilateral partners including the World Bank, the Global Environment Facility (GEF), the Green Climate Fund (GCF), the African Development Bank, the West African Economic and Monetary Union (WAEMU), and the Commissions of the Economic Community of West African States (ECOWAS). These institutions, through their appropriate departments, provide technical and financial assistance (loans and grants) to support the Senegal's renewable energy priorities.

Assessment of Solar Energy Programs and Projects

With horizontal global irradiation of 2,000 kWh/m2 /year and with a daily global irradiation averaging 5.43 kWh/m2 in most parts of the country, Senegal has enormous potential for supplying clean and affordable solar energy. ASER and ANER are the key national agencies that implement the state's vision in this space. Private sector actors, Rural Electrification Concessions (RECs) and Local Initiatives for Rural Electrification (ERILs), also play a pivotal role in rural electrification. The ProGREEN Senegal team visited 11 Photovoltaic (PV) installations during this assessment. Most decentralized systems visited were PV mini-plants, individual systems that support productive and socio-economic activities. Results show that access to energy brings significant changes to the living conditions of communities along with stimulating job creation. The main energy services provided by solar PV systems cover domestic uses (e.g. lighting, mobile phone charging, audio-visual technologies, refrigeration, ventilation), community uses through connection of public infrastructures (e.g. health facilities, schools, places of worship, public lighting), productive uses that support income generating activities (e.g. small businesses, phone recharging points, mills, ice making, milk preservation and access to water for market gardening).

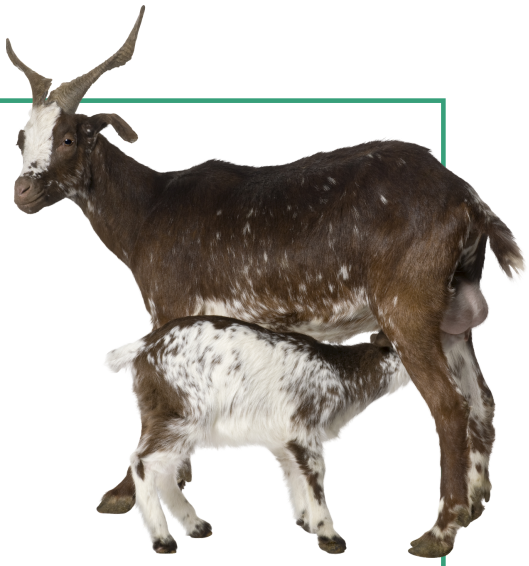
Advantages of PV Installations

- At home, allows for lighting, recharging mobile phones, audio-visual technologies, refrigeration, fans, etc.
- For community facilities, lighting for community buildings, places of worship and street lighting
- For medical facilities, lighting for nighttime births and medical care, refrigeration for medicines, improved conditions with fans, phone charging etc.
- Lower electricity bills for medical facilities with installations of mini-plants
- For education facilities, access to electrical devices such as TVs and computers, lighting for safety and extended learning hours.
- For women and girls, income generating activities including ice cream making, milk storage, and market gardening. Time saved from avoiding travel to grind millet.
- Income generating activities benefit communities as a whole as do solar pumping installations that support gardening and access to water.

Disadvantages of PV Installations

- Insufficient energy production and storage capacity (frequent power and water shortages).
- High consumption of diesel fuel in winter when electricity production drops.
- Expensive electricity bills (flat rate pricing).
- No or little involvement of communities or facility managers in needs assessments and project design
- Low operating revenues to cover depreciation and operating expenses.
- Permanent waste of electricity when a flat rate is implemented with users arguing you lose if you don't consume which makes it impossible to optimize.
- Insufficient production and capacity for the demand at medical facilities for all technologies to run smoothly
- .Lack of qualified skilled technicians for maintenance and repairs in rural areas
- High cost of solar pumps, and no nighttime storage so impossible to pump water at night

Assessment of Bioenergy Programs and Projects



The bioenergy assessment covered biodigesters (domestic and industrial biogas), biofuels and improved cook stoves.

Domestic and industrial biogas: Virtually unknown prior to the launching of the National Domestic Biogas Program Senegal (PNB-SN) in 2009, domestic biogas is gradually gaining interest in rural areas. Biodigesters use organic waste (domestic animal dung) to produce biogas for cooking, lighting and producing biofertilizers. PNB, with its partners, are developing a biofertilizer market which will help communities with or without biodigesters to have biofertilizer for their farms in order to improve agricultural productivity and food security, along with generating income for biodigester owners. A pilot project implemented by THECOGAZ in collaboration with the Senegalese Slaughterhouse Management Company (SOGAS) is currently using organic materials from slaughterhouse operations to produce energy and bio-fertilizer. Thanks to this innovative technology, SOGAS better manages the 200 or 250 tons of waste produced in the slaughterhouses, while simultaneously ensuring a supply of clean energy at a more competitive price. THECOGAS provides 60% of SOGAS' energy and 100% of its needs for its cold rooms.

Biofuels: Currently, there are two biofuel sectors being exploited in Senegal, ethanol and oilseed. For the ethanol sector, development has been slow, with Compagnie Sucrière Senégalaise (CSS) being a nearly exclusive actor, producing molasses from the sugar production process. Other initiatives are beginning to take shape but face technical difficulties that are limiting upscaling. For oilseed, Jatropha curcas oilseed is primary source and the sector is structured according to the method adopted by the two main private investments and the involvement of local producers.

Improved cook stoves: Widely used in urban and peri-urban areas where coal is heavily consumed, several types of improved cookstoves are currently available on the market. The best quality version available in Senegal is the "DIAMBAR" model. Several government and NGO initiatives promote its use and support artisans who make them as well as market development. The use of this tecchnology is almost exclusively associated with cooking, which is an activity primarily associated with women in Senegalese society. With the increasing scarcity of cooking fuels and growing urbanization of the country, the use of improved cookstoves is becoming more and more widespread.

Biogas

Advantages

- Less exposure to smoke for better respiratory health
- Improved conditions for women who spend less time gathering wood for fuel
- Improved agricultural yields through bio-fertilizers use
- Improved incomes from selling fertilizer
- Decreased pollution from fertilizers and decreased pressure on forests

Disadvantages

- Extremely time consuming
- High levels of water consumption
- Potentially dangerous valve failures
- Recurrent breakdowns
- Lack of local qualified technicians
- Sale price of organic fertilizer is low
- Decrease in quantity of dung in rainy season
- Gradual withdrawal of state subsidy

Biofuels

Advantages

- Locally available materials
- Ability to be blended or auto-consumed in diesel mills
- Close local processing facilities which benefits women
- Ethanol sub-stream controlled by processing industry
- Improvements in Jatropha production
- Diversification of production activities for women with jatropha
- Approval of two national standards in 2019 for guaranteeing use of Jatropha PVH in stationary engines

Disadvantages

- Recurring technical problems
- Insufficient power generation
- Lack of financing
- Lack of technical and scientific monitoring
- Lack of market price regulation
- Bad reputation caused by unsuccessful and/or incomplete initiatives
- Potential competition with arable land
- Absence of prior recommendations from the National Oils and Biofuels Committees before issuing licenses at national level

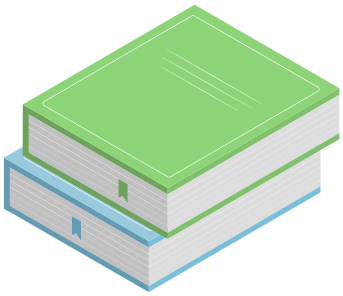
Improved Cookstoves

Advantages

- Reduction in household fuel consumption and energy expenditures
- Income generation through distribution of cook stoves to women's groups
- Development of self-financing mechanisms for women
- General good access to cook stoves
- Credit potential through regular, trusted retailers
- Existence of a large market
- Improvement of living conditions through less polluting methods of cooking
- Reduced pressure on natural resources

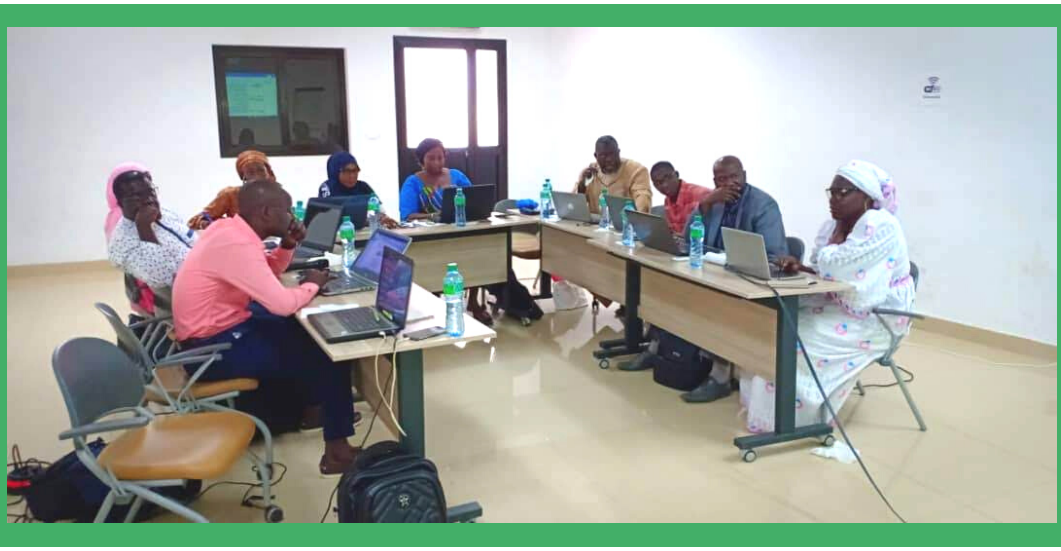
Disadvantages

- Very slow debt recovery
- Insufficient working capital for producers
- Users lack the knowledge for greater development of the cook stove marker
- Difficulties with the supply of raw materials; high costs of clay which comes from far distances
- Lack of equipment to improve quality of production
- Lack of safety equipment for artisans making stoves

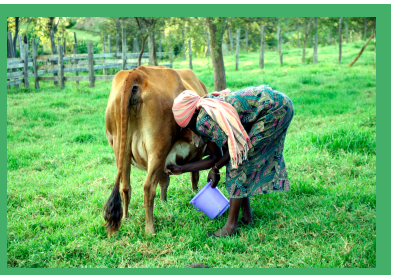


Critical Analysis of Capacity Development Efforts

Schools, training and research centres are supporting capacity development for qualified and skilled young professionals to meet the growing market demand. Vocational and research trainings fall under the responsibility of the Ministry of Vocational Training, Learning and Crafts and the Ministry of Higher Education, Research and Innovation, respectively. With the increasing number of students at universities, the Ministry of Higher Education, Research and Innovation created higher technical education institutes (ISEP) to provide shorter training programs (2 years) for qualified young professionals who are ready to work or to create their own enterprises. Despite the numbers of schools active in the renewable energy sector, fees are relatively expensive for private training schools, and the number of places in public schools are limited. In addition, students at the universities encounter financial difficulties for conducting research, and for attending international conferences and trainings. In parallel, public workers and private actors benefit from capacity building sessions organized by various institutions for specific renewable energy-related projects to reinforce their skills.



Lessons for Livelihoods, Health and Development



Access to renewable energy impacts positively on the living conditions of communities in Senegal and supports income generating activities and job creation. Though challenges still remain, renewable energy plays a key role in developing the green economy in the country, particularly in more remote areas. The stakeholder testimonies featured below provide insights into varying positive and negative experiences.

Site: Ice making unit - Félane: Maman DIOUF (President – Economic Interest Group (EIG)): "We have 2 million FCFA of cash income. Our unit generates up to 14000 F/day with the sale of ice cream and between 3000 and 1000 FCFA with mobile phone charging, whose service cost varies between 50F and 100F per recharging. This income is distributed as follows: 1/3 belongs to the women of Ndefleng EIG; 1/3 goes to the employees as an incentive and the remaining 1/3 is used as working capital and for maintenance when there is a breakdown. Thanks to this money collected, the women have been able to develop market gardening activities."

Mini solar power plant / Village of Ndramé Ibra: Mrs. Fatima Sakho: "Our house is connected to the S4 service level of ASER and we are 3 women who take turns managing the refrigerator for selling ice and juice. This generates about 2000FCFA/day, which is used to pay the water and electricity bills and the remaining profits we share to pay for our other needs."

Mokhtar DIOP: "Among our major difficulties is the high diesel consumption of the emergency generator (4 cans of 20 L/month, i.e. 52400 F/month) which are sucking up the revenue generated (185 500 F/month) especially in periods of low solar radiation (rainy season ...). Flat-rate pricing leads to energy wastage, households consider that whether they consume or not they will pay the same amount, so they turn on all their devices (radio, TV and lamps) all the time. This makes it impossible to optimize the distribution of energy."

Health Post- Thies: MD of the hospital Babacar MANE: "Before the installation of the mini-power station, the Hospital of Thies, like all the hospitals in the country, had a very expensive bill at the end of each month. The bill was often equal to or greater than 8 Million FCFA. Since the installation of the mini-power station, the hospital's bills have decreased by 1/3 to half of the usual amount. In addition, there is more consistency in the electricity supply (reduction of breakdowns, voltage variations and outages)."

Solar platform for the conservation of Diambanouta milk - Kolda: Ms. Diamy SEYDI: "The sale of ice contributes to the remuneration of the platform staff. In 2018, we had a single freezer that generated 500,000F (per month or year), which allowed us to buy a second freezer and both produced more than 300,000F during Ramadan 2019. So, in 1.5 years, the two freezers were both [paid for]."

Mr. Issa KANDE: "The availability of electricity has changed the living conditions of the population with the satisfaction of household lighting, mobile phones recharging, fans, audio-visual, and refrigeration needs. 50% of households are connected to the different levels and pay according to their consumption. Indoor installations and connection were pre-financed by the project and are reimbursed by the households over a period of 48 months. Thanks to this system, ice is available in the village at the cost of 150F instead of 250F, and during Ramadan the price is 250F instead of 350F, whereas in the surrounding villages it is 600F."

Mr. Daouda SEYDI / milk collector: "The platform allowed milk collection all year-round while in the past, milk collection used to stop in February. Personally, with what I earn from milk collection, I buy animals to bear fruit quickly and I also started to build a house."

Constraining and Enabling Factors for Renewable Energy

Enabling Factors

- Policies and practices that promote active Involvement and ownership of beneficiaries in the entire renewable energy program process
- Adaptation of the project to the socio-cultural circumstances of the beneficiaries
- Education (basic training) of beneficiaries on basic maintenance and troubleshooting
- High availability of renewable energy sources
- Downward trend in the cost of renewable energy components
- Formalization of institutional and regulatory frameworks
- Creation of income generating activities to ensure sustainability of the projects
- Existence of untapped income-generating niches
- Utilizing technically skilled designers and installation teams
- Monitoring and evaluation of REPs

Constraining Factors

- Lack of statistics on the durability and acceptability of past programs
- Lack of a consultation network (e.g. an association of renewable energy program promoters)
- Lack of coordination between stakeholders
- Insufficient training and quality control centers
- Insufficient integration of scientific and technical research into program designs
- Lack of financial and technical resources to support \scientific and technical research on renewable energy programming
- Sizing of installations is often incorrect, leading to premature shutdown of installations
- Inadequate quality control of materials
- Difficulties in providing small-scale maintenance locally in rural areas
- Almost no after-sales service systems
- Lack of consultation with beneficiary populations
- There is almost no policy for awareness raising on the advantages of renewable energy
- Weak government subsidies for the promotion of REPs
- Insufficient involvement of private financial services
- Initial Investment in RE Systems is too heavy for project promotors
- Cost of RE systems and access to RE services is relatively high for poor populations

Recommendations for Solar Energy

- Strengthen the regulatory framework through the implementation of appropriate laws and decrees;
- Improve the attractiveness of markets through incentive measures;
- Set up inclusive consultations for gathering inputs from different actors involved in the sector to identify operational problems related to use, carry out practical case studies in the field, disseminate research results, and raise awareness;
- Promote networking and information sharing, especially relating to funding;
- Set up a Renewable Energy Information System (SIER) in order to capture all the experiences, research data and potentialities in this sector. This SIER could play an advisory and orientation role for all solar technologies and serve as a framework for permanent monitoring of PV achievements and applications in Senegal;
- Develop financial support to set up incubators for solar technologies;
- Develop capacities of actors along the entire value chain of small-scale renewable energies from feasibility studies, maintenance of facilities, to design and installation;
- Develop training and capacity development curricula (short and practical) to upgrade the skills of technicians, public officers, private actors and youth in electrical optimization methods, network dimensioning, applying for available funds, economic and financial analysis of decentralized rural electrification systems, facilities maintenance and more;
- Strengthen technical and financial support to research & development (R&D) and innovation to support continuous improvement of the existing solar sector and the emergence of new sectors;
- Promote a multi-stakeholder technical and financial partnership: North-South and South-South, to enable experience-sharing between African countries and promote the pooling of resources.

Recommendations for Bioenergy

Biogas

- Develop and promote the organic fertilizer value chain to support owners in selling the fertilizer produced by their biodigesters.
- Develop dialogue and partnership between stakeholders and institutional actors to discuss and raise awareness of biodigester technologies and connected goods,
- Professionalize the sector by offering training on maintenance of biodigester facilities, monitoring of organic fertilizer production, collection techniques, delivery and storage of fertilizer and the use of fertilizer/substrates;
- Facilitate financing to support dissemination of biodigesters and development of activities linked to biodigesters;
- Promote R&D on bio-digesters to improve and explore their potential;
- Develop a circular economy model that promotes industrial and semi-industrial biodigesters in order to manage waste in urban areas and produce clean energy;
- Promote integrative energy projects combining bio-digesters and other renewable energy systems (solar, wind and biomass) to optimize investments.

Biofuel

- Increase awareness of actors and beneficiaries on the usefulness of the platform;
- Set up diversified trainings for the sector, including capacity development for biofuel production and processing, along with the development of diversified jatropha based products;
- Capacity development to equip youth with the skills needed to monitor and maintain facilities;
- Facilitate funding access to enable actors to increase their production and develop the market.

Improved cook stoves

- Organize technical capacity development for cook stove promoters, but also for the people involved in the marketing and management of programs;
- Set up financing schemes (subsidies, refinancing, etc.) to more easily facilitate access to equipment and working capital in order to broaden scope and impact;
- Develop energy efficiency projects featuring cook stoves in the context of climate change in order to benefit from green financing opportunities;
- Raise stakeholder awareness on the benefits of cook stove technologies, especially among beneficiaries.

Cross-cutting Lessons and Conclusions

To reach the goal of universal access, Senegal is highly committed to increasing energy access in remote areas and numerous decentralized initiatives are being implemented. This assessment aimed to identify the enabling and constraining factors linked to the development of small scale renewable energy projects in Senegal. This assessment highlights the positive impacts brought by renewable energy access in the rural areas located far from the national grid. The assessment finds that access to renewable energy in rural areas impacts positively on the living conditions of local communities through reducing workloads for women and girls, improving health services, education, communication, agricultural productivity and food security, and through supporting the development of income generating activities that promote the green economy (e.g. milling, sewing, welding, pumping water, ice making, phone charging, development of local micro-enterprises (milk), small business for women, youth employment, etc.). This assessment also shows the high potential of developing circular economy programs around industrial and domestic biodigesters.

Many challenges remain, however, for greater transitions to small scale renewable energy systems in Senegal including financial constraints, a lack of quality and affordable equipment, limited raw materials and lands for bioenergy, a shortage of qualified skilled persons to maintain systems, and low support for further research and development.

The results of this assessment and the recommendations put forth in this report will help shape future capacity development and action in the field of small scale renewable energies in Senegal.

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