Draft Pre-Feasibility Report for implementation of solar pumps scheme in Guinea

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1. Executive Summary

- Guinea's energy mix is dominated by hydropower which is **72%** of the total installed capacity.
- Electrification rate in Guinea is **around 35%,** whereas urban and rural areas electrified are 53% and 11% respectively.
- Guinea has huge untapped renewable energy resources potential with an average solar radiation of **5.0-6.0 kWh/m^2/day.**
- Agriculture accounts for **19.7%** of Guinea's GDP, and employs 84% of the economically active population. Most are subsistence farmers, growing cash crops sugarcane, citrus fruits, bananas, pineapples, peanuts, palm kernels, coffee, and coconuts.
- Most agricultural production in Guinea is primarily rain fed and, in some cases, manually irrigated when farms are in close proximity to major water sources.
- The country has a growth in irrigation at an average annual rate of **4.81%**
- The share of agriculture sector in the national GDP has been steadily declining from 26 % in 2009 to 20 % in 2013, with an average of about **22 %**
- The country has a plan to install 20,000 additional solar water pumps for supply of drinking water by 2030
- The ministry has a target of setting up at least 1 solar pump for supply of drinking water in each village where there is a population of around 1000 people
- As highlighted in this pre-feasibility report, solar powered irrigation systems are potentially the most sustainable option for farmers especially considering the savings on the high diesel expenses and requirement of little/no maintenance.

2. Introduction

The land that is now Guinea belonged to a series of African empires until France colonized it in the 1890s, and made it part of French West Africa. Guinea declared its independence from France on 2 October 1958. From independence until the presidential election of 2010, Guinea was governed by a number of autocratic rulers.

Since 1985, the Guinean Government has adopted policies to return commercial activity to the private sector, promote investment, reduce the role of the state in the economy, and improve the administrative and judicial framework. The government has eliminated restrictions on agricultural enterprise and foreign trade, liquidated many parastatals, increased spending on education, and vastly downsized the civil service. The government also has made major strides in restructuring the public finances.

The IMF and the World Bank are heavily involved in the development of Guinea's economy, as are many bilateral donor nations, including the United States. Guinea's economic reforms have had recent notable success, improving the rate of economic to 5% and reducing the rate of inflation to about 99%, as well as increasing government revenues while restraining official expenditures.

Guinea is coastal country in a West Africa with the sources of the Niger, Gambia and Senegal Rivers, Guinea boasts one of the highest hydropower potentials in West Africa. However, the country currently utilizes less than 5 per cent of its technically exploitable potential, which is estimated at 6,100 MW. In 2014, Guinea had only 125.4 MW of installed hydropower capacity from five stations, which accounted for roughly 30 per cent of the total electricity mix; the remainder was provided by thermal generation.

Since commissioning the 240megawatt (MW) Kaleta hydropower plant in May 2015, total power production has roughly doubled. The national grid, managed by Electricité de Guinée (EDG), serves greater Conakry, with several isolated grid networks. Based on 2017 data, Guinea's national electrification rate is approximately 35.44 percent[1] (11 percent in rural areas, 53 percent in urban areas). Despite strong resource potential and long-term opportunities to export low-cost electricity throughout West Africa, Guinea's power sector faces significant challenges including dilapidated infrastructure, high technical and commercial losses, and inadequate overall financial performance.

Guinea's rivers show great potential for hydroelectric power. With Kaleta completed, the government plans to invest in several smaller dams in the near future and has secured Chinese funding for the USD 1.3 billion Souapiti dam, which will be twice Kaleta's size, cost, and generation capacity. Located several kilometers upstream from Kaleta, Souapiti will regulate the Konkoure River to ensure that Kaleta can operate at full capacity even during the dry season. Solar power is also growing in popularity for both corporate and residential use.

Guinea has huge untapped renewable energy resources potential. Guinea has average solar radiation of 5.0-6.0 kWh/m^2/day[2]. The high value of solar radiation signifies great potential for development of solar technologies in the country owing to the abundance of solar insolation. The promotion of solar technology could create conditions, through rapid scale-up of capacity and technological innovation to further drive down costs towards grid parity. Considering the significant dependence on fossil fuel-based generation and imported power, localized solar generation can help Guinea to reduce the import bills and improve the reliability of power.

Percentage of Population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent 2013)	Renewable Energy Consumption (% of total final energy consumption), 2006-2011, 2012
35.44 %	2.22 %	NA	76.32 %

Table 1: SDG indicators[3]

[1] World Bank database from SE4ALL
[2] National Renewable Energy Laboratory
[3] United Nations Environment Programme

3. Geography

Guinea, country of western Africa, located on the Atlantic coast. Three of western Africa's major rivers—the Gambia, the Niger, and the Sénégal—rise in Guinea. Guinea is divided into four main landform regions which include the coastal lowlands, the Guinea Highlands and the mountainous central core, the eastern savannah and the forested jungle regions in the far-southeast.

The country's mountains (running northwest through southeast) are the source for the Niger, the Gambia, and Senegal Rivers, as well as the numerous rivers flowing to the sea on the west side of those same mountains that stretch into Sierra Leone and the Ivory Coast.

Guinea is bordered by Guinea-Bissau to the northwest, Senegal to the north, Mali to the northeast, Côte d'Ivoire to the southeast, and Liberia and Sierra Leone to the south.

Figure 1: Guinea geographic location[4]

[4] Britannica

4. Climate

The climate of Guinea is tropical with two alternating seasons—a dry season (November through March) and a wet season (April through October). The arrival of the migratory intertropical convergence zone (ITCZ) in June brings the heaviest rainfall of the wet season. As the ITCZ shifts southward in November, the hot, dry wind known as the harmattan blows from the northeast off the Sahara.

On the coast a period of six months of dry weather is followed by six months of rain. The average rainfall at Conakry is about 170 inches (4,300 mm) a year, and the average annual temperatures are in the low 80s F (about 27 °C).

In the Fouta Djallon, January afternoon temperatures range from the mid-80s to the mid-90s F (about 30 to 35 °C), while evening temperatures dip into the high 40s and low 50s F (about 8 to 11 °C).

In Upper Guinea rainfall drops to about 60 inches (1,500 mm) a year. During the dry season temperatures of more than 100 °F (38 °C) are common in the northeast.

In the Forest Region at Macenta there may be some 100 or more inches (2,540 mm) of rain annually. Only the months of December, January, and February are relatively dry, with possible rainfall of only 1 inch (25 mm). At low elevations, temperatures resemble those of the coastal areas.

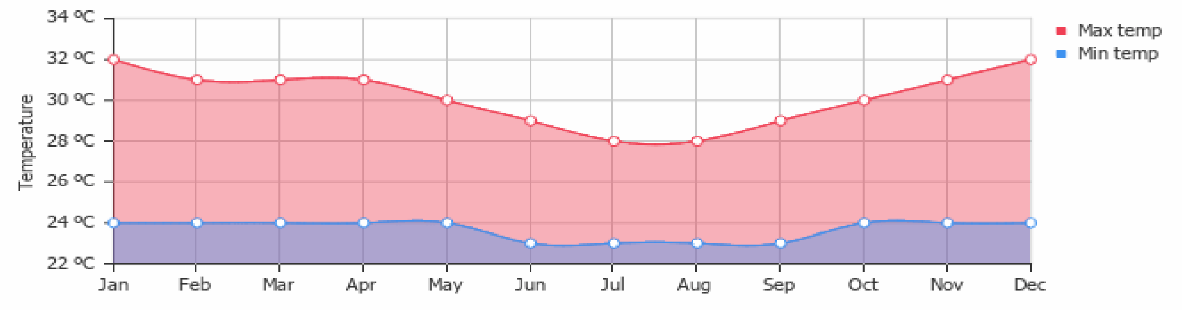


Figure 2: Average temperature pattern in Guinea

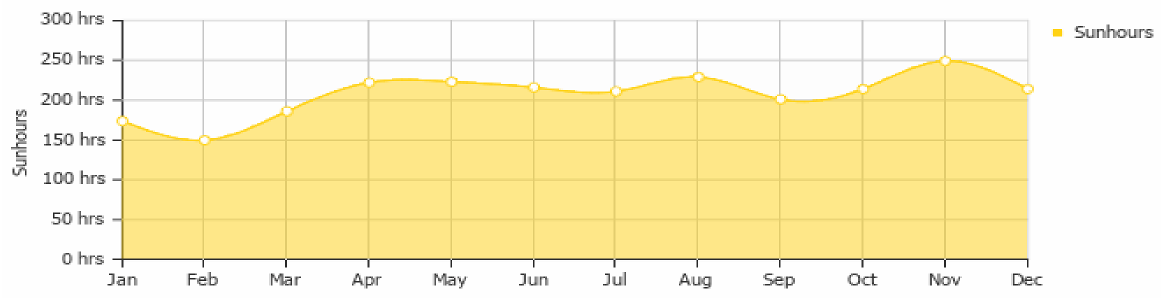


Figure 3: Average monthly hours of sunshine over the year[5]

[5] weather-and-climate

5. Rainfall

Guinea elicits an average of 3,784 mm[6] (149 in) of rainfall per year, or 315.3 mm (12.4 in) per month. On average there are 160 days per year with more than 0.1 mm (0.004 in) of rainfall (precipitation) or 13.3 days with a quantity of rain, sleet, snow etc. per month.

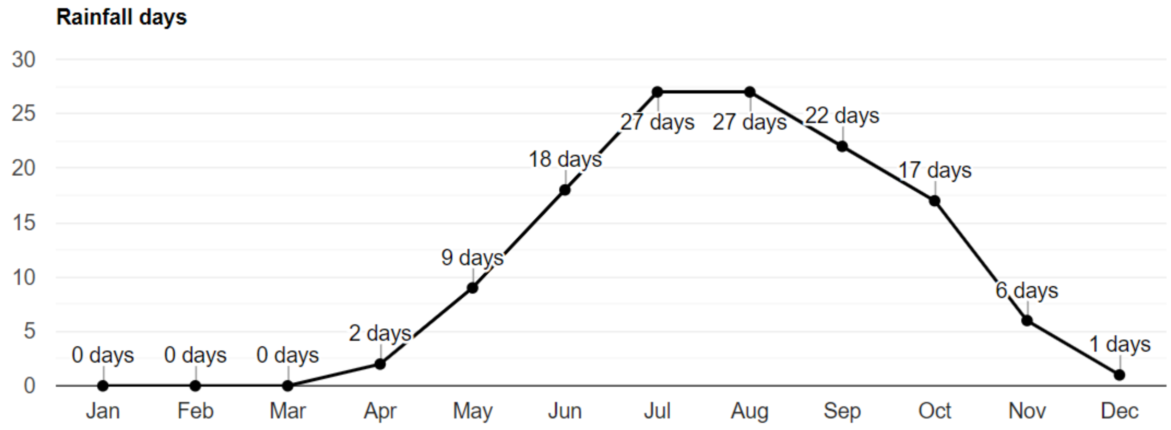


Figure 4: Precipitation map of Guinea

The driest weather is in January & February when an average of 1 mm (0 in) of rainfall (precipitation) occurs. The wettest weather is in July when an average of 1130 mm (44.5 in) of rainfall (precipitation) occurs.

[6] Clima Temps

6. Agriculture in Guinea

Guinea is an agricultural country. The high plateaus of the Fouta Djallon are little more than part-time pastures, with hillsides given over to the growing of peanuts (groundnuts) and fonio (a sorghumlike grain). Along the streams and rivers, rice, bananas, tomatoes, strawberries, and citrus fruits are grown commercially. Most families have truck gardens (gardens that produce specific vegetables in relatively large quantities for distant markets), and tsetse-resistant Ndama cattle, sheep, goats, horses, donkeys, chickens, and Muscovy ducks are raised.

Only 2.6% of Guinea's arable land area is cultivated. Agriculture accounts for 24% of GDP and engages 84% of the active population. The agricultural sector of the economy has stagnated since independence. The precipitate withdrawal of the French planters and removal of French tariff preference hurt Guinean agriculture, and drought conditions during the 1970s also hindered production. Since 1985, however, the free market policies of the Second Republic have encouraged growth in agricultural production, with slow but steady increases in output. Guinea is a net food importer, however, importing some 30% of its food needs.

In Lower Guinea, oil and coconut palms, rice, bananas, vegetables, salt, and fish are important elements of trade. A number of large-scale plantations produce a good quantity of bananas and pineapples. Except for poultry and a few goats, there are relatively few domestic animals. In Upper Guinea, grains and cassava (manioc) are important food crops; vegetables, tobacco, and karite (shea butter) are traded locally; and domestic animals are common.

In the Forest Region, rice is the chief food crop, along with cassava, peanuts, and corn (maize). Gardens of tomatoes, peppers, eggplants, and tobacco are scattered in the shade of fruit trees, and coffee trees, kola nuts, and oil palms are important cash crops. Goats and fowl are the most common domestic animals.

Experiments conducted in the early 1970s with large-scale cooperative agricultural production were unsuccessful. Relatively low government farm prices and the high cost and scarcity of consumer goods caused many producers to return to subsistence agriculture or to resort to smuggling. The production of coffee, formerly the major cash crop, declined. Food imports of staples such as rice, once exported, remain necessary. The production of other cash crops, such as palm kernels, peanuts, pineapples, bananas, and citrus fruits, has improved only marginally since 1984, though considerable potential for expansion exists.

The southeastern rainforest has some valuable species of tropical hardwoods, but forestry generally is hampered by the lack of adequate transportation. Mixed government and private-investment sawmills and plywood plants function below capacity because of insufficient supplies of timber, transportation difficulties, and inadequate capital and managerial input.

Both river and ocean fisheries yield large catches of food fish. Commercial fishing continues to grow with the introduction of U.S., French, Japanese, and other internationally financed and operated fishing ventures. Individual small-scale riverine and marine fishing, producing fresh, dried, and smoked fish for local markets, remains important.

Price controls have also had a dampening effect on output. In theory, until the reforms of the early 1980s, the state controlled the marketing of farm produce. However, even during the late 1970s, when all private trade in agricultural commodities was illegal, only a small amount of agricultural production actually passed through the state distribution system; some 500,000 private smallholders reportedly achieved yields twice as high as government collectives, despite having little or no access to government credit or research and extension facilities. During the 1970s and early 1980s, agricultural exports fell markedly, and food production decreased, necessitating rice imports of at least 70,000 tons a year. (In 1984, a drought year, 186,000 tons of cereal had to be imported.) However, some restrictions on marketing were removed in 1979 and 1981; more recently, prices were decontrolled and many state farms and plantations dissolved. These steps appeared to bring improvements.

The principal subsistence crops (with estimated 1999 production) are manioc, 812,000 tons; rice, 750,000 tons; sweet potatoes, 135,000 tons; yams, 89,000 tons; and corn, 89,000 tons. Cash crops are peanuts, palm kernels, bananas, pineapples, coffee, coconuts, sugarcane, and citrus fruits. In 1999, an estimated 429,000 tons of plantains, 220,000 tons of sugarcane, 215,000 tons of citrus fruits, 150,000 tons of bananas, 174,000 tons of peanuts, 52,000 tons of palm kernels, and 18,000 tons of coconuts were produced. That same year, coffee production was estimated at 21,000 tons, compared to 14,000 tons on average annually from 1979 to 1981. Prior to the reforms, a large portion of the coffee crop was smuggled out of the country. Guinea's trade deficit in agricultural products was $128.3 million in 2001.

The agricultural sector presents an agro-ecological diversity favoring the development of diverse production systems. The country is subdivided into four (4) natural zones, each representing a particular agro-ecological potential. The total cultivated surface area in Guinea for the main subsistence crops was estimated during the 2014/2015 agricultural campaign to be 3,591,141 ha against only 1,339,846 ha in 2000/2001 during the last national agricultural census.

1. Lower Guinea

This region is favorable for high value-added horticultural production. The pineapple sector is in full expansion and modernization. Mango, avocado and banana production is gradually on the rise. In the early 1960s, banana production reached a record 100,000 tons.

2. Middle Guinea

The Region is good for livestock farming, the climate is ideal due to the Fouta Djallon mountains and it is where the following vegetables grow best: tomatoes, onions, eggplants etc. In the past 12 years, potato farming has known a boom not only for local consumption, but also for export as well.

3. Upper Guinea

With savanna like climate, this region is good for growing cotton. Its progressive extension allows an estimated production of about 30,000 tons / year to date. At present, the sector is being restructured. The region also has one of the widest and most fertile prairie lands in Africa along the Niger River, which is very good for rice farming.

4. Forest Guinea

The Region is favorable for industrial plantation of coffee, rubber and palm oil. Approximately 200,000 ha are cultivated. Coffee production rose from 1,000 tons in 1984 to 20,000 tons to date. The SOGUIPAH, one of the leading players in the region, has more than 10,000 hectares of both crops in addition to developing rice and fishery projects in the region.

7. Irrigation

In 2016, total area equipped for irrigation for Guinea was 95 thousand hectares. Total area equipped for irrigation of Guinea increased from 20 thousand hectares in 1967 to 95 thousand hectares in 2016 growing at an average annual rate of 4.81 %.[7]

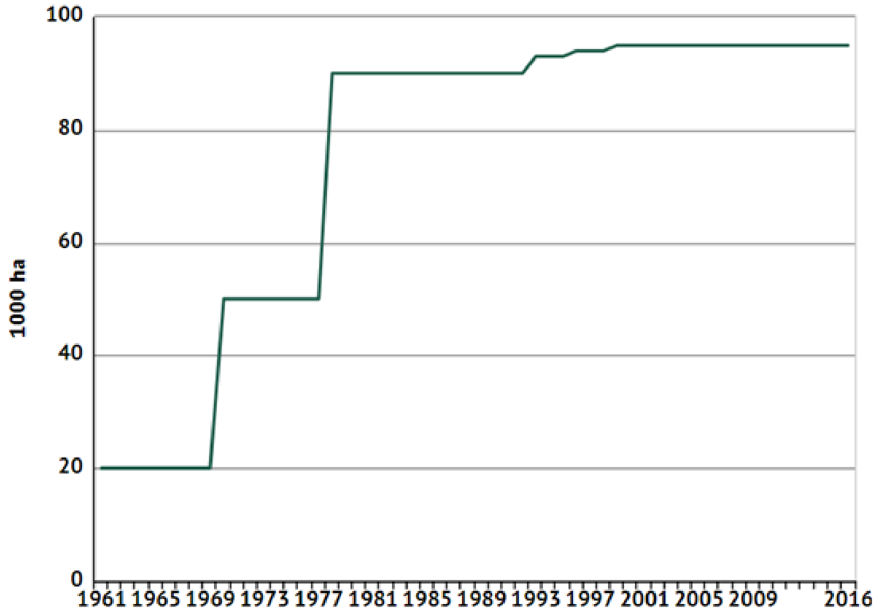


Figure 5: Total area equipped for irrigation

[7] FAO

8. Cropping Pattern

The share of agriculture sector in the national GDP has been steadily declining from 26 percent in 2009 to 20 percent in 2013, with an average of about 22 percent. Most Guineans depend on agriculture as their primary source of livelihood and income; however, the agricultural productivity is low. Poor roads, water and electricity supply hinder both storage and transportation of foods to markets; as a result, in Guinea most agricultural production is for direct consumption.

Cash crop commodity exports, quantity and value, 2011[8]

	Quantity (tonnes)	Value (million USD)
Rubber	10,559	45.1
Cacao beans	16,393	42.8
Coffee	14,456	30.8
Cashew nuts	21,884	27.9
Other	22,354	10.4
Palm oil	468	0.5

Rice is by far the most significant crop and it is grown on about 80 percent of all cereal cropped area and about 50 percent of irrigated land. Other food crops include Cassava and Maize. In addition, Guinea also grows cash crops, particularly cashew nuts, cacao beans, coffee and rubber which make up the bulk of the country's agricultural exports. However, agricultural exports contribute less than 10 percent to the national GDP. Rubber exports are at the top of the list at about 30 percent of total cash crop exports (using 2011 data) followed by cacao beans at 27 percent. Food commodities, mainly, rice, and wheat at import levels of about 300,000 tonnes and 100,000 tonnes (2013 estimates), respectively, from the bulk of agricultural imports.

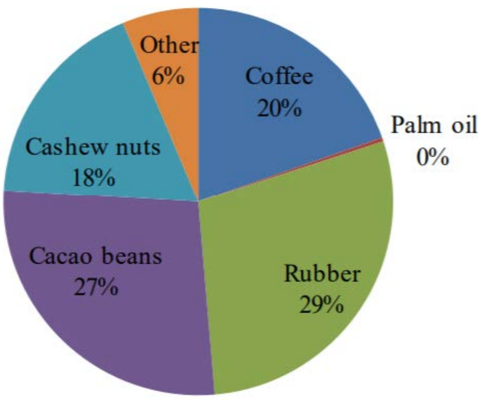


Figure 6: Share of commodity exports in Guinea

(in total cash crop export of USD 157 million in 2011)

The total cereal import requirement is met through commercial imports and some food aid. The assumed level of commercial import level, leaves about 44,000 tonnes of uncovered gap to be filled with international food assistance and/or additional budgetary allocation by the Government. This level of food assistance is more than double the level received in the country in 2014 and higher than the historical high of food aid was 30,000 tonnes in 2008 This would be, especially aimed at providing food assistance to the most vulnerable people affected by Ebola crisis as detailed in the following sections.

[8] FAOSTAT

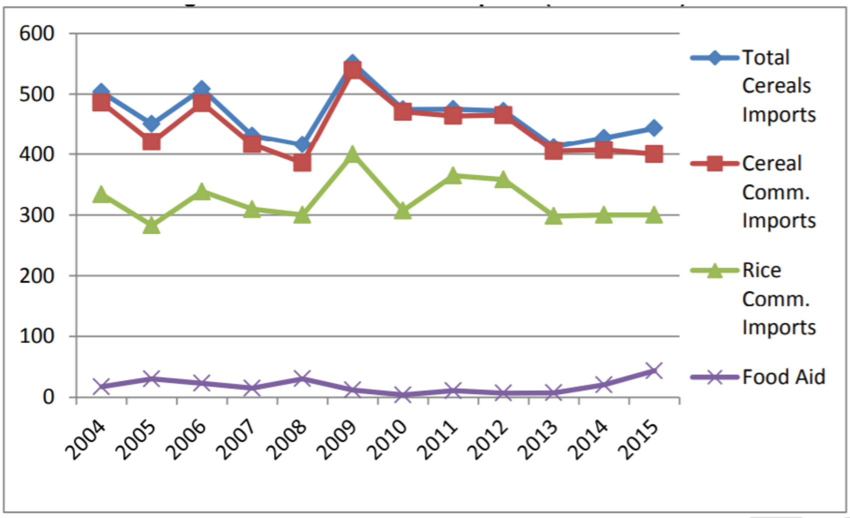


Figure 7: Cereal imports (‘000 tonnes)[9]

The border closures with neighbouring Senegal, Liberia, Sierra Leone and Guinea-Bissau have led to a decline of trade volumes of agricultural commodities between Guinea and neighbouring countries.

While this is the case, urban markets in the regional capitals are currently still well supplied with local produce and ports remain open. The upward pressure on food prices due to disruptions in production and trade restrictions has been offset by the dampening effect of low domestic demand. According to WFP price monitoring, monthly retail prices for key food commodities remained stable between August and November 2014, with the exception of local rice in Labé, which after some months of dramatic increase dropped rapidly.

[9] 2004 to 2014 FAO/GIEWS CCBS, 2015 CFSA

9. Background to solar water pumping in Guinea

Guinea has a plan to install 20,000 additional solar water pumps for supply of drinking water by 2030. As per the Head of State's vision, the ministry has a target of setting up at least 1 solar pump for supply of drinking water in each village where there is a population of around 1000 people. The host country shall provide the data regarding type of pump, depth of discharge head, etc. to carry out the assessment for demand aggregation. The host country would like to take up a few pilot projects with assistance from ISA and accordingly approach the government to replace all the existing diesel pumps with solar pumps. ISA have asked for requisite data which will be shared by the National Focal Point and the Embassy of the Host Country in India. Additionally, ISA is conducting a price discovery bids through Energy Efficiency Services Ltd for 272,579 Solar Pumping Systems based on aggregated demand from 22 Member Countries as of December 31st, 2018. It is expected that there shall be a significant reduction of price through demand aggregation.

Details of the demand submitted by the host country

i. Project location and capacities of the pumps: 5000 pumps for drinking
ii. Current solar and other pumps installed in the country- business/financial model, details about the capacity and cost of the pumps, name of suppliers, depth at which pump is installed: The country has approximately 19000 pump installations out of which 140 are solar powered. Subsidies, tax exemptions offered for solar installations.

10. Solar pump Technology Overview

A PVP (Photo Voltaic Pump) typically consists of the following main components:

1. Photovoltaic array: An array of photovoltaic modules connected in series and possibly strings of modules connected in parallel.
2. Controller: An electronic device which matches the PV power to the motor and regulates the operation, starting and stopping of the PVP. The controller is mostly installed on the surface although some PVPs have the controller integrated in the submersible motor-pump set:
   - DC controller: usually based on a DC to DC controller with fixed voltage set point operation.
   - AC controller (inverter): converts DC electricity from the array to alternating current electricity often with maximum power point tracking.
3. Electric motor: There are a number of motor types: DC brushed, DC brushless, or three phase induction and three phase permanent magnet synchronous motors.
4. Pump: The most common pump types are the helical rotor pump (also referred to as progressive cavity), the diaphragm pump, the piston pump and the centrifugal pump. Some years ago there were PVP models on the market that operated with batteries and a conventional inverter. However it was soon realized that the cost savings on the pump did not make up for the overall substandard efficiency and the higher maintenance cost due to battery replacements. Instead it became clear that it is more economical to rather store water in a reservoir than electricity in a battery bank.

There are currently three pumping configurations commonly utilized in Africa:

- DC drive with positive displacement pumps. This consists of four pump technologies: Diaphragm pump driven by brushed DC motor, Helical rotor pump driven by brushless DC motor, Helical rotor pump driven by surface mounted brushed DC motor, Piston pump driven by surface mounted brushed DC motor
- AC drive powering a submersible induction motor/centrifugal pump unit
- AC drive powering a three-phase permanent magnet synchronous motor. This category consists of:

Positive displacement helical rotor pump, Centrifugal pump

The above technologies have specific features which make them suitable for particular applications. Some of the other key technology terms useful for understanding the functioning of a solar powered irrigation system are described in detail as per the table below.

Term	Description
Array Voltage	Some of the pumping systems have high array voltages. This has the advantage that the array may be further from the borehole without significant voltage drop (dependent on cable size and current). Array positioning may be important where there is potential for theft.
DC Motors	DC motors reach efficiencies of up to 80% and are therefore significantly more efficient than sub-kW three phase motors which have efficiencies in the region of 60% to 65%.
Brushless DC Motors	This combines the high efficiency of DC motors with low maintenance as opposed to brushed DC motors which require regular brush replacement (approximately every one to two years – head and quality dependent).
Three phase permanent magnet motors	This similarly combines the high efficiency of permanent magnet motors with low maintenance.
Positive displacement vs. Centrifugal pump	Positive displacement pumps have a better daily delivery than centrifugal pumps when driven by a solar PV system with its characteristic variable power supply. This is due to the considerable drop in efficiency of the centrifugal pump when operating away from its design speed. This is the case in the morning and the afternoon of a centrifugal pump driven by a PV array, unless that array tracks the sun (which is why centrifugal PVPs effectiveness improves more with a tracking array than a positive displacement PVP). The efficiency curve of a positive displacement pump is flatter over a range of speeds. However the efficiency of positive displacement pumps decreases with the shallowness of the borehole (the constant fixed friction losses become a more significant part of the power it takes to lift water). Therefore it is not surprising that both Grundfos and Lorentz use centrifugal pumps for applications where the lift is less than 20 to 30m but switch to positive displacement pumps for deeper wells.
Diaphragm pump	The diaphragm pump is used for pumping small volumes of water from 100/120m depth. The pump needs regular maintenance (diaphragm replacements, cleaning). If the diaphragm breaks the motor chamber gets wet. The pump can run dry.

Table 2: Key technology terms in a solar powered irrigation system

11. Experience and Perceptions

1. Theft: This is a problem for both PVP and diesel pumping but very costly for the PVP systems due to the main portion of the capital cost being vested in the solar PV modules.
2. Variable water demand: Diesel pumps can pump water on demand. PVPs do not have that flexibility. A hybrid system such as solar diesel would present an attractive solution, however at a higher cost.
3. Supply security: PVP is considered to have less redundancy, is more difficult to repair and is susceptible to lightning strike. Diesel pumping has a more solid service infrastructure and is considered more reliable. The hybrid pumping solutions would improve supply security.
4. The diesel system is considered more flexible (flexible in moving a diesel engine to another borehole).
5. Diesel fuel is part of an existing infrastructure and the owner is able to do the minor service on the engine himself. PVP technology requires knowledge of mechanics, electrical and electronics thus making the user/operator dependent on specialized service which is often only available in Windhoek.
6. PVP are perceived to pump insufficient water.
7. Corrosion is a problem for both diesel and solar pumps.
8. The environmental impact of diesel pumps includes carbon emissions, possible borehole contamination, and threat to borehole sustainability. PVPs can be seen as a resource protection if it is designed for the maximum sustainable yield of the borehole.
9. The operation of PVPs is quiet.
10. PVPs are perceived to be expensive.
11. Many users on commercial farms combine the need for starting the diesel pump the opportunity for inspecting fences, checking on livestock and other farming activities. However, if a PVP is used then the frequency of these trips over the farm decrease[10]

[10] Ministry of Mines and Energy (Namibia), UNDP, GEF

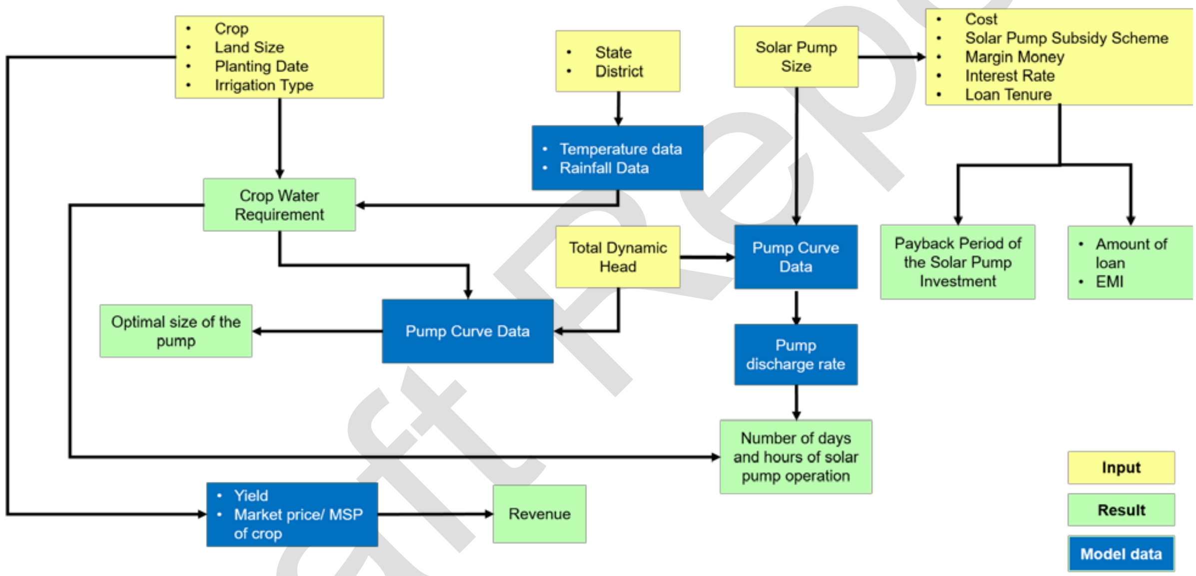
12. Recent Solar Pumps Uptake and Pricing

Information to be furnished by Guinea NFP (if any)

13. Feasibility Analysis

The feasibility of a solar powered irrigation system depends on a wide array of factors ranging from geographic parameters such as temperature, rainfall, water table depth to site specific parameters such as cropping pattern, land size, planting date, irrigation technique etc. Any feasibility analysis of a solar powered irrigation system would involve both the technical feasibility and the financial feasibility. The technical feasibility would analyze the site-specific conditions to determine whether such system can be installed considering the different technical aspects such as solar irradiance, size availability, panel size, tracking systems, water table depth etc. The technical feasibility would also provide recommendations on the ideal pump size and type considering the dynamics of the site. Once technical feasibility for a given system is established, the costs involved, and the expected returns are calculated using financial feasibility analysis. The below figure summarizes the interplay of various parameters involved in technical and financial feasibility analysis.

Figure 8: Factors involved in feasibility analysis of a solar powered irrigation system



13.1 Technical Feasibility Analysis

13.1.1 Solar Irradiance

The efficiency of solar panels and consequently the solar energy output depends on three factors: the intensity of the solar radiation flux; the quality and the operating temperature of the semiconductor in use and the operating temperature of the semiconductor cell. Though the two latter factors may somehow, in one way or the other, be altered and improved; the intensity of the solar radiation flux however, to a great extent, is simply a given natural resource. The actual level of solar irradiance depends on the latitude and local climatic conditions. Annual solar irradiance, for instance in northern Europe is different from that noted within the sub-Saharan region. The below figure shows the long term global horizontal irradiance over Guinea.[11]

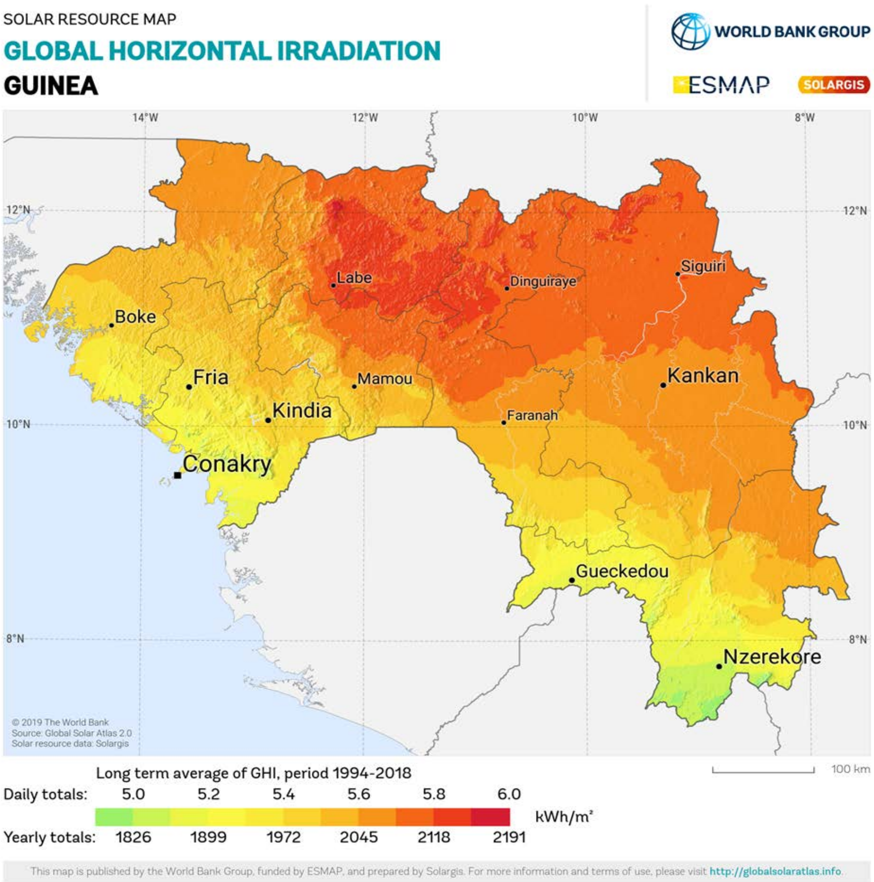


Figure 9: Solar Resource Map of Guinea

Guinea has average solar radiation of 5.0-6.0 kWh/m^2/day[12]. As clearly indicated from the above, the North part of the country particularly in the Guinean forest-savanna mosaic to the north, the GHI values vary between 5.4-6.0 kWh/m^2 while in the Southern part it is less than 5.0 kWh/m^2. The high value of solar radiation signifies great potential for development of solar technologies in the country owing to the abundance of solar insolation. The utilization of solar energy can further be increased by utilization automatic/ manual trackers to ensure maximum absorption of solar irradiance by the panel surface.

I. Pump Location

The pump should be located in an enclosed room called a pump pit or a pump house. Surface pumps are not water proof and need to be kept away from water and protected from environmental conditions

[11] Global Solar Atlas
[12] http://www.reegle.info/countries/Guinea-energy-profile/BJ

to prolong their lifetime and reduce maintenance requirements. Distance between the pump and the PV panels should be kept to a minimum to reduce voltage drop in the cables. Increased distance causes harmonics and would require a harmonics filter to avoid damages to the pump and the inverter/controller.

II. Pump Sizing

Oversizing would incur unnecessary costs, and under sizing would lead to insufficient performance. This is why each component needs to be properly designed and sized to meet the specific requirements of the project. It is the only way to guarantee reliability and system durability and achieve the desired performance. Similarly, when sizing a solar system, it is recommended to use the 'worst month method'. By sizing the systems for the month with most adverse conditions in the year, it will be ensured that water supply will be enough for all the other months. The worst month in the year will be that in where the gap between the energy required to supply water and the energy available from the Sun is higher. In case the daily water requirement is the same all the year round (meaning too that the energy required is the same all the year round since pump will run for the same number of hours any day), the worst month will be that with least solar radiation.

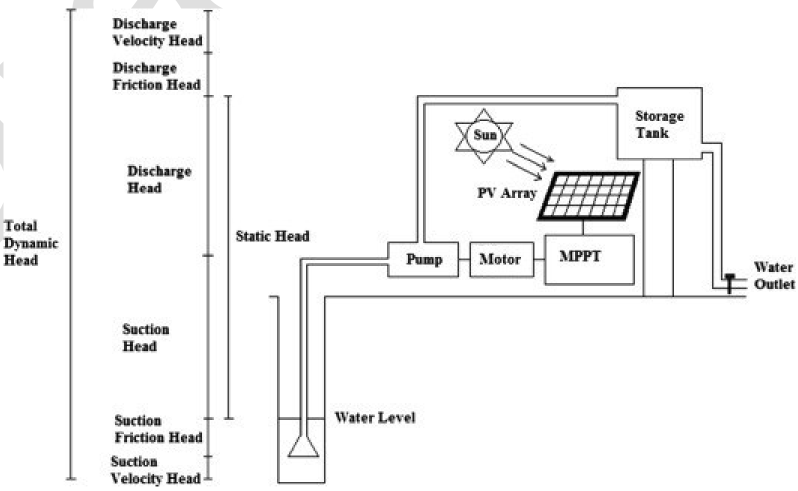
III. Water Demand

Water demand is the major factor affecting the size of the pumping system. For solar systems it is calculated as a daily consumption rate (m3/day). The storage capacity is the volume of water that need to be stored to ensure sufficient and continuous supply of water to end users. Storage tanks usually range in a volume of between 1 to 5 days of daily water requirements, depending on the location and the usage patterns.

IV. Total Dynamic Head

[13]The total dynamic head is a very important parameter of a solar pumps which determines the various head losses that the pump must overcome. It is a summation of the suction head, discharge head and the friction losses. The total dynamic head and the desired flow rate of the system are applied to the pump performance curve, which is used for proper pump selection based on required electrical power input and optimum efficiency.

Figure 10: Total Dynamic Head of a solar pump



[13] ScienceDirect.com

13.2 Financial Feasibility Analysis

Financial feasibility analysis to be conducted based Information to be furnished by Guinea NFP

14. Advantages of solar powered irrigation

Socio-economic advantages		Environmental advantages
Farm level	National level	
Financing and cost of solar panels continue to drop, making SPIS economically viable and competitive with other sources of energy.	Potential for job creation in the renewable energy sector.	No greenhouse gas emissions.
Rural electrification and access to renewable energy, especially in remote areas.	Contribution to rural electrification and renewable energy targets.	Potential for adaptation to climate change by mobilizing groundwater resources when rains fail or rainfall patterns are erratic.
Independence from volatile fuel prices and unreliable and costly fuel supplies.	Reduced dependence on energy exports. Energy subsidies for fossil fuels can be reduced while offering an alternative to farmers and rural communities whose livelihoods would otherwise be negatively affected.	Potential for improving water quality through filtration and fertigation systems. Less pollution resulting from inadequate fuel handling from diesel pumps.
Potential for increasing agricultural productivity and income due to improved access to water.	Food security may be improved if introduction of SPIS is accompanied by changes in irrigation technologies and agricultural practices.	
Potential for income diversification due to multiple uses of energy (e.g. feed-in to grid, lighting, cooling) and water (e.g. livestock watering, domestic uses).	Rural development through improved access to water and energy.	
Reduced cost for water pumping in the long run. If system is being modernized for pressurized irrigation, increases in energy costs are offset through the use of solar energy.		
Potential time saving due to replacement of labour intensive manual irrigation, which can lead to other income-generating activities. Women and/or children might profit from time not spent on watering anymore.		

15. Key Stakeholders

Organization/ Agency	Role
Ministry of Energy	• Policy making body for solar energy and manufacturing od solar panels and storage batteries • Nodal ministry for coordination and implementation of solar related projects.
Ministry of Finance	• Plans and budgetary allocation for solar Projects • Mobilize and approve the financing for solar related projects in Guinea
Ministry of Hydraulic (Water)	Assess the requirements for solar pumps for drinking purpose and monitor the implementation of the projects.
Ministry of Foreign Affairs (MoFA)	Coordination between the Government of Guinea, private sector and ISA.

Table 3: Key stakeholders in Guinea

16. Recommendations

Guinea has a plan to install 20,000 additional solar water pumps for supply of drinking water by 2030. As per the Head of State's vision, the ministry has a target of setting up at least 1 solar pump for supply of drinking water in each village where there is a population of around 1000 people.

A five - day mission visit with delegates from ISA and KPMG was undertaken to understand the existing ground level scenario in Guinea and to validate the demand. During the discussions, it was noted that while Guinea has participated in the programme, the details of the location, sizing and other aspects of demand estimation has not been worked out by the respective Ministry. This report, hence assesses the feasibility of implementation of solar pumps with reasonable assumptions as detailed in the report. However, to arrive at a detailed feasibility assessment, site specific and other relevant details (such as costing of solar pumps, applicable taxes etc.) are required from the relevant Ministry so as to support the country in developing a bankable project. The details of the information requested from the Ministry is provided in Annexure A.

Further, it is expected that the outcome of Price Discovery International Competitive Bid being carried out by ISA for Solar Agricultural Pumps will be finalized by November 2019 and the country specific rates for various categories of pumps will be informed to Guinea. The same may be examined and if acceptable, Guinea may enter into a contract with the selected bidder(s). The prices discovered will also help Guinea in ascertaining a benchmarking price for various capacities of solar water pumping systems for future projects.

Annexure A

Key questions

1. Basic Information

The country profile and ISA link with the country (NFP, Ministry, etc.):

- Name and contact details National Focal Point (designation, postal address, E Mail, Telephone, Whatsapp Number – of NFP)
- Nodal Ministry/Department responsible for implementation of solar water pumping systems and its structure (state level, provincial level & district level, etc.)

2. Country profile:

The country's present statistics about energy and agriculture:

- Total area of country (in Square kilometers)
- Total area under agriculture (in Square kilometers/hectare)
- Energy scenario of the country (may attach sheet for details)
- The crop pattern and number of crops per year
- Existing irrigation methods/techniques (canal, sprinkler, drip irrigation, any other.)
- Existing farming techniques/methods (individual, community based, co-operative, commercial, any other.)
- Average land holding of the farmers (in hectares)
- Number of farmers with land holding of

  a. ______ (less than or equal to) 1 Hectare
  b. 1 – 2 Hectare
  c. ______ (greater than or equal to) 2 Hectare

3. Technology

Aspects related to pumping systems

- Number of agricultural pumps already installed in the country (number of diesel pumps/ electricity run pumps) (# number)
- What was the approach adopted for determination of number of solar pumps including area wise distribution or crop wise distribution?
- What are the types of solar pumps required in the country (off-grid, grid connected, etc.)?
- The capacity of pumps required for installation (normal range is 3, 5, 7.5, 10 hp; AC/DC; Surface, submersible.)?
- Data availability for ground water, recharging rate and water table level?
- If data for ground water is not available, any proposal to assess the water availability by the country?
- Who are the existing players in the diesel/ grid connected pumps?

- Is there are service delivery mechanism for irrigation? If yes, what is the model and what are the typical charges paid by the farmers?

4. Policy/Finance

- What is the current funding mechanism for financing government-based irrigation projects? How much of it is spent by the government exchequer? What are the typical lending rates for these projects?
- What is the sources of funding for existing pump sets? Does the farmer take loans from banks or does government provides subsidy/ financing for the same?
- Whether any financial assistance is available in the country to support SWPS programme
- If financial assistance is available, what is the pattern and model of implementation?
- What could be the modality of implementing the programme if there is no financial assistance available by the government?
- Which are the financial institutions/banks active in the area of SWPS implementation?
- Any international cooperation available for financing of SWPS/solar projects?
- Any Foundations/ Non-Government Organizations active in the country to support the SWPS/solar programme?

5. Existing ecosystem for solar pumps

- Has there been prior pilot projects implemented for solar pumps in the country? If yes, how has been the experience/ challenge etc.?
- What is the estimated utilization of solar pumps by farmers practicing subsistence farming?
- What is the level of theft/ security for solar technology in general and solar pumps in particular?
- What is the custom/import duties/ taxes on various solar pump components?
- What are the requirements from international/ national solar pump suppliers to do business in the country? Is there any mandatory requirement of setting up of project office for solar pump supplier?
- Which are existing solar pump suppliers in the country?
- What is the general awareness levels of the farmers regarding solar technology in general and solar pumping technology in particular?
- What are the views of the state on implementation of solar pumps programme and possible business models?

6. Project feasibility

- What are the prevalent interest rate for RE projects in the country?
- What is the cost of diesel pump per HP?
- What is the cost of diesel?
- What are the living expense of the farmer (as a % of crop revenue)?

- What is the month on month crop water requirement?
- How many days in a year does a farmer typically use a pump set?

7. Project implementation

- What are the required timelines for delivery of solar pumps?
- What is the implementation plan for solar pumps including agency to be involved, human resource capabilities, training requirements, phase wise implementation etc.
- Have the sites been identified for solar pump implementation? If yes, can these be shared on the map?
- What are the areas where ISA can facilitate the implementation of solar pumps?

8. Others

- Any other information the country would like to share that shall facilitate the implementation of solar pumps?