INTERNATIONAL SOLAR ALLIANCE

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

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1. Executive Summary

- Niger is a land-locked nation with particularly harsh climate and inhospitable geographical features - 11.43 percent of the land is arable. It is the largest country in West Africa with an area of 1,267,000 km^2, characterized by a tropical climate with two main seasons - dry and a rainy season.
- The country is characterized by a tropical climate with two main seasons, one dry season from October to May and a rainy season from May to September. The country has three climatic zones:
  - In the north, the Saharan zone represents 3/5th of the country, and is dry and rich in mineral resources;
  - In the centre, a Sahelian pastoral zone has average rainfall of 200-300 mm of rain per year;
  - In the south, the Sudan region is called agricultural and is very favourable for breeding, with rainfall of 350-600 mm per year.
- Niger's economy is dominated by rain-fed agriculture, while livestock production accounts for about a third of the value added in the agriculture sector. There are 2 cropping seasons in a year with rice grown near the river and vegetables such as tomato grown in the central parts of the country.
- Agriculture contributes approximately 40 percent to gross domestic product (GDP) and 87 percent of the labor force is employed in this sector. Niger has a largely free-market system in which the prices are set by the market.
- Average water table in the country is around 10-40 m. This varies depending on the season and region of the country. There are approximately 10 million hectares of land available for agriculture with less than 3000 hectares under irrigation.
- Niger derives nearly 86%[1] of its energy supply from biomass. Owing to the effects of climate change and deforestation, firewood availability in the country is continuously decreasing.
- Niger has significant energy potential, rich and varied, but is weakly exploited. 65% of electricity needs is fulfilled through import of power from Nigeria.
- Solar energy is possible throughout the territory where the average insolation level is 5 to 6 kWh/ m^2/ day with an average 8.5 hours of sunshine per day.
- Niger aims to increase the share of solar energy in its energy mix and has target to become a major exporter of the same.
- At an average price of USD 5,097 per 5 HP pumpset, Niger requires financing of USD 76.46 million to roll out deployment of 15,000 Nos. solar water pumping systems across the country.

[1]ANERSOL, Niger and ISA mission visit in Niger

2. Introduction

Niger has significant energy potential, consisting of biomass (firewood and agricultural residues, the main source used by households for cooking), uranium, mineral coal, oil, natural gas, hydroelectricity and solar energy. Biofuels and waste are the largest contributor to energy production followed by petroleum as illustrated in the figure below.

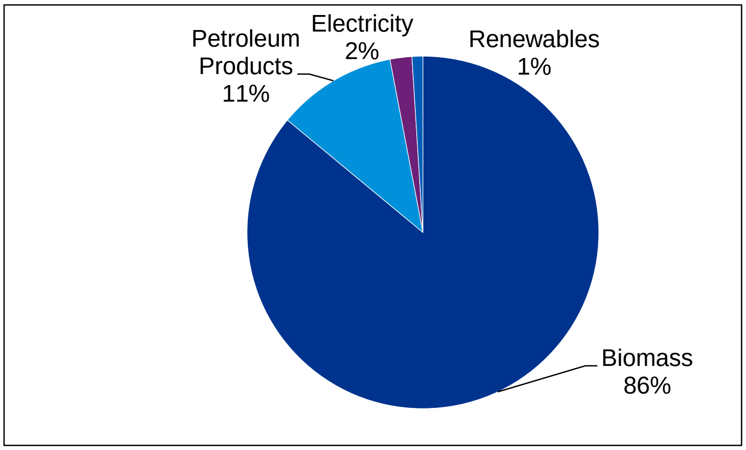


Figure 1: Energy Supply Mix

Source: ANERSOL, Niger

The total installed capacity was 284 MW in 2018[2]. Access to electricity in the rural areas at ~1% which is significantly less than 49% access in urban areas. The existing power infrastructure in Niger is underdeveloped, and the country continues to rely heavily on imported electricity from neighboring Nigeria. The development of the renewables sector has been slow, despite the government's approval of a 2004 National Strategy on Renewable Energy which aimed to increase the share of renewable energies (biomass excluded) in the national energy balance from less than 0.1% in 2003 to 10% in 2020. However, Niger recently took important steps to rationalize its legal framework[3]:

- the Energy Sector Regulatory Authority was created in December 2015;
- a new Electricity Code was enacted in May 2016; and
- in September 2016, three important decrees were adopted under the Electricity Code:
    - the first fixing the conditions of third parties' access to the grid;
    - the second specifying the tariffs applicable to the electricity sector; and
    - the third laying down the terms and conditions of delegation agreements (conventions de delegation) and the award of importation, exportation and transport licenses.

[2]https://www.usaid.gov/powerafrica/niger
[3]https://www.insideafricalaw.com/blog/niger-electricity-and-renewable-energy

The energy consumption is distributed into different categories where the majority is used for residential purposes as illustrated in Figure 3.

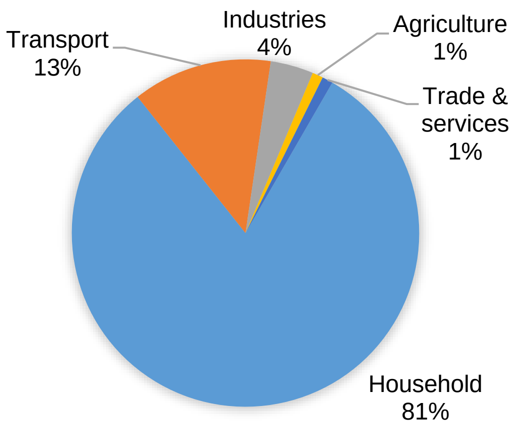


Figure 2: Energy Consumption

Source: International Energy Charter

Grid unavailability in rural areas has led to increasing reliance on biomass for meeting the energy needs leading to rapid deforestation. The annual per capita energy consumption in Figure 4 shows a growth at slow pace.

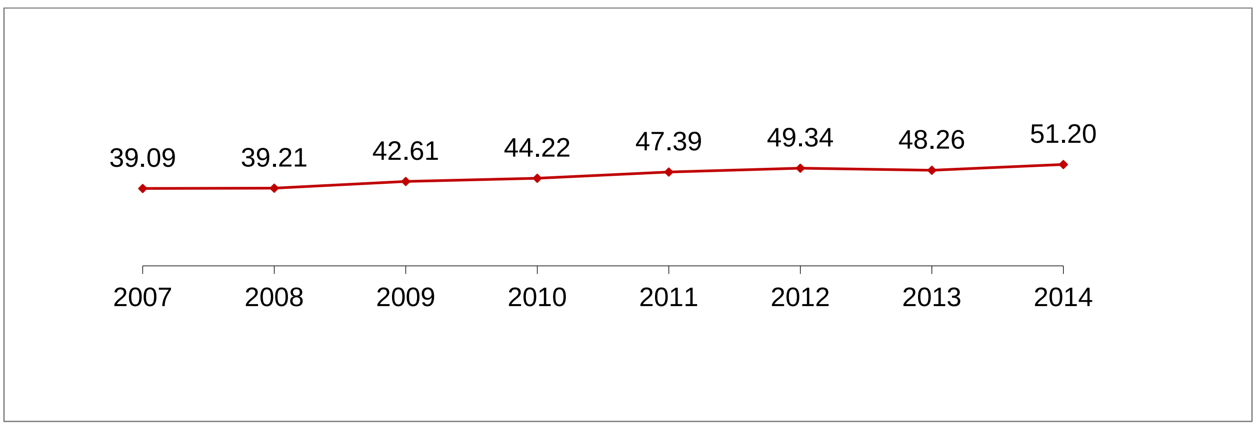


Figure 3:Annual increase in per capita energy consumption

Source: World Bank

Farmers primarily depend on rain fed irrigation for meeting their crop water requirements. The country has faced frequent droughts in the recent past and the huge solar potential in the country, with average daily solar insolation of 7 - 9 hours, can help the farmers develop solar powered irrigation facilities.

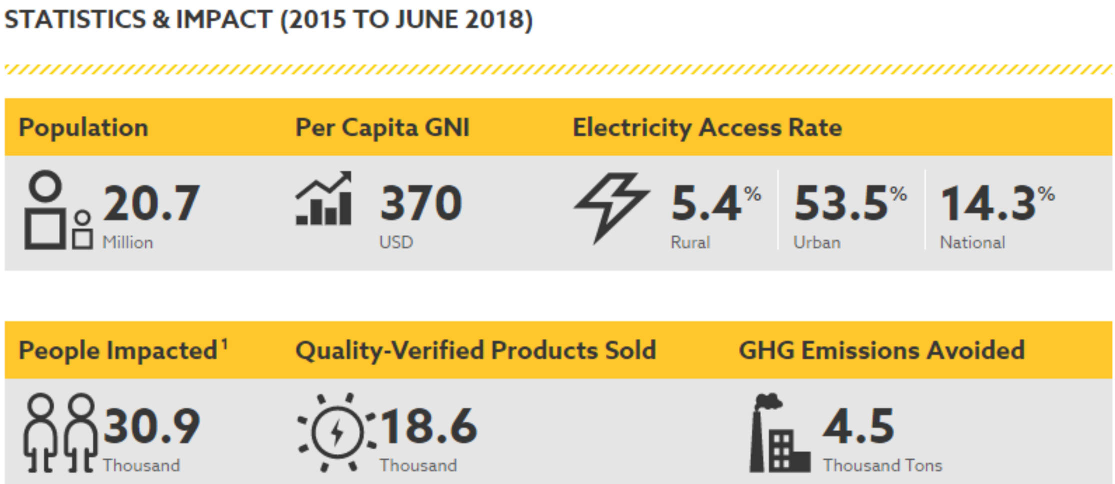


Figure 4:Statistical highlights about Niger

Source: www.lightingafrica.org

Following are the key stakeholders in the electricity subsector in Niger:

S.No.	Key Stakeholders	Institution
1	Ministry	Ministry of Foreign Affairs
		Ministry of Energy
		Agence Nilgerienne pour la Promotion de l'Electrificationen milieu Rural (ANPER)
		Ministry of Planning
		Ministry of Agriculture
		Ministry of Hydraulique (Water)
2	Authorities	Autorite de Regulation du Secteur de l'Energie (ARSE)
		Office National des Amenagements Hydro Agricoles (ONAHA)
3	Solar Industrial association	APE Solaire (Association for collaboration between various developers, NGOs and other players in solar industry)

Table 1: Role of various institutions involved in the electricity sector in Niger

3. Geography

Niger, officially Republic of Niger, is a landlocked western African country. It is bounded on the northwest by Algeria, on the northeast by Libya, on the east by Chad, on the south by Nigeria and Benin, and on the west by Burkina Faso and Mali. The capital of Niger is Niamey and the country takes its name from the Niger River, which flows through the southwestern part of its territory.

Figure 5: Niger Map

Source: Britannica

Niger extends for about 750 miles (1,200 km) from north to south and about 930 miles (1,460 km) from east to west. The country divides naturally into three distinct zones—a desert zone in the north; an intermediate zone, where nomadic pastoralists raise cattle, in the centre; and a cultivated zone in the south. The southern zone has the greater part of the population, both nomadic and settled.

4. Climate

Niger extends southward from the tropic of Cancer, and the northern two-thirds of its territory lies in dry tropical desert. In the southern part of the country the climate is of the type known as Sahelian, which is characterized by a single, short rainy season. In January and February, the continental equivalent of the northeast trade winds, the harmattan, blows southwestward from the Sahara toward the equator. Typically, dust-laden, dry, and desiccating, the harmattan hinders normal living conditions on the southern fringe of the desert. From April to May the southern trade winds blowing from the Atlantic reach the equator and are diverted toward the Sahara where they meet with the harmattan—an encounter that results in violent line squalls and that signals the beginning of the rainy season. The rains last from one to four months, according to the latitude; August is the rainy month everywhere except in the far north, where the rainfall is unpredictable.

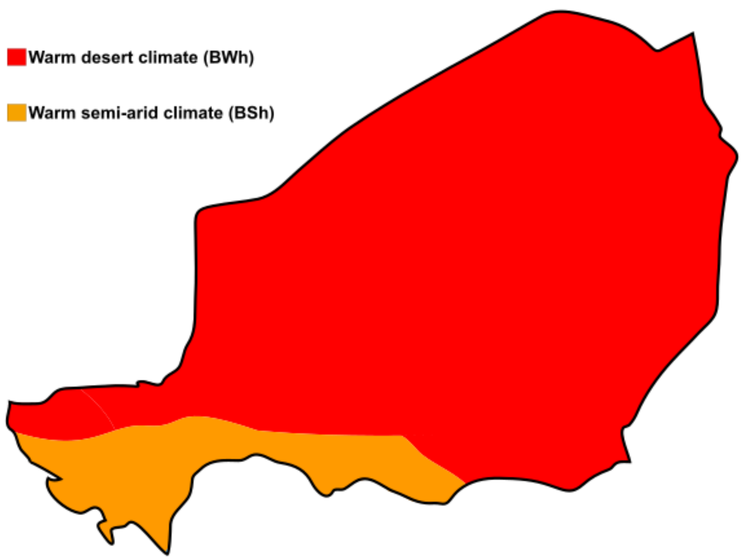


Figure 6: Climate Classification Map

Source: Wikidata

Niger lies in one of the hottest regions of the world. Temperatures rise from February to May and drop during the “winter” rainy season, rising again somewhat before falling to their annual minimum averages in December or January. During May (the hottest month), afternoon temperatures are high everywhere, ranging from a low of about 108 °F (42 °C) at Nguigmi on Lake Chad to 113 °F (45 °C) at Bilma and Agadez, both in the northern desert. In January, afternoon temperatures average more than 90 °F (mid-30s C) at most stations but at night may drop to freezing level in the desert. The daily range is greater in the desert north than in the south and is also more extreme during the dry season. The graph below in Figure 7 is Data from nearest weather station: Niamey, Niger.

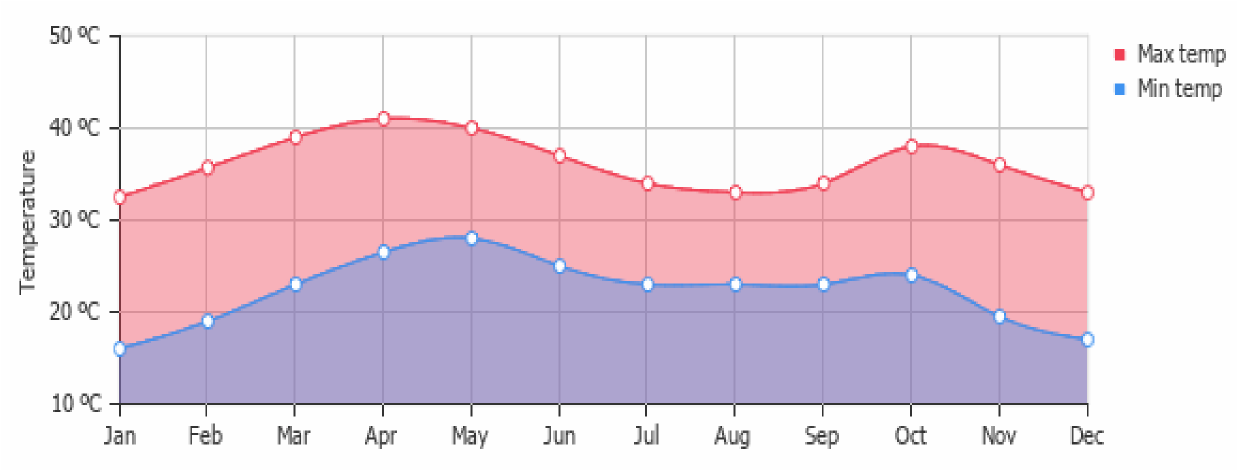


Figure 7:Average Min and Max Temperature Trend in Niamey Niger

Source: weather-and-climate.com

5. Rainfall

Rainfall varies according to location as well as season. The 10-inch isohyet (line on a map connecting points having equal rainfall) follows a line from near Tahoua to Gouré, in effect marking the northern limit of nomadic pastoral life, for the rainfall permits a sparse vegetation to grow. To the extreme south the 30-inch isohyet marks the southern limit of this zone, after which the southern agricultural zone begins. In the course of the same rainy season a most irregular spatial pattern of rainfall may occur, while from one year to another the total amount of rainfall may also vary; in addition, the rainy season itself may arrive early or late, thus jeopardizing crops.[4]

To show variation within the months and not just the monthly totals, the graph below, shows the rainfall accumulated over a sliding 31-day period centered around each day of the year. Niamey experiences extreme seasonal variation in monthly rainfall. The rainy period of the year lasts for 5.1 months, from May 7 to October 11, with a sliding 31-day rainfall of at least 0.5 inches. The most rain falls during the 31 days centered around August 10, with an average total accumulation of 5.5 inches. The rainless period of the year lasts for 6.9 months, from October 11 to May 7. The least rain falls around December 24, with an average total accumulation of 0.0 inches.

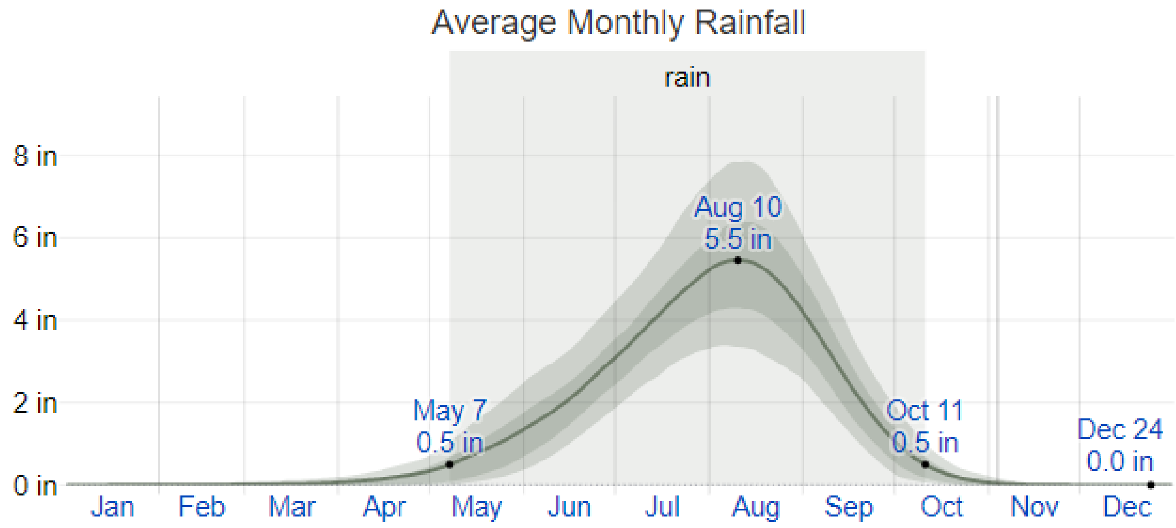


Figure 8: Average Rainy Days in Niamey Niger[5]

Source: weather-and-climate.com

[4]https://www.britannica.com/place/Niger/Climate
[5]https://weatherspark.com/y/47072/Average-Weather-in-Niamey-Niger-Year-Round#Sections-Topography

6. Soil

The soils fall into three natural regions. In the Saharan region in the north the soil is infertile, except in a few oases where water is found. In the region known as the Sahel, which forms a transitional zone between the Sahara and the region to the south, the soils are thin and white, being covered with salty deposits resulting from intense evaporation that forms an infertile surface crust. The third region (in the south) is cultivated. In this area the soils are associated with extensive dunes or uplands or with basins or depressions. Some of the soils in the latter, such as those in the Niger basin and in the gulbi, are rich. Black soils occur in the Kolo basin. Throughout the region, however, and above all on the plateaus, less fertile lateritic (leached iron-bearing) soils occur.

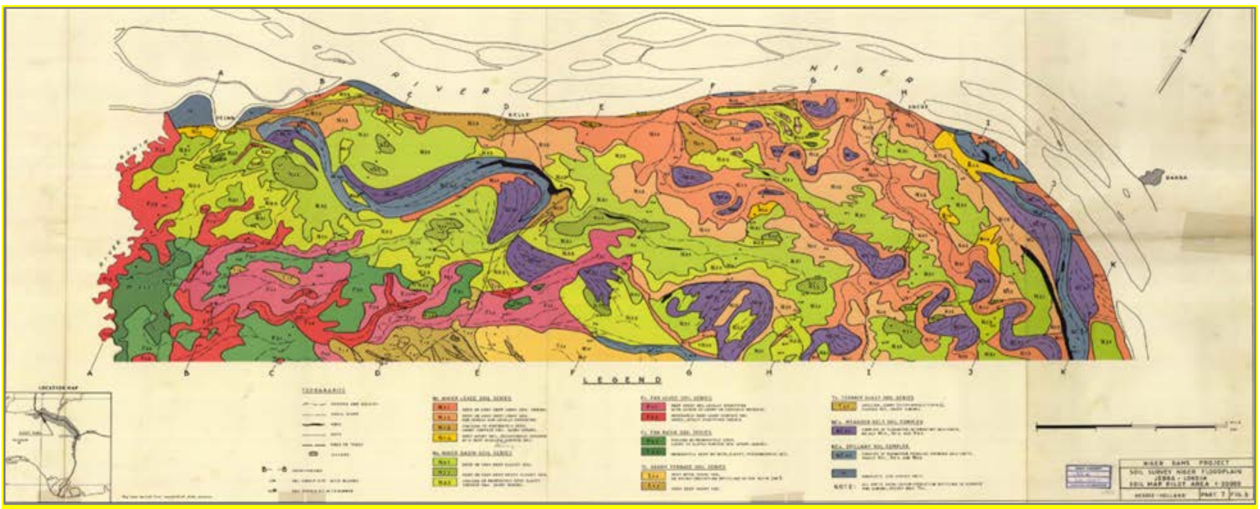


Figure 9: Soil Map[6]

[6]https://esdac.jrc.ec.europa.eu/images/Eudasm/Africa/images/maps/download/afr_ndp3.jpg

7. Agriculture and Irrigation in Niger

Agriculture and agricultural products constitute the largest sector of Niger's economy in terms of the number of persons employed and the percentage of gross national product (GNP). Millet and sorghum, the main food crops, are grown in the south, as are cassava and sugarcane. Rice is grown in the Niger River valley. Peanuts are the most important cash crop; other important crops include cotton and pulses.

Livestock is an important sector of the agricultural economy and is a major export. Cattle, sheep, and goats are raised for meat, milk, and hides. Niger's ability to remain self-sufficient in food and livestock production is closely linked to rainfall, and periods of drought have resulted in shortfalls requiring imports and food aid. To increase production and avoid cereal shortfalls, the government has invested in irrigation projects and an "off-season growing program" of small-scale production and irrigation operations.

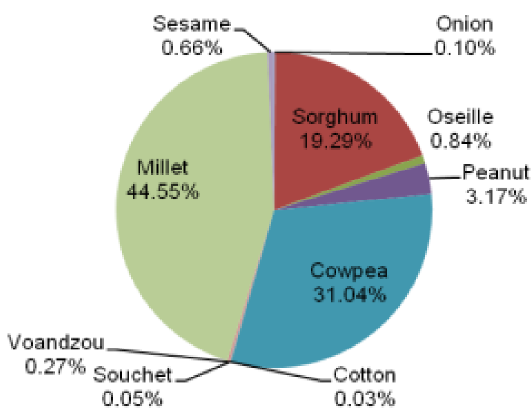


Figure 10: Average crop acreage (Yr. 1995 – 2011)

Source: Climateinvestmentfunds.org

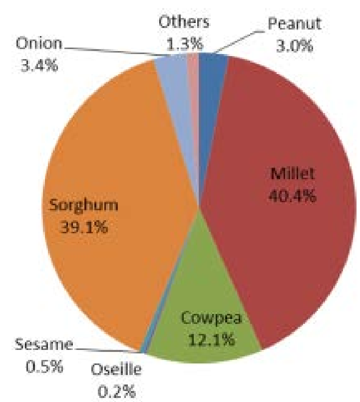


Figure 11: Crop production during (Yr. 1995 – 2011)

Source: Climateinvestmentfunds.org

8. Cropping Pattern

In Niger, a landlocked country in West Africa, crop and livestock production are the foundation of the national economy, contributing about 40% to its GDP. Agricultural and pastoral activities are carried out in four distinct major agro-ecological zones namely: (i) the semi-desert area in the north, which receives 0 to 50 mm of rainfall per year, (ii) the sub-Saharan pastoral zone in the longitudinal East-West center core of the country and receiving 50 to 200 mm of annual rainfall, (iii) the Sahelian agro-pastoral zone extending in the central to southern part of the country and receiving 200 to 500 mm of rainfall per year, and (iv) the Sudano-Sahelian zone covering the southern part of the country, receiving 600 to 800 mm of annual rain, and being most suitable for agriculture.[7]

Less than 10% of the cropped area is under irrigation and there are limited areas around permanent (i.e. the Niger and Komadougou-Yobe rivers) and semi-permanent (large ponds) water systems and in valley or dallol areas (dallols Bosso and Maoury. Major cultivated crops are staples, with a clear predominance of pearl millet, sorghum and cowpea. In addition to these main crops, there are other crops that are often grown under rainfed and/or irrigated conditions, such as cassava, sweet potato, rice, maize, wheat and fonio (finger millet). Cultivated area is now expanding due to the development of irrigation schemes. Other crops such as cotton, groundnuts, Bambara groundnut and nutsedge are also cultivated in some regions, such as Maradi, Zinder and Dosso. It should be noted that the agricultural systems in Niger are mixed with practically no region, exclusively specialized in one crop. Intercropping (cereals-legumes or cereals-cereals) is widely practiced. In some areas with considerable soil heterogeneity across the field, a farmer may plant different crops (millet, sorghum, maize or legumes) in the same field. If the field has heterogeneous soil types, each crop is planted on the type of soil to which it is best adapted. One crop is usually cultivated per year (during the rainy season). Exceptions are areas around rivers and designated areas, where irrigation allows cultivation of a second crop during the dry season (particularly, maize, rice, wheat, tubers and vegetable crops). The cropping calendar for Niger is provided below:

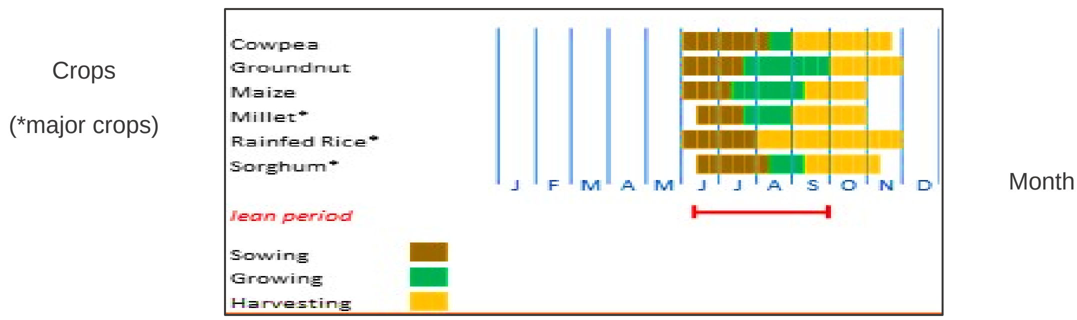


Figure 12: Cropping Calendar

Source: FAO.org

[7]http://www.yieldgap.org/niger

9. Background to solar water pumping in Niger

The Niger has submitted a demand of 15,000 solar water pumping systems. The ISA mission team discussed the potential of solar water pumping system for irrigation & drinking water and the likely transformational change it will bring to agricultural/ social sector by ways of increased productivity, higher income for farmers and drinking water to rural/semi urban communities. The Country templates have been shared with the National Focal Point to consider submitting their demand for Solar Pumping Systems. Additionally, ISA team shared with NFP and Ministry of Agriculture about its initiatives in conducting a price discovery bid through Energy Efficiency Services Ltd for 272,579 Solar Pumping Systems based on aggregated demand from 22 Member Countries. It is intended to have significant reduction of price through demand aggregation. The Government of Niger has expressed interest in the program and the Ministry of Energy and Ministry of Agriculture will be coordinating with the concerned Ministries and Departments for implementation of aggregated demand of solar pumps which can be used for irrigation, drinking water and sanitation purposes to cover agriculture, health and education sector.

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.

Term	Description
AC Motors	The motor operates on alternating current; the direct current produced by solar panels gets converted to AC using the inverter. The conversion from DC to AC leads to loss of power from generation to consumption.AC motors gain importance in applications where higher output/head combinations are required.
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% to65%.
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.
Surface pump	Surface pumps are installed at ground level to lift water from shallow water sources such as shallow wells, ponds, streams or storage tanks. Surface pumps can also be used to provide pressurized water for irrigation or home water systems. These pumps are suitable for lifting and pumping water from a maximum depth of 20 meters.
Submersible pump	Submersible pumps installed where there is a requirement for the submerged in the fluid to be pumped These pumps can be used in areas where water is available at a greater depth and where open wells are not available. Typically, the maximum recommended depth these systems can pumps is 50 meters.

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

11. Experience and Perceptions

1. **Theft**: This is a problem for both PVP (Photo Voltaic Pump) 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[8].

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

12. 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.

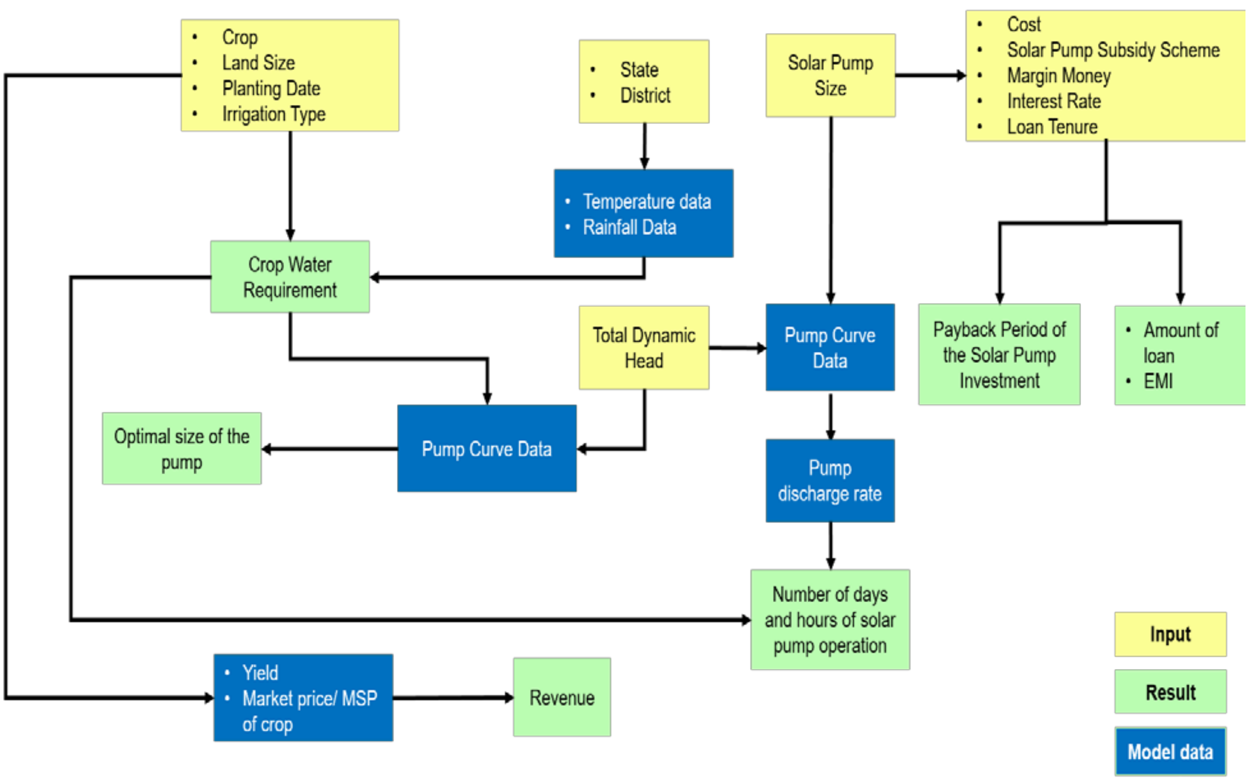


Figure 13: Technical and Feasibility Analysis

12.1 Technical Feasibility Analysis

12.1.1 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 Niger.

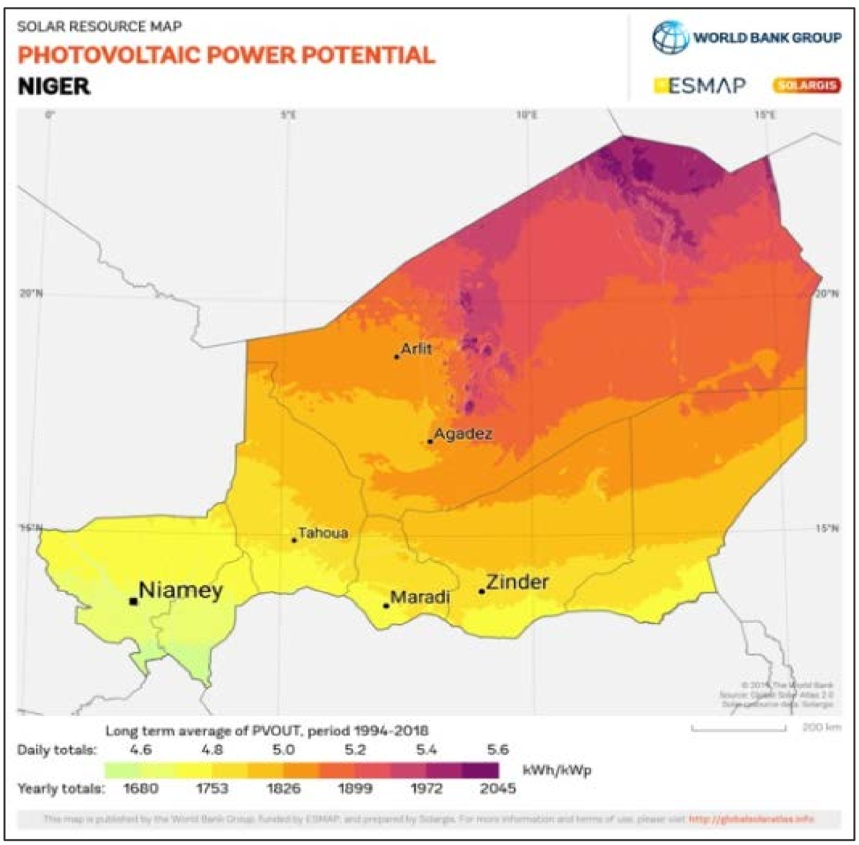


Figure 14:Solar Irradiation Map

The average solar radiation lies between 5 - 6 kWh/m²/day across the country.

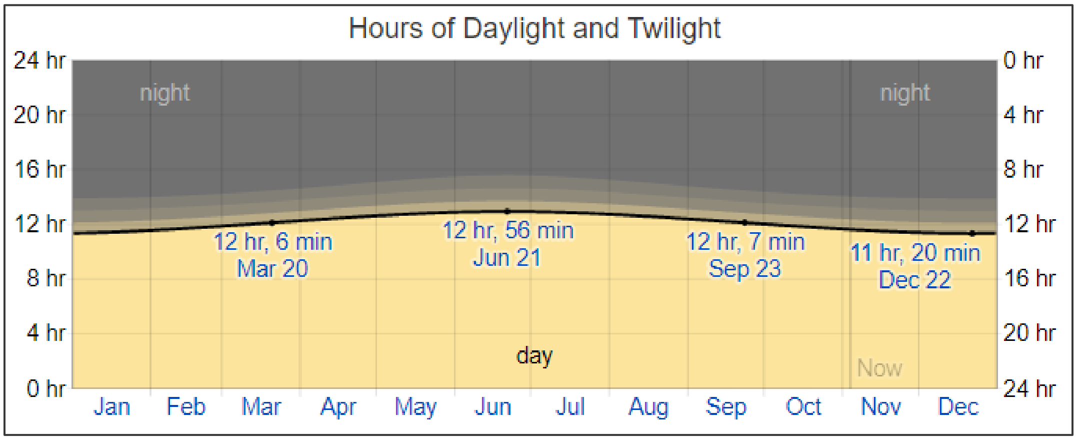


Figure 15: Shows the variation of length of the day during the year[9]

The length of the day in Niamey varies over the course of the year. In 2019, the shortest day is December 22, with 11 hours, 20 minutes of daylight; the longest day is June 21, with 12 hours, 56 minutes of daylight. The earliest sunrise is at 6:23 AM on June 1, and the latest sunrise is 56 minutes later at 7:19 AM on January 24. The earliest sunset is at 6:21 PM on November 20, and the latest sunset is 1 hour, 2 minutes later at 7:23 PM on July 10.

Existing solar data clearly indicates that the solar energy resource in Niger is high throughout the year. Grid connected Utility Scale Solar could play a big role in future addition of electricity installed capacity. Hydro resources could help in balancing the intermittence of solar generation.

12.1.2 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 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.

12.1.3 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

[9]https://weatherspark.com/y/47072/Average-Weather-in-Niamey-Niger-Year-Round#Sections-Topography

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[10].

12.1.4 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 (m^3/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.

12.1.5 Total Dynamic Head

[11]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.

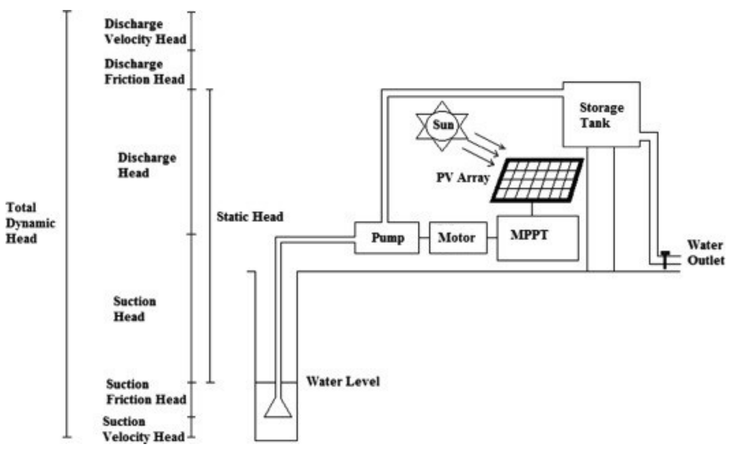


Figure 16: Total Dynamic Head of a solar pump

[10] Sun-Connect News
[11] ScienceDirect.com

12.2 Financial Feasibility Analysis

Indicative Inputs

S.No.	Particulars	Unit	Value	Source
1	Crop to be Irrigated		Rice, Maize	
2	Land Size	hectares	0.5 (for each crop)	
3	Planting date		As per cropping calendar of Niger	
4	Irrigation type		Flood: Lined canal supplied	
5	Selected Size of Solar Pump	HP	5	
6	Total dynamic head inclusive of friction losses	meters	40	
7	Cost of Solar Pump	USD	5,097	Average of L1 prices discovered in ISA tender for 5 HP AC/DC, Surface mounted/ submersible pumpsets
8	Subsidy	%	0%	
9	Margin Money	%	10%	
10	Loan Amount	%	90%	
11	Interest Rate	%	1.5%	EXIM Bank LoC Interest rate
12	Loan Tenure	years	7	
13	Cost of diesel pump per HP	USD	56	FAO
14	Cost of diesel	USD/litre	1.09	Published reports and articles
15	Hike in diesel prices (y-o-y)	%	3%	Based on global averages
16	Inflation rate	%	1.8%	World Data Info
17	Living expense of the farmer (as a % of crop revenue)	%	60%	Based on global estimates, KPMG Analysis
18	Maintenance costs for diesel pump (as a % of capital costs)	%	10%	Based on global estimates, KPMG Analysis[12]

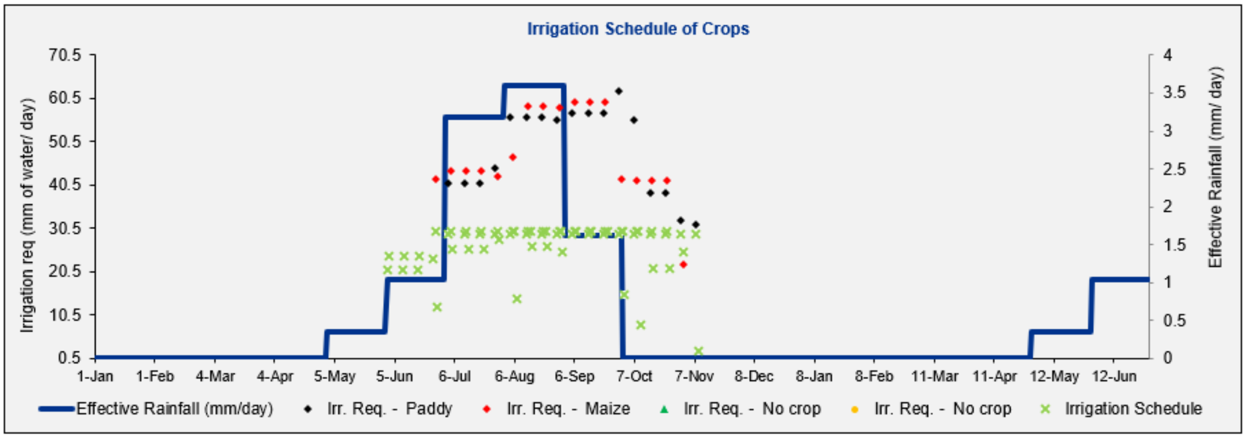
Indicative Crop Water Requirement[13]

Total Crop Water Requirement (m^3)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
-	-	-	-	-	820	993	1488	2273	2263	517	-
Annual crop water requirement (m^3)						8,353					

Indicative Irrigation schedule

[12] The toolkit developed by KPMG for Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH was used to undertake the analysis.

[13] Note: This is just an indicative analysis to be used only for reference purposes. We have taken reasonable assumptions wherever reliable data was not available. A more accurate analysis can be conducted after more data has been obtained from the respective nations.



Irri. Req. indicates the net irrigation requirement (considering rainfall) for individual crops
Irrigation Schedule indicates the consolidated schedule over the time period for all the crops

Indicative Outputs

S. No.	Particulars	Unit	Value
1	Amount of subsidy	USD	0
2	Amount of loan to be availed	USD	4587
3	Yearly installment towards loan repayment	USD	695
4	Monthly installment towards loan repayment	USD	58
5	Savings in monthly diesel expenses on an average basis for 20 years	USD	81
6	Number of hours of solar pump operation required	Hours	315
7	Number of days of solar pump operation required	Days	39
8	**Incremental payback of solar pump w.r.t. diesel pump**	**years**	**6**

Niger has submitted demand for 15,000 Nos. solar water pumping systems. At an average price of USD 5,097 per 5 HP pumpset, Niger requires financing of USD 76.46 million to roll out deployment of 15,000 Nos. solar water pumping systems across the country.

13. 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.		

Table 3: Advantages of solar powered irrigation

14. Key Stakeholders

Organization/ Agency	Role
Ministry of Energy	The mandate of the Ministry is to Establish, Promote the Development, Strategically Manage and Safeguard the Rational and Sustainable Exploitation and Utilization of Energy for Social and Economic Development. Ministry is responsible for policy making – solar, etc. It is a nodal ministry for coordination and implementation of solar related projects.
Ministry of Planning	The ministry is responsible for the formulation of economic and fiscal policies and mobilize resources for the implementation of government programs. The Ministry in addition to the allocation of the budget also mobilises and approves the financing for solar related projects in Niger.
Ministry of Agriculture	The Ministry is the overseer of the Agricultural sector where it formulates, reviews and implement national policies, plans, strategies, regulations and standards and enforce laws, regulations and standards along the value chain of crops, livestock and fisheries. The Ministry is responsible for the assessment of the requirements for solar pumps in agriculture and monitors the implementation of the projects related to solar pumping system.
Ministry of Hydrauliqe (Water)	The Ministry has the overall responsibility of the development, managing, and regulating water resources in Niger. It assesses the requirements for solar pumps for drinking purpose and monitor the implementation of such projects.
Office National des Amenagements Hydro Agricoles (ONAHA) (Irrigation)	Coordination with Water Users' Associations and Cooperatives for implementation of large irrigation projects.
Agence Nilgerienne pour la Promotion de l'Electrificationen milieu Rural (ANPER)	The Ministry promotes and governs the implementation of Electrification projects in Rural Niger.
Ministry of Foreign Affairs (MoFA)	The mandate of the Ministry is to build relations with other countries for mutual development. The Ministry is responsible for the coordination between the Government of Niger, private sector and ISA, for the implementation solar pumping systems.

Table 4: Key stakeholders in Niger

15. Recommendations for implementation

Following are the recommendations for the implementation of solar pumps in Niger based on the above analysis and discussions undertaken during the visit of delegation from ISA Secretariat to Niger:

1. **Number and type of pumps**: Niger has submitted demand for procurement of 15,000 solar water pumps. Considering the low levels of electricity access and frequent brownouts/ blackouts especially in rural areas, off-grid pumps are required to be installed. Further large pumpsets presently being used for water lifting from Niger river may be solarized.

2. **Location of pumps:** In the initial phase, it is advisable to select few concentrated areas and install the solar water pumps in order to have a good demonstration effect. For example, solar pumps may be installed at Niger river area where farmer user groups have been formed and are already paying for water irrigation facilities provided by Government of Niger. If the solar water pumps are scattered across different areas, it will lead to high transportation and maintenance costs. Also, the installation of solar water pumps in a concentrated area will help in better visibility and strong impact of the programme**.** Despite having no ocean or deep draft river ports, Niger does operate a ports authority. Niger relies on the port at Cotonou (Benin), and to a lesser degree Lomé (Togo), and Port Harcourt (Nigeria), as its main route to overseas trade. The Niger River is navigable 300 km from Port of Niamey to Gaya on the Benin frontier from mid-December to March only (https://en.wikipedia.org/wiki/Transport_in_Niger).

3. **Financing:** There are limited sources available for the government of Niger to fund the solar pumps and therefore subsidy shall not necessarily be available for solar pumps. Hence, the financing models envisaged should majorly consider either subsidy from external donor agencies or financing by MFIs/DFIs for the cost of the pump. The subsidy may be required for initial implementation of the solar pumps considering the technology is still new in the country. With the progress of deployment and improvement in costs, the subsidy may be reduced in a phased manner. Further, some amount maybe paid by the farmers upfront while the remaining may be done on periodic basis in the form of loan repayments.

4. **Financing structures:** Considering external financing would be required as mentioned in point 2. above, mobilization of financing should be done by the authorities and suitable financing structures should be developed to enable the deployment of pumps.

5. **Knowledge development:** Number of motorized agricultural pumps deployed in Niger are very limited and farmers have relied on rain water, surface water or hand pumps for irrigation. Therefore, awareness creation and knowledge development of the farmer with regard to deployment of solar pumps is necessary to enable effective adoption and utilization of the solar enabled pumps. Initially these activities may be undertaken by i-STARCs to be developed in Niger under the ISA's programme.

6. **Ecosystem availability:** Though Ministry of Hydraulics has already implemented solar water pumping systems for drinking water, the solar ecosystem is not well developed in the country. Therefore availability of local manpower for solar and pumps may be a challenge during the initial phase of implementation. However initial training on the operations and maintenance aspects of the solar pumps will mitigate the challenge to an extent.

16. Proposed next steps

1. **Pre-feasibility report:** The pre-feasibility report may be shared with Multilateral Development Banks (MDBs) such as World Bank, EXIM Bank for financing solar water pumping systems in Niger. This report 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, applicable taxes, duties, government incentives etc.) are required from the relevant Ministry.
2. **Capacity building:** Post bid process and financing arrangement, Identification of foundations/ institutions in Niger to assist in the capacity building of farmers and knowledge development of local technicians may be initiated by pump suppliers and through i-STARCs.
3. **Implementation scale:** Considering solar pumps have not been deployed at a major scale in Niger, implementation may be planned in phased manner for better visibility and strong impact of the programme which may further be scaled to the country level. The roadmap for the same may be prepared by Government of Niger in consultation with ISA.
4. **Field preparation:** Boring activities may also be suitably initiated by farmers in the area where the solar pumps are planned to be initially implemented.
5. **Supply and project monitoring:** Regular project monitoring for supply and installation of pumps may be undertaken by ISA and NFP Niger basis field reports and feedback from farmers, suppliers/ installers and government agencies.