Solar Irrigation

Fact Sheet

Introduction

Around 60% of the population in sub-Saharan Africa (SSA) relies on agriculture, with an estimated 250 million smallholder farmers and pastoralists producing about 70% of the food supply.[1] However, of the 183 million hectares of cultivated land, 95% is rainfed, which is inefficient and subject to shocks.[2,3] Solar irrigation is a type of "productive use of (renewable) energy" (also called PURE or PUE) that increases agricultural yields, which leads to a substantial increase in smallholder farmers' income as well as food security. This fact sheet provides an overview of solar irrigation pumps. It also references a case study from Senegal focused on potato farmers, where the commercialisation of solar pumps is scaling up.[4]

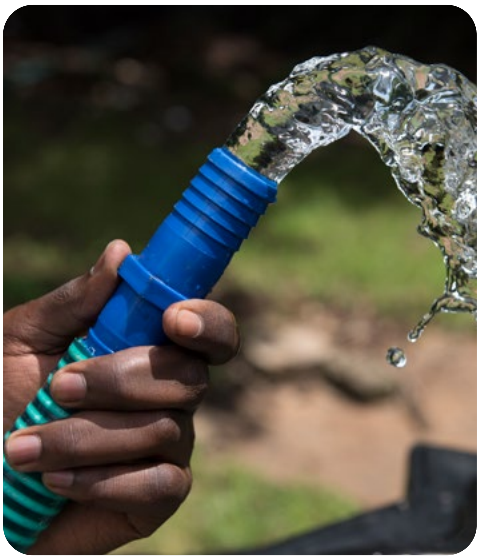
Key Facts of the Application Environment

The market potential for solar irrigation pumps is largely untapped. In SSA, groundwater-fed and surface-water-fed irrigation (including pumping water from lakes and rivers to fields) could be developed over the next decade in over 8.6 million hectares of land. Around 74% of these new irrigation systems could be powered by solar power.[5] The main potential customers for solar irrigation pumps are smallholder farmers. In Tanzania, smallholder farmers generate 80% of the total crop production without irrigation by mechanised equipment.[6] These potential customers are currently relying on rainfall alone, which hampers agricultural productivity and causes food shortages during the dry season.

In most cases, solar pumping is used by individual farmers. Therefore, many solar pumps irrigate between 0.5 and 1.5 hectares. Larger solar pumping stations, which can serve a cooperative of farmers, are still primarily used in the context of demonstration projects only. Managing these larger pumping stations requires organisational structures that are not in place.

Application in a Nutshell

Technology	Solar pumping for irrigation.
Application	Solar pumps are often bought by individual farmers, but central irrigation systems used by cooperatives are currently being piloted. Brownfield investments, i.e. replacing a diesel/petrol pump with a solar pump, are increasing due to the greater ability-to-pay of farmers already using pumping for irrigation. Greenfield investments, where farmers use solar pumps as their very first pumps, are less common.
Technology Overview	Solar pumps are part of an irrigation system, which also includes: solar panels, a reservoir (possibly), and a sprinkler or a drip system. Surface pumps can be used for shallow water sources (less than 7 metres deep), and submersible pumps can be used for deep wells and boreholes. For standalone pumping systems, pumps with DC brushless motors are preferred to their AC equivalents, as they are more energy-efficient.
Economic and Financial feasibility	Brownfield investments are investments used for replacing parts of existing facilities with newer technology. Such investments are common because they are economically attractive. Loans can typically be repaid within two years. Greenfield investments can lead to an additional harvest per year, which may lead to an increase in income. However, if a borehole is required, the cost of drilling may deter the investment.
Benefits and Outcomes	Irrigation can increase yields by 2.7 times[7] compared to rainfed agriculture in a given crop cycle. In many countries in SSA, irrigation makes cultivation in the dry season possible, increasing smallholder farmers' income. Irrigation also contributes to food security and increases the country's resilience to international shocks. In the long run, farmers may move to more intensive and commercial farming.
Constraints and Risks	While technical constraints can be mostly overcome if local suppliers are trained and advise farmers carefully, the relatively high upfront cost of the technology (combined with the lack of consumer-finance options) is a major barrier to the development of the sector. Strengthening downstream value chains between farmers and agri-processing industries and exporters are required to reduce the market risk and ensure that all produce is sold.
Future Perspectives	Solar irrigation systems are starting to be commercialised at scale. To catalyse the market, interventions could include making more consumer-finance options available, such as: supplier credit; lease-to-own; and PAYGO (pay-as-you-go). These options can be provided by system suppliers and distributors or larger agricultural value chain stakeholders (e.g. in the context of outgrower schemes). Interventions can also include supporting commercial banks (e.g. guarantee funds) to unlock financing.



Technical Information

A solar pump is part of an overall system that also includes: a sprinkler; drip or underground irrigation system; often a tank or reservoir; and pipes. If there is no surface water, a well has to be dug. A submersible pump is required for wells deeper than the suction limit for surface pumps (about 7 metres). Submersible pumps can operate automatically when combined with control float switches in the water tank and the well. In contrast, surface pumps are usually manually controlled by an operator who supervises them. Surface pumps are cheaper than submersible pumps and can be installed and accessed more easily (e.g. for maintenance). However, the choice between surface and submersible pumps depends on water availability. A solar pumping system has to be carefully sized according to: the depth of the water source; head (e.g. height to a tank or a field); and water demand/flow rate, which depends on the type of crop, plot size, and irrigation method used. The size of the PV panel increases according to the dynamic head,8 to the flow, and the required pressure. Drip irrigation is more water efficient overall, and requires less energy for the same volume of water due to a lower flow rate than an underground irrigation system requires. Batteries are usually not included, as it is more cost-effective to store water in elevated reservoirs—from which gravity pressures water to flow down to the field. The tank is filled when solar energy is in excess and water can be used to irrigate when irrigation is more efficient, such as during the late afternoon, at night, and early in the morning. For stand-alone pumping systems, pumps with DC brushless motors are preferable to their AC equivalents as they are more energy-efficient because they can directly use the current generated by the PV panels without adding inverters. Additionally, the decrease in the price of DC pumps in recent years makes them the most cost-competitive option.

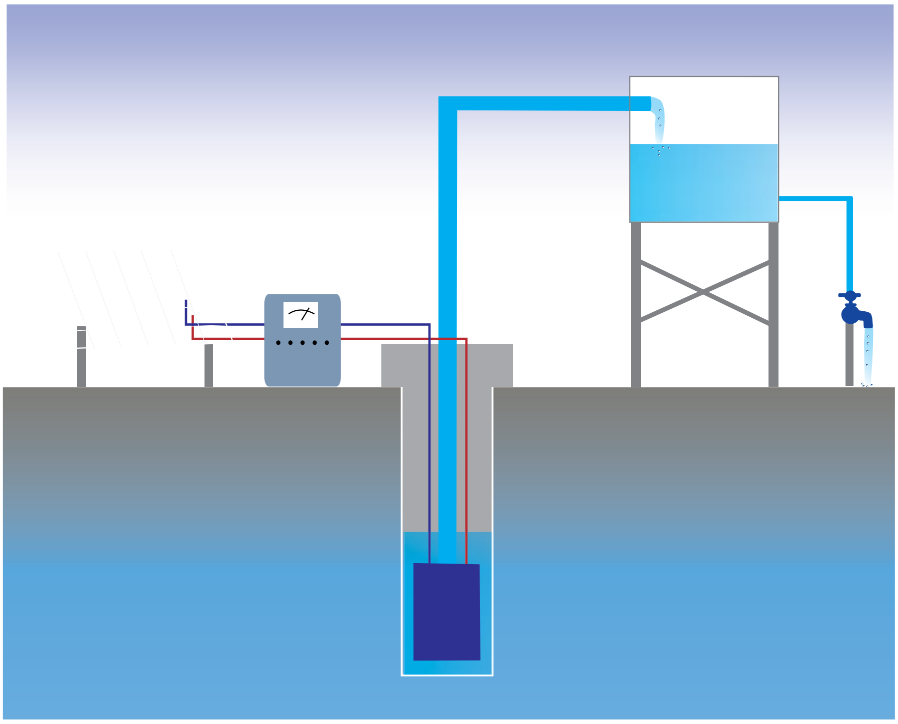


Figure 1: Solar pumping system[8] (RENAC, 2022)

Economic and Financial Feasibility

Solar pumping for irrigation is the only PUE application that has reached some scale in commercialisation. In 2019, GOGLA reported 28,000 yearly sales worldwide, but this estimate is incomplete.[9] Some business developments, such as those pursued by Bonergie in Senegal and Simusolar in Tanzania, indicate that the solar water pumps market is maturing. Bonergie in Senegal set up a special purpose vehicle with the institutional investor, InfraCo Africa, which committed USD 2.4 million of equity, and partnered with an Israeli supplier of drip irrigation systems. Simusolar in Tanzania extended its business to solar pumps in 2015. Between 2015 and 2020, their total revenues increased by a factor of 10, and solar pumps represented 31% of their revenues by 2020.

Case Study: Potato Farm in Senegal

Using examples and findings from a case study focused on a potato farmer in Senegal, the economic feasibility of solar pumping systems will be described. In this case study the farmer cultivated 1.5 hectares and replaced the diesel pump with a solar pump between 2017 and 2018.[11] The main financial benefits of the solar pump compared to its diesel equivalent are low maintenance costs and large fuel savings. In this case study, the farmer saved USD 2,545 per year from 2018-2019 (USD 2,384 fuel cost savings and USD 161 maintenance cost savings) and earned an additional €763 per year from the increase in yield. Thus, the investment was profitable, with a project IRR of 55% and a payback period of less than two years. Hence, a loan amount-ing to 70% of the upfront investment costs (with an interest rate of 20%) can be paid back within two years.

Since 2017, the evolution of the cost of diesel and the decrease in the price of solar pumping systems have reinforced the profitability of such an investment. Overall, the viability of the investment is highly dependent on the type of crop (and its specific water needs and retail value); on climate conditions (e.g. precipitation frequency and pattern and temperature); and on the irrigation technique the farmer uses (namely, drip or underground irrigation, which are both the most water and in turn energy-efficient solutions).[7] Sizing the system correctly and choosing the optimal irrigation technique are critical to maximising the system's financial viability. Suppliers usually offer advice on efficient irrigation systems and practices so that the water demand is minimised and the required capacity of the pump is reduced.

Technical configuration	
Installed PV panel capacity (kWp)	1.5
Flow rate (m3/day)	60

Investment costs	
Scenario 1: solar pumping system	$5,300
Scenario 2: new diesel pump	$180

Revenues	
Fuel savings (p.a.) Based on 7L/day during 306 days in the dry season and 3.5L/ day, during 23.5 days in the rainy season	2,224L $2384
Yield increase (p.a)	+12.5% 2,500 kg
Income increase (p.a.) Based on $ 0.305/kg	$763
Weeks to Simple Break-Even	52

Profitability	
Project Investment Rate of Return (IRR)	55%
Debt-Service-Coverage-Ratio Based on 70% loan @20%, 2-year tenor	1.2
Payback period (year)	1.75

Benefits and Outcomes

Irrigation can increase yields by 50% to 170%[7] compared to rainfed agriculture in a given crop cycle. In many countries in SSA, irrigation makes cultivation in the dry season possible, leading to potentially significant increases in smallholder farmers' income.

Through increased yields, irrigation not only improves farmers' livelihoods, but also, more generally, increases local food security and the country's resilience to international shocks. In the long run, farmers can move to more intensive and commercial farming practices.

Modern irrigation techniques do not have the drawbacks of traditional practices. One major drawback of traditional practices is their susceptibility to flooding, which leads to waterlogging, salinisation of soils, topsoil/nutrient depletion, and increased prevalence of water-borne diseases, like malaria.[10]

Constraints and Risks

The relatively high upfront cost of the technology, combined with the lack of consumer-finance options, is a major barrier to the sector's development. Historically, solar pumps have been sold as cash sales, so farmers had to pay the full price of the system upfront. In recent years, solar pump distributors, like Simusolar, have applied payment schemes such as lease-to-own, allowing farmers to pay off the system through instalments over 1.5 to 2 years. However, most companies have difficulties scaling up consumer-finance options because it increases their working capital needs.

Technical constraints can mostly be overcome by training local suppliers and by providing guidance to farmers. Remote system performance monitoring can also help to detect irregularities early. Lack of maintenance, incorrect system engineering (e.g. a missing water-level sensor or lowered pump tolerance because of sand or mud), or installation issues may damage the system significantly, compromising the investment as a whole. A methodical assessment of water and energy demand is essential for sizing the system correctly. Oversizing will lead to increased CAPEX, and undersizing may lead to lower yields than expected. In both cases, the profitability of the investment will be reduced. Additionally, efficient irrigation practices increase the probability that expected yields materialise and ensure sustainable management of water resources. Finally, strengthening downstream value chains between farmers and agri-processing industries and exporters is required to reduce market risk and ensuring that all produce is sold.

Future Perspectives

To overcome barriers to accessing finance, three main interventions are recommended:

- Support local suppliers, such as local pump distributors, in developing business models and extending consumer-finance schemes (e.g. supplier credit and lease-to-own). Support may also include helping suppliers render add-on services to their customers, such as enabling market access for the irrigated crops and offering information on efficient irrigation and good farming practices.
- Encourage agri-processing industries or exporters to finance solar pumping at the farm level.
- Provide guarantee funds and strengthen the capacity of banks in developing loan products, which can be accomplished by facilitating cooperation with reliable local suppliers and supporting banks in appraising loan applications for solar pumping—potentially reducing uncertainty and risks, and in turn, unlocking commercial financing.

While promoting solar pumping, offering advice on climate-smart agriculture practices is crucial to ensuring sustainable management of water resources and resilient communities.

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