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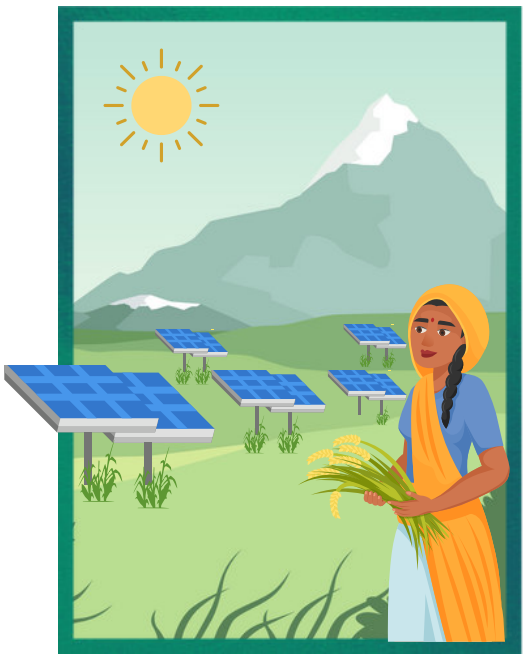

Grid-connected solar irrigation in Nepal – Exploring opportunities and identifying hurdles

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The Alternative Energy Promotion Centre (AEPC) offers subsidies for off-grid Solar Irrigation Pumps (SIPs) to promote sustainable irrigation practices. The utilization of these off-grid SIPs is low due to irrigation demand patterns. The potential for grid-connected solar irrigation is increasing as Nepal's national utility grid network grows. Nevertheless, despite net metering regulations, off-grid SIPs are not integrated into the national grid.

The Swiss Agency for Development and Cooperation (SDC) is implementing a pilot project called Solar Irrigation for Agriculture Resilience in South Asia (SoLAR-SA). The project aims to explore grid-connected solar irrigation and answer policy questions on the best techno-institutional model for grid integration in Nepal. Collaboration among major stakeholders during the implementation of pilot projects will contribute to developing guiding policies for grid-connected solar irrigation. Establishing specific policies for net metering targeted at agriculture meters is crucial for the scalability of grid-connected solar irrigation.

Introduction

In the southern Terai region of Nepal, there are approximately 1,337,000 hectares of irrigable agricultural land, only 18% of which is irrigated with groundwater (Kansakar 2006). Historically, to access pumped irrigation, the market was dominated by diesel pumps. Guided by the Subsidy Delivery Mechanism, 2016, Alternative Energy Promotion Centre (AEPC) is promoting solar irrigation by offering farmers a 60% subsidy (Pandey et al. 2020). The majority of AEPC-subsidized Solar Irrigation Pumps (SIPs) are small-sized systems of 1 horsepower (HP) (52%) and 2 HP (31%) and are concentrated in the Terai region (Kafle et al. 2022).

AEPC's solar irrigation program has been very effective in promoting solar irrigation and making solar irrigation one of the mainstream technologies in the Terai region. In reference to Figure 1, the demand for AEPC-subsidized SIPs has surged in recent years as farmers want to shift from expensive diesel-based irrigation to SIP, which has zero operational costs.

Current budgets to subsidize SIP are insufficient to meet the soaring demand for SIP. Hence, there is a need for a sustainable and scalable business model for solar irrigation.

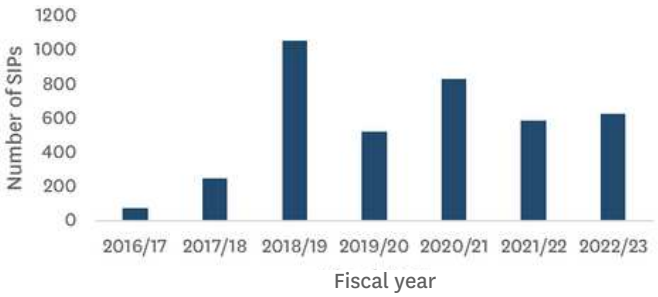

Figure 1. Number of AEPC subsidized SIPs installed per year
Source: Data received from AEPC in 2022.

Opportunities for grid-connected solar irrigation

Mérida García et al. (2019) suggested establishing a grid connection to an isolated SIP increases the possibility of using 80% of the plant's energy. Grid-connected SIP has lower Levelized Energy Costs (LEC) than off-grid SIP, and addresses over-abstraction of groundwater issues by feeding excess energy into the grid (Mantri et al. 2020).

The AEPC-subsidized SIPs in Nepal are off-grid systems and are installed at least 300m from the nearest grid. As the grid expansion of the Nepal Electricity Authority (NEA) occurs, the gap between grid-connected and off-grid areas will diminish rapidly. This presents an opportunity for grid-connected solar irrigation.

The economic value of wasted energy is significant

As of fiscal year 2021-22, there are close to 2,500 SIPs currently installed in the field, which have an estimated combined panel size of 4.5 MW with an annual generation of 6,125 MWh. Due to the nature of irrigation water requirements, the off-grid SIP's Capacity Utilization Factor (CUF) is very low. The cumulative annual energy wasted is estimated to be around 4,165 MWh, as shown in Table 1 on the following page. The value of the wasted energy as per NEA's new net metering tariff of NPR 5.94 is around NPR 24,739,700. The grid integration helps not only improve the CUF of these SIPs to 100% but also helps to inject wasted energy into the grid for productive use.

Peak annual irrigation demand unmet by off-grid SIP

A study conducted by the International Water Management Institute (IWMI) suggests that farmers who have access to SIP use less diesel, although SIP does not totally replace diesel pumps (Varshney et al. forthcoming). One of the main reasons for this is that off-grid SIPs are small and can only operate for around 4-5 hours per day, making them incapable of meeting peak annual irrigation demand (irrigation for paddy). Grid-integrated SIP has no restriction on operating hours, allowing them to meet peak irrigation demand and expand the coverage area.

Net metering revenue can be critical to the SIP's long-term business model

Suryashakti Kisan Yojana (SKY),[1] the grid-connected solar irrigation program in Gujarat, India, was reinstituted in 2023 after being introduced in 2018. This scheme combines a subsidy with financing to pay for the system, where the farmers need to pay 5% of the total cost of the system upfront, and receive 60% subsidies from the state and central government. For the remaining 35%, a low-cost loan is arranged for 7 years. In many cases, the net metering revenue from solar can cover the loan. This is represented and shown as an overlap shown in Figure 2.

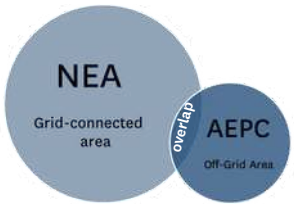

Figure 2. As the NEA's grid expansion occurs, there is an overlap between the working areas of the NEA (grid-connected electric pumps) and AEPC (off-grid SIP) in the irrigation sector.
Source: Author's creation.

In Nepal, a scalable business model for solar irrigation that combines subsidies and financing is required. Additional revenue from net metering, like the SKY plan, can play a key role in defining creative business models for growing solar irrigation.

Localized generation will help improve grid voltage

Frequent power outages and poor grid voltage quality are major problems in rural electrification in Nepal, as farms are frequently located at the tail end of the grid. Farmers are often unable to fully exploit the subsidized tariff in the NEA agriculture meters. Localized solar energy generation can help enhance grid voltage in rural areas and supply farmers with stable dual power sources. This access to a secondary source of stable electricity will greatly minimize the use of diesel-powered irrigation.

[1] https://sarkariyojana.com/gujarat-suryashakti-kisan-yojana-sky-solar-panel-scheme-farmers/

Table 1. Estimated energy wasted annually from currently installed AEPC subsidized SIPs.

Parameter	Value with units	Remarks
Current AEPC subsidized SIPs	**~2500 nos.**	AEPC database 2021-22
Estimated panel size	**4.5 MW**	Estimated based on AEPC database with 1.3 factor for solar
Annual energy generation	**6,125 MWh**	PVsyst Simulation
Annual utilization	**1,960 MWh**	CUF 32% based on SoLAR Phone Survey 2021
Annual wasted energy	**4,165 MWh**	Assuming all 2500 SIP are operational.
Value of wasted energy	**NPR 24,739,700**	NEA net metering tariff of NPR 5.94

Nationally Determined Contribution (NDC) target of 15% energy mix from renewables

Hydroelectricity dominates Nepal's energy sector, making up over 95% of the nation's installed capacity. The hydropower projects are vulnerable to frequent major earthquakes as well as climate change. It would not be suitable for Nepal's energy sector to put all its eggs in one basket (hydropower). As a result, energy diversification is a key agenda in the NDC target to reach a 15% energy mix from renewable sources such as solar and wind. As an estimated 4.5 MW capacity of solar from APEC's subsidy program is already in the field, a grid-connected SIP can help meet this target with minimal expenditure.

SoLAR pilot in Nepal

In India, there are several national and state-level projects, such as SKY and PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) schemes that have already implemented grid-connected solar irrigation projects. In Nepal, despite the working procedure for net metering of solar plants being in place since 2018, the grid integration of solar photovoltaic (PV) projects is limited to solar rooftop and utility-scale projects.

Figure 2. A farmer holding a basket full of fruits in Saptari district, Nepal.
photo: IWMI Nepal.

Grid-connected solar irrigation is an important concept that can improve long-term sustainability outcomes by preventing stand-alone, off-grid pumps from being abandoned once the national grid reaches these off-grid areas in Nepal (IWMI 2019).

A demonstration pilot project on grid-connected solar irrigation is being implemented through the Swiss Agency for Development and Cooperation (SDC) financed Solar Irrigation for Agriculture Resilience in South Asia (SoLAR-SA) project.

The main objective of the project is to answer the following policy questions (IWMI 2019).

- How can the off-grid SIPs be integrated into the national grid so that are not made obsolete once the grid reaches farmers who had no access to the national grid?
- What is the best techno-institutional model for grid connection of SIPs in Nepal?

To find a suitable site for the pilot, data from 22 rural municipalities were reviewed. Among them, eight sites were visited across five districts in the Terai region, which helped to shortlist two potential sites in Parsa and Udaipur districts. A feasibility survey was conducted at each site, which helped to finalize Chhipaharmai Rural Municipality in Parsa.

To implement the pilot project, Chhipaharmai Rural Municipality, AEPC, and NEA partnered with IWMI by signing a four-party Letter of Intent (LoI). The Farmer User Group (FUG) was formed based on the selected sites recommended by the feasibility study. The private sector was involved in the project as a contractor for IWMI, and helped with implementation of the project. The partnership modality of the grid-connected solar irrigation pilot is shown in Table 2 and Schematic shown in Figure 3.

Table 2. Partnership modality.

IWMI	• Lead the overall project design and implementation. • Provide technical and financial assistance and capacity building support.
Chhipaharmai Rural Municipality	• Local level facilitation and policy uptake from the learning. • Provide appropriate public land and complementary fund.
Farmer User Group	• Participate in the pilot project. • Allow decommissioning of the older SIP.
AEPC	• Uptake of research results and learning for policy.
NEA	• Provide equipment support. • Facilitate the process of installing net metering.

Issues and challenges with the adoption

In Nepal, grid-connected solar irrigation hasn't taken off despite the provision for net metering since 2018. Despite support from the implementing partners, Nepal's first pilot for grid-connected solar irrigation encountered several hurdles during project implementation. So, what hurdles need to be overcome to implement grid-connected solar irrigation in Nepal, and how can it be scaled?

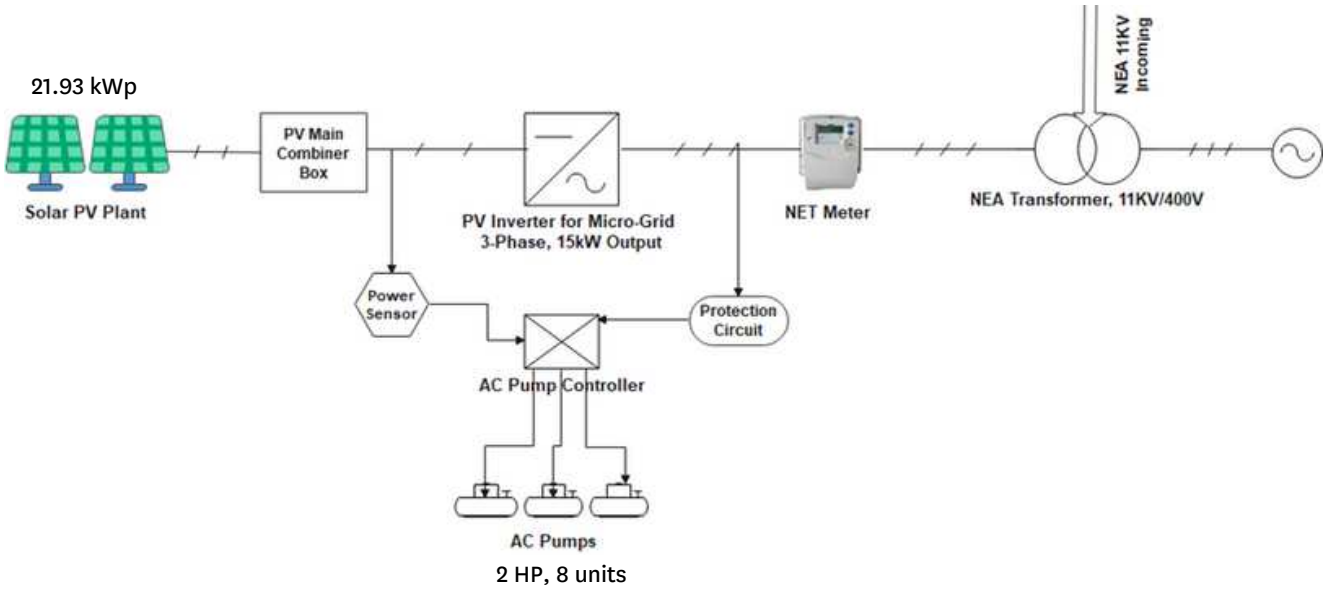

Figure 3. Schematic of the grid-connected solar irrigation pilot.
source: Author's creation.

A solar panel installed at Vasedwa Village, Katahariya Municipality, Rautahat District of Nepal.
photo: IWMI Nepal.

Gaps in government institutions overseeing grid-connected solar irrigation projects

AEPC's mandate is to operate in off-grid areas and its programs mostly implement off-grid SIPs, whereas NEA focuses on major hydropower projects. With the increase in generation and surplus energy during the monsoon and take-or-pay contractual obligations with Independent Power Producers (IPPs), NEA is prioritizing increasing energy consumption rather than buying energy from smaller solar PV systems. While NEA is also focusing on the agriculture sector for the consumption of surplus energy, buying energy from grid-connected solar irrigation is not on its primary agenda.

As a result, it is unclear which government institution should lead and promote the country's grid-integrated solar irrigation initiatives. This creates a significant deficit in national-level institutions in charge of such projects.

Guiding policies for grid-connected solar irrigation

Institutional solar grid-tied projects with net metering have been around for many years in Nepal. Grid-connected solar irrigation, on the other hand, is a novel concept in the country. The revised net metering policy approved by the NEA's Board of Directors was developed primarily for institutional solar rooftop projects offering a rate of NPR 5.94/unit. Agriculture meters (also known as *Krishi* meters) given by NEA get a subsidized NPR 2.3/unit tariff. As a result, it makes no economic sense for the NEA to sell energy at NPR 2.3/unit while purchasing surplus solar energy at NPR 5.94/unit.

To encourage and grow grid-connected solar irrigation in Nepal, guiding regulations aimed at NEA's agriculture meters are required, and tariffs should not add any financial burden on NEA.

Net metering in rural areas

Many institutional solar grid-tie projects are already commissioned with net metering. However, majority of these projects are limited to industrial and urban areas. In rural and semi-urban areas, the local NEA Distribution Center office lacks experience with net metering and procedural clarity in implementing grid-connected solar irrigation projects with net metering. Furthermore, the existing net metering setup is effectively a net-billing system in which the NEA does not pay the user for any excess energy put back into the grid.

Lack of clarity on the type of farmer user group

There is a lot of procedural unclarity for a farmer group to obtain a bi-directional Time of Day (TOD) agriculture meter. This is because there is no guiding document to provide clear information on the type of user community needed to apply for such connections, where they need to be officially registered and the number of members required in the user group. This leaves the sanctioning of such a system at the discretion of the person in authority.

Social dynamics and ownership of the system

The cost of grid integration for each system individually is high. In order to make grid-connected solar irrigation projects economically viable and scalable, we must examine grid integration at the community scale. Moving from an individual system to a community-level system may pose questions about system ownership and the social dynamics of the community will determine the project's success or failure. Maintaining the community's commitment to pay the electricity bills and maintaining the benefit-sharing mechanism for farmers to divide net metering income among themselves may also be difficult.

Way forward

To develop a scalable model for grid-connected solar irrigation, there is a need to address two key issues. First, specific policies for net metering targeted at the agriculture meters need to be established and the tariffs need to be set accordingly. Second, there is a need to explore other typologies for grid-connected solar irrigation suitable for Nepal.

Major stakeholders such as NEA, AEPC, local government, private sector and FUGs need to join hands and implement several pilots at different sizes (individual, community and institutional levels). The learnings from various pilot projects need to be captured and utilized to develop guiding policies for grid-connected solar irrigation. Guided by the learnings from the pilots, the net metering guidelines could be tailored for grid-connected solar irrigation that puts less financial and technical burden on NEA.

A vegetable market in Saptari district, Nepal.
photo: IWMI Nepal.

A woman plucking chillies at a farm located in Saptari district, Nepal.
photo: IWMI Nepal.

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Project

The Solar Irrigation for Agricultural Resilience in South Asia (SoLAR-SA) project aims to sustainably manage the water-energy and climate interlinkages in South Asia through the promotion of SIPs. The main goal of the project is to contribute to climate-resilient, gender-equitable, and socially inclusive agrarian livelihoods in Bangladesh, India, Nepal and Pakistan by supporting government efforts to promote solar irrigation. This project responds to government commitments to transition to clean energy pathways in agriculture. All countries in this project have Nationally Determined Contribution (NDC) commitments to reduce greenhouse gas (GHG) emissions and SIPs can play a significant role in reducing emissions in agriculture. https://solar.iwmi.org/

About SDC

The SoLAR -SA project is supported by the Swiss Agency for Development and Cooperation (SDC). SDC is the agency for international cooperation of the Federal Department of Foreign Affairs (FDFA). Swiss Agency for Development and Cooperation, which is an integral part of the Federal Council's foreign policy, aims to contribute to a world without poverty and in peace, for sustainable development. SDC, through its Global Programme Climate Change and Environment (GPCCE), helps find solutions to global challenges linked to climate change. It engages in global political dialogue and manages specific projects in the fields of energy, climate change adaptation, sustainable development of mountainous regions and prevention of natural hazards that are likely to influence regional and international policy.

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