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Factsheet Series: Sustainability Solutions for Mountain People and Landscapes

Connecting Micro Hydropower Plants to the national electricity grid in mountain areas in Nepal

Transmission line of the Tara Khola Mini Hydropower Plant in Baglung, Nepal. (Photo: Winrock, 2024)

Introduction

Nepal is known for its successful rural electrification through Micro Hydropower Plants (MHP), managed and owned by communities. MHP usually refers to power plants with a generation capacity of up to 100 kW. Over the last 30 years, MHPs have provided access to energy services in remote areas where the national grid was not available. In total, the Alternative Energy Promotion Centre (AEPC) and other partners have supported the rural communities in installing over 1800 MHPs (Energy Sector Synopsis Report, 2021/2022)[1]. The MHPs, managed by the communities, have transformed rural electrification efforts in the country's remotest communities, providing basic lighting, generating income, reducing drudgery, and improving health and education. In the last few years, the government of Nepal has been investing in expanding the national grid.

In many cases, local MHPs are gradually phased out when the national grid reaches the MHP area, as they cannot cover their financial operating costs when competing with it, posing a risk to the sustainability of the systems. Furthermore, the local community is often divided into supporters of the national grid and supporters of the MHP. However, the extension of the grid can also present an opportunity for well-managed and technically robust MHPs to reshape and strengthen their business models. By selling electricity to the national grid, the MHPs can grow their businesses and enhance their capacity to invest in local communities.
This factsheet introduces different facets of grid interconnection in the Nepalese context, as well as examples of their application.

The solution

The benefits of operating MHPs in rural, remote areas in recent decades have been manifold. MHPs have proven to be suitable for managing changes in electricity demand without costing a lot. They have also been able to handle fluctuations in demand better than traditional power stations, which are mainly designed for steady levels of demand and take longer to start up and operate. Moreover, they have been economically viable in comparison to the large investment needed to expand the national electricity grid[2]. As rural communities have been significantly involved in the installation and operation of the MHPs, the level of identification by the communities with the MHPs is high. Connecting MHPs to the national grid is one of the solutions available to sustain MHPs even after the national grid reaches the catchment areas.

The benefits of grid interconnection stem from their high efficiency (70 – 90 %), high capacity factors (>50 %), minimal power output fluctuations, and relatively low investment costs compared to other renewable technologies. It has been observed that when micro hydropower systems are integrated into the grid as part of distributed generation, they not only boost feeder line voltage but also reduce power losses by injecting power closer to the load centre[3].

In addition to this, the payback period for grid-connected systems is typically quite reasonable, often ranging from five to nine years. Consequently, when the national grid is close, MHPs can be interconnected, thereby reducing line losses, increasing load diversity and enhancing load factor. This leads to improved power quality and additional income generated for the MHPs[4].

There are technical, managerial and administrative requirements, however, that need to be addressed so that the MHP can be integrated into the national grid. The technical pre-conditions for grid interconnection are as follows:

- At a general level, the systems must share the same nominal frequency of 50 Hz.
- They must regulate this frequency to achieve and maintain synchronism.
- The systems need to interconnect at a common voltage level.
- The protective system must be coordinated, and adjustments need to be made when two systems are interconnected.

Until now, administrative requirements and processes, for example the connection agreement, Power Purchase Agreements (PPA), operating procedure, testing and commissioning, etc., are lengthy processes. Consequently, some communities have preferred to abandon MHPs instead of going through these processes[5].

Because of this, simplification of the licensing process for grid interconnection needs to be in place before a large number of rural communities can take advantage of the government's policy to interconnect MHPs of less than 100 kW.

Operator of the Nisi Khola III MHP in Baglung, Nepal. (Photo: Winrock, 2023)

For the grid interconnection to be feasible and financially beneficial for the communities, they have to be managed by a business or cooperative to provide a clear incentive to increase revenue and generate profits (Also see: "Towards entreprises or cooperative business models for MHPs in rural Nepal"). Furthermore, due to national regulations/laws, informal committees cannot be contracting partners. Thus, the organisation managing the MHP has to be officially registered.

Business and financing models

1) Power Purchase Agreements

A PPA is a contract between two parties, one who produces or generates power for sale (in this context the MHP cooperative/entrepreneur) and one who seeks to purchase power (Nepal Electricity Authority)[6]. In this case, Nepal Electricity Authority will buy all the generated electricity from the MHP at a predetermined rate per kWh. The first PPA of this type in Nepal was concluded in 2016.

By 2024, four of the ten MHPs connected to the grid are connected via Power Purchase Agreement. Initially, Power Purchase Agreements (PPAs) were preferred for the interconnection of MHPs. However, the PPA requirements for an MHP are similar to those for large hydropower plants. Because of this complex procedure, municipalities no longer opt for PPAs.

2) Net metering

Nepal passed a net metering policy in 2018, and the Ministry of Energy, Water Resources and Irrigation published a net metering directive in 2018[7]. Net metering is an electric billing mechanism that uses the electric grid to store and sell surplus energy produced by the MHP to the Nepal Electricity Authority (NEA). Six of the ten MHPs connected to the grid to date have implemented net metering, which allows them to sell electricity to households and NEA or buy it from the grid when there is excess demand.

3) Community-Private Partnership (CPP)

While the communities have experience operating Micro Hydropower Plants (MHP) in off-grid mode, they face challenges with grid-connected operations. Adjusting technical parameters based on grid variability can be difficult, and remote engineering support is sometimes required to fix controller faults.

Hiring a full-time engineer for such a small plant is impractical; engineers are often unwilling to work in remote locations for extended periods, and higher salaries would place a financial burden on the community. A potential solution is the Community-Private Partnership (CPP) model, where the community leases the MHP to a private company for operation and maintenance.

The private sector could manage multiple MHPs in the area, for instance several grid-connected plants in the same district, by establishing a team of engineers and technicians at the district headquarters responsible of all those MHPs. This arrangement could improve plant efficiency while providing the community with hassle-free revenue. Although the CPP model has not yet been implemented for grid-connected MHPs, it offers several advantages over the community model. Establishing a couple of demonstration projects under this model would be important to validate and promote this alternative.

Investment cost and business projections

To connect an MHP to the national grid, new distribution power lines have to be constructed. In Nepal, the grid interconnection of existing MHPs (just considering the cost of interconnection) is financially viable for MHPs above 20 kW if the interconnection distance (distance between MHP powerhouse and the nearest point of interconnection with the grid of 11 kW) is less than 1 km[8].

The power purchasing rate for MHPs up to 100 kW in size is NPR 8.4/kWh for 8 months (wet season) and NPR 8.4/kWh for 4 months (dry season).

The table below illustrates the financial performance of interconnecting a MHP of 50 kW to the national grid.

Projections for 50 KW Micro Hydropower

Particulars	Remarks
Annual electricity generation (at 75% plant factor)	325,000 kWh
Annual income from the sale of 45,000 units to 250 HH	NPR 450,000
Annual income from the sale of remaining 280,000 units to NEA (considering weighted average of NPR 6/kwh for entire year)	NPR 1,680,000
Estimated annual expenses (including salaries of two operators, one manager, and repair and maintenance)	NPR 1,300,000
Estimated Annual Savings	NPR 830,000
Cost of grid interconnection (capital investment)	NPR 6,000,000
Payback period Bank debt (12% interest rate) covering 100% of capital investment	around 9 years
Grant/subsidy covering 30% of capital investment	7 years

Note: The Government of Nepal provides up to 50% of the capital expenditure for MHP grid interconnection. Therefore, the figures in the table may vary depending on the proportion of expenditure supported by the Government of Nepal.

Socio-economic and sustainability impacts

Grid interconnection not only has the potential to improve the viability and longevity of MHPs. It is also a means to achieve broader socio-economic goals in rural, remote areas of Nepal, making it a solution that can help improve rural livelihoods.

Interconnection of MHPs to the grid can improve the reliability and quality of grid service through dynamic energy exchange between the plant and the national grid, as well as reducing consumer tariffs. Consequently, there are specific benefits for businesses (e.g. increased productivity and improved working conditions), households (e.g. improved lighting, use of electrical appliances such as radio or e-cookers)), and communities (e.g. reliable electricity for local health facilities). Another advantage is that the sale of (surplus) electricity to the grid generates an additional revenue stream for the community. Moreover, selling surplus energy to the grid provides additional incentive for the local community to monitor the power plant and invest in technical support[9].

Capacity building for grid interconnection is crucial to exploit potential employment opportunities, as specific skills are needed to install, operate and maintain the MHPs. For grid-interconnected MHPs to bring maximum benefits to the communities, a strong emphasis must be placed on productive uses of electricity. For instance, by using the improved electricity service to grow existing business or create new value chains. Finally, it can reduce the economic pressure to migrate in rural communities by creating quality jobs and income in the communities.

Grid interconnection can improve quality and reliability of grid services benefitting productive uses of energy for businesses. (Photo: WISIONS, 2023)

Scaling-up potential

Grid interconnection in Nepal has significant scale-up potential, as there are many MHPs greater than 30kW that are potentially suitable for grid interconnection.

The technical standard for grid interconnection was approved by NEA in 2014 and has opened up the opportunity for many MHPs in rural areas to connect to the national grid.

Moreover, financial and technical support for grid interconnection is currently available through the Nepalese Sustainable Energy Challenge Fund (SECF). It is a funding mechanism based on viability gaps to make projects feasible and bankable, offering results-based payment and technical assistance through project assessment, implementation support, and monitoring[10].

However, despite the successful interconnection of several MHP systems and multiple solar PV systems, the existing policies remain unclear, and implementation lacks consistency. Consequently, ongoing lobbying and advocacy efforts are necessary to promote grid interconnection for renewable energy projects. This approach is crucial for exploiting the advantages of distributed generation, which not only improves grid reliability but also enhances the quality of electricity supply[11].

Case study

Syaurebhumi MHP, Nuwakot
Installed capacity: 23 kW
Business model: PPA
Source: HPNET (here)

Syaurebhumi MHP has demonstrated that grid interconnection is both technically feasible and financially attractive. The grid interconnection of MHP is a viable solution for utilising existing power generation capacities from natural resources. Furthermore, the voltage of the feeder line has been increased by 2% at the point of common coupling.

Thus, the distributed generation (grid-interconnected system) has not only minimised the transmission and distribution losses but also improved the quality and reliability of the distribution system.

Lessons learned

Based on experience to date, the following recommendations can be made for scaling up grid interconnection of MHPs in Nepal.

1) Simplified net metering procedure

A rural community has to travel to the capital Kathmandu to sign a net metering agreement. The utility could also do this through its field offices, as it does for small scale solar projects.

2) Technological advancement

A number of projects have shown that Electronic Load Controllers (ELC) and Automatic Voltage Regulators (AVR) need to be modified to make them more robust and community-friendly. An integrated controller for grid interconnection needs to be developed.

3) Policy support

The benefits of grid-connected MHPs have been recognised by utilities as they help to improve the reliability and quality of lines and reduce electricity losses. However, there is no specific policy for grid-interconnected MHPs. They depend entirely on the decision of the utility's board of directors, which can be revoked at any time. There should therefore be a specific policy to support it.

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This factsheet is part of the series “Sustainability Solutions for Mountain People and Landscapes,” developed within the WISIONS Innovation Lab Nepal. The aim is to promote an integrated approach to strengthening the livelihoods of people living in mountain communities. Each factsheet provides information on specific sustainability solutions in the fields of energy and landscape management that have shown promising potential for improving the livelihoods of mountain people but have a low level of adoption in Nepal and other mountain regions. The information is tailored to the specific context of Nepal's mountain landscapes and offers practical insights and guidance for scaling up the application of these solutions. Additionally, it presents an integrated approach that begins with an understanding of the opportunities and challenges faced by mountain communities, enabling the systematic deployment of synergies between solutions from the energy and landscape sectors.

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