Rewriting the Indian micro hydro story

Exploring possibilities through grid-connected and hybrid systems, new business models, and innovative support systems

SHAKTI SUSTAINABLE ENERGY FOUNDATION

WEFT

NBIRT
EMPOWERING RURAL INDIA

About the Initiative

India has significant hydro potential, which it has effectively tapped since independence to address its growing energy needs. Of the hydro power mix (large, small, and micro), micro hydro power (MHP) projects (5–100 kW) are important as they address the energy needs of rural communities in remote locations. However, many MHP plants have become non-functional over time, due to various reasons.

An initiative on 'Strengthening Micro Hydro Power for Sustainable Energy Access' by WEFT Research and NB Institute of Rural Technology, with support from Shakti Sustainable Energy Foundation, proposes an approach to not only revive such non-functional MHP plants but also develop them further to maximise their potential. The central idea is to improve the reliability of electricity supply within the local communities, and ensure the viability and long-term sustainability of such projects.

The overall approach involves: (1) revival/ restoration of the MHP or establishment of an MHP where potential exists and has not yet been tapped; (2) integration of the MHP with the grid to enable free flow of power to and from the grid; and (3) where techno-economically feasible, integrate the system with solar photovoltaics (PV) to tap the seasonal complementarity of solar and hydro resources.

The project involved a step-wise modular approach (Figure 1). Based on the analysis of data on small hydro and micro hydro potential as well as other relevant data such as state of DISCOMs (distribution companies), grid electrification status, etc., the project team shortlisted the states of Manipur, Meghalaya, Odisha, Uttarakhand, West Bengal, Assam, and Arunachal Pradesh as priority and high-potential states. From these states, 10 sites were selected where pre-feasibility studies were conducted. Finally, on the basis of a multi-critieria site assessment framework developed by the team, three sites were selected: (1) a remote village in Odisha, (2) a tea estate in Meghalaya, and (3) a campus in Manipur. For these sites, detailed project reports (DPRs) and project information memorandums (PIMs) were prepared to facilitate the implementation of these projects.

The project team learnt many lessons in the process; a few important ones are shared in the subsequent pages of this document. The team also shares its insights on how policy and regulatory push and institutional strengthening can accelerate sustainable growth in the MHP sector.

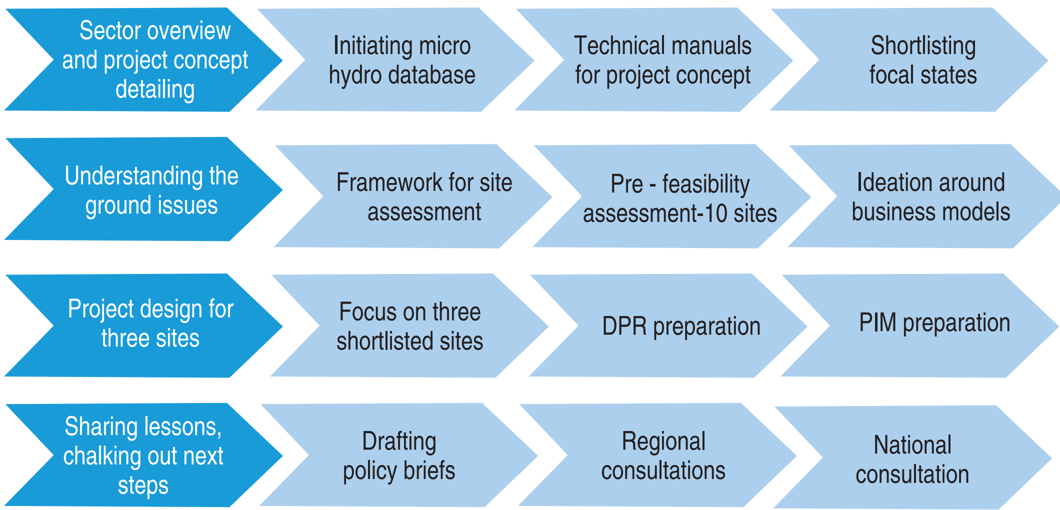

Figure 1: Step-wise modular approach

HIGHLIGHTS

- Micro hydro power (MHP) in India dates back to over a century and the technology is well-established. Yet, there is large unutilised and inoperative micro hydro capacity in the country, due to various reasons.
- Many of these inoperative plants may be restarted with minor renovation or even after debris cleaning.Their capacity utilisation and economic viability will improve considerably if they are connected to the grid and supported with feed-in tariffs. At some sites, plants have been shut down due to low water flow in the dry season. In such sites, hybridisation with solar PV along with grid connection will ensure year-round operation to reliably meet the growing electricity aspirations of communities and commercial enteprises.
- The investment requirement for such strengthening of existing MHPs with grid interconnection and solar hybridisation compares favourably with benchmark costs for rooftop solar panels. Policy incentives for grid connection and hybridisation as well as attractive feed-in tariffs will be important to ensure viability.
- MHPs were earlier seen as social sector projects based on grants and subsidies. Private sector activity was minimal despite incentives. Yet, many successful MHPs are run by commercial organisations such as tea estates. Commercial business models must be explored with focus on viability. Micro hydro start-ups ('water to wire' companies) must be nurtured to ignite the sector.
- Skill-building and technology support for innovations that enhance efficiency, safety and resilience, along with demonstration projects showcasing techno-economic viability will be important for replication. With replication, costs will drop further.
- Several MHPs have been affected by natural disasters like floods and landslides. Risk mitigation options such as weather-linked insurance and bridge finance to cover additional costs for higher resilience will have to be factored in by policy makers and financiers.
- The Ministry of New and Renewable Energy (MNRE) along with its state nodal agencies (SNAs) and their district officers need to anchor this effort along with various agencies. Active engagement with the state electricity regulatory commissions and power distribution companies will be key.

Contents

SECTOR BACKDROP

Hydropower is based on the concept of the force of moving water rotating a turbine that activates a generator and generates electricity.

India has a long history of hydropower, but its share has been declining

- India's first formal hydropower project was a 130-kW small hydro power (SHP) project established in Sidrapong, Darjeeling, in 1897.
- India's share of hydro was over 45% in the early 1960s, but has now declined to just 13% (Figure 2).

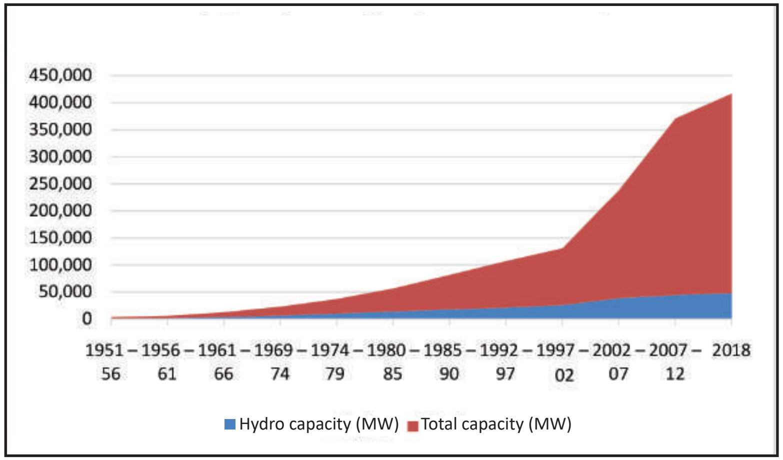

Figure 2: Declining share of hydropower

Share of small hydro has remained low, but there is enormous potential, only 25% is tapped

- SHP capacity (less than 25 MW capacity) is just one-tenth that of large hydro.
- From 63-MW SHP capacity in the 1980s, the SHP capacity has increased to over 4.5 GW today with incentives being offered by the Ministry of New and Renewable Energy (MNRE).
- Some capacity established by the private sector; 24 states with specific policies to attract private sector investment in this space.
- Decline in SHP capacity addition in recent years due to
  - higher costs (as the sites are more remote),
  - no corresponding increase in feed-in tariff,
  - predominance of solar photovoltaics (PV) following the launch of the Jawaharlal Nehru National Solar Mission (JNNSM), and
  - focus on grid electrification resulting in a shift away from decentralised power generation.

Micro hydro, a subset of small hydro

- On the basis of capacity, small hydro projects, which are considered as renewable,[1] have been classified as pico / watermills (up to 5 kW), micro (6–100 kW), mini (101–2000 kW), and small (2001–25,000 kW).

[1] For the purpose of RE accounting, large hydro has also been classified as renewable since early 2019

- Based on the method of storage of water to run the turbine,[2] hydropower projects may be classified as (i) storage (uses a dam to create a massive water reservoir downstream of a river), (ii) pumped storage (uses two reservoirs at different levels to maintain water flow), and (iii) run-of-the-river (uses the current of a diversion canal to rotate a turbine and does not need a storage reservoir). Most mini/micro hydro projects are run-of-the-river type and a few are of pumped storage type.

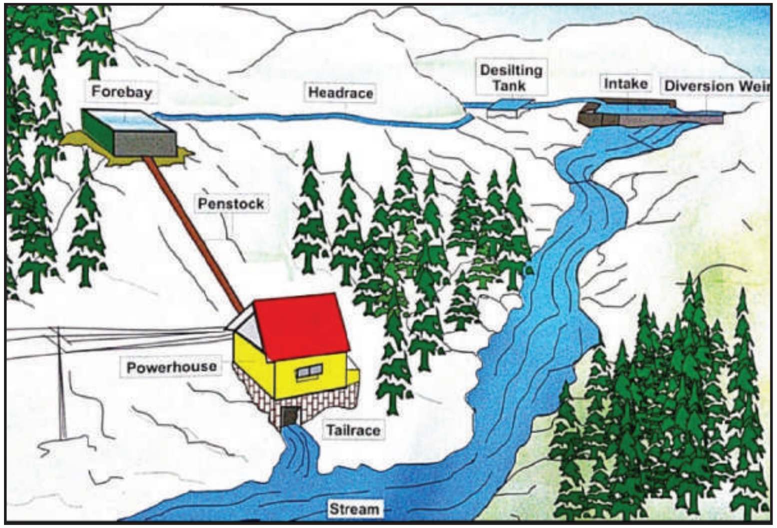

Figure 3: Schematic representation of a micro hydro plant

Micro hydro projects in India: now faced with challenges

Historically, MHPs have played a significant role in providing first-time electricity access to remote and marginalised communities. Technology is proven and many projects have operated effectively for decades. However, discussions with MHP project operators and experts point to several challenges, as listed below.

- Because of their positioning as stand-alone[3] solution for rural electrification in remote areas, there has been little commercial or business orientation in running MHPs except in the tea estates.
- Several MHPs that have worked well in the past are no longer functional due to either lack of capacity for operation and maintenance (O&M) and/or due to the arrival of the grid. Though there is community interest in reviving them, there is lack of confidence in the system's ability to provide reliable and affordable power, and in local capacity to operate and maintain these systems.
- Seasonal variations in water flow combined with poorly designed and maintained systems have meant that such MHP projects are unable to operate on a continuous basis to meet the demand for electricity through the year.

No structured information base specifically for mini/micro hydel projects

Data gathered for 19 states from state nodal agencies (SNAs), Alternate Hydro Energy Centre (AHEC) database, and informal discussions with various sources including technology / equipment providers indicate the following:

- Of 177 sites across 19 states, only 10 have been confirmed as working. This points to the likelihood of a large number of defunct plants, indicating wasted investment.
- Among nine existing MHP sites visited for pre-feasibility assessment, only two were found to be working. Both of these are in tea estates.

A new project concept involving hybridisation and grid-connected MHPs may address several of the issues being faced by MHPs in India.

[2] The key components of an SHP/MHP project are: (i) water conveyance system (including intake, penstock, forebay tanks, settling basin, etc.), (ii) turbine, (iii) generator, and (iv) controller/load flow controller.

[3] Not grid-connected

THE PROJECT CONCEPT

About the Initiative

An initiative conceptualised by WEFT in technical partnership with NBIRT, with support from the Shakti Foundation, **aimed to demonstrate improvement in the operational and financial sustainability of MHPs, mainly through hybridising MHPs with solar energy as well as connecting them to the grid** (Schematic representation of project concept in Figure 4).

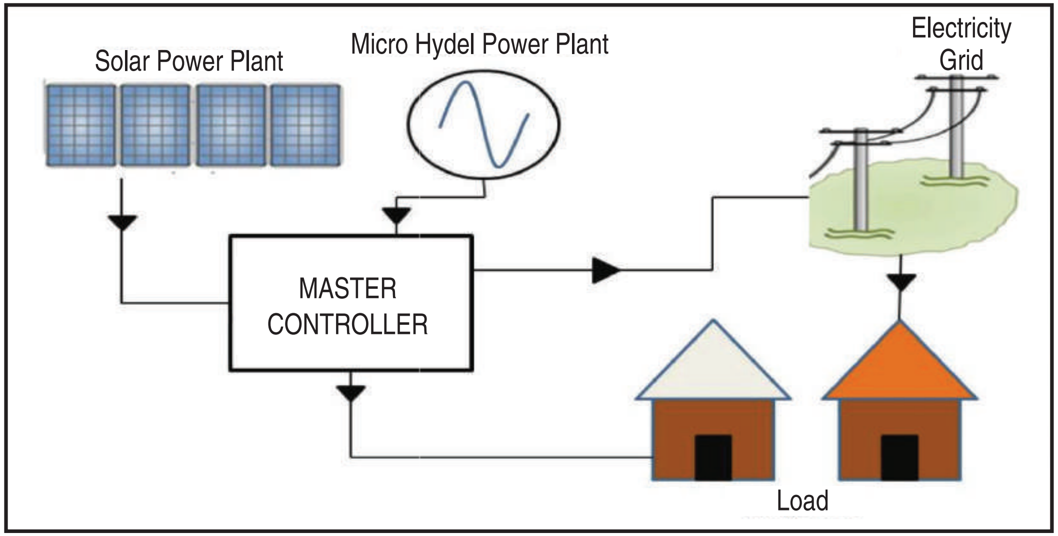

Figure 4: Schematic representation of a grid-connected solar–hydro hybrid project

What is the basis for this idea?

- Data show that there is seasonal complementarity between hydro and solar resource availability (see Figure 5 for two sites in Odisha and Meghalaya); while hydro generation peaks during rainy months (typically July to October), the solar resource is highest during the rest of the year. As a result, stable flow of electricity is possible from two variable sources – solar that has day-night variations and hydro that often (but not always) has seasonal variations.
- The inclusion of microcontrollers and grid-integration makes these systems sustainable even after the grid arrives.
- Reliable in-house or on-site generation of power reduces dependence on the grid, resulting in cost savings on account of grid power as well as on back-up power (such as kerosene lamps and diesel generators)
- With an appropriate feed-in tariff, sale of excess electricity to the grid brings in revenue, which can be used towards the maintenance of the MHP project as well as for additional income.
- This is also beneficial to the grid with reduced electricity flow over long distances and associated losses due to the presence of a tail-end generating plant.

In summary, this concept renders past and future investments in MHPs sustainable.

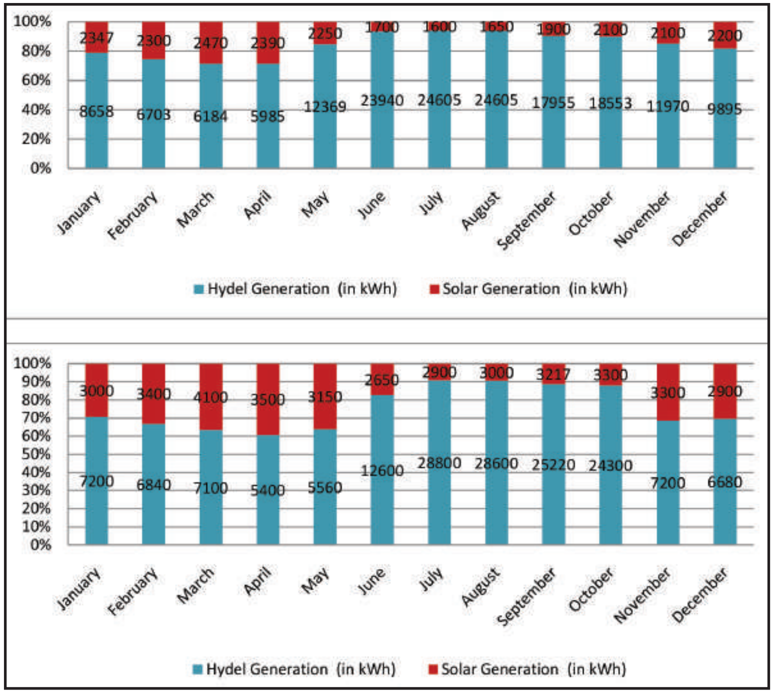

Figure 5: Hydro–solar balancing diagram showing complementarity of the resources at Odisha (top) and Meghalaya (bottom) sites

Where will this project concept work?

In order to first shortlist states where such a project concept is likely to be effective, the following criteria were employed:

- Micro hydro potential
- Potential and relevance of hybridisation with solar PV by verifying if there is seasonal variation in water flow
- Solar PV potential (this can be assumed to be reasonably available across the country)
- Low risk of natural disasters
- Health of the DISCOMs given that the project will be grid-connected
- Status of electricity access in the area (projects are more likely to be supported in areas with unreliable grid electricity)
- Ease of doing business/favourable small- and medium-sized enterprise (SME) ecosystem.

Based on these criteria, the states of **Manipur**, **Meghalaya**, **Odisha**, **Uttarakhand, West Bengal, Assam, and Arunachal Pradesh emerge as high-potential states**.

Further, at a specific site (with an operational, inoperative or potential MHP), the feasibility for such a project may be undertaken employing a multi-criteria framework (see Figure 6).

TECHNICAL FEASIBILITY	NEED FOR PROJECT	CAPACITY TO IMPLEMENT AND MANAGE	CAN BE FINANCED WITH EASE?
• Is the project site accessible? • Is there a potential for new MHP or for repair/renovation of existing MHP at reasonable cost? • Is there potential for solar PV (around 50% of MHP capacity) • Is there need for solar integration? That is, does the MHP run at low capacity during dry season? • Is it technically possible to connect to the grid?	• Will this project address a gap – reliability, affordability, quality – in the current source of electricity? • Is there demand/offtake potential?	• Is there an enterprise / NGO / other organisation that has interest and capacity? • Is the SNA active? • Is skilled/trained manpower available locally? • Is there any organisation (community organisation/ local enterprise/ any other) with interest and ability to run the project?	• Is the risk of offtake low or manageable? • Is there a high likelihood of remunerative tariff? • Have project/ equipment quality issues been addressed adequately? • Have durability issues for the project due to political and environmental risks been addressed adequately? • Is project performance protected from weather-related factors?

Figure 6: Multi-criteria site assessment framework

Is such a project viable? Are there any risks?

In this study, 10 sites were evaluated for pre-feasibility. Nine of these were found to be techno-economically feasible (Table 1). In cases where the MHP exists but has become defunct, there is some MHP renovation involved apart from grid connectivity and investment in solar PV capacity; the cost varies from a little over Rs 20,000 per kW to around Rs 68,000 per kW (depending on the extent of MHP renovation needed). There is also an instance where an 80 kW project can be revived merely by minor repairs to the MHP and grid inter-connection (at an investment of just Rs 17.55 lakh) where solar PV capacity is neither possible nor necessary. **The per-kW cost for most projects compares favourably with the benchmark cost of grid-tied solar rooftop PV** (at around Rs 50,000 per kW). [4]

But these projects are not without risks as they are typically located in remote and hilly areas. **Of the nine existing MHPs surveyed, six have suffered varying degrees of damage due to rock-fall, landslides or floods.** Thus, risks relating to weather/climate can be high, and will have to be mitigated (as described later). There are also risks around policy uncertainty, unpredictable changes in electricity demand, emergence of disruptive technologies (e.g., on energy storage), and economic and political risks in some sites. The design of policy/regulatory support and business model can provide much-needed buffer.

Has the project been tried anywhere in India?

This project concept has its genesis in an early pilot that was demonstrated in a **grid-interactive micro hydel-solar hybrid system in Assam**. This is a 10-kW MHP on Ampi stream in Upper Killing village in Kamrup, Assam, catering to 48 households and a community centre. This was commissioned in 2007, but was shut down after the arrival of the grid in 2014. When the grid proved to be unreliable, the project concept was demonstrated with MHP renovation, inclusion of a 5-kWp solar PV plant, control, synchronization, protective and metering equipment, and smart-grid-based connectivity with the grid.

[4] https://mnre.gov.in/sites/default/files/webform/notices/Off_Grid-&-Grid-Benchmark-Cost-2018-19.pdf

Table 1: Summary of pre-feasibility assessments: Positive findings at nine sites out of ten covered

Site - state	About the site and project	Hydro-capacity (kW)	Solar-capacity (kW)	Estimated project cost (Rs lakh)
Karnibel – Odisha	Remote tribal village, Commmunity centric inoperational MHP, minor repairs needed	28	15	17.90
Karlapath – Odisha	Remote tribal village, Commmunity centric inoperational MHP, major damage by floods	38	21	31.66
Purnagumma – Odisha	Remote tribal village, Commmunity centric inoperational MHP, minor repairs needed	12	6	12.12
Amthaguda – Odisha	Remote tribal, village, Commmunity centric inoperational MHP, major damage by floods	20	10	23.47
Umlun – Meghalaya	Tea estate, operational MHP runs for 4 months	50	25	23.00
Kanyalikote-Uttarakhand	Remote hilly terrain, inoperational MHP, Minor damage to MHP, solar hybridisation not recommended	80	0	17.55
Ambootia – West Bengal	Tea estate, MHP recently inoperational, no major problem	80	40	26.03
Rungmook – West Bengal	Tea estate, operational mini hydro project, runs for 4 months	250	125	78.17
Hengbung – Manipur	Greenfield project, MHP with solar-powered pumped storage	12	40	63.00

DPRs and PIMs have been developed for three different types of projects:

- An inoperative MHP in a remote tribal village in Odisha: MHP to be renovated, grid-connected and hybridised with solar PV (owned, operated and used by a village community).
- Existing operational micro hydro project in a tea garden in Meghalaya: Minor repairs to the MHP, hybridised with solar PV and connected to the grid (for commercial use by the tea estate).
- New micro hydro project on a campus in Manipur: MHP to be set up, solar PV plant to be set up (to power the pumped storage to ensure year-round operations of the MHP), and both plants to be connected to the grid (for mixed use by community and social enterprise).

DETAILED PROJECT INFORMATION FOR THREE SITES

Reviving and strengthening an inoperative micro hydro project in a remote tribal village in Odisha

Site location

The project site is Karnibel village in Thaumal-Rampur block, Kalahandi district, considered to be among India's poorest districts. It is located 60 km away from the district headquarters and the nearest rail head, Bhawanipatna. Karnibel village has 22 households, all tribal. Karnibel is remote and poorly endowed in terms of infrastructure, with no community facilities like a hospital, school or community centre. There is one bank in the vicinity, Utkal Grameen Bank. The average 5–6 member household in Karnibel has an income of around Rs 4,000 per month.

Turbine at Karnibel power house

Penstock alignment

A typical house is 'kutcha' with an area of not more than 40 sq.m., with two lights and two charging points. All households are now connected to the grid (since 2012), but grid electricity is unreliable with power outages for over 12 hours every day. Sometimes, power outages last for many days at a stretch. The typical electricity bill is Rs 150 per month (flat bill on account of being in the lowest slab of electricity consumption). The major occupation is farming, which is mostly for subsistence, with small parts of their produce being traded in local markets. Average landholding is 4 acres per household.

The MHP

A standalone MHP was set up on the Karnibel stream in Karnibel village in 2009 by an NGO, Gram Vikas, with funding support from Swiss Agency for Development and Cooperation (SDC). The project functioned well, though only at 8 kW capacity reportedly, due to inadequate water flow in the stream. The project met the household and limited livelihood energy needs of the local community. In 2016, the MHP was damaged and it has not been functioning since then. Availability of grid power (though unreliable) and inability to mobilise investment needed to renovate the MHP, reportedly, resulted in inertia to restart the MHP.

Proposed project

The proposed project involves the following:

- Renovating and restarting a 28-kW MHP (some debris cleaning, civil work in power house should help improve the efficiency of the system and restore water flow)
- Installation of 15-kW solar PV, which would work well during dry months
- Grid connection (master controller, grid-interconnection, and metering arrangement) to allow two-way flow of electricity

The project will be owned and operated by the Village Committee with initial hand-holding by Gram Vikas. Till economic activity and infrastructure take off in the village, there will be significant surplus of electricity, given the low level of current household demand. Thus, it is critical for this project to be connected to the grid in order to realise its benefits.

The total project cost is Rs 17.90 lakh and is seen to be viable (positive NPV) based on an assumption of a feed-in tariff of Rs 6.50/kWh.

Benefits: Optimal utilisation of investment made in MHP by converting it into a green RE power project with year-round reliable electricity generation; reduced dependence on grid; possibility of additional energy consumption; and possibility of additional revenue from sale of surplus electricity to the grid.

Project in a tea estate in Meghalaya: strengthening the operational MHP by inclusion of solar PV and grid inter-connection

Site location

The project site is at the Anderson Tea Estate located at Umran Dairy, Ri-Bhoi district, Meghalaya. It is around 40 km from Shillong and 2 km off the Guwahati–Shillong Road (SH 6). Located at an altitude of around 700 m, it experiences moderate climate with the temperatures ranging from 35 °C in summer to 10 °C in winter. The weather is predominantly dry except during the monsoons from June to September. The site is not only easily accessible by road but also has access to other facilities such as health care and banking within close proximity. The estate is spread across an area of 300 acres and has a facility for the post-harvest processing and manufacturing of about 100 tonnes of tea per year. Based on the typical load-curve information, it is estimated that the maximum power requirement during the peak season is around 75 kW for a period of 13 hours. Additionally, the total load within the accommodation provided for staff and labour is around 5 kW.

The MHP

A 2 × 25 kW standalone Umlun MHP was set up on the Umium stream with the tea estate's own funds and government subsidy in 2016. Electricity user is the tea factory – tea processing equipment (withering fans, hot air blower, CTC cutter, CTC sorter, fermenting fans, drier, packaging). The electricity generated by the MHP offsets the electricity

Power house at Meghalaya site

consumption from the main grid as well as the diesel generator, which is operated when the grid is not available. **If reliable electricity is available round the year, the tea estate will reportedly be able to enhance its portfolio of teas, apart from reducing diesel costs for back-up electricity**.

Proposed project

The proposed project involves the following components:

- Minor repairs to the MHP, as most of the structures and equipment are in good working condition
- Setting up a 25-kW solar PV plant with synchronising unit
- Master controller, grid-interconnection, and metering arrangement

The estimated project cost is Rs 23 lakh and is expected to be funded by the company's own resources with some small loans. The project will be owned and operated by Anderson Tea Estate. While there will be no significant surplus of electricity during the peak season of tea processing, it is expected that there will be significant surplus during the lean season, when there is little or no captive demand. As the energy consumption by the tea estate is comparable with that of the energy generated, and the energy (variable) tariff is high and is comparable with expected feed-in tariff, net metering has been assumed here for the purpose of computing the net benefits. Based on an assumption of feed-in tariff of Rs 6.80/unit, the project is expected to be viable (positive NPV).

Benefits: Better capacity utilisation of MHP and additional power generation from MHP and solar; possibility to produce more varieties of tea with year-round, reliable availability of power and surplus power generation during off-peak season.

Water conductor channel – Meghalaya tea estate

Greenfield project on a campus in Manipur: grid-connected MHP with solar PV-powered pumped storage

Site location

The project site is at the campus of FEEDS (Foundation for Environment and Economic Development Services) at Hengbung, Kangpokpi district, Manipur. It is about 50 km from Imphal and just off the Asian Highway 1 (AH 1) / National Highway 2 (NH 2). Located at an altitude of around 1,177 m, it experiences moderate climate with temperatures ranging from 35 °C in summer to 10 °C in winter. The site is not only easily accessible by road but also has access to other facilities such as schools, churches, health care and banking, within close proximity. Hengbung, along with the surrounding area (includes a few more villages), is administered through the Village Authority System, with a chief, who is also the founder/ head of FEEDS. Hengbung has around 279 households, which will benefit from the project. The primary economic activity within this settlement is agriculture (rice and jhum cultivation – maize, potatoes, vegetables). Households are also involved in cattle rearing, poultry, though in large part for own consumption, and piggery. The typical monthly earnings per family ranges from Rs 4,000–10,000 per month.

Electricity requirement at the FEEDS Campus is for a range of activities that revolve around finding alternatives to ecologically damaging jhum or slash-and-burn cultivation (e.g., orchid research, Krishi Vigyan Kendra, ethno-medical research, college of horticulture, mushroom spawn production centre, fruit orchards, community FM radio station, proposed rural tourism centre).

The proposed project

The proposed project aims to improve the reliability of supply to the FEEDS campus and the settlement nearby. Solar is owned and operated by FEEDS and is being funded by the Department of Science and Technology and Mission Innovation. A team of four engineers have been assigned the task of supervision of implementation and later, the O&M for the project. Figure 7 represents the proposed project schematically.

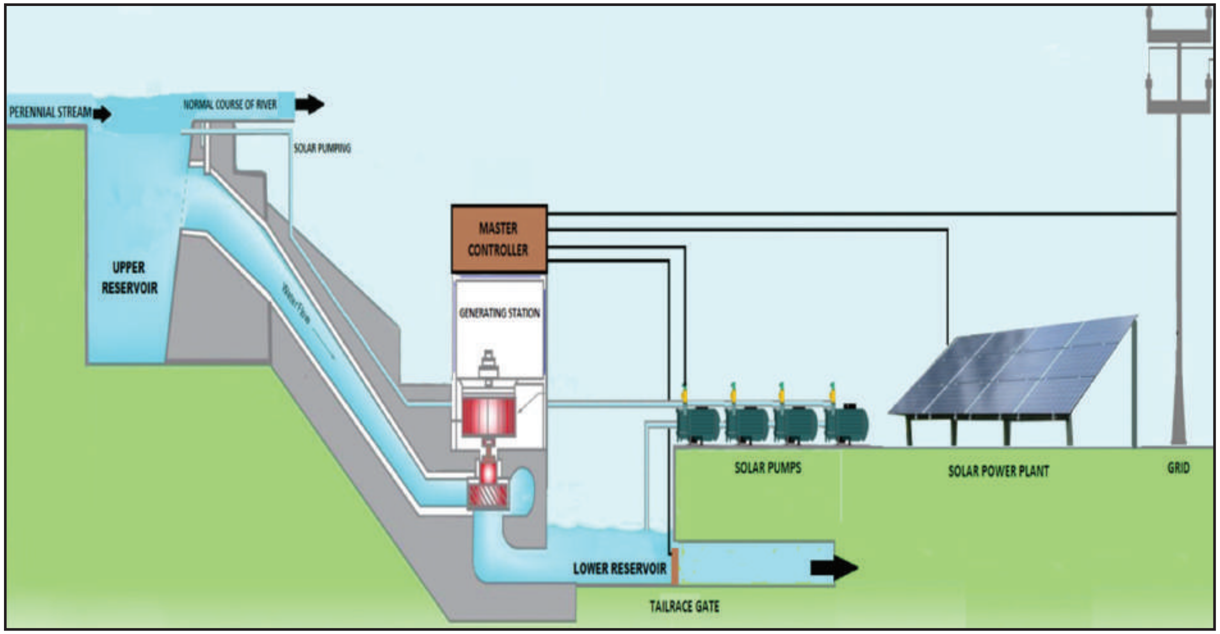

Figure 7: Schematic representation of grid-connected micro hydro project with solar-powered pumped storage

Manipur site work ongoing

This project is a demonstration project and the operational and financial aspects of the project are expected to be discussed shortly.

Upcoming project in Jharkhand

The Ramakrishna Mission TB Sanatorium in Ranchi district, Jharkhand, has been catering to the medical needs of poor patients suffering from TB for more than 60 years. The Sanatorium has substantial power requirement, but depends heavily on diesel generators as grid electricity is erratic. Based on micro hydro and solar PV potential in the area, it is proposed to install a solar PV-powered pumped storage project (similar to the Manipur project) with15-kW hydel and 60-kW Solar PV to cater to the power requirements of the Sanatorium. Minimum civil construction work is required as the 283-acre campus already has a large reservoir at an elevation where water gets stored and is then released into the lower stream as required.

This project has several innovative aspects:

- Use of a vortex type turbine, given the low head
- SPV-based pumped storage facility for better capacity utilisation of the MHP
- A hybrid system with an intelligent controller that determines whether the energy generated is routed to pump water for storage or fed to the grid
- Given the increasing focus on storage due to the intermittent nature of renewable energy sources, the demonstration of an SPV-pumped storage, if successful, has the potential for significant scale-up as it will avoid expensive energy storage
- Such pumped storage schemes are also relevant for canal drops

Upcoming site in Ranchi, Jharkhand

Expanding possibilities with new business models

Look beyond the government and the NGO - Adopt a truly business-oriented model

The MHP sector has traditionally been anchored around the SNAs and/ or NGOs. However, there are successful MHPs run by commercial enterprises (such as tea estates). A study of existing MHPs in India and in other countries shows that a number of business models exist with a variety of hosts for MHPs with different objectives and value propositions. Table 2 gives the nature of these business models.

A review of international and national experiences with MHPs (see Box) points to three types of models that may be considered, which have also been seen at the three project sites described earlier.

Table 2: Characteristics of three broad categories of business models

Key executor / anchor	Social enterprise	Community-based entity (SNA or NGO)	Business enterprise
Customer segment / principal users	Mixed (community and enterprise)	Household and community segments	Typically, captive consumption by enterprise
Primary motivation	Higher profit or cost reduction plus community benefits	Community benefits	Higher profits or cost reduction
Value proposition	Increase in reliability of supply, reduction in cost of energy, and/or expanding availability of energy	Improved or expanded energy access	Increase in reliability, lower cost of energy, higher profits
Ownership and operation	Social enterprise owns and operates	Community owns and operates, operation initially facilitated by NGO or SNA	Enterprise owns and operates

Social sector models with some innovations

In India, the micro hydro sector has been dominated by MHPs that were designed to meet community electricity needs at remote locations. Here the project was typically led by an NGO or the SNA and anchored around the village energy committee. Successful international experiences (such as those of IBEKA in Indonesia, which operates 87 projects with an aggregate capacity of 2,260 kW and Sarhad Rural Support Programme [SRSP][5,6] working in remote tribal areas in Pakistan, which has built 189 micro hydro schemes, bringing electricity to around 365,000 households since 2004) indicate that social sector models need to revisit their approach:

- Upfront grant funding may not be readily available. New innovative ways of funding, including green finance, will have to be explored. Aggregating or clustering projects may facilitate easier access to finance, as transaction costs would be lower.
- Design with community inputs, local technology is critical to ensure sustained O&M. This may in some cases involve not adopting the latest technology.
- Hand-holding by an NGO or SNA will be necessary. However, after a mutually agreed time period, day-to-day operations, especially the technical aspects, will have to be handed over to a local organisation (preferably one with experience in the sector and operating in a professional manner) while the technology supplier will have to be kept in the loop through a long-term warranty to ensure system sustainability.
- There has to be in place detailed process for daily and monthly maintenance schedule (including greasing of equipment, clearing of debris to ensure smooth water flow, etc.), roles and responsibilities of various agencies/individuals, clear basis for calculating tariffs, etc.

[5] http://web.srsp.org.pk/index.php/our-projects/peace-project/rural-electrification
[6] https://www.ashden.org/winners/sarhad-rural-support-programme-srsp-1

Cooperative model

The cooperative model (between the private sector and community-based organisations) offers an opportunity to tap the strengths of both types of organisations. Listed below are some features of, and lessons from a micro hydro cooperative in Myanmar:

- Power plant owned by a cooperative private sector (50% stake) and community/users (50% stake)
- Operates a number of plants in the area, with 6 dedicated staff, 450 customers over 11 villages
- O&M, metering, collection by cooperative staff, technical support and maintenance by private company
- Viability improved through linkage with productive uses
- Preferential tariff or other incentives for households and community services like hospitals and schools
- Locally developed, easy-to-maintain-and-operate technologies: this would not only enable ease of O&M, but will also help develop local enterprise and reduce costs.

'Rent a site' model of 'water-to-wire' companies

This model involves an enterprise engaged in developing MHP sites.[7] The enterprise may operate on a rental or revenue-sharing basis, similar to solar rooftop leasing model. The enterprise may be a cooperative or may work in partnership with community/users. In the site leasing model, the lessor (owner of the site) develops the site on his own or jointly with the enterprise at zero risk to himself, and with an assured return in the form of an annual lease payment (a certain percentage of the operating income from the site).

[7] http://greenbugenergy.com/shop-hydro/shop-hydro-products-services/lease-your-waterpower-site

The sector needs an institutional anchor, innovative regulation, and a policy push

The recent focus of RE policy and programmes has been predominantly on solar at the MW and kW scales, resulting in the neglect of other decentralised renewables including micro hydro. Hydro power has suffered from bad publicity around flooding and environmental hazards associated with dams that have been badly designed, inappropriately located, and inadequately managed. Micro hydro projects, particularly run-of-the-river projects, do not have these negative effects, but suffer from the same image.

Network of agencies need to work together – led by MNRE and the SNAs

MNRE supported by strong SNAs with their network of dedicated district officers will be at the core of MHP strengthening. Additionally, our site visits have shown that at the local level, micro hydro systems benefit enormously from strong village committees, local leaders, NGOs, community-based organisations, and commercial enterprises who own, operate or manage the MHP and/or are its key customers. Involvement of all these groups will be critical as seen below. It is also suggested that a small group of experienced micro hydro practitioners and technocrats (tentatively referred to as the Micro Hydro Group) be set up to advise and detail next steps. This Group would also be key to fostering specialised micro hydro energy entrepreneurs or enterprises.

Engagement with the state electricity regulatory commissions (SERCs) and DISCOMs will be critical on aspects such as tariff setting, grid connection, power purchase agreement, and grid quality.

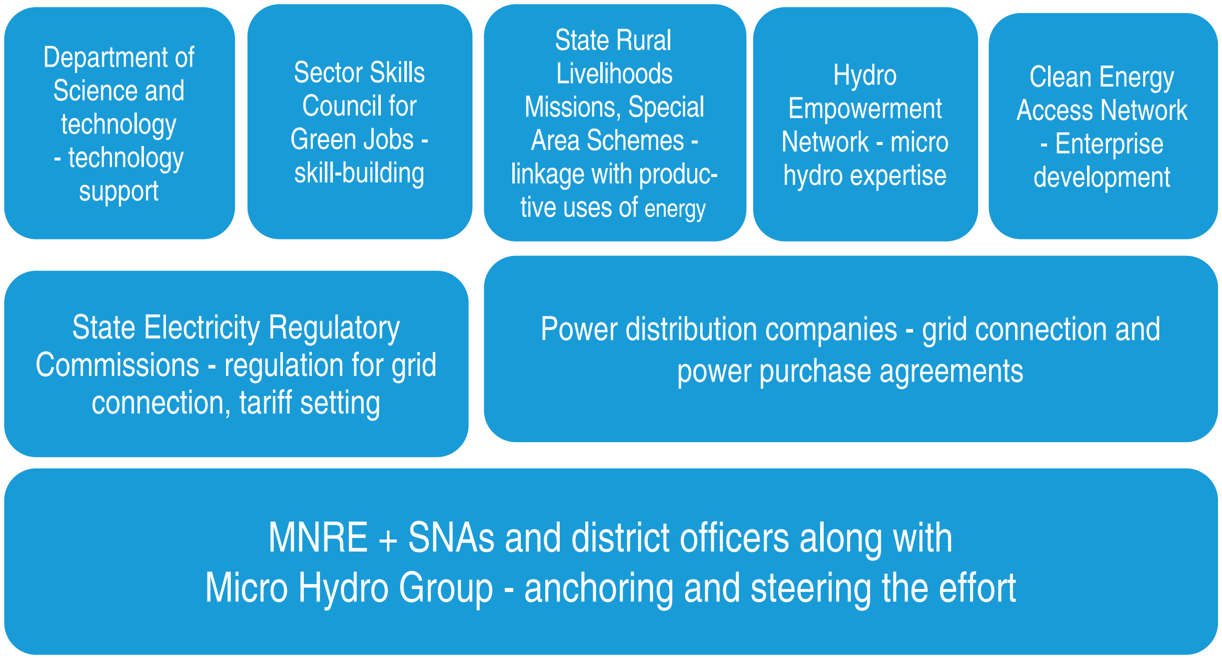

Figure 8: Agencies to be brought on board in and their roles

SNAs and district officers: key role in mapping and assessing MHP sites

There is an urgent need to develop a reliable database of micro hydro sites with an aim to assessing their potential. A step-wise approach may be adopted for mapping of MHP sites as shown in Figure 9.

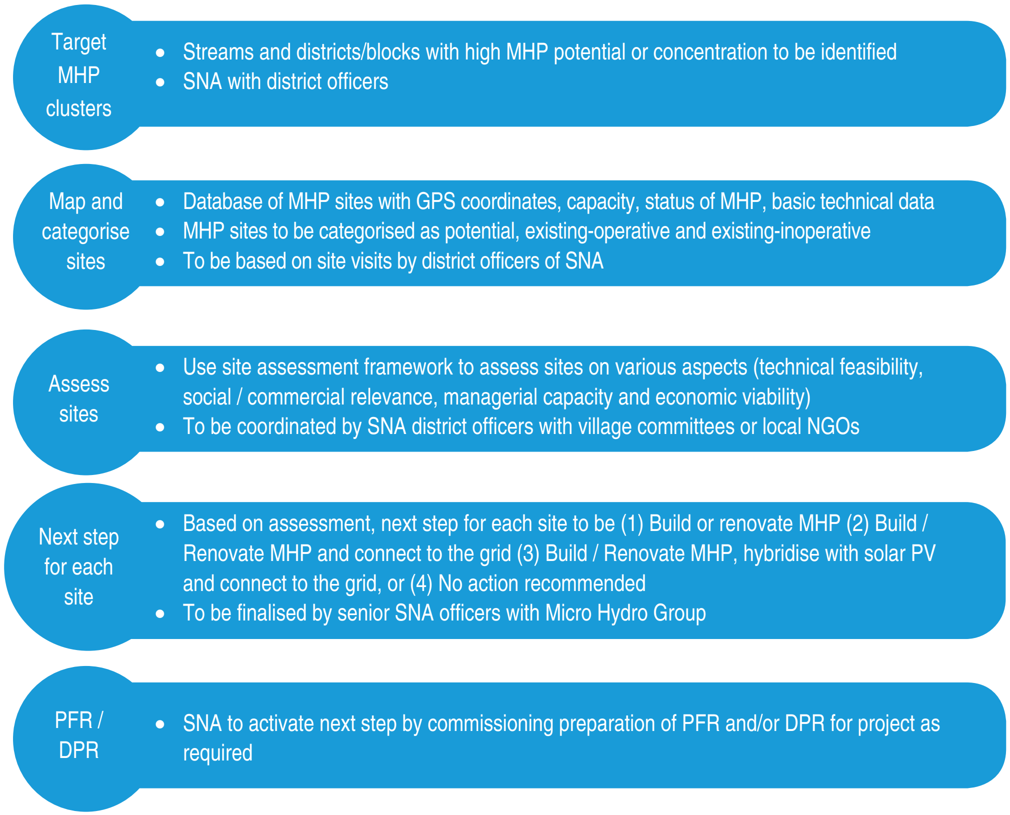

Figure 9: Step-wise approach to map and categorise sites

Site assessments tend to focus exclusively on technical factors such as RE resource availability with little focus on assessment of demand or managerial aspects. This has resulted in MHPs becoming inoperative due to over- or under-sizing, poor understanding of local electricity needs and ability to pay, and poor assessment of local capacity to operate and maintain the system. To address this, a multi-criteria site assessment may be adopted (see Figure 9). This would have to be conducted in a decentralised manner to be coordinated by SNAs through their district officers and in association with village committees or local NGOs. **This has to be a bottom-up assessment process given the decentralised nature of the sector.**

Provisions in policy needed to facilitate appropriate and effective adoption

The following provisions/inclusions are suggested in a scheme for micro hydro to be developed by MNRE:

- Provision for 'hybrid' systems: The scheme may mention the potential of new hybrid projects, highlighting the importance of hybridisation leading to improved capacity utilisation and reliability of both solar and micro hydro projects. Incentives proposed for small hydro and for solar PV may be extended to such hybrid projects. Hybridisation with solar PV may take two forms:
  - Complementing the generation of solar PV and hydro depending on seasonal and diurnal variability of water and solar resources; or

– Use of solar PV for pumped storage so that solar power may be used during hot, dry months to pump water to ensure that water flows are not reduced in the hydro plant during the lean season.

A hydro-solar plant may be recognised as a hybrid plant if the rated capacity of the solar component is at least 25% of the rated capacity of the hydro plant.[8] Additionally, it is recommended that in a hybrid system without battery, solar PV capacity should not exceed 50% of hydro capacity to ensure stability of the local grid. It must also be pointed out that this restriction is not meant for solar-powered pumped storage projects, where the solar PV capacity may significantly exceed the MHP capacity.

- Provision for grid integration in new and existing MHPs to be mentioned as critical for sustainability of projects; facilitative role of SERCs and DISCOMs to be highlighted.
- Provision for feed-in tariff: [9] The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) Scheme scheme provides entry points for this. However, state mini grid regulations (such as in Odisha) that provide for direct sale to consumers as well as for supply to the grid at feed-in tariffs could act as catalysts.
- it must be pointed out that revival of micro hydro plants may be possible with grid integration and supportive policy alone without solar hybridisation. In such a situation, if the micro hydro plant has been established many years ago, the cost of power generation could be attractively low.

Uttarakhand is the only state that has a state-level policy to promote mini and micro hydro plants. The state has also tried other measures to support the sector (highlights in Box 1)

Box 1: Micro hydro focus in Uttarakhand

Uttarakhand's policy of promoting mini and micro hydro power up to 2 MW (2015) encourages non-government participation with these projects being reserved for Panchayati Raj Institutions (PRIs) on their own or with partners (for-profit or not-for-profit entities). The policy extends a range of tax, duty, and royalty waivers. The policy allows captive use, third-party sale or grid export options.

Uttarakhand's attempt to monetize the CDM (clean development mechanism) benefits of 20 stand-alone MHP projects, though unsuccessful, is a pointer to how such projects can benefit from access to clean energy funds or climate financing.

Subsequently, Uttarakhand Renewable Energy Development Agency (UREDA) also explored interconnecting these projects to the grid in order to improve the sustainability of these projects.

Options to address risks and bridge viability gap

The projects being considered here, as is the case with most renewable energy projects, are exposed to various types of risks associated with policy uncertainty, unpredictable changes in electricity demand, emergence of disruptive technologies (e.g., on energy storage), fluctuations in weather conditions (rainfall, sunny days, etc.), natural disasters which have been exacerbated by climate change (floods, drought, changes in water flow and direction in streams, rock fall, landslides) as well as economic and political risks at the global, national, and local levels.

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[8] As also indicated in the National Wind-Solar Hybrid Policy

[9] The typical setting for a micro hydro plant is a remote location in difficult terrain with few households (usually scattered rather than dense settlements) and hardly any economic activity. In such a setting, where generation of electricity is very likely to significantly exceed offtake, feed-in-tariff is a relevant policy tool.


Power house site at Kanyalikote, Uttarakhand


Power house at Karlapath, Odisha, fully damaged by floods

The design, sizing and location of these projects must be carefully done keeping in mind variations in system output due to a range of factors and also the offtake pattern. Involvement of MHP specialists will be key. **The design of risk mitigation instruments, including insurance schemes, as well as providing financing for higher costs on account of improved project resilience will have to be an important factor for policy-making and financing for these projects**.

Micro hydro revival is an opportunity that must not be missed

As mentioned earlier, indications are that there are a number of untapped (potential) MHP sites and many others that have become inoperative over the years. Inoperative MHPs point to wasted investments but also to opportunities that can be quickly tapped to enhance clean energy access. **Reliable micro hydro power is not only a green source of power; it is also seen that such decentralised projects are the only source of electricity in some natural disaster situations that completely destroy grid infrastructure**.

The revival of inoperative micro hydro plants may, in several cases, involve small investments in minor repair and debris removal. This along with grid interconnection may make the plants viable even at relatively low levels of feed-in tariff. The inclusion of solar for hybridisation may be an attractive investment for stable electricity generation in areas with large seasonal variation in water flows.

About the Organisations

Shakti Sustainable Energy Foundation

Shakti Sustainable Energy Foundation (Shakti Foundation) works to strengthen the energy security of India by aiding the design and implementation of policies that support renewable energy, energy efficiency and the adoption of sustainable transport solutions. (More details at www.shaktifoundation.in).

Water Energy Food Transitions (WEFT) Research LLP

WEFT is a development advisory focusing on energy and water-sanitation sectors. We observe, analyse and interlink to catalyse transitions to circular economy, resource equity and resource democracy. Our work includes research for policy advocacy, development of decisions support systems, designing financial and business models for new and innovative projects in the areas of sustainable energy access and resource-efficient livelihoods. (More details at www.weft.co.in)

NB Institute of Rural Technology (NBIRT)

A not-for-profit organisation committed to empowering rural India and with a focus on training and education, NBIRT is a well-recognised institution in eastern and north-eastern India and is a National Training Centre of the Ministry of New and Renewable Energy, Government of India. Headquartered in Kolkata, NBIRT also has campuses in Guwahati and Agartala. The organisation works closely with rural communities, designing innovative green energy solutions for their ease of living and livelihoods. It offers various vocational courses including a one-year diploma in renewable energy at the ARKA-IGNOU Community College. (More details at www.nbirt.org.in/)

Core Project team:

S P Gon Chaudhuri, NBIRT (Technical Advisor)
Richik Ghosh, NBIRT
Rekha Krishnan, WEFT (Project Coordinator)
Hari Natarajan, WEFT
Nitish Jha, WEFT

Editing and Design: ADCS (Academic and Development Communication Services)
7/4, 3rd Street, Bhakthavatsalam Nagar
Adyar, Chennai - 600 020 INDIA

The team acknowledges inputs from the technical survey team, various government officials, hosts / anchors of project sites, NGOs, funding agencies, participants at the Regional and National Consultations. Above all, the team acknowledges the funding support and valuable insights from the Shakti team.

This short document outlines the key takeaways from an assignment on “Demonstrating techno-economic feasibility of hybridisation of micro hydel plants with solar, and their integration with the electricity grid for enhanced electricity access”. The assignment was carried out by WEFT Research in technical partnership with NBIRT, with funding support from the Shakti Foundation. Queries may be directed to rekhak@weft.co.in.