GENDER MAINSTREAMING IN ENERGY PROJECTS

TRAINING MANUAL FOR PICO HYDRO INSTALLATIONS

PRACTICAL ACTION
Technology challenging poverty

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ISBN 978-955-9417-59-0

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Funded by : ENERGIA
Publisher : Practical Action, Regional Programme (Sri Lanka, India & Pakistan)
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FOREWORD

'Pico Hydro' is an innovative and flexible technology that generates hydroelectric power from nearby streams using basic equipment. While the amount of power generated from a pico hydro unit is comparatively small (1kW), the ability to install these units in areas close to water sources with minimum construction utilizing local material are definite advantages. Therefore, pico hydro units can help to serve isolated rural households, which are not connected to the national electricity grid. In doing so, they help meet the energy requirements of households and women in particular, as it is often a woman who manages a household's energy needs. Power generated from a pico hydro unit will not only reduce the use of kerosene and firewood, which will promote a safer and cleaner means of power generation, but will also save women time and labour.

Practical Action has worked on pico hydro technology for several years and recommends the participatory approach during the total process. As pico hydro technology is closely linked to its users, participation of the household and all its members in planning, installing, operating and maintaining the unit are imperative for its sustainability. In this regard women have an important role to play and this training manual is developed keeping that in mind. Implementers of pico hydro projects should be aware of different strengths that women beneficiaries bring to such a project.

This manual provides implementers with technical information on how to install an efficient pico hydro unit with community participation (including that of women in the community who benefit the most from this technology). It further helps practitioners made aware of how best to harness strengths of women's participation and ensure successful running of the unit. The manual provides a step-by-step process from the initial energy assessment, financing, planning, installation and finally operation and maintenance of the pico hydro unit. While providing necessary technical information to the practitioners the manual also highlight gender dimensions that need to be considered during a pico hydro installation process not only to ensure that the unit is technically efficient and sustainable but also to provide users with the best benefits.

CONTENTS

INTRODUCTION

Lack of access to energy, which we define as "Energy Poverty" is one of the leading factors for poor standard of living and continuous poverty in communities. In some cases, impoverished households are isolated and lack access to large or community-sized solutions to energy provision such as the main grid and micro hydro plants. The scattered positioning of houses makes it costlier and sometimes impossible for government grid electrification programs to reach them. Pico Hydro (PH) is a technology that provides a good energy alternative in such cases, generating energy for one or several households depending on household energy requirements and the hydro potential of the site.

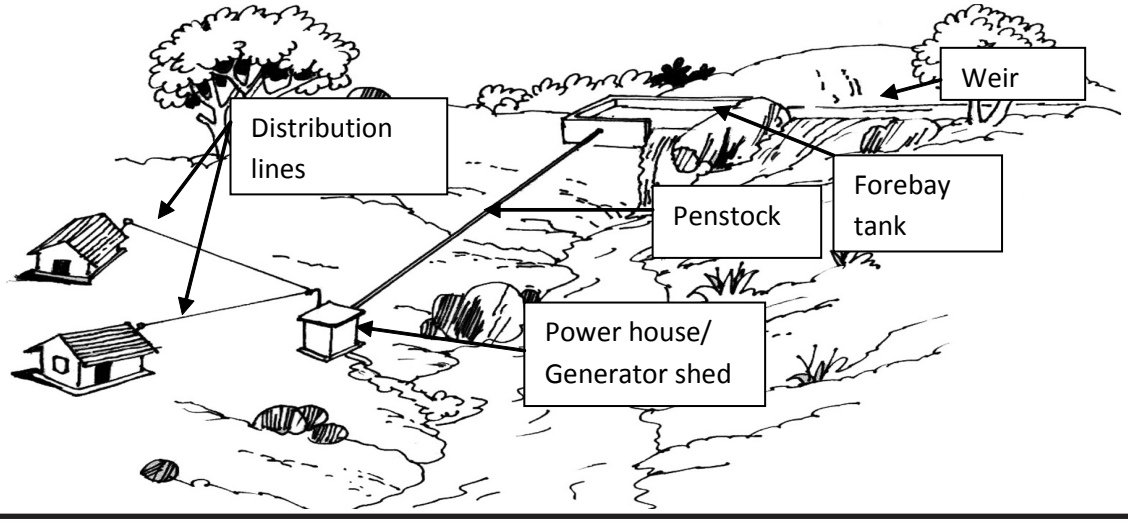
What is a pico hydro unit?

A pico hydro (PH) unit generates hydroelectric energy where the amount of power which is usually generated is up to 1kW.

Pico hydro is a simple technology which can be installed and run without any negative impact to the environment, and provides sufficient lighting and energy to a household. Components of the PH system comprise a flowing water channel, pressure pipe (penstock), turbine, generator, electrical controller, distribution cables and safety devices. Often the technology, material, resources and skills are available locally. A PH system taps a small water source and do not require water storage, a massive diversion, or any major permanent construction. Therefore it minimizes disturbance to the natural condition of the water source. Water is released back to the same water source after passing through the turbine.

A typical PH system is presented in Figure 1. Water from the stream is diverted using a simple weir and directed to a fore bay tank. The penstock is the pipe that carries water under pressure from the fore bay tank to the turbine. The nozzle focuses the water flowing through the penstock to the turbine runner, allowing it to impart the maximum amount of kinetic energy into the turbine. The turbine-generator system converts the kinetic energy of water in to mechanical energy first and then into electrical energy. The distribution line carries the generated energy to the point of use i.e. households.

Figure 1 : Simple Pico hydro system with components marked



Importance of gender sensitivity in pico hydro energy

Pico hydro energy units are household based units, meant for small amounts of power generation. It is often the women in families who deal with and are aware of a household's energy needs – from collection of firewood for cooking and heating to the use of kerosene lamps for light. As such, the energy generated by a PH unit is most important for women within the household, and therefore, are often the most enthusiastic about installing these units.

In addition, the women in households are often able to devote more time to operate PH units and are willing to find funds for constructing and running them. Their knowledge on the flow of the stream, accessibility of sites for the power house[1] and voluntary labour provision for the construction of a PH unit are key contributions towards the successful completion of a unit. Thus, their inputs and participation in the planning, implementation and operation of the unit should be facilitated.

Gender sensitivity aspects to note when installing a PH unit include:

- Consult women in the household during all discussions – including discussions for the household energy assessment and concerning financing, planning, implementing and operating the PH unit
- Get feedback from women when inspecting the site for the first time
- Include women in the construction process
- Ensure the location of the power house is easily accessible to women
- Ensure women know how to operate and maintain the unit as they may be the main unit operators

A pico hydro installing project has to have a team in place to work with the communities. Throughout the project team's engagement with households they should make beneficiaries aware of the different technical and gender-based aspects of the technology, providing them with information about the smoke-free, safety aspects of the technology and the quality, capacity and reliability of energy provided.

What skills are required in a team undertaking a pico hydro project?

The ideal size of a project team for ground implementation of a PH unit is two or three people. There should be at least one female member in the team. Below is a description of the skills required:

Field officer – he/she should be able to use equipment (such as the altimeter) and perform simple calculations. He or she should also have the ability to select the appropriate PH design for the site.

Social mobiliser – should have the ability to build a relationship with household members and to encourage their participation in the initiative. It is preferable if the mobiliser is a woman as this will make it more comfortable for women in households to come forward and participate in the work.

Technician – he/she should have the capacity to install the PH equipment and oversee the construction of the infrastructure required for the unit.

1 In some instances a power house may not be required and a temporary shed may be built around the generator instead.

Step 1 – Conduct an energy assessment and physically identify the site

1. **Identify the household's energy needs** - The team should visit the beneficiary household/s and discuss energy requirements of the household/s. It is important that as many members of the household participate in this discussion – women, men and children.

Factors that need to be identified :

- Number of members in each household
- Type and amount of energy required (heating or cooling, cooking, lighting etc.)
- Current source of energy and the current energy appliances used
- Hours of energy use and time of day energy is used
- Specific energy needs of women should be highlighted during the discussion as they most often manage the household
- Household's income source
- Level of contribution expected from the household (in terms of money contributed towards the unit, days free to participate in construction activities etc.)

Using the above information a work plan should be drawn up for each household.

This initial discussion sets the foundation for building a relationship with the household/s, which needs to be strengthened as the project progresses. The ability to communicate with male and female members of the household/s and to earn their cooperation and participation is important for the successful planning, implementation and sustainability of the PH unit.

It may be necessary, especially at the beginning of the project and depending on the culture of the beneficiaries involved, to hold separate discussions with men and women. In such a case, the female member of the project team could conduct discussion with the women in the household/s to gain their views and identify their needs more openly.

2. **Recording the physical location of the pico hydro site** - The project team should visit the stream around which the PH unit is to be based. Ideally a member of the household should accompany the team to the site. It is important that the team ensure presence of the person who has the most information on the stream. This may often be the women of household/s as they go to the stream to fetch water, bathe, wash clothes etc. and are therefore more likely to be knowledgeable about the flow of the stream and the terrain.

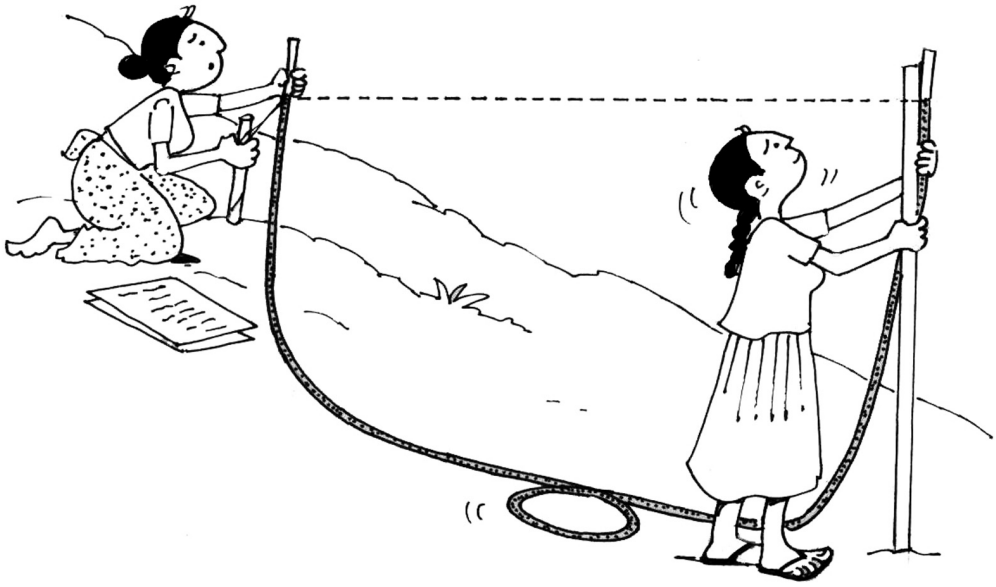
At the site the team should record the following information:

- the behaviour of the stream during the dry season and wet season
- the flood level
- the minimum flow
- other upstream tapping – i.e. other people using the stream and different uses of the stream
- flora and fauna present in the surrounding

The following measurements should also be taken:

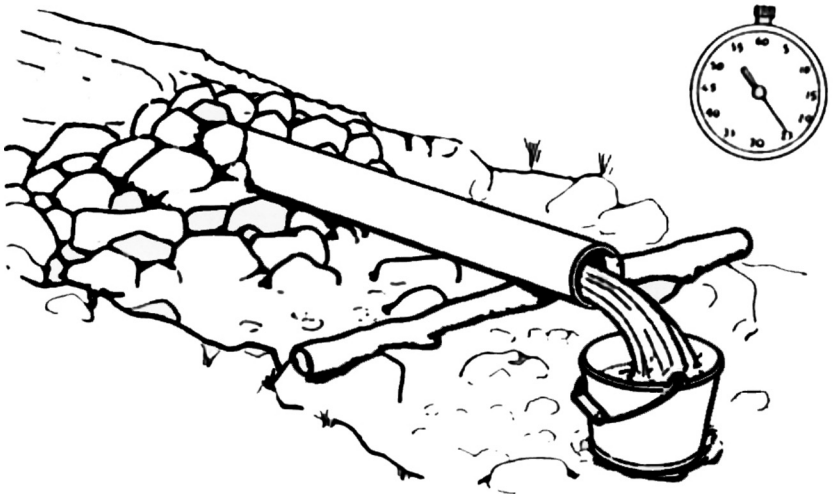
- Head measurement - measurement of the fall of water from upstream to downstream. The measurement should be taken along the area where there is the steepest gradient. An altimeter or a level tube (as shown in Figure 2) can be used to make this measurement.

Figure 2: Level tube method



- Flow measurement - measurement of the rate of water flow which occurs during the dry season. There are two methods to measure this. One is the bucket method, where a temporary weir is constructed upstream and the measurement is based on the time taken to fill a bucket with water from the stream. The other is the floating method in which the measurement is based on the time taken for an object to travel a certain distance along the stream.

Figure 3: Bucket method



- Pipe length
- Length of the electricity distribution line
- Civil structure of proposed PH unit – i.e. the length of weir and the size of the fore bay tank
- Location of power house/generator - when deciding on the location of the power house / where the generation should be kept, apart from the technical considerations, the officer should also take into account that the operator (who needs to visit the power house daily) may be a woman. As such, the power house should be in a location that is easy and safe to access.

On completion of the site visit and energy assessment the appropriate design of the PH unit can be drawn up by the team. Based on the chosen design, the cost estimation and bill of quantities can be developed. (Annexure 1 provides a diagram showing the main equipment that is found in a pico hydro unit.)

The following tables were produced based on Practical Action's experience in PH project implementation. Over 90% of these sites had a head over 8m and less than 20 l/s flow rate. The average length of the pipe line was around 150m. The overall efficiency of a PH unit varies from 30% to 43% and the average can be taken as 35%. A Two-Jet Pelton Turbine was the most common type of turbine used in almost all the sites because it is easier to manufacture, has higher efficiency and is easier to maintain.

The following tables were generated as a rule of thumb for technicians to use in the PH field in Sri Lanka:

Table 1 provides guidance on how to calculate the power that can be generated according to the head and flow availability at the site

Table 1: Pico Hydro power calculation sheet according to head and flow availability

FLOW (l/s) \ Head (m)	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
1											96	103	110	117	124	130	137	144	151	158	165	172	179	185	192	199	206
2				96	110	124	137	151	165	179	192	206	220	233	247	261	275	288	302	316	330	343	357	371	385	398	412
3		103	124	144	165	185	206	227	247	268	288	309	330	350	371	391	412	433	453	474	494	515	536	556	577	597	618
4	110	137	165	192	220	247	275	302	330	357	385	412	439	467	494	522	549	577	604	632	659	687	714	742	769	797	824
5	137	172	206	240	275	309	343	378	412	446	481	515	549	584	618	652	687	721	755	790	824	858	893	927	961	996	1030
6	165	206	247	288	330	371	412	453	494	536	577	618	659	700	742	783	824	865	906	948	989	1030	1071	1112	1154	1195	1236
7	192	240	288	336	385	433	481	529	577	625	673	721	769	817	865	913	961	1009	1058	1106	1154	1202	1250	1298	1346	1394	1442
8	220	275	330	385	439	494	549	604	659	714	769	824	879	934	989	1044	1099	1154	1209	1264	1318	1373	1428	1483			
9	247	309	371	433	494	556	618	680	742	803	865	927	989	1051	1112	1174	1236	1298	1360	1421	1483						
10	275	343	412	481	549	618	687	755	824	893	961	1030	1099	1167	1236	1305	1373	1442									
11	302	378	453	529	604	680	755	831	906	982	1058	1133	1209	1284	1360	1435											
12	330	412	494	577	659	742	824	906	989	1071	1154	1236	1318	1401	1483												
13	357	446	536	625	714	803	893	982	1071	1161	1250	1339	1428														
14	385	481	577	673	769	865	961	1058	1154	1250	1346	1442															
15	412	515	618	721	824	927	1030	1133	1236	1339	1442																
16		549	659	769	879	989	1099	1209	1318	1428																	
17		584	700	817	934	1051	1167	1284	1401																		
18			742	865	989	1112	1236	1360	1483																		
19			783	913	1044	1174	1305	1435																			
20				961	1099	1236	1373																				

Assumptions

Overal efficiency is arrou 35%

P_e=H*p*g*Q*eff.

P_e= Electrical Power out put (W)

H= Gross head (m)

Q= Design flow (m^3/s)

p= Density of water (1000 kg/m^3)

g= Acceleration due to gravity (9.81m/s^2)

Table 2 provides guidance on how to select the suitable type of uPVC pipe and the Nominal Pipe Diameter for the PH site

Table 2: Pico Hydro power calculation, uPVC pipe selection (Pipe type and pipe size) sheet according to head and flow availability

FLOW (l/s)	Head (m)																												
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
1											96	103	110	117	124	130	137	144	151	158	165	172	179	185	192	199	206
2				96	110	124	137	151	165	179	192	206	220	233	247	261	275	288	302	316	330	343	357	371	385	398	412
3		103	124	144	165	185	206	227	247	268	288	309	330	350	371	391	412	433	453	474	494	515	536	556	577	597	618
4	110	137	165	192	220	247	275	302	330	357	385	412	439	467	494	522	549	577	604	632	659	687	714	742	769	797	824
5	137	172	206	240	275	309	343	378	412	446	481	515	549	584	618	652	687	721	755	790	824	858	893	927	961	996	1030
6	165	206	247	288	330	371	412	453	494	536	577	618	659	700	742	783	824	865	906	948	989	1030	1071	1112	1154	1195	1236
7	192	240	288	336	385	433	481	529	577	625	673	721	769	817	865	913	961	1009	1058	1106	1154	1202	1250	1298	1346	1394	1442
8	220	275	330	385	439	494	549	604	659	714	769	824	879	934	989	1044	1099	1154	1209	1264	1318	1373	1428	1483			
9	247	309	371	433	494	556	618	680	742	803	865	927	989	1051	1112	1174	1236	1298	1360	1421	1483						
10	275	343	412	481	549	618	687	755	824	893	961	1030	1099	1167	1236	1305	1373	1442									
11	302	378	453	529	604	680	755	831	906	982	1058	1133	1209	1284	1360	1435											
12	330	412	494	577	659	742	824	906	989	1071	1154	1236	1318	1401	1483												
13	357	446	536	625	714	803	893	982	1071	1161	1250	1339	1428														
14	385	481	577	673	769	865	961	1058	1154	1250	1346	1442															
15	412	515	618	721	824	927	1030	1133	1236	1339	1442																
16		549	659	769	879	989	1099	1209	1318	1428																	
17		584	700	817	934	1051	1167	1284	1401																		
18			742	865	989	1112	1236	1360	1483																		
19			783	913	1044	1174	1305	1435																			
20				961	1099	1236	1373																				
	T250							T400								T600									T1000		

Assumptions

Overal efficiency is arrou 35%

Length of penstock 150m or bellow

P_e=H*p*g*Q*eff.

60 mm uPVC

90 mm uPVC

110 mm uPVC

140 mm uPVC

160 mm uPVC

P_e= Electrical Power out put (W)

H= Gross head (m)

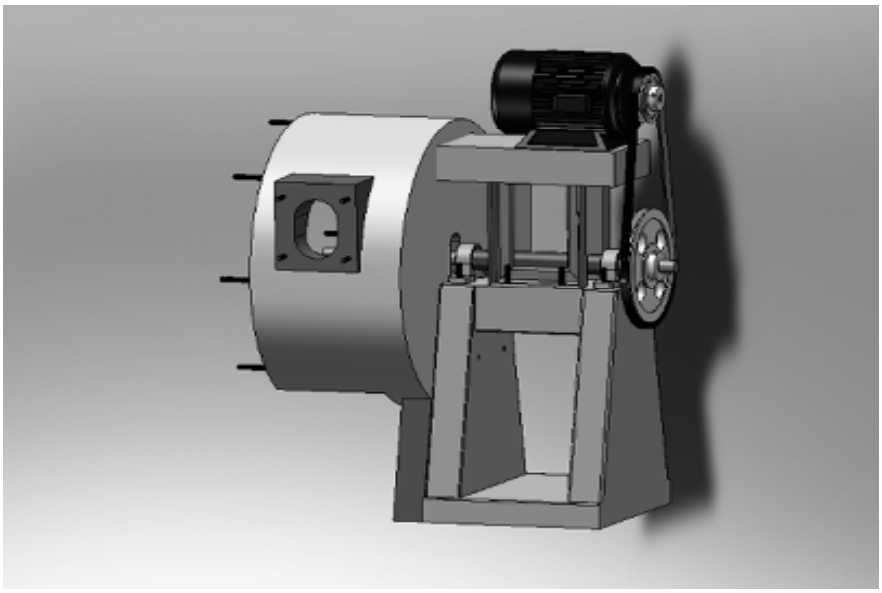
Q= Design flow (m^3/s)

p= Density of water (1000 kg/m^3)

g= Acceleration due to gravity (9.81m/s^2)

Figure 4 is a drawing of the common multi-jet pelton type turbine used in PH sites in Sri Lanka

Figure 4: Multi-jet pelton type turbine



Step 2 – Determine how to finance the installation and run the pico hydro unit

At this stage, the team should discuss with household/s how the PH unit is to be financed – this involves not only the **construction costs** but also how **future operation and maintenance costs** will be met.

The following items should be discussed:

- an **energy saving estimate** should be made by the project team and presented to the households to help them decide on how to finance the unit. The energy saving estimate should provide a cost comparison of the current energy source and the proposed PH unit and state how long it will take to recover the investment in the PH unit through income saved from reduced energy costs.
- the power capacity of the proposed unit and the reliability of the energy supply provided (during wet vs. dry seasons)
- the number of light points in the house/s and their locations
- what materials can be obtained locally (free or purchased)
- what the households are able to contribute (in terms of time and labour, material, and in meeting expenses)
- what assistance the project team will provide
- **micro credit schemes** available to provide loans for energy units or to women in particular. The project officer should make a special effort to inquire into such possibilities and discuss available schemes with households.
- ways of funding future maintenance costs of the unit such as lubricating and replacing belt drives annually and replacing bearings every three years.

Presence of women in these discussions is equally important here as well. Often responsible for managing the household, women place a greater importance on energy and are willing to find funding for energy generating units. They usually take out family loans in order to do so.

Step 3 - Plan the installation of the pico hydro unit

Planning of the installation needs to take place with the involvement of the household/s.

The construction work should be scheduled to take approximately two days.

Planning process:

1. The team should point out to household members the possible locations for different types of infrastructure. They should then discuss with them the appropriateness of such locations. The site of the power house/generator is especially important as the operator will need to have easy access to it at all times of the day and during the rainy season as well.

2. As the civil construction will be performed by household members, the team should educate them on all aspects of construction.

3. Duties will need to be assigned to all members, from carrying the material to the site to laying the penstock. The team should be mindful to involve women in the planning process and facilitate their involvement in the construction process as well.

Figure 5: Women helping to lay the penstock at a pico hydro site

4. The future operator and maintenance persons for the PH unit should be appointed. The project team should inform households about the sorts of skills and time required for these duties based on which the households should appoint the appropriate persons for these duties. The operator should be a responsible adult who is mostly at home and can access the power house, and has the ability and willingness to take on the responsibility. Often it is the women of a household that fit the aforementioned criteria.

Step 4 - Install the pico hydro unit

The team should organise the members of the household so that there are a minimum of two to three people at the site at any given time.

Figure 6: Women helping in the construction of a generator shed

The person who has been appointed as the operator of the unit should be involved in the installation of the unit. Operators of the units are often women and as such the team should obtain the active participation of women during the installation of the unit.

During the installation the team should train one or two people to maintain the PH system.

Safety aspects need to be included when installing the unit and the control panel must include safety equipment (such as trip switch, main switch, system earthing) and a generator cover.

Step 5 – Operate and maintain the unit

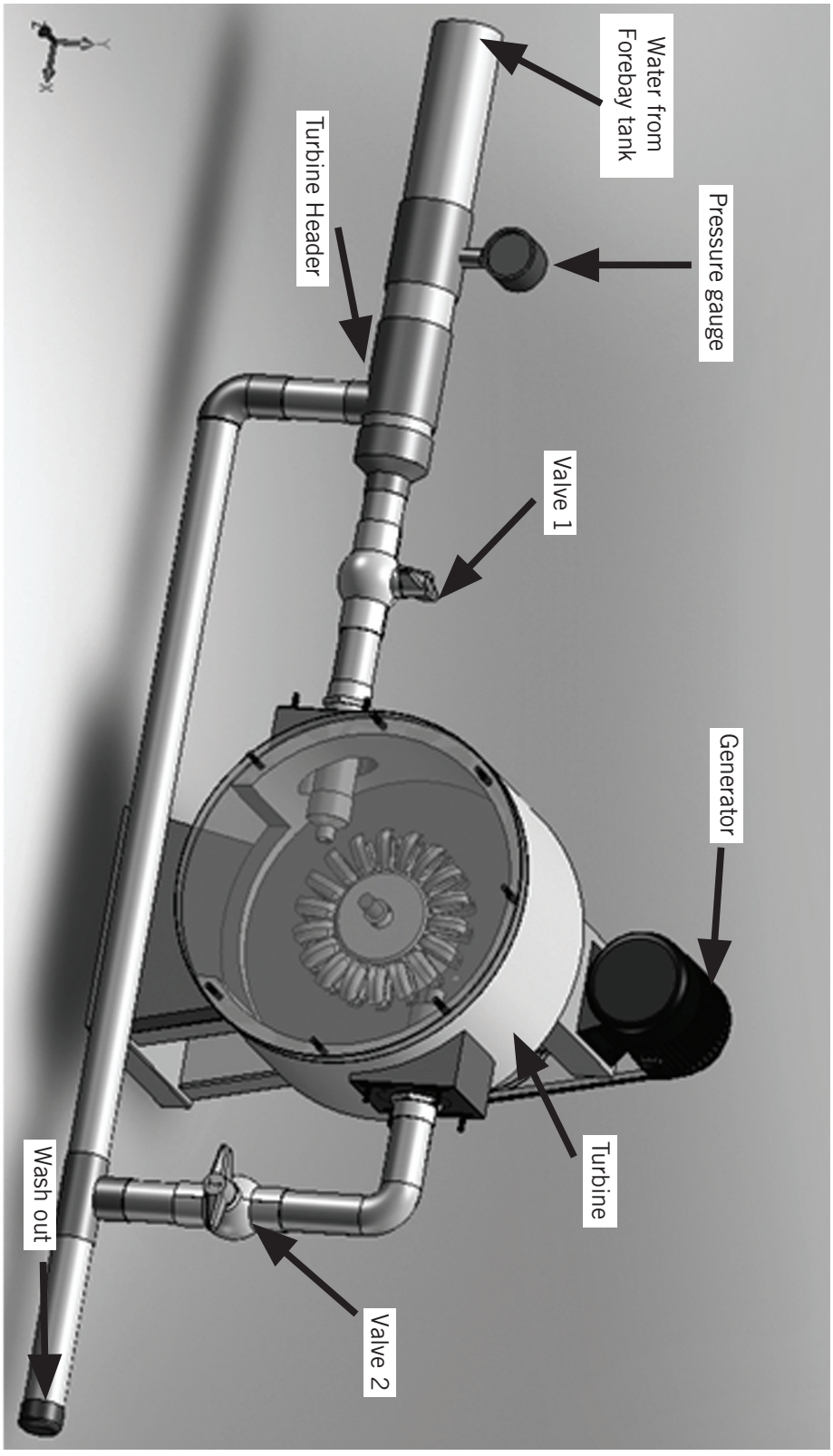
The following steps should be taken to ensure the smooth operation and maintenance of the PH unit:

- **Train the operator** - A log book should be kept on unit start and shut down times and voltage recordings (please refer Annexure 2 for a format of such a log book). The operator should be trained and educated on how to make these readings, and on the importance of recording and identifying possible problems.
- **Educate household members (to ensure responsible users)** - Users should be educated on the appropriate use of equipment (main switch, trip switch, etc.), type of appliances that can be used given the amount of energy generated from the unit and how many appliances can be used simultaneously. The mother or woman in the family often oversees this, therefore, the team should make a special effort to ensure she is educated on these aspects.
- **Train the person/s appointed to maintain the unit** - training should be provided on civil construction, on the necessary tools to carry out repairs, maintenance of tanks/ pipelines, maintenance of turbines, generators, house wires, bearings and belts, replacing bulbs etc. The contact details of the developer or equipment supplier should be provided in case advice or further services are needed.

Figure 7: Assembling the turbine and penstock

Annexure 1

MAIN EQUIPMENT IN A PICO HYDRO UNIT



Annexure 2

POWER STATION – LOG BOOK

1. Name of the power station:

2. Name of water source:

3. Consumer/s name/s:

4. Address:

5. Capacity of the power station:

6. Number of houses covered:

7. Name of the project developer, address and telephone number:

8. Contact person:

9. Estimated cost of the project:

10. Details of funds received:

Funds received from	Amount received (Rs.)

11. Household's contributions:

    Money

    Voluntary labour

    Building equipment

12. Name of the bank/s from which loans were taken:

13. Donor of machinery, organisation's name, address and telephone number:

14. Machinery – guarantee period and type of guarantee:

15. Date the project started:

16. Date the pico hydro unit commenced operation:

17. Organisations / persons from which training was received on unit operation:

18. Project data

- Level of water head (metres):
- Water pressure (litres per second)
- Type of turbine:

1. Amount of electricity generated (kW)	
2. Design water flow rate	
3. Planned water head (metres)	
4. Efficiency	
5.	

Generator brand, model, capacity, serial number and year of manufacture:

19. Other notes: .....

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20. Details of new work:

Date	Time		Main Volt meter reading	Pressure meter reading (when starting the unit)		Operator’s name	Signature	Remarks: (problems, unexpected occurrences, repairs, lightning arresters damage, debris cleared from fore bay tank, visitors, note the dates when the unit and other machinery are not working)
	Start	Finish		Before	After			

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