MANUAL ON MICRO HYDRO DEVELOPMENT

Prepared for:
NGO Capacity Building for Poverty-reducing Sustainable Energy Solutions in South Asia Project
INFORSE

Prepared by:

Centre for Rural Technology, Nepal (CRT/N)
GPO Box 3628,Tripureshower, Kathmandu
Tel: 4260165, 4256819 Fax: 4257922
Email: info@crtnepal.org

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1.0 Introduction:

1.1 Background

Supply of energy in a suitable form is considered to be one of the main inputs required to raise the standards of living of the people and to minimize the damage to the ecosystem. Supplying improved energy services to people for the first time is difficult; but supplying such services profitably to very poor people who live far away from roads and the electricity grid pose a particularly difficult challenge. However micro hydro compares well with other energy supply technologies in these difficult markets. But despite this, micro hydro appears to have been relatively neglected by donors, the private sector and governments in the allocation of resources and attention. In the past rural electrification by means of grid extension was the option favored by donors.

Micro hydropower is an indigenous and renewable source of energy for which the potential exists in almost the whole Hindu-kush Himalayan Region, which includes Afghanistan, Bhutan, China, India, Myanmar, Nepal and Pakistan. Micro Hydro (MH) is generally defined as decentralized small-scale water power plant less than 100 kW.

Micro hydro can provide electricity to rural communities which otherwise might take years to be served by national electricity services. Its comparative advantages are:

- The components of MH can be locally manufactured and the MH systems can be locally built
- MH Plants are comparatively easy to manufacture and install indigenously, thus boosting employment, economic activity and the industrial base
- The MH systems can be locally managed, operated and main much lower trained with training input to the local people. The organization and management cost are lower than for the other energy systems
- The adverse environmental effects are minimal

The present manual provides details on various types of micro hydro, its installation, operation and maintenance that include peltric set and improved water mill.

1.2 Characteristic of Potential Target Sites and Target Group for Installing MH Systems

The possible target sites for MH systems are the isolated areas, which are not connected to the national grid.

The target beneficiaries are the rural people residing at a considerable distance away from transmission line and distribution networks. Access to the nearest road head on foot for these people may vary from few hours of walking to several days. But then, these rural areas are expected to have following characteristics:

- It should have potential to generate power (water source flowing from considerable height)
- There should be enough household demand for electricity
- Consumers of services from MH systems should be willing to pay local tariff
- Consumers and potential users of energy from MH should be willing to take up productive end-use activities.

2.0 Technical Features of Micro-hydro Technology:

2.1 General

The basic principle of hydropower is that if water can be piped down from a certain level, then the resulting water pressure is converted to work. If the water pressure is allowed to move a mechanical component then that movement involves the conversion of the potential energy of the water into mechanical energy. Hydro turbines convert water pressure into mechanical shaft power, which can be used to drive an electricity generator, a grinding mill or some other useful device.

The power potential is computed by assessing the following values:

- Flow or the quantity and speed of water in the river, measured in cubic meters per second (m3/s) or in liters per second (l/s)
- Available head or the height through which the water falls, measured in meters (m)

2.2 Comparison of the various MH Technologies

Features	MPPU	Cross-flow	Peltric

Head (m)	2-15	>10	20-200
Discharge (LPS)	10-100	>20	1-50
Speed (rpm)	100-200	200-1500	1000-1500
Capacity (kW)	0.5-1.5	<250	5
Efficiency (%)	40-60	60-75	>50
Life Span (years)	10	15	10
Average Cost (NRs)	The average cost of MH schemes is around NRs.1, 00,000 to 1,50,000 per kW		

Note: Multi-purpose Power Unit (MPPU)

2.3 Components of the MH System

The various components of a micro hydro installation are (also refer to Figure 1 below):

a) Civil Components: Structures designed to conduct water from source to the turbine for optimum energy generation. It has several sub-components described below.
b) Turbines: The turbine converts energy from the falling water into rotating shaft power.
c) Drive System: Transmits power from the turbine shaft to the generator shaft or the shaft powering other devices. It also has the function of changing the rotational speed from the one shaft to another when the turbine speed differs from the required speed of the alternator or device.
d) Electrical Systems: Convert mechanical power into electric power. This consists of a generator and alternator.

2.4 General Layout of MH System

Various possibilities exist for the general layout of a hydro scheme, depending on the local situation:

1. Low head with a river barrage
2. Low head with a channel
3. High head with no channel
4. High head with channel

A number of essential factors must be kept in mind when designing a micro hydropower system. These are available head, flow variations, sediment, floods and water turbulence.

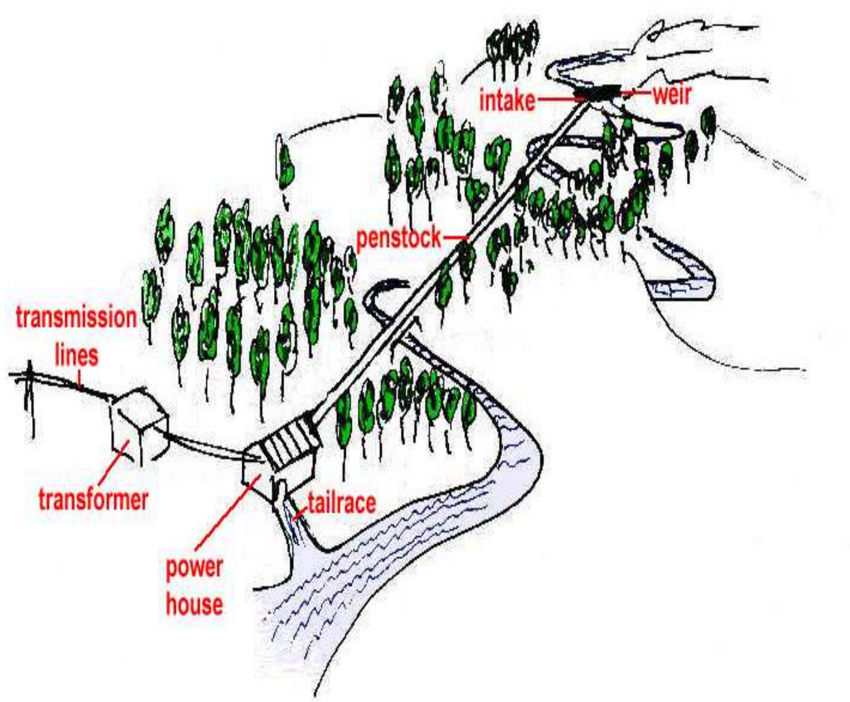


Figure 1: General Layout of a Micro hydro Scheme

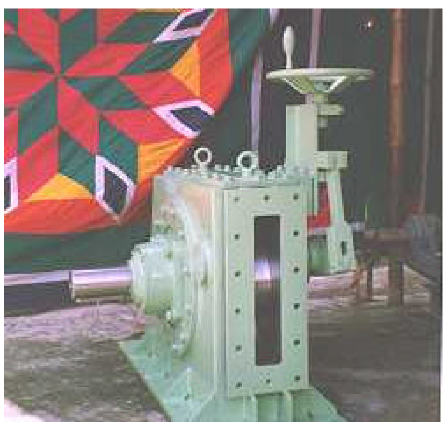
2.5 Civil components

The main civil components of the MH systems are as follows:

Weir and Intake:	Weir and intake extract water from the river in a reliable and regulated way.
Channels	Structure designed to create a head through which the water falls and also to conduct the water from the intake to the fore bay tank.
De-Settling Basin	The water drawn from the river to the turbine usually carries suspended small particles that are hard and abrasive such as sand. This settling basin is used to settle down the suspended particles and flushed out.
Spillways	Structure designed to permit controlled overflow at certain points along the channel.
Fore bay Tank	The fore bay tank forms the connection between the channel a nd the penstock
Penstock	The penstock is the pipe, which conveys water under pressure from the fore bay tank to the turbine

2.6 Turbine Types

Presently in Nepal the following types of turbines are commonly in use:



Picture: 5 (Cross flow)

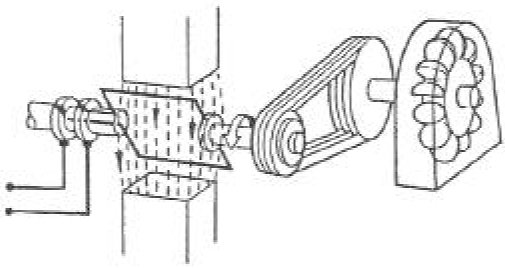
Picture: 5 (Pelton wheel)

2.7 Drive and Power Unit Components

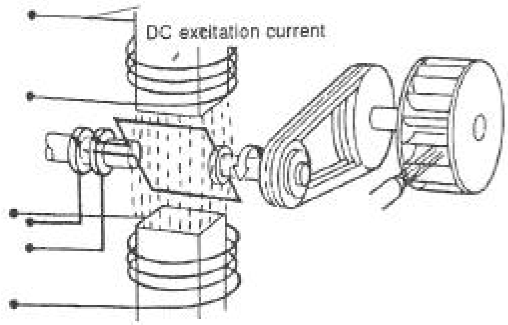
The drive system consists of belts that help translate rotary motion of the turbine shaft into energy for operating various appliances

2.8 Electric Components

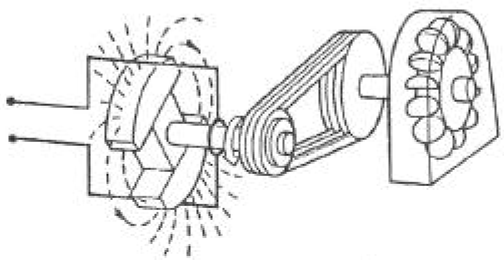
The Electric components consist of charge controller, generator and alternator.



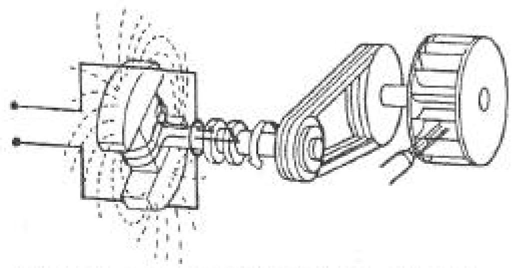
(a) Coil rotating in the field of a permanent magnet



(c) Coil rotating in the field of an electro-magnet powered by DC current



(b) Permanent magnet rotating within a stationary coil



(d) Electro-magnet rotating within a stationary coil

2.9 Operation and Maintenance Procedure:

The amount of water and its falling upon the turbine determines the performance of the turbines. The flow through the penstock on to the runner, wherein the shaft attached to the runner starts to rotate. This shaft in turn drives either the mechanical utilities that are attached to it or drives the generator shaft, which in turn produces electricity. The system should be periodically maintained and repair, if needed, as per the maintenance and repair guidelines provided for each component.

2.10 Human Resources

Requirements of human resources will depend on the types and scale of MH system being installed and operated. The human resource needs of a typical MH system up to 10 kW with agro-processing is presented as below:

SN	Description	Labor-days required	
		Grinder only	**Grinder + Huller+ electric generator**
1.	Technician / operator	1	2
2.	Skilled Labor	1	2
3.	Unskilled Labor	2	6

2.11 Training and Useful Life of Micro Hydro System

2.11.1 Training

For any endeavor, especially concerning the introduction of a new technology to an underdeveloped and remote rural area, training is perhaps the most important intervention. In the case of micro hydro development training to various related groups especially managers/operator of micro hydro. Some of the training needs are as follows:

- Communities and their leaders should be informed about the benefits and limitations of MMHP installations, plus their responsibilities and actions desires in this respect. Additionally, some basic information should also be provided to consumers regarding other end uses.
- Owners/managers should be trained in various aspects of plant operation, including load management; following operation procedures; watching out for signs of malfunctions; book keeping; organizations and scheduling of maintenance and repairs etc.
- Operators should be trained in operation and maintenance procedures
- Mechanics/technicians (eg from nearby workshops) should be trained in various aspects of plant machinery, its functioning, assembly and so on, so that they can undertake repairs easily. They should also be trained in the appropriate repair procedures.

2.11.2 Useful Life

The functional life of a micro hydro plant is considered to be 15 years. However, a lot depends on how the plant is maintained. Civil structures usually last for a long time, if they do not subject to natural calamities like folds and earthquakes. The life of electro mechanical components depends on the quality of the products installed and on how they are maintained. Regular preventive maintenance generally increases the lifetime of the equipment.

3.0 Peltric-Set:

3.1 General Introduction

The Peltric-set is the most useful water powered miniaturized and local version of vertical shaft Pelton Turbine coupled with Induction Generator. The water of small streams and rivulets flowing high near human settlements in the hill and mountains could be used to produce electricity that can be used for various end uses. The technology available for this purpose is called Peltric Set technology.

3.2 Functions/Application

Peltric Set is the only kind of local technology that can be used to generate electricity which can have the following applications or end uses:

- Lighting households (1kW of electric power can light 10-12 rural households);
- Charging batteries (electricity can be stored in the battery in the day-time);
- Operating radios, televisions and VCRs.

There are more than 500 sets under operation in the country without any serious problem. Nearly 100 Peltric sets are produced in Nepal every year. The system is successful because of its reliability, durability, economic feasibility and simplicity.

3.3 Technical Features

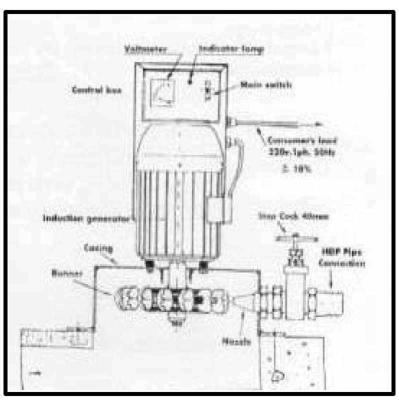


Figure 1: Peltric set

Impulse turbines derive their power from the water pressure caused by a high head which flows through a nozzle(s) that accelerates the water before striking a number of especially designed buckets attached round the periphery of the wheel.

- The induction generator produces electric power when it revolves at its designed speed -given the right amount of excitation capacitors.
- It can operate with a small quantity of water; 2.5-20 litres/sec and a falling head of 25-50m of gross head.
- Power output can be 600-5,000 watts at 220V single phase.
- The weight of a v150.2j 10 model Peltric Set is 35 kg.
- A Peltric Set is suitable for installation with multiple nozzles which lower the individual cost and make it possible to increase the power me in the future if power needs increase.

Common parameters:
H = 25 m onward up 300m
Q = 0.5 to 30 l/s
P = 0.1 to 40 kw
$\eta_{overall}$ = 50 to 55%

3.4 Components of Peltric set

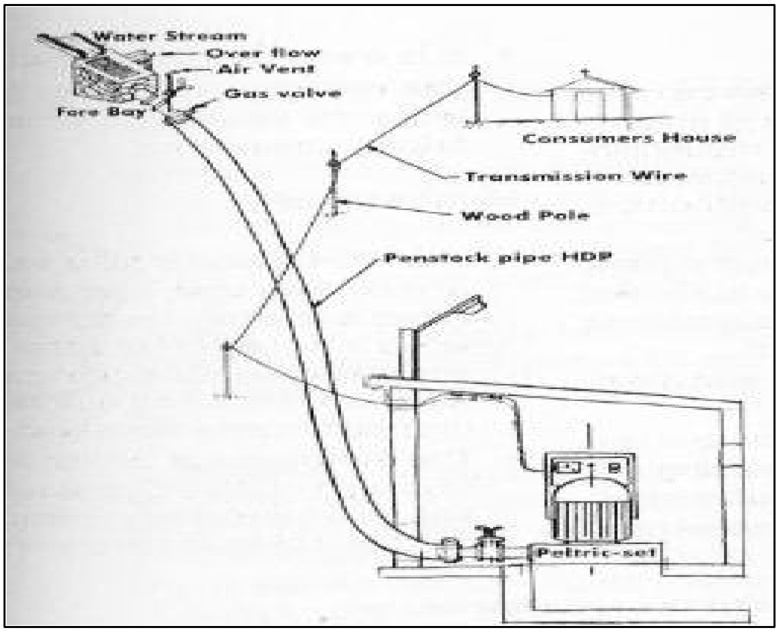


Figure 2: Working of a Peltric set

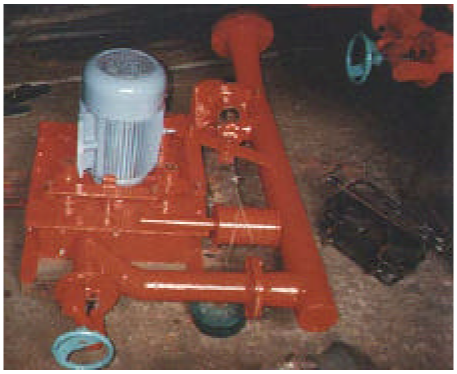
Peltric Set requires only small quantity of water therefore, the construction work such as Intake, Fore bay, Penstock route, Power house etc. are built saving considerable time and money. Peltric Set can be made with multi - Nozzles, which lowers the individual cost and makes it possible to increase the power output at any time in the future if required.

Major parts and specifications:

Parts	Specification
Runner	The runner is made from bronze buckets bolted on and securely locked by dovetail grooves on a disc. The runner is keyed directly on to the generator shaft.
Casing	The casing is fabricated from 6mm thick M.S. plates to ensure long-lasting resistance to rust.
Generator	The generator is the induction type: brush less and self excited. It is durable and virtually trouble free except that the bearings have to be changed every 10,000 hours of running.
Control Box	The control box contains all the necessary excitation circuits,volt-meter,indicator lamp, and main switch(MCB).The miniature circuit breaker allows no overloading on the generator.
Inlet	The inlet consists of a gunmetal 40mm size stopcock to put the set on and off, but it does not regulate the flow.
Nozzle	The nozzle is fabricated from M.S. and is conical in shape.

3.5 Necessary Human Resources

SN	Description	Time required
1	Feasibility study	1 day
2	The peltric set can be made ready for delivery	21 days after order.
3	Installation except for civil construction canal, intake, fo rebay and tailrace discharge facilities.	2 days



2 Jet x 5 kW Peltric Set with deflector

1 kW Peltric Set on a workshop test rig

4.0 Improved Water Mill (Ghatta)

4.1 The Technology

The improved water mill technology is a modified version of the traditional water mills designed on the principals of Impulse Turbine. Table below provides a comparison between the two.

Traditional Ghatta	Improved Ghatta
Wooden runners	Metallic runners
The wooden blades need replacement every year or two, as the flowing water wears them out	Metal runners, are designed to optimise the efficiency of the runner as well as to gain maximum power from the available hydro- power

4.2 Components of the Technology

The various components of an improved water mill are as follows:

Phali	Metallic structure placed in the groove at the lower surface of the upper grinding stone and the key of the shaft. It helps transmit mechanical power in the system
Shaft	It is placed on the Chakati (Base Plate) with Takker (Pivot) as a bearing and also holds the runner. It transmits mechanical power from the runner to the upper grinder through the Phali.
Runner	It consists of Fourteen numbers of buckets joined with runner hub by arc welding and to give it a circular shape with the help of runner strip and guide ring. It is attached with the shaft by nut-bolts. It converts the kinetic energy of waterfall into mechanical energy.
Takkar (Pivot)	It is placed in the lower hole of the shaft and the Chakati (Base Plate). The Takkar and Chakati jointly work as a bearing for shaft. The water works as a coolant for the Takkar and Chakati.
Chakati (Base Plate)	It is a base plate for the Takkar and shaft. It is joined to the wooden column at the ground surface with a screw.
Hopper	The hopper is normally made of wood or tin and used for feeding the agro products into the grinding stones for processing.
Penstock	Penstocks convey water from the source from a required height on to the runner to rotate it and produce mechanical energy. The penstock can be made of wood or plastic pipes.

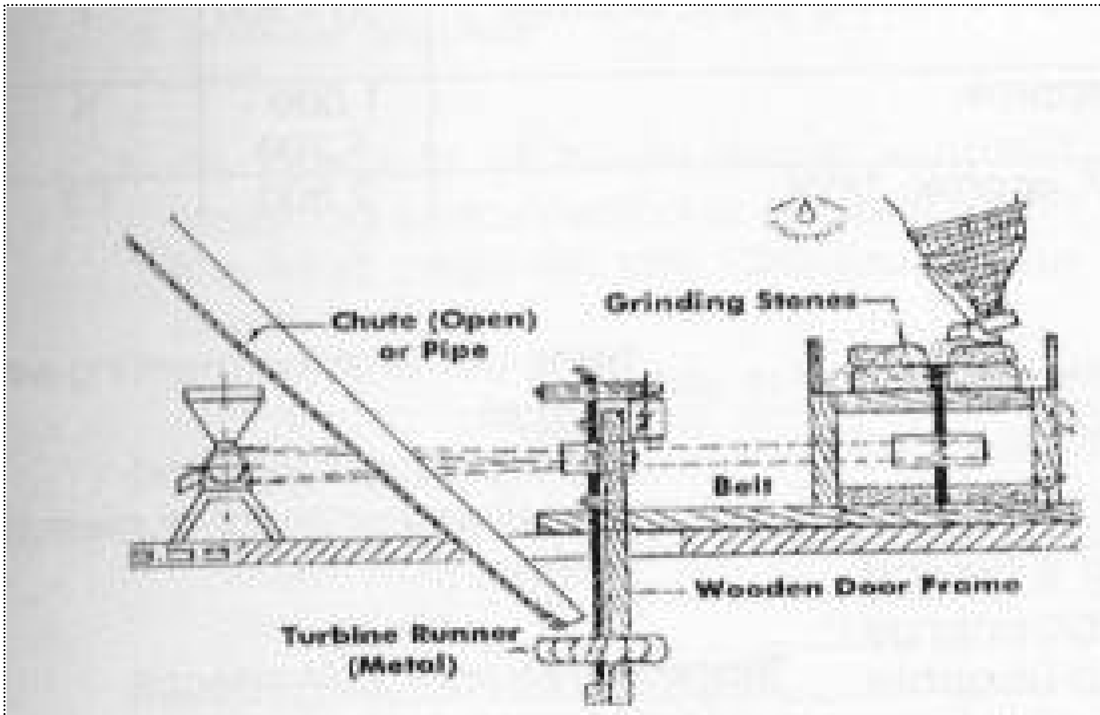
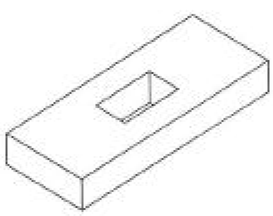
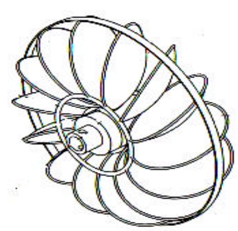


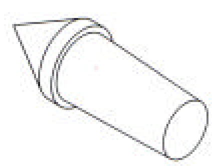
Figure: Improved Water Mill for Multiple Application



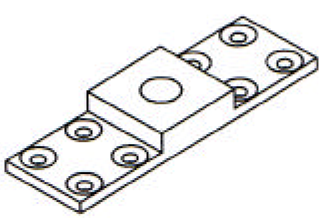
Phali



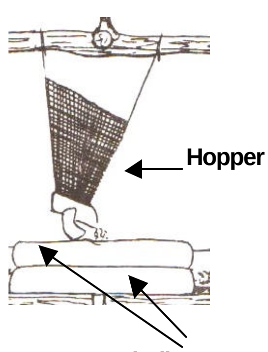
Runner



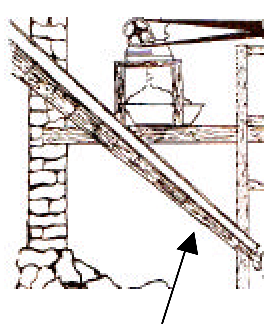
Takkar (Pivot)



Chakti (Base Plate)



Grinding Stones



Penstock

4.3 Operating Procedure:

- Fill the hopper with grinding materials.
- Allow water to enter the penstock pipe, which is tilted at 30^0 with the horizontal.
- In case of additional end use connect it to the shaft coupled a pulley using flat belts

The water hits the runner blades and the shaft coupled with the runner begins to rotate. When the runner rotates, the grinding stone also rotates at the same speed. The feed to the grinding stone should be controlled from the hopper itself.

4.4 Required Human Resources

For the successful installation and commissioning of improved water mills, manpower required during the period of installation plays important roles. The installer should have qualification of a diploma or certificate in engineering trade with some training in this area or/and experience of installation.

Table 4: Manpower Required

SN	Description	Man-days required	
		Grinder only	**Grinder + Huller**
1.	Technician	1	2
2.	Skilled Labour	1	2
3.	Unskilled Labour	2	6

5.0 Main problems in MH Systems:

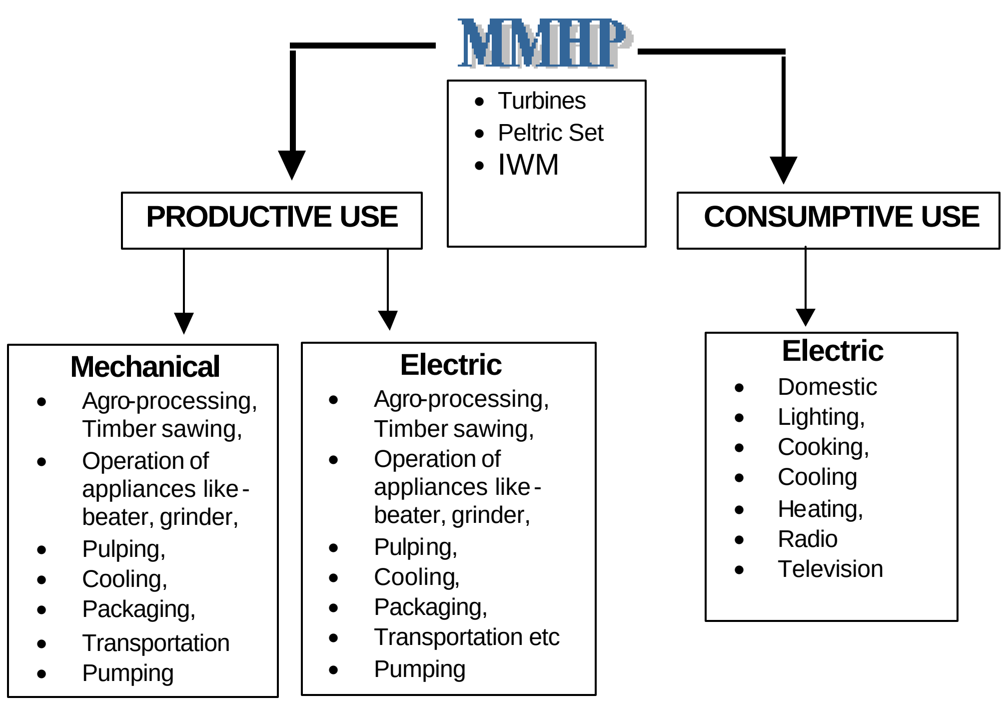
Micro- and Mini-hydro projects have some problems.

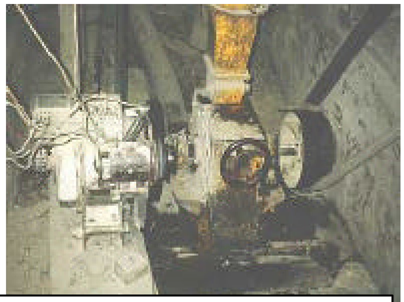
- Insufficient site studies
- Lack of operating capability
- Insufficient structures for service and preparations.
- And, despite heavy subsidies, problems with ability to pay of the target population.

6.0 End-Uses

The use of power generated by micro hydro stations can be categorized as productive and consumptive use.

- Productive use of power will be in the form of a) mechanical or b) electrical for Income Generating Activities
- Consumptive use which takes place in or near the house.





Picture: 1 (Electrification)

Picture: 2 (Oil Expeller)

Picture: 3 (Compressor)

Picture: 4 (Bitten rice)

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