Uses of Solar Power in the Jhikhu Khola Watershed

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1. INTRODUCTION

Ninety-five percent of Nepal's energy requirements is met with biomass sources. Hydropower, despite its huge potential, is currently producing only 0.6% of the total energy consumed in Nepal (Rokaya, 1993). Hostile geography and resource constraints restrict the use of electricity to urban residents (10% of total population). In the Jhikhu Khola watershed, electricity is accessible to only a handful of houses clustered along the road.

Our meteorological and hydrological stations are several kilometres away from the road and are not accessible by vehicle. Several of these stations are equipped with automated data loggers, collecting large sets of data which are downloaded regularly using a laptop computer. These loggers are powered by rechargeable batteries which need regular recharging and in the absence of accessible power sources, solar photovoltaic (PV) systems were selected as the most promising renewable energy source to recharge computer batteries at each site. The use of solar power has subsequently been diversified to include solar-powered water pumps for irrigation and electrification of our field research station and individual farm houses.

There are many encouraging signs that solar power can be used in many aspects of development (drinking water supplies, home power supplies, rural telephone services, etc.) and the present paper is intended to provide information on our experiences in using PV systems for research activities and farm development in the Jhikhu Khola project.

2. APPLICATION OF SOLAR ENERGY

The collection of solar power is relatively easy. The solar panel intercepts sunlight and converts the radiation into electrical energy. This power can be used to power a solar pump directly or can be stored in batteries where fluctuations in solar intensity are controlled through a regulator. The recharged batteries are used to generate light in the field research centre and power the computers and data loggers. Table 1 provides an overview of the solar panels, their capacity and their use.

A typical 53-Watt panel (rated 3.05 Amperes) will take 6.5 (20/3.05) hours to fully recharge a 40 Ah battery (a lead acid battery normally operates at up to 50% of its capacity).

2.1. Project's Research Activities

2.1.1. RECHARGING BATTERIES

All five tipping-bucket rain gauges, three climate stations and four hydrometric stations are equipped with data loggers which record data continuously. The data are downloaded with a portable computer once a month. Similarly, the hydrometric data loggers are connected to a pair of rechargeable batteries that are replaced every second month. Both computer and batteries are recharged in the field office when required, helping to speed up data acquisition and allowing the field staff to verify data in the field.

Table 1. The use of solar panel and batteries in the Mountain Resources Management Project.

Item	Capacity	Quantity	Application
Solar Panel (12 volt)	17 Watts	3	Lighting
	31 Watts	1	Charging Computer
	53 Watts	1	Charging Computer
Rechargeable Battery (12 volt)	6.5 Ah	16 (portable)	Hydrometric Data Loggers
	40 Ah	2	Lighting
	50 Ah	2	Computer + Lighting
	120 Ah	1	Computer + Lighting

2.1.2. PROCESSING SEDIMENT SAMPLES

Large numbers of sediment samples are collected during high flows of flood events. Solar-powered light has made it possible to process, analyze and filter the samples at night. Within a few hours, bottles are cleared for reuse. This saves time and is very effective in providing accurate and timely results. The use of energy efficient lights with portable batteries is extended to the gauging station where hydrometric measurements can now be made more effectively during storms which occur at night. A minor but important component is that the cleanliness in the kitchen has noticeably increased since lighting has become available.

2.1.3. REHABILITATION OF DENUDED LAND

The tree nursery, which is an integral part of the rehabilitation project, demands a regular supply of water to maintain seedlings and cuttings of various nitrogen fixing trees and grasses. During the dry periods (December - May), water shortages are acute and a regular supply is essential, especially to the transplanted seedlings which quickly reach wilting point. Andheri Khola is the only water source but it is about 200 metres away and about 35 metres below the nursery. The project introduced two solar pumps to lift stream water on a step basis to the nursery and the transplanting areas. Water is collected in drums at different sites, minimizing the water transport required.

The operational capacity of the first pump is lower than that of the second. The first pump uses 80 Watts (double panel) and delivers 150 litres of water per hour over a vertical lift of 12 metres. The second pump requires only 40 Watts and provides 270 litres of water per hour over a vertical lift of 20 metres. The technical details of pumps and panels are provided in Table 2. The differences in water delivery is associated with the efficiency of the pumps.

To meet our water requirements, the pumps operate a few hours a day lifting an average of 700 - 900 L/day. Water-efficient techniques such as trickle and sprinkle irrigation are applied to off-season crops namely capsicum, water melon, cucumber and strawberry, as well as to fruit trees (mango, lychee, etc.).

Table 2. Technical aspects of the two solar-pump installations.

		Pump A	Pump B
Panel Specifications	Manufacturer	Siemens	Siemens
	Rated Output (W)	40	48
	Voltage (V)	12	12
	No. Panels	2	1
Pump Specifications	Manufacturer	Flowlight	Minnesota Electric Technology
	Vertical Lift (m)	12.23	20.4
	Discharge (L/min)	2.5	4.6
	Installation Date	March, 1994	November, 1994

2.2 Rural House Electrification

Many villages do not have access to an electricity supply. Naturally, the bright light of the PV set drew many villagers to the research station. They frequently examine our set and enquire about the costs. In 1993 a PV set (a panel, battery, regulator and a fluorescent lamp) was given to a farmer (Bela, see Table 3) on a trial basis. Operation at the farmer level was smooth and in 1994 we extended the trial to a resource-poor female farmer in Jaretar. The project provided a PV set and operational instruction. Although the trial was designed for a single farmer (because of the low capacity of a 17-Watt panel and a 40-Ah battery), another two households joined and each received one light. The light is very efficiently designed consuming about 8 or 10 Watts of power. The farmers use the light for 1-3 hours per day. Solar power supply for light is now operating at three sites, including the project field research centre. The different technical specifications are provided in Table 3.

Table 3. Photovoltaic module used for light.

Items		Site 1			Site 2	Site 3
		Field Camp			Bela (north facing slope)	Jaretar (valley bottom)
Solar Panel	Number	1	1	1	1	1
	Watts	17	31	53	17	17
Battery	Number	1	1	1	1	1
	Ah	40	50	120	50	40
Light (fluorescent)	Number	1	5		2	3
	Watts	20	10		10	10
Ethnic Group		Various			Brahmin	Danuwar

Although the setup is new at Jhikhu Khola and the experience is too short to make big claims, the farmers nevertheless feel that it is a useful tool to:

- motivate children to complete school work in time (education)
- encourage female farmers to weave cloth in the evening (cottage industry)
- save kerosene, thus it lessens the smoke problem inside the house (health)

Significant results can be achieved through community-level installations. Shrestha and Sharma (1994a) indicate that the entire village (46 families) of Pulimarang, Tanahu, Western Nepal, is benefitting in many ways (adult education, hygiene, off-farm employment, birth control, etc.) from community-based, self-contained, home solar systems.

3. BENEFITS FROM SOLAR PHOTOVOLTAIC SYSTEM

The advantages that the project received from the use of the solar system are two-fold: economic and environmental, the first being more obvious than the second.

3.1. Economic Advantages

3.1.1. SAVINGS BY NOT USING KEROSENE LAMPS

Based on our previous experiences, we would need three pressure lamps (petromax) to conduct the intensive field work. This would have involved continuous expenses and repair. The operational cost during the lean period (October - May) would be about one third that of the peak season's (June - September). The breakdown of the costs is provided in Table 4 below.

Table 4. Breakdown of costs for kerosene lamps (Nepalese Rupees).

	Capital Investment	Operational Cost (per month)	
Item	Pressure Lamps	kerosene (L)	maintenance (mantle/glass)
Quantity	3	60	3
Unit Cost	1000	10	60
Subtotal	3000	600	180
Total	3000	780	

Nb. The operational costs for June - Sept and Oct - May are 3120 and 2080 NRs respectively.

The project's annual expenditure on light alone consists of capital investment + total running cost= 3000 + 3120 + 2080= 8200 NRs, if kerosene light is used. Because of their poor quality and extensive use under field conditions, these lamps usually do not last for more than one year. At least 10 nets are used every month and a new glass is required every second month. Depending upon the capacity, the cost of the Solar Power set ranges from NRs 15,000 to 37,000. Hence the initial solar investment would be paid off in 2-3 years, which is well below the lifetime of these solar systems.

3.1.2. SAVINGS BY NOT USING KEROSENE PUMPS

In a stream water lifting trial, we ended up using three kerosene pumps in a row to deliver water to the point of interest. Although the delivery of water is large, the associated cost of transportation of the fuel (kerosene) and the rental charge for one hour (minimum) at a time is considerable. Details are in Table 5.

Table 5. Breakdown of costs for using kerosene pumps (Nepalese Rupees).

Item	Quantity	Cost Per Unit	Total Cost
Pumps hired	3	80	240
Transportation	3	40	120
Kerosene (litres)	3	20	60
Total (per week)			420

If pumping is done once a week over the eight month dry period, the total annual cost would be 420 x 32 = 13,440 NRs. The cost of a solar pump, in comparison (depending on its capacity) is in the range of approximately NRs 30,000. Once again, the solar investment is paid off in 2-3 years.

3.2 Environmental Benefits

Locally-available, low-grade kerosene burns poorly and produces smoke. Spilling of kerosene from pumps into the stream-water is harmful to aquatic animals. Disposal of dry-cell batteries can adversely affect the ground water and the surrounding area. Solar PV systems do not have these problems.

The solar PV module has distinct advantages in that it minimizes environmental degradation (air pollution, greenhouse effect and acid rain) and the non-renewable resource savings can be significant (as shown below in Table 6).

Table 6. Environmental benefits in the Jhikhu Khola Project by using solar rather than kerosene power.

Power saved	2,700 kWh
Petroleum saved	4.8 barrels of oil
Coal saved	1,225 kg
Carbon dioxide kept out of the atmosphere	1,814 kg (a major global warming agent)
Sulphur dioxide kept out of the atmosphere	10.6 kg (contributor to acid rain)

Note: The calculations are based on (Schaeffer, 1991):

1 PV = 50 Watts
1 PV module will last 30 years
1 kWh of electricity is generated from 11,605 kJ (11,000 Btu)
6.59 million kJ (6.25 million Btu) = 1 barrel of oil
Coal required to generate 1 kWh = .454 kg (1 lb)
Carbon Dioxide emissions per kWh = 0.68 kg (1.5 lb)

4. SOME PROBLEMS ASSOCIATED WITH USING PHOTOVOLTAIC SYSTEMS

There are some limitations and constraints when using PV systems. Our experiences are as follows:

- initial capital investment is high for rural farmers
- it is easy to destroy the system, particularly the regulator; power regulators blew due to improper connection of the power terminals
- dry-cell batteries demand distilled water over time
- the solar pump demands clear water; regular cleaning of super fine filter is essential to optimize its delivery capacity
- the solar system operates inefficiently during monsoon season for two reasons: high sediment load in the stream water and low sunlight exposure due to frequent cloud cover. Fortunately, the water demand during this season is not great.

The life span of a solar photovoltaic panel and battery is 30 and 3 years respectively. Literature indicated that some materials in PV cells could be toxic which may be hazardous during production and disposal (Renewable Energy, 1994).

5. FUTURE TRENDS IN SOLAR ENERGY

The PV system is a useful achievement which has many positive effects on the life pattern of people surviving under global resource pressure. The system used is portable and ideal for remote locations. The set can easily be installed and dismantled within a few minutes. Upgrading of the system is easily done without requiring large modifications. Ever rising prices in nonrenewable sources of energy (largely petroleum products and coal) force us to use more alternative sources, and solar energy is a realistic alternative. Furthermore, solar energy's price is continuously decreasing, as revealed by the cost/Watt, which was US $1000 in 1960 and is now US $5.

The energy of the sunlight intercepted by the Earth every day is estimated to be 170,000 Terawatts or 2.5 million barrels of oil per day equivalent (bdoe), which is 10,000 times greater than the world population's annual energy requirements (Renewable Energy, 1994). The radiation in Pulimarang (Middle hill of Western Nepal) is measured to be 960 W/m^2 (Shrestha, 1994b). Massive research on thin-film photovoltaic cells hints that the cost of a PV module could be less than US $1 per Watt in the future (CRE, 1995).

There is now a wide selection of photovoltaic systems available in Kathmandu with the main suppliers being:

1. Solar Electricity Company Pvt. Ltd.
GA 2-718, Bagbazar
P.O. Box 249
Kathmandu, Nepal
Tel 225 253; Fax 977-1-414 653

2. Lotus Energy Pvt. Ltd.
Cha 2-271, Bhatbhateni
P.O. Box 9219
Kathmandu, Nepal
Tel 418 203; Fax 977-1-412 924

3. **Wisdom Light Group Pvt. Ltd.**
Durbar Marg
P.O. Box 6921
Kathmandu, Nepal
Tel 230 973; Fax 228 696

6. CONCLUSIONS AND RECOMMENDATIONS

The MRM project found that solar photovoltaic systems are very useful in field research and provide power to run laptop computers and backup batteries, operate solar pumps and provide rural lighting in individual houses.

The associated benefits are:

- running television and cassette players
- motivating school children to read
- creating off-farm employment (weaving and knitting)
- improving health conditions in the kitchen

The solar PV sets used in the projet greatly facilitated field-based research in remote areas. These trials should be continued since they have the potential to assist and improve rural development.

7. REFERENCES

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