An Assessment of Pico Hydro as an Option for Off-grid Electrification in Lao PDR: case study of Thapene village

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ABSTRACT

The objectives of a Pico Hydro Power study at Thapene village are improving the knowledge of people handling the Pico Hydro systems safely, improving the technological side to establish a higher efficiency, and improving the knowledge of the people concerning energy management. In Thapene, situated at the Khouang Xi River, in a small village near the former capital of Louang Prabang in Lao PDR, in one of the poorest countries of the world the inhabitants refuse any grid connection as they run their own power stations, small but efficiently. The power consumption for each household has been limited to 2 lamps of maximum 8 W each, with a monthly price of 8,000 KIP (0.75 $). This system has been run by the village up to now with the head of the Village assuming financial and maintenance responsibility. There is one responsible technician who was taught by the project installers, and still maintains the system properly. As when using electrical energy for light only, the demand also grows for using electric equipment such as fans, radios, stereos or televisions.

In Thapene village there are 50 households and load demand per family is about 95 Watt. The total Pico Hydro systems installed are 21 units, full power capacity 26 kW but generate power supply only 4.80 kW for the basic require load demand 7.28 kW. After improve the efficiency of BOS (Balance Of System) power supply can be improved capacities from 4.80 kW to 7.28 kW , the power supply efficiency of system improve from 18.50 % to 28 % respectively . The off grid electrification at Thapene village is completely provided by Pico Hydro by 100 % by the people of the village.

After training operators of the Pico Hydro system will able to understand the correct way in which to handle the system by continuous knowledge build-up regarding energy management. These two important aspects have made the project enormously successful.

Keywords : *Pico hydro, Off-grid electrification.*

1. INTRODUCTION

Lao People's Democratic Republic (Lao PDR) is a tropical country, whose climate is affected by the southwest monsoon which brings high rainfall, high humidity and high temperatures between mid-April and mid-October. Annual rainfall varies throughout the country from 1,200 to 2,800 mm. Accordingly, Lao PDR has a high hydropower potential of about 22,500 MW within its territory. At present, less than 2% of the total potential has been developed with 55 % to 60% of the production exported to neighboring countries. Considering the topography of the country, it can be expected that macro hydropower could be an important source of electrical and possibly mechanical power to rural mountainous areas. At present, micro hydropower stations with a total installed capacity of 615 MW have been completed. Lao has 60,000 cubic meters of renewable water resources per capita, more than any other country in Asia. There are 38 small/micro hydropower stations that range from 5 kW to 250 kW that have operated in parts of country with total installed capacity of 2,381 kW. Including all hydro power stations there is an installed capacity of 5,653 kW. Recently, many families in mountainous areas and villages close to streams have been using small Pico Hydro power generators of capacity between 200 W and 5 kW for their electricity demands. These generators, imported from China and Vietnam, are not high quality but the price is very attractive to Lao PDR [1]. Pico Hydro has negligible environmental impact since large dams are not involved, and the systems can be managed and maintained by a community and even by villagers themselves. This is comparable to

other electrification systems such as battery charging and solar home systems to be a significant energy source for rural area in Lao PDR.

2. LAO PDR RURAL ELECTRICITY DEMAND

Lao PDR is a landlocked country with an area of 236,800 km^2 and has a population of about 5 million inhabitants. The Lao populations live in over 9,000 villages scattered through the country with an average of about 300 inhabitants, there are about 80 % of the population which are employed in agriculture including livestock, fisheries and forestry. The other 20% of the population live in urban areas. Only 25% of the whole populations have access to electricity. The electricity supply system is just beginning to develop in Lao PDR, with electricity services provided on a regular basis in the country's capital and in the major provincial capitals. The total energy consumption in the country, in the form of wood fuel, charcoal, petroleum products and electricity from hydropower, was 630 MJ during the year 1993 (Figure 1) wood fuel accounted for 74.4%, petroleum products 11.6%, hydropower 9.4% and charcoal 4.6% [1].

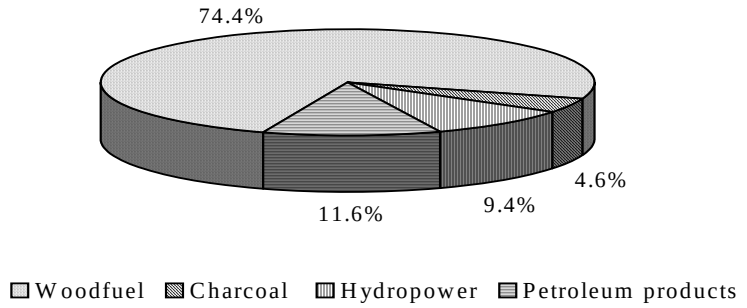

Fig. 1 Source of energy consumption in Lao PDR.

Electricite du Lao (EdL) has an expansion plan for the rural electrification together with a transmission and distribution system. Average growth rate of energy consumption in the period of 1995 to 2000 was 15.1% or increasing by 61.5 GWh per annum. The energy demand projection in year 2010 will be approaching 1,314.7 GWh with an approximate doubling of energy consumption in the year 2000, which is an increase of 11.75% per annum.

The Government's strategy is to raise the national electrification rate to an ambitious target of 90% by the year 2020. EdL, the agency responsible for generation, transmission and distribution of electricity in the country is currently engaged in an ambitious program of rural electrification through extension of the national distribution grid to reach around 80% of households. However, it will not be economically viable to extend grid electrification to all areas of the country, and development of sustainable off-grid electrification systems such as Pico Hydro, village hydro/diesel, solar, wind, biomass, etc, will be required to serve about 10% of households, if the Government's rural electrification targets are to be achieved.

3. CASE STUDY OF PICO HYDRO IN THAPENE VILLAGE

Thapene Village is located in the Louang Phrabang province. Thapene is a remote village about 30 km from Louang Phrabang near the Khouangxi waterfalls. The village is unlikely to have an immediate access to grid electricity, and the access road to the village is usually badly affected during the rainy season. There are 84 households in the village, with a population of about 425 inhabitants. The average yearly family income is approximately 340 US$, and almost all the income comes from agriculture and labor work. Previously the villagers mostly used kerosene for lighting.

Pico Hydro systems in Thapene village

Thapene village has no access to the grid which is about 15 km away. In 1999 the World Bank installed a 3 kW Pico Hydro system (Fig. 3). This Pelton station has two penstocks (20 cm diameter) with an end pressure of 3.5 kg/cm^2, and provides power to households during 18.00 – 06.00. The system allows a maximum of 2 lamps 6 W or 9 W each to the consumers. The villagers have to pay monthly 8,000 Kip/household (US$ 1 ≈ 7,890 Kip rate of change in 1999 now in 2005 US$ 1 ≈ 10,800 Kip).

Fig. 2 World Bank financed 3 kW Pico Hydro system in Thapene village.

As there is no possibility of having more than 2 lamps for each household, certain households with commercial activities and those who have higher income, use their own Pico Hydro power generation for lighting, watching television and listening to the radio. Only 45 households in November 2004 are now left to get their energy from the world bank financed system. Up to the survey by the Asian European Renewable Energy Cooperation Agency (AERECA) and the School of Renewable Energy Technology (SERT), faculty of Naresuan University Phitsanulok, no safety and controller systems had been installed. The lamps had a very limited operation time because of a possible over voltage and frequently the generators became hot when there was no last.
After installing controller systems these problems were solved, the villagers reported up to eight times longer operation time for their lamps. To minimize the risk of over-heating the generators, and expenses for new lamps and also maintenance, even at the present time sets are mostly used only during a time for generating light and television that means from 1800 to 2000. By 2200, when people switch off their lights and television, the set is normally removed from the water.

Fig. 3 Modified propeller Pico Hydro system in Thapene village.

Components of Pico Hydro systems

The installation cost survey made by AERECA and SERT for each Pico Hydro system technology. The civil works of the world bank, Francis, modified propeller Pico Hydro is 12%, 21% and 0% of cost scheme respectively (Figure 4, 5 and 6). Community labor was provided free of charge. For the intake, use was made of natural features to minimize the building work required to avoid a large and expensive concrete structure. The turbine and generating equipment was sourced through local markets to minimize costs and ensure that local repair and replacement is possible.

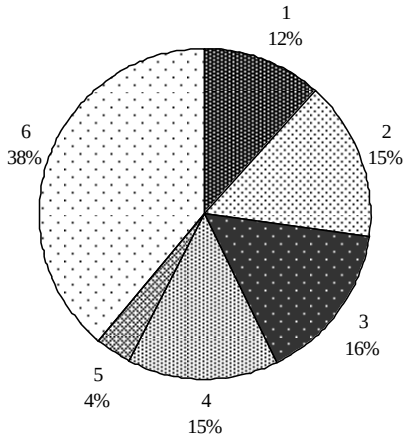

Fig. 4 World Bank financed 3 kW systems. Total cost is 12,850 US$ (45 houses).

Note: 1. Civil works (turbine house); 2. Penstock; 3. Turbine, generator, controller and protection; 4. Distribution system cable, house wring and light bulbs; 5. Labor cost; 6. Project design and management cost.

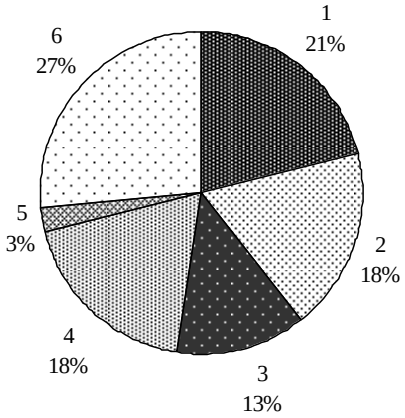

Fig. 5 Francis 0.5 kW system. Total cost 880 US$ (1 house).

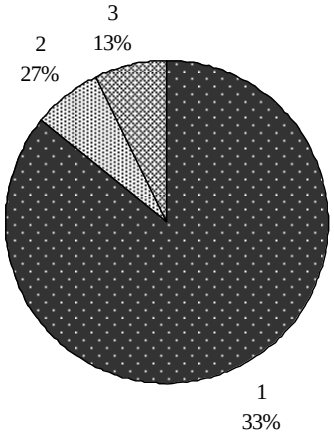

Fig. 6 Modified propeller 0.2 to 2 kW system. Total cost 1,400 US$ (20 houses).

Note: 1. Turbine, generator, controller and protection; 2. Distribution system cable, house wiring and light bulbs; 3. Labor cost.

Table 1 Pico Hydro system scheme specifications

	System A: World bank system	System B: Francis	System C: Modified propeller
Power output (electrical)	3 kW	0.5 kW	0.2 – 2 kW
Number of houses connected	45	1	20
Penstock	30 m	6 m	None
Type of turbine	Pelton	Francis	Propeller
Type of generator	Induction (4 pole)	Induction (4 pole)	Induction (4 pole)
Head (net)	27 m	2.5 m	None
Flow (design)	42 l/s	20 l/s	None
Efficiency (turbine + generator)	50 %	48%	20-30%
Distance of furthest house	200 m	50 m	20 m

Cost comparison of off-grid electrification options

Table 2 compares installed costs of typical solar, Pico Hydro system and grid extension in Lao PDR.

Solar Home systems

Annual maintenance costs based on battery depreciation (cost new = US$ 50, lifetime of 2 years). (Assumed to be zero for years 1 and 2 because a new battery is installed with the system.) Measured watts per panel were used rather than manufacturers' rated output for a realistic estimate of likely power output. The average insulation is assumed to be five hours throughout the year.

Pico Hydro systems

Power from Pico Hydro is continuous and used continuously. Tariff for operation and maintenance is US$ 0.83 per month for 20 W supply.

Grid extension

Power from utility grid is continuous and used continuously. Tariff for operation and maintenance is US$ 12.5 per month for 20 W supply.

Table 2 Cost comparison of off-grid options for household electrification in Lao

Type of system	Installed cost per household (US$)	System life time (years)	Annual maintenance and operation costs (US$)	Life cycle cost (US$)	Energy per household over lifetime (kWh)	Average cost US$ per kWh
PV 20 Wp	150	20	10	850	730	0.94
Pico Hydro 20 W average	100	20	10	300	2,000	0.15
Grid extension	600	20	150	3,600	2,000	1.8

4. RESULT

Table 3 Pico Hydro installed Power Data

Power Size System (W)	Number of Units	Total Power (W)
200	6	1,200
500	9	4,500
1,000	3	3,000
1,500	2	3,000
3,000	1	3,000
Total	21	13,700

Average Peak Load	4.80	kW
Load Demand per Family	95	W
Number of Families	50	Households
Power Supply Efficiency	18.50	%

Operating time 18.00 PM. – 6.00 AM.

Table 4 Estimate Price of Pico Hydro

Size in Watt	Price in Kip
200	300,000
500	400,000
1,000	600,000
1,500	700,000
2,000	800,000

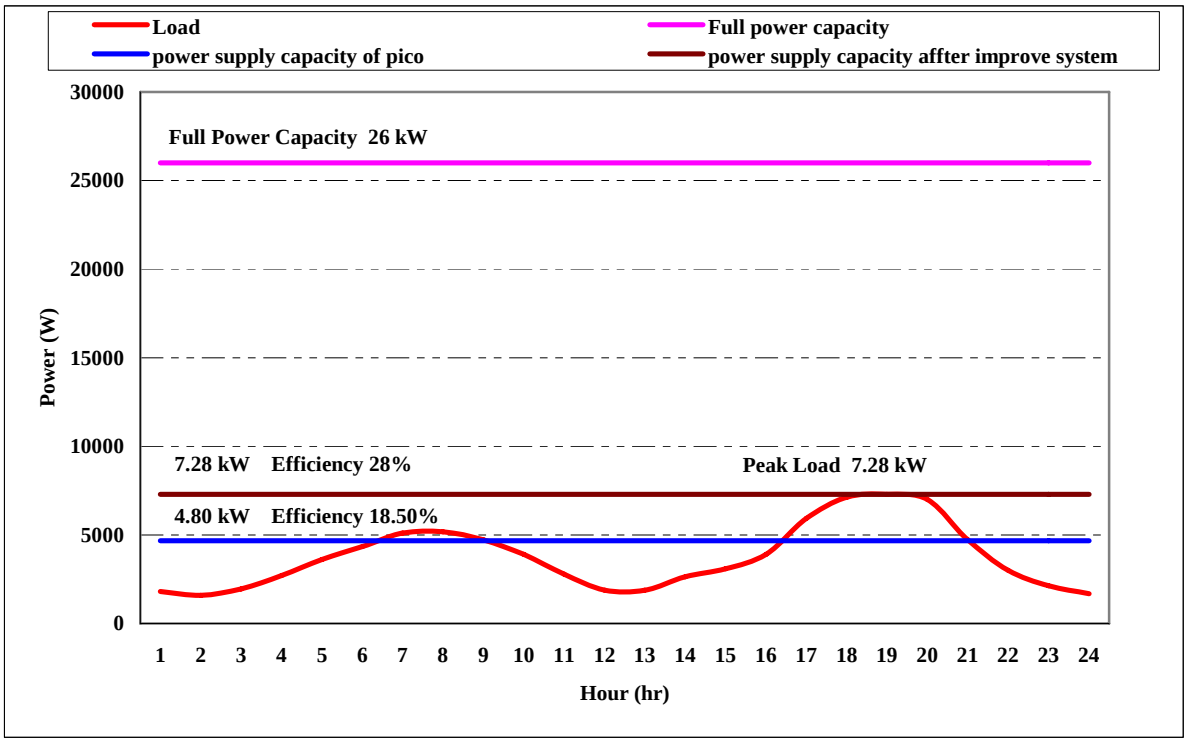

Fig. 7 Load Profile after improve the Efficiency Demand peak load 7.28 kW Power Supply Capacity 7.28 kW Out put Supply Efficiency 28 % Number of family 50 Household Load demand per family 145 W

Significant Data after improve efficiency Pico Hydro

Number of Family	50	Households
Basic Require Load Demand per Family	145	Watt
Number of Pico Hydro Systems	21	Units
Full Power Capacity	26	kW
Power Supply Capacity	7.28	kW
Peak Load Demand	7.28	kW
Power Supply Efficiency	28 %	

5. CONCLUSION

The Thapene Pico Hydro Power project owes its success to the advances in a technical, social and economical way. The project was first begun by obtaining all relevant information concerning Pico Hydro power in Lao in the second half of 2003. The Khouang Xi River produces enough water to supply power at all times. However, in the event of an insufficient demand of power which would create the risk of generator over-heating, controller systems have been installed which absorb the over-power. As the total cost of a Pico Hydro system is inexpensive, it could be assumed a high-voltage-controller is also inexpensive. As installed power supply is an indicator of the standard of life for statistics world wide, and directly affects the dramatically changed quality of life for the villagers. People of Thapene already realize a good energy management:

The installed power increased from 4.80 kW to 7.28 kW during the second half of 2004. The benefits can already be clearly seen, there are many more lamps allowing the people to work in the evening, to watch television (already there are 16 owners of televisions and satellite systems). Not least, music can be listened to while comfortably relaxing in a cool breeze from fans. Also batteries can be charged for electrical equipment for when working in the fields. Thapene power installation can produce up to 63,000 kWh per year. This energy is permanently available and in the future should be used much more for production of ice, used for sale in the local market as well as drying of vegetables for export. As the Thapene power is 100 % clean energy, villagers also have the option to sell their CO^2 emission certificates to energy suppliers producing too much CO^2. The produced energy saves a CO^2 output of approximately 1.8 Tons In Thapene a new way of economically thinking is being created.

There is little doubt that young people in the village, who previously saw no chance of a bright future, will now see opportunities closer to home. Many will decide to stay and help in the development of the village and local community. There are clear reasons for staying, farmers and agricultural workers can continue their lifestyle, but in far more comfort, further education will be available for those wishing to increase their future status, in addition this particular region of Lao is indeed one of the most peaceful and beautiful places on earth.

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