REPORT OF OFF-GRID HYDRO POWER ASSESSMENT OF MYANMAR

Submitted

By

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Contents

Abbreviation

CFL	Compact Florescent Light
DA	Department of Agriculture
DHPI	Department of hydro Power Implementation
DRD	Department of Rural Development
HH	Household
HPP	Hydro Power Project
HT	High Tension
kV	Kilo Volt
LCC	Life Cycle Cost
LED	Light Emitting Diode
LT	Low Tension
MCB	Miniature Circuit Breaker
MOEP	Ministry of Electric Power
NGO	Non Government Organization
NEP	National Electrification Project
O & M	Operation and Maintenance
RCCB	Residual Circuit Breaker
VHP	village Hydro power Project
VIP	Very Important Person

1. Introduction

National electricity grid penetration in Myanmar is about 32% at present however the state level penetration varies from 6% to 42%. People living in certain un-electrified areas have been using micro hydro power, solar and diesel generators for satisfying their basic needs such as lighting, viewing TV and communication. At current electrification rate the 100% coverage would be achieved only by 2040. However, the National Electrification Project (NEP) plans to achieve 100% electrification by 2030 by heavily investing on generation, transmission and distribution. It is estimated that approximately 250,000 off-grid households consumers has to potential to use stand alone solutions such as mini grids and off-grid solar home systems. The World Bank conducted this study to assess the situation of the existing off-grid hydro power projects and to identify a suitable methodology to uplift the off-grid hydro power sector as a pre electrification measure in line with the National Electrification Project (NEP).

The objective of this assignment was to evaluate the electrification program and schemes of the Village Hydro Power (VHP) and to make recommendations for improving the effectiveness and sustainability of these electricity services under an expanded DRD-led program. The World Bank conducted this study as part of the preparation of an off-grid component of the National Electrification Project (NEP) of Myanmar.

The estimated cost of the overall off-grid electrification program of DRD in 2014-15 is 37,300 million Kyats (approximately US$ 38.5 million), a significant increase (almost 20 times more) over the previous two years since the program started. Given the very significant investment to be made, the DRD must assure that the VHP that are procured and installed are of good quality and will be providing reliable electricity services to the consumers. It is necessary to assure that an organizational mechanism is in place to manage, maintain and operate the VHP and to collect necessary revenues, and to ensure the availability of expertise for such work. In addition access to repairs and funding for functioning of such a facility must also be assured.

A basic procurement specification prepared by DRD has been provided to the State/Regional office which is responsible for procurement of the VHP. However this specification is inadequate to ensure that the procured system delivers the required kWh reliably over a long period of time. As significant improvements are required, the developers needs to formulate technical performance requirements and specifications based on the village hydro schemes experience in Sri Lanka and other countries.

2. Methodology

This assessment was carried out during the period of 7th Nov. to 27th Nov. in Shan, Chin, Mandalay and Sagaing States/Regions of Myanmar. The activities were conducted during this period is as follows:

Consultations with Government Officials

Consultations were held with the officers of Ministry of Electric Power (MOEP), Department of Rural Development (DRD) and Electricity Supply Enterprise (ESE). Information collection was done based on a carefully prepared questionnaire but not necessarily confined to it due to varying social, financing, economical and technical context from region to region.

Consultations with other key stakeholders

Beneficiaries of hydro projects, service providers and manufacturers were interviewed to obtain more information.

Stakeholder Workshop

Further information was gathered from the participants of the workshop on "Micro Hydro and Decentralized Renewable Energy for Myanmar Practice-to-Policy Dialogue Applying Lessons from Indonesia, Nepal, and Sri Lanka" held by Renewable Energy Association of Myanmar (REAM) from November 24th to 28th, 2014 in Yangon, Myanmar.

Assessment of off-grid village scale hydro systems

For this assessment, 22 off-grid hydro power projects (including individual and community system) were inspected and at least 3 people from each project including the operator, 6 hydro project developers/ manufacturers were interviewed. Table 01 shows a brief description of visited. The inspected sites were geographically located in Shan, Chin and Magwe States. The details of all the visited projects, government authorities met/participated and service providers are included in the annexes.

Table 01. Description of visited HPP

No	Project name and location	Funder / Developer	Description	Power			Head (ft)	Remark
				Designed (kW)	Actual (kW)	Per HH (W)		
1	Var HPP Chin state, Falam	DHPI	2,315 HH, O & M by ESE, Distributes through 17 nos. Of transformers, Commissioned in 1986	500kW x3 turbines	500kW x3	N/L	400	At a moment single turbine runs
2	Laiva HPP Chin state, Hakha	DHPI	5,240 HH, O & M by ESE, Distributes through 24 nos. Of transformers, Commissioned in 1994	255kWx 2 turbines	255kW x 2	N/L	636	National grid covered part of project area, both turbines synchronise and run, over 1000kW potential site is in down stream
3	Dongvar HPP Chin state, Hakha	DHPI	72 HH, O & M by ESE, Distributes through 2 nos. Of transformers, Commissioned in 1984	200kW-3 turbines	200kW - 3	N/L	210	National grid covered part of project area, at a moment single turbine runs
4	Mong In HPP	DRD/ Sea Pelicon Co. Ltd	Under testing on visited day, 60HH,	5	0.9	15	8	1 mile away from the national grid
5	Owe Kong HPP Pidaya, Shan state	Owner	Private own HPP, electricity, grain crusher and oil expellers are running, started in 1990, 80HH,	N/A	N/A	40	10	Project within the national grid covering area
6	Min In HPP I Pidaya Shan state	DRD/ Sea Pelicon Co.Ltd	DRD developed in 2012, O & M by Villagers	N/A	N/A	[illegible]	18	Project within the national grid covering area
7	Min In HPP II	UNDP	Used from 1996 to 2014, O & M by Villagers	30	N/A	N/A	7	Not functioning, national grid reached
8	Min In HPP III	Owner	Private own HPP, electricity, grain crusher and oil expellers are running, started in 1990s	N/A	N/A	N/A	5	Electricity use only by owner, neighbours has national grid supply
9	Tha Pyay Kong HPP	DRD	73 HH, started in 2014 February, O & M by Villagers	10	3.8	30	7	
10	Myosoe HPP	DRD	130 HH started in 2014 February,	7kWx2	4	30	6	Two turbines run in parallel

			O & M by Villagers					
11	Taung Gyi HPP	Villagers/developer	commissioned in 2004, Not functioning over last 4 months, O & M by Villagers	50	N/A	N/A	200	Due to endless failures project has been stopped
12	Pan Oo Taung HPP	Villagers/Turbine manufacturer	2011 commissioned ,220HH, O & M by Villagers,	75	25	N/L	N/A	Water taken from Irrigation lake
13	Taung Chae HPP	Villager/developer	250HH, Shan state, O & M by Villagers, 2007 commissioned	100	N/A	N/A	N/A	
14	Laouk Lon HPP	UNDP /developer	140HH, Chin state, O & M by Villagers, 2011 commissioned	20	8	20	100	
15	Kalay HPP	Owner and Magwe state/ Owner	2008 commissioned, 66HH, turbine manufacturing workshop run with this power	75	35	50	20	Turbine manufacturer own
16	Individual owned HPP	Owners/developer	6 readymade turbine and single water wheel	1>	0.3>	300>	5>	7 projects visited

Note:

N/A: Not available

N/L: No Limitation

3. Findings of the field visits

Overview of the HPPs in Myanmar

At present off-grid hydro power schemes are operated under minimum monitoring and supervision and technology of the government authority, the professionals and non-government sector. Because of these shortcomings it leads to a very high O & M cost and poor performances & quality of electricity for the end users. In this section these aspects are discussed in detail.

Following consequences can be listed because of poor monitoring and supervision,

- Energy charge per unit of most of the VHP is very high comparative to the national grid
- Do not maintain records of financial transactions and social functions
- Lack of transparency in handling finances
- Technology is fully dependent upon a single company or person of the project
- Frequent occurring of the same technical failures

Poor technology machinery (turbines and generators) parameters which do not match with the site parameters, poorly finished machines, unbalanced rotating parts, high voltage drop in distribution lines and non standard controlling systems, are the main technical shortcomings. The turbines are locally manufactured, the voltage and the frequency are controlled by running either a fixed load or adjusting sluice gate or gate valve. So voltage and frequency are varying between 150V – 270V and 35Hz – 70Hz respectively at the user points. The machine capacities of the government constructed projects are relatively larger than locally manufactured machines (above 200 kW) and all are imported machines. Although these machines have in build automatic flow controllers, none of those were functioning at the time of observation. Contrary, some turbines with automatic control systems were installed in 2013. So the operator has to adjust the flow controlling device from (?) time to time. As such these projects would meet many difficulties.

Energy demand of off-grid communities

Conventional lighting source of rural Myanmar people is candles. Generally a rural family uses four candles per day. Additionally three dry cell batteries are used for torches and radios. The monthly candle and battery cost is between K 1,000 and 1,500 per family. However they are not satisfied with this form of energy and there is a big trend to go for an alternative solution. Therefore a good market has been created for hydro power and solar PV systems. There is a daily growing market for solar PV systems and even small cities have a few solar parts retailers.

The number one choice of people in the hydro potential areas is hydro power and solar power is the second option. The energy demand of more than 50% of the off-grid hydro power beneficiaries is less than 50 W or 15 kWh per month which limits the consumption to use of two to three numbers of bulbs. However the cost of this small amount of energy is about K 2,000/=. This is equal to the monthly energy cost of national grid beneficiaries of 60 kWh. Although the supply of electricity from off-grid hydro power projects is very limited, over 95% of HHs within the area is connected to the scheme. Further, there was apparently no complaint or punishment on unpaid families. In some projects the generated capacity is not enough to use for even TVs. Therefore some people have used solar systems with an inverter just for the TVs and hydro electricity for lighting.

It was observed that during last couple of years, there is a tendency among consumers for using TVs and the Rice cookers (power of rice cookers 750 W – 1000 W). It is necessary to provide a capacity of at least 100 W per household in the future hydro-projects so that a TV as well as some lighting can be facilitated. With a capacity of over 10 kW even a rice cooker can be used during the off peak period.

Categories of off-grid Hydro Power

The off-grid hydro power schemes in Myanmar can be classified into three categories based on the differences of social, financing and technical approaches;

1. Domestic Hydro Power Project (HPP)
2. Village HPP
    - 2.1. Private HPP
    - 2.2. Community developed HPP
    - 2.3. Department of Rural Development (DRD) developed HPP
3. Department of Hydro power Implementation (DHPI) developed HPP

In detail of these sectors are discussed in following sections.

4. Domestic HPP

Domestic HPP is a single family own system and the power is used for their own consumption. Some of them give a limited amount of power to their neighbours and earn an extra income. Most of these projects use low head propeller turbines and have a rated capacity ranging from 100 W to 1 kW range. Seven domestic HPPs in Taunggy, in Shan state and Kalay in Magwestate were visited. This specific modal of propeller turbines are manufactured and marketed by Asian Phoenix Resources Ltd, 2-416 Dallas Road, Victoria, BC V8V 1A9, CANADA, under the brand name "Powerpal" (http://www.powerpal.com/). But all the visited systems generators were from China and mechanical components were locally fabricated. According to the original supplier's specification, they also provide hydro units with an electronic load controller, but it could not be found a single unit with a controller.

Fig 1. Low head propeller turbine (Source: powerpal.com)

Further, the service providers informed that they are not aware of such a controller. Some users run the turbine at fixed load by directly connecting bulbs while the others use a voltage stabilizer. However, the voltage and frequency supplied from these vary from 100 V to 260 V and 35 Hz to 65 Hz respectively. This continuous unstable power leads to low efficiency levels and reduction in lifetime of both power plant and appliances. Distribution line is directly extended from generator to house without even an isolation switch. Power can be off at turbine by diverting water flow out of turbine. Fuse, Miniature Circuit Breakers (MCB) or Residual Circuit Breaker (RCCB) are not used at turbine.

The most critical component of this system is the permanent magnet generator which is imported from China and available in major cities of Myanmar according to the turbine manufacturers. Some local workshop owners manufacture balance mechanical components including turbine, guide vane, and power shaft and fix to the generator. One of the domestic HPP manufacturer is U win Soe (Shwe Yaw) (annex 04) and he manufacturers up to 100 kW village hydro power equipment also. He has sample of few sizes of propeller turbines (figure 02) and which are used as the prototype of propeller turbines.

Fig 02. Propeller turbine sample in workshop of U win Soe (Shwe Yaw)

Most of these projects are developed by local technicians (developers) who act between manufacturer and the users. Developers have a lot of contacts in his working areas and involved not only in hydro power but also electrical work such as house wiring, small generators (diesel/ petrol) repairing and lighting function etc. If someone is interested on having a domestic hydro unit, he would meet a developer. Then developer inspects the site and gives a cost estimate. The major technical inputs given by the developers are site identification, turbine selection and design and supply the canal end. Canal end is a steel sheet fabricated unit that includes a water inlet, a draft tube and an involute shaped housing. Most of the sites visited are based on an irrigation channel. Those constructed with wooden plank and log, and the canal end is fabricated with steel sheet. The heads of the visited projects are 3 to 5 feet range. Fortunately at this head range, turbines maximum speed does not exceed high speed and the maximum system frequency is limited below 70 Hz.

In most of the visited sites, there was around 1 foot further head drops in head race and/or tailrace. Further, the developer manufactured involutes profiles do not have the profiles of original designs. These weaknesses are happening due to poor knowledge of developers and ultimately it reduces the overall efficiency.

According to the beneficiaries, they have only one maintenance issue that is regular bearing failure. Bearing lifetime varies 1 to 4 months. Two bearing cost is Kayt 4,000/= to 6,000/=. Especially this is an unbearable cost for the turbine which has one month bearing life span. This is the main operation cost of a domestic HPP. This is a main weakness of the local turbine manufacturer because they use deep groove ball bearing which cannot be taken an axial load. By using angular contact ball bearing or tapered roller bearing, lifetime can be extended drastically. Figure 03 shows a successfully running Domestic HPP (left) with bearing lifetime of 3 months and the developer modified turbine(right) to increase the power. This developer is very keen on improving the power and quality of the system. He has invested over Kayt 600,000/= for this modified unit. But it could not even generate power. According to the developer, if there is technology of more power there is a good demand for it.

Fig. 03 Domestic HPPs

Although hydro projects use insulated wire for the distribution lines, there are so many un-insulated joints were observed. Further, a small wooden stick or live trees are commonly used as poles. There are distribution wires crossing each other where there is multiple numbers of unit installed. There is high potential of electrocution.

In order to install such a turbine in an irrigation channel, the owner should have enough money to buy the unit and the ownership of the irrigation channel. Most of the turbines have been installed next to the owner’s farm land but residences are over 300 m from the turbine. If the owner is prepared to supply electricity for the neighbours that facility can only be enjoyed by those who are willing to pay for the energy at the price set by the owner of the HPP. The amount of power/energy supplied is decided by the number of bulbs used. Since very limited capacity of these units, beneficiaries can use electricity only for lighting. Only incandescent bulbs and magnetic ballast type fluorescent lamps can be used with this poor quality power. According to the beneficiaries, CFL and LED bulbs electronics circuit have very short lifetime.

It was observed that some paddy fields where low head turbines were installed have abandoned for a two to three years (Fig. 04). Short term crops have also been grown in some of the paddy lands. If the rice is grown then water has to be supplied for the field and the turbine has to bypass. So people might trend to abandoned the paddy field and continuously run the turbines. However the exact reasons for not growing paddy in these lands could not be identified. Due to the limited hydro power potential are available, new families who want electricity have to go for solar power systems.

Fig 04. Domestic HPP in abandoned paddy field and unsafe distribution lines

These hydro power unit cost varies between kayt 500,000/= to Kayt 750,000/= and all units have been purchased by cash paying to the developer.

Among the visited domestic HPPs there was only one project with a water wheel. That has been constructed in 1978 and still provides electricity with minor repairs. At present owner's family uses 5 bulbs and a TV. Furthermore they supply electricity for five neighbouring houses. Each of them uses two magnetic type fluorescent lamps (20W) at a rate of Ks. 2,000/ per month. At present owner does not have an idea of total project cost since present owner's father was the designer and passed away in 1990s. For this turbine a water diversion channel has been constructed.

Fig. 05 Water wheel type Domestic HPP

5. Village HPP

Village hydro power project is typically in 5 to 100kW range. They serve a community; primarily household up to a few hundred through a distribution network that may reach 5 km from the power house, nominal 220V three phase AC. Energy meters are not being used and two payment systems are in existence as a fixed free for the all household or a free depending on the numbers of light and appliances. Some projects of Shan state are run in irrigation channels bypassing farm land water supply. These projects consist of locally fabricated turbines and do not use standard control system. Actual power output could not be measured during the visit due to poor quality of power and as some mechanical driving machines are permanently coupled. All the households which use TV and audio systems run with voltage stabilizes (Fig. 06). All the technical input comes from a single person or an institute who developed project. Standard as well as non-standard type's turbines are used in this sector.

Fig.06 Voltage stabilizer use for TV and audios system

As for switch gears, these projects have only isolation switches in power house. Untreated wooden poles are used for distribution lines (Fig 07). The actual capacity in each Taungyi and Pan Oo Taung HPP is around 25kW and use 11kV HT transmission lines. Concrete poles are used for these HT lines. Very high voltage drops in the distribution lines could be observed since very small cables are used. Furthermore 1mm to 3mm diameter galvanised steel wires are also used in some projects.

Fig. 07 Distribution panel of in power house (left) and distribution line (right)

Switches are used only as a safety device for the house wiring and wires have been laid in shortest path without properly fixing as in fig. 08.

Fig.08. poorly wired house

These hydro projects can be further classified into three sub groups based on the funding source, and the O & M process as follows:

A. Private HPP
B. Community developed HPP
C. DRD Developed HPP

In the following section it is discussing these three types of projects in detail.

Private HPP

Private hydro power projects have been established by the private entrepreneurs with the focusing of hydro energy based industries. Owe Kong, Ming In HPPs from Shan state and Kalay HPP from Magwe state are visited projects of this category and these projects have a single person for ownership. All the transactions, operations and maintenance are managed by experiences of the owners without record keeping. Shan state two projects have been started in 1990s as a very small scale and gradually developed up to present status over cause of last 20 years. The Kalay project has been developed in 2008 by a hydro power machine manufacturer. These all projects have low head sites and there are unnecessarily installed idling shafts, flywheels and pulleys. These unnecessary parts reduce the efficiency and increase maintenance cost. Fig. 09a. shows the complex drive system of Kalay project but the complete system could not be captured in a picture due to little space and poor lighting condition inside the power house. Average generator lifetime of these projects is less than 5 years. Fig. 09 b. shows permanently damaged generators of Owe Kong HPP. The main reason to reduce lifetime of generators must be highly fluctuation of voltage and frequency. Table 02 shows important information three visited projects.

a) b)

Fig. 09 a. Drives system of low Kalay HPP b. Damaged generators

Table 02. Private HPPs' details

No	Description	HPP			Note
		Owe Kong	Ming In	Kalay	
01	Owner	Owe Kong	Ming In	U win Soe (Shwe Yaw)	
02	Capacity	Approximately 15kW (mechanical and electrical power)	Approximately 15kW (mechanical and electrical power)	Designed 75kW Actual 35kW (fully electrical output)	Owe Kong & Ming in mechanical power could not be measured
03	Turbine	Two cascaded propeller turbine	Water wheel	Single propeller turbine	
04	Industry	Rice mill, oil expeller and cereal crusher, 5 to 10 worker	Rice mill, oil expeller and cereal crusher, 3 to 6 l worker	Turbine manufacturing, 5 worker	
05	Investment	80,000,000 (approximately) included production machinery	Do not know	Ks. 100,000,000/=	Kalay HHP has received Ks. 2,000,000 local government grant
06	Nos. Of beneficiaries	80	0	66	
07	Tariff	1 liner florescent bulb Ks 1000/= 2 liner florescent bulb Ks 2500/= TV /Video 1,000/=	0	Appliances based 1 liner florescent bulb Ks 2500/= 2 liner florescent bulb Ks 5000/= TV /Video 12,000/= Energy based Ks. 550/kWh	
08	Connection charge	30,000 to 70,000			
09	Distance from the national grid (km)	250m (230V)	Within grid coverage	12 km	
10	Started year	1990s	1190s	2008	
11	Equipment manufacturer	Purchased from city	Purchased from city	Design and manufactured by the owner	
12	Maintenance	owner	Owner	Owner	
13	Control system	Does not use controlling system these projects. Generator maximum frequency is 70Hz at no load. According to village loads system frequency automatically dropping.			
	Comment	Cascaded two powerpal turbines are used. By modifying in to single turbine efficiency can be improved	Water vs. propeller turbine technology have to be studied		

The maintenance activities of these machines are performed by the owner. Kalay project supplies free electricity connection for household and use appliance based tariff as in annex 03. From the mid of 2014 energy meter system have been introduced. At present only 20 numbers of household use appliance based tariff while the balance use fixed meters and pay Ks. 550 per kWh. Average monthly energy consumption of energy meter connected houses is 30kWh then charge is Ks. 16,500/= per month. Distribution lines and power house are fully maintained by the owner.

Fig. 10 Kalay HPP

Owe Kong HPP's 80 numbers of households have been joined over the four stages of 20 years life. As the new connection charge Ks. 30,000 to Ks. 50,000 is imposed from HH, this amount is decided by the cost of distribution line and the number of households. Now the owner is fully responsible for maintaining the distribution line. Very recently he has started construction of concrete pole since the wooden poles life time is around 2 years. Further he has another power house in standby in the same premises. In case of failure of main power house, the standby system can be run by diversion of water channel.

Ming In village has three HPPs those have been developed by UNDP, DRD and the other is private entrepreneur. The Private owned project is also processing cereal as Owe Kong HPP, but generates electricity for his own consumption. Neighbours of this power plant have been facilitated with electricity from the UNDP developed HPP until the early of 2014. After national grid reached to this village, all the villagers have shifted to national grid due to endless failures of power in those projects. So there was no electricity demand from the neighbour for this private project. DRD developed project discussed under separately.

In addition to the electrification of HH these industries give important opportunities for rural economy by value addition of local products, and creating job opportunity. By transferring hydro power technology and business management system this sector can be improved. Further these industries can also be used as models new projects.

Community developed HPP

In community developed HPPs both the management and the capital cost are born by the villagers. Hydro power developers, are acted as an intermediary linking villagers with equipment suppliers. These developers are experienced person of hydro power (both community based and domestic) technology and financing system. Further, the developer creates the concept of hydro power for these villages. PyinOoLwin and TaungGyi HPP are belonging to this category among the visited HPPs. In these projects, there are hydro power committees who are actively participating in implementing, operating and maintaining the plants. All the activities of the hydro power projects are managed with mutual understanding among the committee members without keeping formal records or government monitoring. Technical and financing advices are taken from the developer or machine manufacturer who involved in initial stage. According to developers' estimate of project cost, the committee members are collecting money from villages in equal amount.

In Pyin Oo Lwin project both the turbine manufacturing and development are done by U Sai HtunHla, Sai Htunhla & brothers Company. They identify potential sites and encourage villagers and government authority to develop. Villagers have formed a working committee for the hydro project. Developer has given only one document for the project which includes HT and LT lines cost break down. Translated summary is in annex 3 under Pyin Oo Lwin project. Total project cost was Ks. 60,000,000/= in year 2002 and Ks. 10,000,000/= has been received as a loan from Mandalay region government. Loan period was one year with zero interest. Beneficiaries have paid back the loan on time from monthly income of the project. Water is taken from irrigation and a drinking water tank. The official permissions for the HPP have been given in words by authorities. Designed capacity of this project is 75kW but the maximum demand around 7.00 Pm was 23kW. Maximum generating capacity could not be measured without equivalent capacity electrical load. This project's income is spent on village road and school development. At present two teachers' salaries (Each Ks. 50,000) are paid from the income.

TaungGyi HPP has been developed by Mr. U Tun Min who works as a medical officer of nearby town Pyin Oo Win. He has seen such a project in another village of Shan state and followed that practices. Designed capacity is 50kW with "Pump as Turbine" technology. Total project cost is Ks. 22,000,000/= and it has been collected from 200 households in year 2002. 2 years had been spent for project construction since the villages could not contribute their portion once. Since the end of May 2014 this project is not running because generator failure. Within life span of 12 years, the generator was burnt 2 times with lightening and another two times penstock blasted and generator burnt due to water spray while running. Now developer and villagers are fatigue with failures and no plan of repairing again. Committee members were not aware on the monthly income or expenses.

DRD Developed HPP

There were five hydro power projects fully developed by government (DRD) and managed by community in Shan state (Mong In, ThaPyayKone, Myosoe, Ming In and ThaPyay Kone). The project implementing firm is selected through an open tender process by the DRD within last two years. Villagers provide labour in-kind. Skilled labour, machinery and equipment are supplied by the contractor. After commissioning of the project, O & M are equal to community based HPP. DRD form a village committee to look after the O & M. However neither DRD nor the project implementing firm has the technical capacity on hydro power technology in all aspect, turbine or power output. Furthermore DRD has no monitoring system after commissioning the project.

Laouk Lon HPP project initially is developed by UNDP in 2005 and it has been renovated and increased the capacity in 2011 by one local donor. In both stages projects have been developed and handed over to the villages. According to the observation this project implementation and running procedures are equal to DRD developed HHP.

Above mentioned all three categories have following features in common:

- Other than private owner HPPs, leaders' team has been formed from the village that serves as the committee of hydro power. Further they have given electricity for public places such as monastery, school, and health centre free of charge.
- Although village committee does not keep record on HPPs the entire projects have been running for few years. In future projects it is very important introducing panel board meter logging in specific interval; maintenance , financial and social records keeping methodology to identify energy demand, machinery performance variation, technical failures, and excess capacity (for new members) so on.
- Unlike a diesel generator, HPPs have very well planned maintenances procedure since small failure can be extend up to huge damage of machinery such as generator, bearing, shaft, turbine failure.
- According to the given detailed bills of the distribution and the transmission line of the two projects have been constructed by equipment suppliers. These could be done through in-kind by training the villages. These will be reduced the cash collection from the villages, develop technical capacity and help to maintenance of the lines.

- Over 95% of the villages have get electricity of inspected project. This is a good indication off harmony, reasonable cost and trust of committee.
- Few households those were not supplied with electricity and are using solar system. Government area/ state officers are not aware on the information which I collected based on previous studies and seminars. Regional government did not maintenance a list of government developed projects. By introducing registration and monitoring method of HPP, it will be very helpful for this sector.
- Hydro power sites head and flow rate are identified by just looking at the site. Optimum energy potential, penstock sizing, turbine selection are being done without scientific methodology. Any developer or a manufacturer could not explain technical design and project capacity estimation method which they are practice. So most of the project's actual outputs are less than 50% of expected values. By observing the project it can be stated that the actual power output is less than 30% of site energy potential.
- In addition they are not aware on energy loosing points and actual power measuring methods. Incorrect type, speed and size turbine selection, poor finishing and wrong control methods are the main weak points which reduce efficiency of machinery.
- Losses were there in the penstock lines due to incorrect water inlet, sharp bend, sluice gate /valve controlling and wrong nozzles. Low head HPP's civil construction had been completed according to practices of irrigation. Machineries have been mounted on both cement and wooden structures.

Figure 11 shows water intake of two hydro power projects and figure 12 shows forebay tank constructed with wood planks lined.

Fig. 11 Water intake of village HPPs (left kalay Town and right Owe Kong HPPs)

Figure 12 Forebay tank of Loauk Lon HPP

Among the three high head projects Pyin Oo Win turbine was connected into irrigation tank output pipe and civil construction had been constructed in very standard level. The other high head project was constructed in satisfactory level with earth channels and settling tank. Turbine had been mounted on wooden structures.

Brushed type three phase synchronous generators are used in all these projects. Since voltage stabilizers are used with all appliances other than bulbs there is less potential burn quickly due poor quality power. But inductive and reactive components (capacitor, inductor and transformer) in circuits must be over heated as supplied of too high/low frequency. Most of projects do not use high efficient CFL and LED bulbs due to very short life time resulting from unstable voltage. Turbine and generator which are running at wrong speeds lead to reduce performances of equipment in power house as well as houses. One of a main reason to drastically reduce the lifetime of turbine, bearing and generator is poor controlling method. Although domestic appliances have lot of failures, people believe that because of the low grade equipments. 11kV line has been used only at the two projects and concrete poles have been used in these lines. Locally prepared untreated wooden poles are used for the LT lines.

Lighting and audio/ video system are number one and two priority of electricity requirement of all villages respectively. In few projects rice cooker are being populating since last few years. So future hydro power projects it has to be identified suitable power for household depend up on site capacity and numbers of HH. Only few HHP of Shan state HPP had developed industries. These were limited to mechanically powered industries within the power house. By introducing reliable electricity it can be run electric machinery and extend these industries up HH. Further suitable industries can be introduced for the other HPPs.

6. Government developed HPP

Var, Lainva and Dongvar visited HPP are developed by Ministry of electric Power (MOEP) and maintained by ESE. So there was not community involvement for the project development and beneficiaries get electricity by paying. Relationship between the ESE and beneficiaries is same as the national grid users and present average cost per a new connection is Ks. 100,000/= included a 300ft service wire and an energy meter. National grid energy charge is applied and rates are,

1 to 100 unit	35 kyat
101 to 200 unit	40 kyat
Above 200 unit	50 kyat

There is no constraint for the beneficiaries to use electricity but only use to lighting, audio/video/TV and rice cooker. Above projects are in Chin state of low temperature. So electric fans or AC are not been used. However in dry season, electrification time is limited to few hours depend up on water availability. Standby diesel generators supplies only limited areas of cities including VIPs quarters. ESE issued electricity bill shows in fig. 13.

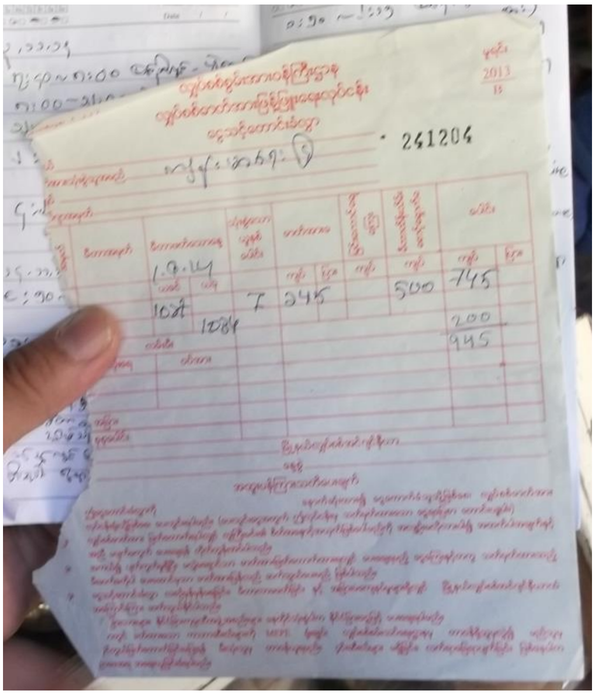

Fig. 13 Electricity bill issued by ESE

The installed capacities of Var, Lainva and Dongvar plants are 1,500kW (500x3), 510kW(255x2) and 600 kW (200x3), respectively. All these projects were developed in 1980s and at that time there were only two turbines for each project. In 2013 another two turbines were installed for the Var and Dongvar projects as there were a lot of technical failures in old machines. These have been installed in parallel to old turbines by connecting branch for the existing penstock. Through new switch board, power is feeding in to existing distribution systems. All machinery Var, Lainva and Dongvar was supplied by foreign companies. Only in Laiva project, two turbines are synchronized and run in parallel. But the other two projects, one turbine is adequate to meet the demand. Profit or loss of these projects is absorbed by ESE. Further, civil construction, machinery and distribution systems of these projects maintain very high standards. Each of these projects supplies power to more than one village through 11kV distribution lines. For HT line it has been used steel tower but LT lines have been used both concrete and wooden poles.

According to distribution layout of Hakha town, Lainva , Dongvar HPP and 3 diesel power plants have been networked as in fig. 14. As mentioned above only lainvar two turbines synchronized and run in parallel which are in same power house. All the other generators and Dongvar hydro plant were running in standalone by isolating from the mini grid before the national grid extended to Hakha. Further diesel generators have run to supply very limited areas and VIP quarters of this network in dry season. As the HPPs, no one is maintaining running hours or fuel consumption of these diesel generators.

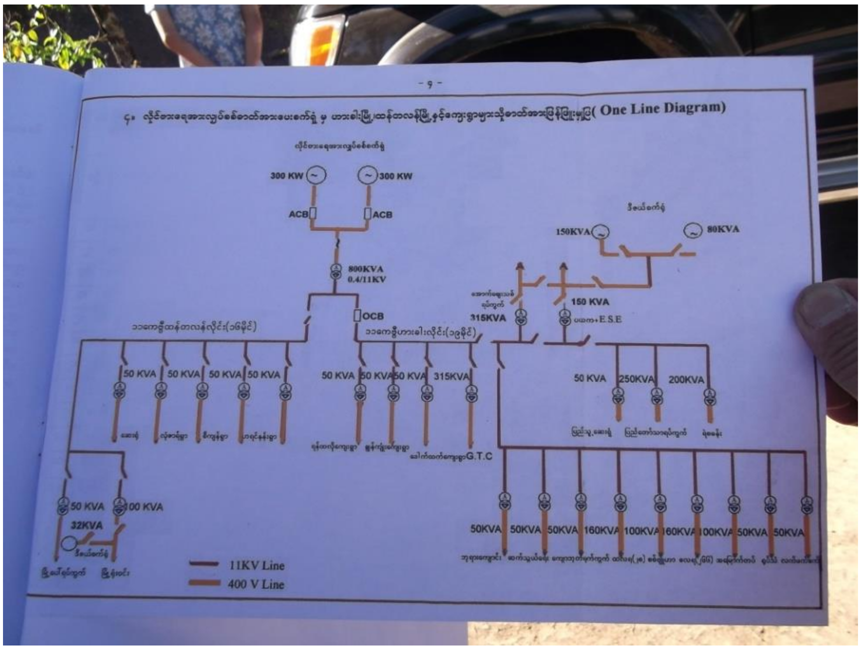

Figure 14 Hakaha town (Chin state capital) electricity network

All these project have inbuilt automatic flow controlling systems. Unfortunately all these automatic controllers were not functioning and operators were manually adjusting it by observing the frequency.

So system frequency varies between 48Hz to 53Hz and voltage in the power house varies between 200V to 240V in the power house. Due to manual controlling, these projects need to have more than one operator at a time and compulsory to pay close attention while operating the system. Further careless flow control or unexpected demand fluctuation may lead to failures or cause damages mechanical and electrical component in the system (such as bearing, shaft, generator in the power house and any appliance connected in to electricity at user end). According to the ESE engineers, only Laiva project is running with minor troubles over the last two decades. Other two projects have had frequent bearing failures, water leaks through the seals and generator breakdown. So much failures rates are unusual in hydro power projects. Frequency of bearing failures is about 5 times a year, rectifier diodes failures 4 times a year during last couple of decades. Further generator failure, water leakage from seals and shaft breaks have occurred at number of instance. One of the reasons for having less trouble in Laiva project is, this that it is an impulse (Pelton) turbine while other projects have reaction (Francis) turbine[1]. In 2013 a Turgo turbine was installed at Var and this turbine has had less failure when compared with the initially installed Francis turbines.

All the visited HPP in Chin state had very steep terrain. According to ESE engineers there were no natural disasters such as earth slips or damage to the power plant due to bad weather. This is a good evidence of good design, construction and minimum impact for environment from hydro power projects. This has a crucial bearing on system design –if instead of a reaction turbine, an impulse turbine had been used, diesel usage could have been reduced because of the higher part load efficiency impulse turbines.

As in the case of national grid, the household voltage of these projects varies between 240V to 150V. It has been identified two reasons for so much drop in these category of project as poor voltage

[1] Reaction turbines' runner rotates in high pressure involutes chamber. Project total water pressure directly applies on water seal of the shaft. Further fine clearance are there between rotating parts and stationary parts (the housing). So a special skill, genuine spare parts and attention required to fix turbine. If there is a miss alignment at assembling turbine bearing failure or water leak can occur. But impulse turbines' a free water jet strikes the turbine buckets tangentially. Water seal required to avoid splashing water leak. Further there is very large space between runner and the housing. So turbine assembling and disassembling can be done very easily with respect to reaction turbines.

controlling (annex 2 Var project voltage profile) in PH and line losses(HT and LT). All beneficiaries have to use voltage stabilizers as the other two categories of HPPs. Since all the beneficiaries use voltage stabilizers and energise throughout the day there must have considerable loss.

Poor record maintaining, delay to repair forebay tank screening system and not searching permanent solutions for regular occurring failures are indication of less attention on O & M.

7. Service providers of off-grid HPP

As mentioned above, it has been developed different level of service providers for the hydro power sector as turbine manufacturer, retail sellers (of powerpal), NGOs and developers. Few developers, NGO and manufacturers were met in this visit but retail sellers could not be identified since they are in few cities and could not developed a contact. Details of these peoples and organization are listed in annex 4.

Hydro power machine manufacturers have self developed and running with poor technology. Very old and worn out lath, drilling and milling machine are being used. Turbine design according to own thumb rules and could not be identified mathematical designing procedure. This is the main reason to reduce efficiency and reliability. Some manufacturers are little aware on electronic load and flow controlling but have not chance to acquire these technology. By introducing control technology it can be improved the quality and efficiency hydro power sector. At the manufacturing stage there are lot of bad practices are as

More than three bearing fixing single shaft (fig.15)

Poor finished turbine bucket use

Unbalance rotating item use

Lower rated (capacity and price) bearings and belt use

Fig. 15. Partially completed turbine in Kalay workshop

Most of the manufacturers act as developers. They identify suitable sites through personal contacts and encourage villages on hydro electricity. Then he is advising on aspects such as financing, social and technical. Further villages have to purchase all equipment from the developer. This is the way he charges his expertise. Furthermore he is earning money by repairing. Both service providers and manufacturers are very poor in scientific approach on hydro power technology. They have to be trained on hydrology, penstock selection, turbine designing and electricity.

TaungGyi HPP's developer is only person who act as a developer for village HPPs. He has contact of turbine manufacturer to purchase equipment. Up to now he has developed 3 HPP of community based level and over hundred of domestic level HPPs. U win Soe(Shwe Yaw) (annex 4) has developed over 1000 turbines for various developers and one turbine for own power house Kalay HPP(annex 3). Since he has lot of turbine orders not interest on act as a developer. Although these two peoples have developed large numbers of HPPs, they are very poor knowledge on technology and have not followed even technical course. Khinmynmung, U Sai HtunHla, U Khunkyaw, and U Khun Aung Myo are act as developers and machine manufacturers. They have followed technical level or engineering courses. So these people can trained for scientific approach on HP technology. These people are aware on details of distribution lines that may be following information of government practicing bill of quantity. It has been given descriptive break down of HT and LT lines. For the hydro machines it they are mentioning only generator and turbine. It was not explain specifications of these equipments.

Sea Pelicon Pvt. Ltd. is a DRD developed hydro power service provider. Although Sea Pelicon has developed few DRD funded HPPs and technical staff, no technical knowledge about hydro power. Few visited site have been used non standard types of turbines.

8. ESE developed diesel power plant

Data from two diesel powered projects run by ESE were collected from Taunggy DRD office for the analysis. These two projects supply few hours per day electricity throughout the year. However these projects could not be visited. This information is shown in the table 03.

Maximum 4 kWh per litter can be generated by a diesel generator. Presently diesel litter price is around Ks. 700/=. Then generating direct cost is Ks. 175/= per kWh but ESE selling prices is Ks. 35/=. It is clear that this is a very high subsidiary price.

Table 03 Diesel power plant information

Description	**Project**	
Project name(Location)	NaungKe	Naung Mon
Capacity(kVA)	48	35
Nos. of HH	206	96
Management system	ESE	ESE
Project cost	15,000,000	10,000,000
project commissioned date	1991	2004
Generator type	Skoda	Kasala
Fuel type	Diesel	Diesel
Electrifying time(hrs/day)	2	2.5
Monthly generation(kwh)	6005	3456
Rate(Ks/kW)	35	35
Monthly income(Ks)	210,175	120,960
Distribution line length(miles)	4.5	2.01
Distribution cost	146,250,000	65,325,000
Voltage(V)	230/400	230/400
Maintenance cost(month)	70,000.00	60,000
Fuel cost (Ks)	1,340,000	938,000
Contact person	U Win Hlainghtwe	U HlaSein
Contact	94936802	9259435128

9. Off-grid HPP electricity Pricing

This section analysing energy and project cost to compare alternative solutions based on information collected from the site visits and interview the stakeholders.

I. Electricity Pricing

In the table 04 it is showing energy cost calculation from different projects. To estimate cost of energy unit (Ks/kWh) it is assumed

- Lighting time is 10 hrs for each projects
- Average lighting powers of household taken according to villages given information without formal study

There are two types of beneficiaries for the domestic HPPs as the owner and the users. Maintenances cost of domestic HPPs is considered as owner's monthly energy cost. The users have defined energy cost by the owner as discussed earlier. Village hydro power project have different categories of energy users depend upon types of appliances. Those group energy costs were there and separately calculated the energy cost under same project names. ESE controlling projects apply national grid standard tariff structure. According to ESE and beneficiaries information it could be identified average energy cost of ESE customers is Ks. 2,000/=. In this analysing electrical load and time of these costumers were taken approximate values to match the government rate Ks. 35/= for less than 100 kWh user.

Table 04 Energy pricing

Project			Electrical loads						Energy		
	Monthly Charge (Ks)	os. of beneficiary	Lighting		Audio/ TV		Rice cooker		per Day (kWh)	Monthly (kWh)	Cost (Ks/kWh)
			Power (W)	Time (hrs/day)	Power (W)	Time (hrs/day)	Power (W)	Time (hrs/day)			
Domestic HPP											
Domestic HPP(Powerpal Owner)	3000*	3	80	10					0.8	24.0	125
Domestic HPP (waterwheel Owner)	4500*	5	200	10	80	5			2.4	72.0	62
Domestic HPP (user)	2,000	1	40	10					0.4	12.0	166
Community based HPP											
Owe Kong	1,000	10	25	10					0.20	7.5	133
	2,500	20	45	10					0.4	13,.5	185
	3,500	50	45	10	60	5			0.8	22.5	155
Ming In HPP	1,000	40	25	10					0.2	7.5	133
	2,500	40	40	10					0.4	12.0	208
Pan Oo Tang	2,000	170	50	10					0.5	15.0	133
	2,000	70	80	10			750	1	1.60	46.5	43
	4,500	30	80	10	60	5			1.1	33.0	136
Tha Pyay Kone	3,000	73	55	10					0.6	16.0	181
Myosoe	3,000	130	40	10					0.4	12.(	250
Taung Gyi	3,000	200	60	10					0.6	18.0	166
Laouk Lon	200	20	15	10					0.2	4.5	44
	400	30	30	10					0.3	9.0	44
	900	90	30	10	60	5			0.6	18.0	50
Kalay	2,500	15	20	10					0.2	6.0	416
	5,000	25	40	10					0.4	12.0	416
	17,000	26	40	10	60	5			0.7	21.0	809
Government HPP Diesel Power											
All Projects	525		50	10					0.5	15.0	35
	1200*		50	10	80	8			1.1	34.2	35
	2000*		50	10	80	8	750	1	1.8	56,.7	35

Note: * Approximate values used.

According to this analysis all the projects energy cost is higher than the national grid tariff. Most of the projects energy cost is over Ks. 100/= per kWh. The highest cost is Ks. 806 which is 23 times of national grid rate. Only domestic HPP owner, who has a water wheel, has over 46 kWh /month consumption. Government HPPs rice cooker consumers, non rice cooker consumers and light only consumers monthly energy demands are 56 kWh, 34 kWh and 15 kWh respectively. Accordingly the basic energy demand of a household can be considered as 56 kWh since they consume electricity without a capacity constraint. This can be considered as the base line for determining the capacity of the future HPPs.

II. LCC analysis

Life Cycle Cost (LCC) analysis is used here to determine the cost-effective option considering the performance of the plant life. LCC is used here to compare existing technology with more efficient and reliable technologies.

Options Comparison

This comparison is done to compare the technologies of existing plants in Myanmar with technologies used in Sri Lanka. Life time of machinery is assumed based on product quality and failure rate of critical components. For this options analysis only the electro-mechanical item will be replaced. The penstock and distribution lines will not be replace as there is no adequate information to propose alternatives. Same Penstock can be used in most cases and to estimate distribution line cost further information is required. Further voltage drop at generation is more sensitive than distribution drop.

For comparison purposes I have proposed two options.
Option 1: Generating same actual power utilizing efficient technologies
Option 2: Generating same designed power utilising efficient technologies

Most suitable option can be determined considering the total electricity demand of the village and availability of water. To get present capacity relative small capacity and high efficient turbine can be used.

For Domestic HPP only one option is considered for analysis as there is no need to increase the actual generation to a greater extent. Further it was not possible to analyse the LCC cost of the Government projects due to lack of information on O & M costs.

The results of LCC analyse is shown in the Table 5.

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Table 05: Life Cycle Cost (LCC)(ks/kW)and capacity cost(ks/kWh) for 20 years and energy cost

Project name	Option	Initial investment(ks) ('000,000 Ks)	valued Year	Age (years)	Annual maintenance cost ('000 Ks)	Power			Energy		Avg. Lifetime	20 yrs LCC ('000Ks) @10%	Capacity cost @ 20 yrs ('000Ks/kW)
						Design (kW)	Actual (kW)	Time (hrs)	per Day (kWh)	Annual (kWh)			
Domestic HPP	Present machine	600.0	2014	-	40.0	0.5	0.25	10	3	1	10	219.2	6,000
	Actual Power	700.0	2014	-	8.0	0.4	0..4	10	4	1	10	122.1	3,342
Community based HPP													
Pan Oo Tang	Present machine	60.0	2,002	12	1.1	75	25	15	375	137	5	1,132.7	23,256
	Actual Power	60.0	2,002	12	800.0	25	25	15	375	137	15	130.1	8,012
	Designed power	90.0	2,002	12	800.0	50	50	15	750	274	15	95.6	5,889
Mong In	Present machine	5.0	2,014	-	100.0	5	1	10	9	3	8	551.8	12,083
	Actual Power	3.0	2,014	-	100.0	1	1	10	10	4	10	246.6	6,750
	Designed power	8.0	2,014	-	100.0	5	5	10	50	18	10	98.6	2,700
Owe Kong	Present machine	50.0	2,014	-	400.0	40	15	15	225	82	8	202.4	6,650
	Actual Power	30.0	2,014	-	400.0	15	15	15	225	82	15	38.9	2,400
	Designed power	90.0	2,014	-	400.0	40	40	15	600	219	15	38.9	2,400
Ming In	Present machine	5.0	2,012	2	250.0	N/A	3	8	24	9	4	1,005.9	8,812
	Actual Power	5.0	2,012	2	250.0	3	3	8	24	9	10	195.2	4,275
Laouk Lon	Present machine	10.0	2,011	3	750.0	20	10	8	80	29	5	467.4	5,118
	Actual Power	13.0	2,011	3	30.0	10	10	8	80	29	15	54.0	1,775
	Designed power	15.0	2,011	3	450.0	20	20	8	160	58	15	40.7	1,335

The table indicates that both LCC and unit capacity cost can be reduced drastically with the introduction of efficient machinery. Project implementation cost is relatively higher than present practices; however LCC is low due to low maintenance cost and increase in machine life time. Further benefits can be achieved during dry seasons due to use of efficient turbines which requires less water. Finally it can be observed that by investing on advance turbine it can generate electricity at a reduced cost.

10. Environmental practices of off-grid hydro power

At present all the hydro power is developed with minimum facilities with no attention is paid for protecting the environment. It is not required to get any written permission for developing HPPs. The designing is done to run the hydro power projects even during drought periods. Then there were no complaints/ damages from earth slip, serious soil erosion, flooding or any other form of disaster. Furthermore stakeholders are not aware of endemic species of flora, fauna and aquatic life of Myanmar which may be affected due to construction of HPPs. Although distribution lines and house wiring is very unsafe, fortunately there are no reported incidences of damage or accident.

This section discusses possible environment problems of different categories of HPP.

I. Domestic HPP

All the domestic HPP projects developed in Shan and Magwe states are low head. Most of the systems have used irrigation channels and few projects have used water diversion channels parallel to a small stream. Although hydro units have been installed in irrigation channel, the farm land supply gates have to be closed to get enough water to maintain the height in the most of the projects. So most of the hydro units run at night where electricity is necessary. Already most of the paddy lands are not cultivated and are abandoned or diverted to other crops which require less water. In future paddy cultivation may further be discouraged due to increasing demand for the electricity. Possible form of environmental effects are flood level increase, farm or home land erosion, damage to aquatic life etc. Furthermore these locations are densely populated. If there would be any damage to their properties neighbours would oppose the HPP. Such a clash in domestic HPP was not observed.

II. Village HPP

Village HPPs are built in both flat and steep terrains. All the construction is completed without any noticeably negative effect on the environment. Especially in Chin state, earth slips occur in most of the hills. But none of hydro projects are so far affected by earth slip.

At present there is no environment impact assessment or certification system for these HPP. However while expanding this category of hydro power projects systematically, it is recommended to conduct environment impact assessment.

III. Government HPP

As mentioned earlier these projects were developed in 1990s and project documents or officers who were in charge at the development stage cannot be contacted. So it was not possible to locate any government procedure for issuing environment clearances for these projects. According to ESE engineers, it has not so far come across any severe impact such as earth slip and floods although these project areas have sharp terrain. Since the capacities of these projects are relatively higher, it is important to have a proper procedure in place for getting environmental clearances.

11.Conclusions and Recommendations

I. SWOT analysis

By improving off-grid hydro power sector, pre- electrification or a permanent solution can be given to a considerable number of HHs in Myanmar. It can be achieved by renovating existing HP and developing new projects. Developing appropriate technology and supporting for investment are the most important two factor need to be addressed. According to hydro power service providers, there are few thousand projects. As the off-grid hydro power sector in Myanmar at present is still at the primary stage in every aspect, suggestions on areas to be improved are presented here.

Strengths
• Fabricated locally - At present Hydro developers and machine manufacturers locally produce certain items. • Villagers willing to pay/invest- The total cost of community based HPP is born by the villagers • Very slow grid extension – People do not have expectations regarding national grid reaching the village
Opportunities
• Very large hydro power potential in the country • National Electrification Project – Under NEP 80 million USD has been allocated for off grid electrification • Donors- Local and international donor are willing to support • Hydro power is a matured technology in the developing countries- VHP is a matured technology in most developing countries which can easily be transferred to Myanmar
• Weaknesses
• Poor monitoring and supporting mechanism in place with government intervention – government does not monitor community based and domestic project and supporting only a limited number of project

• Inefficient technology – due to sub standard technology efficiency levels are low and power supply is unreliable • No national standards in place for hydro power in Myanmar.
• Threats
• High competition for limited potential – In some villages hydro potential may not be able to electrify the whole village

As a pre-electrification and permanent solution for rural people, off-grid hydro power can be improved up to a significant level for increasing electricity access in Myanmar. Two simultaneous programs are suggested to improve off-grid hydro power sector.

Upgrade/rehabilitate the ongoing hydropower practices up to appropriate level

Develop new sites, taking into account the possibility of connecting them to the national grid at a later stage when the grid arrives.

It is essential to improve the capacity of private entrepreneurs; government and NGOs who are involved in the sector. Further banks, government authorities should get involved in financing the sector. Advanced technology and a management system need to be introduced. National level study should be conducted to establish and map the hydro power potential of the country.

II. Business models for different of HPP categories

Among the three types of off-grid hydro power projects, discussed in the section 3, community based and domestic hydro power systems can be developed as village level projects as happening in other developing countries. Government developed hydro power projects are of relatively high capacity and electrifying multiple cities and villages. Such large electrifying areas will be covered under the initial stage of the NEP and should be developed targeting to feed national grid at a later stage. Following sections discuss recommendations for each type hydro power sectors and national level implementation.

Domestic HPP development

At present the domestic hydro power sector uses only the low head technology. Moreover service providers lack knowledge on the standards, efficiency level and quality of power. For the domestic HPPs, there is no need to have a business model. But this serves a good opportunity for the service providers. Readymade components of domestic HPP can be sold in the open market similar to solar power market. In order to improve overall contribution from domestic HPPs the following actions are suggested.

It can be introduced income earning opportunities based day time power. Battery charging, phone charging and computer courses (based on laptop) are some activities that can be used with this little power.

Project ownership certificate

In the future there will be competition to access the limited hydro potential due to increasing electricity demand. Further hydro power systems may indirectly affect the irrigation and drinking water supply system. In order to avoid such a competition, ownership certification by local government authorities is suggested. Since the capacity of these units is a fraction of a kilowatt, it not necessary for a specialist to inspect all schemes. A government officer in charge of the village and a few villages from the vicinity of the project can handle the certification process. A standard application and guideline has to be developed for this certification.

Capacity building of service providers

Presently the manufacturers and the developers are the key stakeholders in this sector as service providers. Manufacturers have to be trained to improve the quality of products of presently manufacturing types of equipment as well as high head turbine technology such as pelton, turgo turbines. (Large numbers of government and village hydro power projects in Chin state is indication of potential of high head domestic HPP). By training the developers to install and maintain the machine it can be run more efficient way.

Because of domestic HPP capacity is very low in capacity; it is not economical as service providers had to travel long distance to install and repair work. By training few developers and service providers in each potential area, domestic HPP can be promoted more effectively.

Certification for the manufacturer

Domestic HP turbine testing facility has to be established in main cities of hydro potential areas. Each manufacturer or service provider need to test their products before marketing. A test bench can be developed or purchased at a reasonable price for the domestic hydro power since the capacity is very low. Government authorities such as ESE, DRD and Department of Agriculture (DA) should work together for testing and certification.

Controller technology

In a correctly designed hydro power unit, there must be a controller to protect both generator and appliances from frequency and voltage fluctuations. Sensitive electronic appliances such as computer, phone can be used only with correctly controlling HPPs. Furthermore output power increases since turbine runs at rated speed. A simple low cost controlling system has to be introduced for domestic HPP. Controlling technology is not familiar among the Myanmar HP players of Myanmar. For the few projects imported controllers are recommended and later, technology can be transferred in step by steps.

Development of manuals

By developing books and user manual for domestic hydro HPP users and services providers, it is possible to get better results. Local language and graphical demonstrations can be used for this purpose.

Community based hydro power concept

This is the most suitable capacity range for village hydro power projects which is practice in developing countries. For this capacity range projects, banks for financing, specialist for environment impact assessment and engineers for technical input have to be involved. A strong community structure and technology should be introduced to achieve a reliable and self sustainable level. Initial costs increases with standard equipment and controlling systems and therefore it is essential to establish an additional fund/loan mechanism to bridge this gap. On the community side, domestic wiring has to be improved up to a minimum safety standard. Although there were three categories of these projects in the present scenario (section II) two business models are recommended as follows,

- Community managed HPP
- Private ownership HPP

Community managed HPP

Community based hydro power project concept is being practiced in Sri Lanka, India and Nepal successfully. Community based society with all the beneficiaries are the owner of the project. Board of directors or a team of working committee has to be appointed among the beneficiaries. All the decisions are taken collectively. Selected members have to be trained on financial, official, legal and technical work of this scheme. At present Mong In, Ming In, ThaPyayKone, Myosoe and Pan OoTaung HPP are practicing a very similar method based on mutual understanding. But it has to be improved in a more formal way by training and coordinating these societies. Recommendations for this business model are;

- Form a legally accepted electricity consumers' society: To monitor overall performances, record keeping,
- Practice collective decision making methods: Group decision making provides advantages over individual or specific sub group
- Train financial, social and technical record keeping: To practice transparent O and M both society and machineries
- Capacity building on financial, social, environmental and technical sides: To improve overall performances
- Facilitate for subsidy / loan: To minimize the initial investment

Private ownership HPP

At present there are few HPPs developed by private entrepreneurs (Owe Kong, Ming In kalay). Basically these project has been developed based on own businesses. In addition to supply of electricity to the neighbors, it is also value addition to the local products. This is a very good method for both grid and off-grid area. So it is recommended to improve this model of business. By introducing reasonable tariff structure and a sharing mechanism of water potential it can be maintain fair energy cost for the beneficiaries. These industrial applications can be continued even after national grid has reached the project area.

For projects of very high cost and low income beneficiaries who may not be able to bear the implementation costs, local investors can be got involved. Furthermore the project payback period can be reduced through a considerable amount by using affective applications. Following suggestions are proposed for private owned HPP concept

- Standard /reasonable tariff structure
- Fair agreement between inventors and beneficiaries
- Registration and monitoring system projects

Government HPP

As mentioned earlier these projects capacity range is extend up to few thousand kilowatts and supply electricity few cities and villages with 11kV HT transmission lines. National grid may pass nearby or through such a big coverage area in early stage of NEP. So these projects have to be developed targeting to grid connection. Developing this hydro potential can be done either by the Government or by the private sector. Government HPP is same that is practicing in visited Var, Laiva and Dongvar projects. In this case the full project develops by government and electricity is supplied to the consumers at national grid rate.

If government has no capacity to develop large numbers of project within a reasonable period, private sector can be encouraged to develop these projects. Until the national grid is reached the owners can earn income from the beneficiaries at a reasonable tariff. When the national grid reached these areas the plants can be connected and feed in to the national grid at reasonable rates. All beneficiaries will be connected to national grid and project owners can earn money from the government.

All these projects are developed and managed by government procedures. Presently all the visited projects are running with a lot of technical issues as mentioned in annex 2. Although it is not targeting this capacity rage project by this study, following recommendation would like to present.

Maintaining record of O & M

Each project has to be maintain hourly panel meter readings, power failure or cut detail and repairing record in power house and ESE office.

Graphically mark the performance reading and display

Hourly panel meter reading have to be mark in a graph of wall mounted. Then it can be easily observed the variations of performances even less educated operators.

Deeply analyse and find solution for regular failures

All the HPP have occurred same trouble again and again. It is recommended to get the solution from an expert for such a failures.

III. Elements of a National off-grid hydro power program

Registration, authorization and monitoring

Presently most of the off-grid activities are going on without the knowledge of the government. In some of the visited projects, beneficiaries do not know what is happening to the income of the HPP as it is not transparent enough. Further government authorities don't not have a mechanism to monitor these HP projects. In some regions, people informed that there are so many HPPs in the vicinity. Further on the way from Kalay to Hakha, distribution lines of three HPPs could be identified along the road. But the state government, DRD or ESE has no records of those projects. Therefore the following actions are recommended in order to improve the off-grid sector.

- National or state level registration of HPP
- Approval from authorities for all aspects (social, technical, environmental)

- Appropriate guidelines for community management and operations

Registration of all HPP

At present there is no mechanism to identify HPP consumers. One most important recommendation is to develop a registration system for all HPPs. A standard application has to be prepared by covering social, financial, environmental and technical aspects. The depth of those aspects can vary according to the capacity and/or the number of beneficiaries.

Approvals for existing and new projects

These projects should be complied with specific environment, social, irrigation, technical and safety rules. It is recommended to develop a mechanism to certify these aspects. Further suitable authorities have to be identified to study these projects and build capacities on the subject as well as hydro power technology.

Appropriate guidelines for community management and operations

It is clearly observed that currently most of the HPPs are running under the mutual understanding of some members of beneficiaries (working committee). Financial activities are not transparent in some project. Beneficiaries are not aware of financial transactions. This could be a big barrier for obtaining loans from financing institutes. To avoid these drawbacks it is strongly recommended to go for the community based concept. Legislation, book keeping, annual budget and monthly/ quarterly meeting have to be   practiced for community based HPP.

Technical capacity development

Presently the technology of all type of hydro power is at very low level in Myanmar when compared with the other countries in the region. As a result all the beneficiaries suffer from poor quality of power, high O & M cost and electricity shortage in dry season. Furthermore present systems are not in a sustainable level due to various failures. To overcome these barriers technical capacity has to be developed in following subjects;

- Hydro power site survey and potential study
- Turbine designing and manufacturing
- Distribution line designing

- Hydro controller technology
- Capacity building for manufacturers and technical monitoring people
- Grid connection of off-grid HPP

Improving data and institutional capacity

A national level plan has to be suggested to harness the economically viable off-grid potential. Based on topographical maps, rainfall and other hydrology data, country wide potential has to be identified and mapped. At the same time these sites have to match the present and proposed national grid line. Most important pre- electrification project and regions can then be identified. Hydro power developers have to focus on these areas. Furthermore solar power systems can be promoted where hydro potential is not available.

For the project analysis, more accurate rainfall data and topographical maps are required. This information has to be collected and entered into a database. Following activities are suggesting to address national level off-grid potential;

- Develop a database of rainfall, hydrology and topographical maps
- Introduce a standard project report format for off-grid HPP and capacity building of stakeholders on these specifications
- Develop/ translate hydropower information in local languages
- Identify and capacity-build of present hydro power practitioners as well as new stakeholders (financing institutes, environment, technical institutes and decision makers etc.)
- Exposure visits to develop confidence of stakeholder
- Pilot project developing
- Introduce new technologies such as mini network systems based on community based HPP
- Single phase HT system for small (20kW<) HPP
- Introduce industries such as battery charging, dryers, computer training centres etc. that use electricity in small scale
- Networking of Hydro power society and sharing of knowledge

Financial plan for off-grid HPP implementation

A financing mechanism is essential for improving the present practices and to accelerate the pre-electrification plan. Funds have to be allocated to get experience from neighbour countries, uplift the manufacturing capacity/ quality of equipment, technology transfer, financial assistance for capital cost of project, development of monitoring, evolution and certification methodologies etc. Furthermore it is necessary to identify micro level financing institutes, to build the capacity hydro power technology of financing institutes and to provide working capital for the micro financing institute. Recommendations for financial contribution for off-grid hydro power sector are;

- Identify micro financing institutes for hydro power project level financing
- Identify baseline for co-financing facility for project level
- Infrastructure development to improve overall project
- Financing support for the acquisition of technology

Off-grid hydro power project monitoring mechanism

In parallel to project development, monitoring system has to be developed covering all aspects. Pre-electrification projects should have at least 15 years of life and within that period it should be operated with strong social, financial, technical and environmental management. These aspects and project cost of a HPP are strongly interconnected. Selected few project has to be very closely monitored for a few years and identify the suitable monitoring system.

Annexes

1. Annex: Officers participated with field visits

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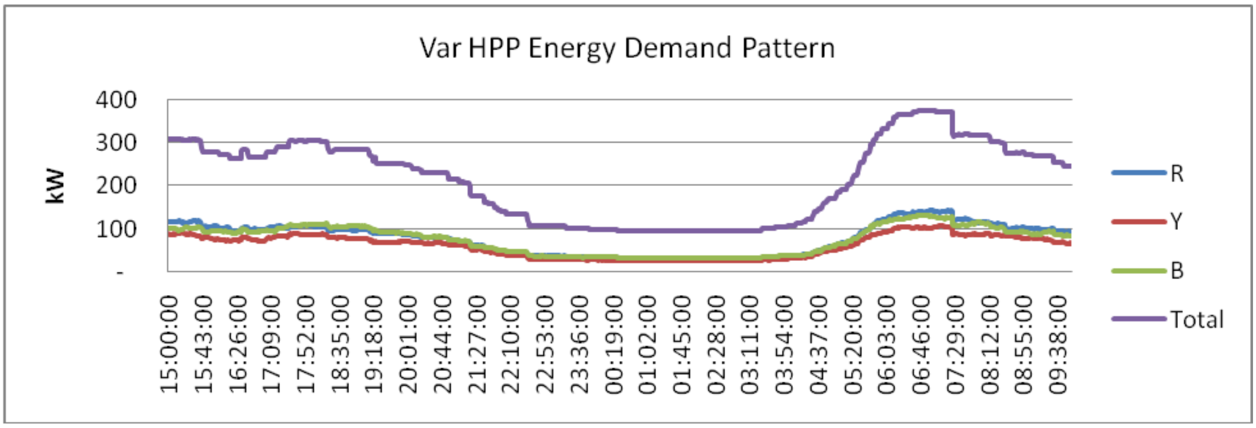
2. Annex : ESE Runs Mini Hydro Projects

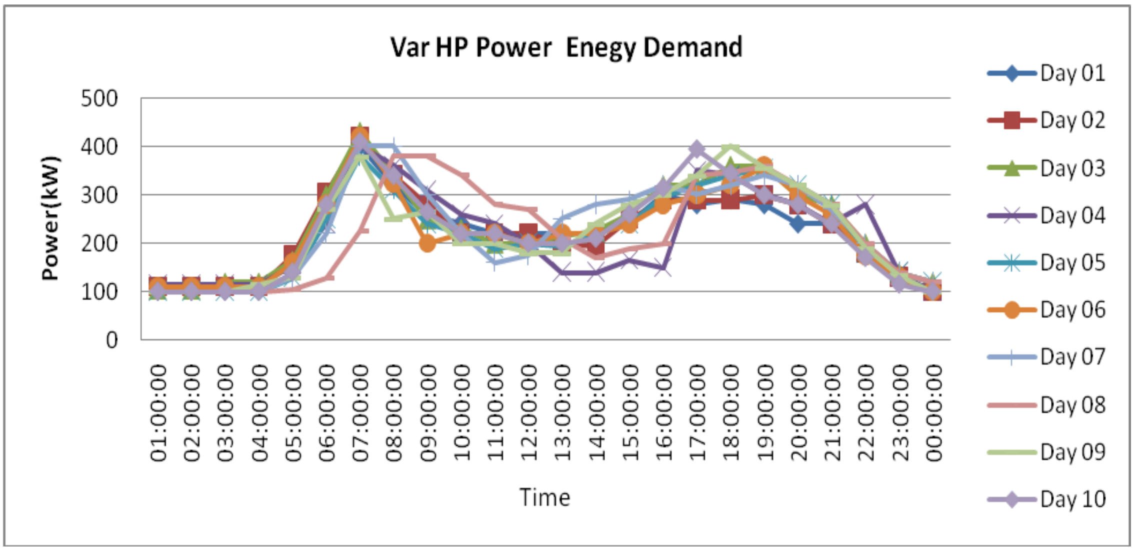
Var Hydro Power Project

Var mini hydro project has been developed by ESE in 1986. It is situated 12miles from Falam town in Chin state. Initially (1986) it has installed 500kW X2Francis turbines. The head of the site and the penstock length are 400ft and 1530ft respectively. Penstock is 28 inches diameter steel pipe. Since these turbines are very old, and regularly failure, another 500kW capacity Turgo turbine has been installed in 2013. This power station supplies electricity for Falam town and another 11 suburb village with the facility of 17 numbers of transformers. Total number of beneficiaries are 2,315 households and all have standard domestic tariff structure. Monthly income of the project is between 3-4 million Kyats. ESE anticipates that the national grid will cover this area within next year. At present one of Francis turbines has been permanently stopped due to endless technical failures and the second one is kept as a standby. This standby turbine's flow controlling system (wicket gates) is not working and water flow is controlled through butter fly valve. This is a huge energy loss when running at part load. Further that butterfly valve is operated by a manually operating hydraulics jack (Automobile type jack). So this Francis turbine operation is very cumbersome work and may not control voltage and frequency reliably. So recently installed Turgo turbine is continuously running since its commission in last year.

Single turbine power is sufficient even for the peak demands (Energy demand curve shows below) and runs one turbine at a time within last 28 years.



Energy demand variation from 3.00pm to next day 9.40 am captured from data logger



Var HPP energy demand pattern of consecutive 10 day based on daily logged

There are 8 operators directly involved in this project on shift basis. In addition to operation, they have to record the panel meters reading hourly. A lot of failures have happened at the two turbines installed initially as mentioned below.

The generators have been burnt out at least 10 times and bearing had to be replaced over 100 times within last 20 years. According to the operators there are water seal and shaft alignment problems also reported. So water passes through bearing. This leads to bearing damaged so many times.
Turbine shaft has been broken 2 times. That may poor quality shaft selection, incorrect shaft designing or wrong practices of repairing. Generator burnt out about 2 times. Once generator burnt out has been caused due to fusing of HT distribution line due to a tree fallen.
Automatic hydraulics controllers of three turbines are not functioning. Especially this is a serious problem of the last year commissioned Turgo turbine's controller. However another new controller has been purchased and planed to install within next month.
Although so many failures have happened there are no records of failures documented in power house or regional ESE office. There are two diesel generators of 120kVA and 12kVA supplied in 1998 to supply power in dry seasons. 120kVA generator has a technical problem and could not be commissioned yet. The smaller generator is used to supply electricity for the Very important person (VIP) in Falam City in dry seasons.

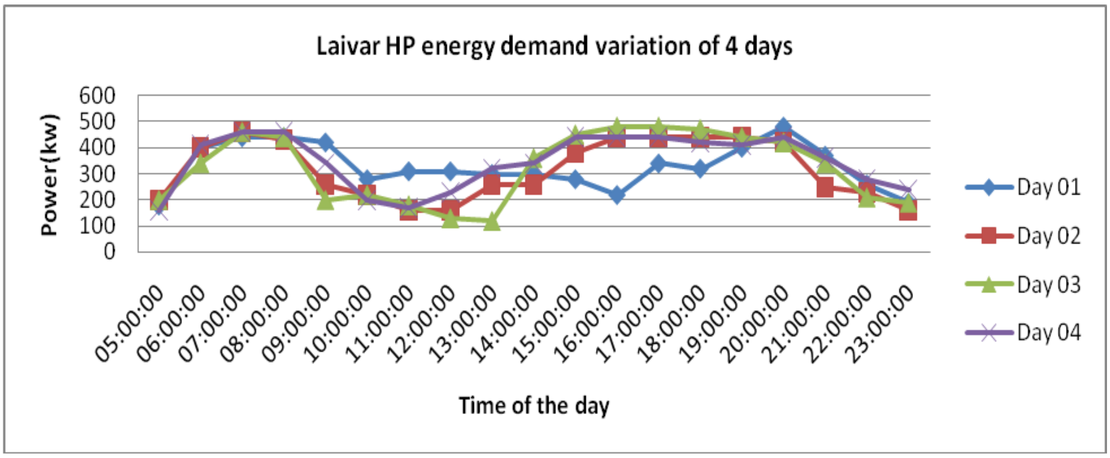
Laiva Mini Hydro Power Project

Laiva HPP is situated 22 miles from North West of Hakha. This mini hydro project has 255kW X2 (generator capacity 300kW) Peltons, 1000 rpm turbines and commissioned in 1994. There are 5,240 numbers of consumers. Originally this has been designed to electrify Hakha and Htantalan towns and 8 villages. But 10 months ago Hakha town has been covered by the national grid and disconnected from this mini grid. However, this could supply only 6 months for 24hrs electricity demand and the balance of the year has to be covered by the turbine running which depends upon the water availability. Following graph shows the hourly electricity demand variation few days of November 2014. Further those days, there was not a power cut or failures. According to that graph energy demand vary from 150kW to 490kW. There are 24 numbers of transformers connected to this project. Present project head is 636ft and power house faces to main road. Down to this project, there is a head over 1,000ft drop. But this has not been developed a HPP because present project is covering all villages in surrounding area.

At present both turbines are manually synchronized and supply the demand. Automatics hydraulics governing systems are also not functioning. This project has very less technical failures with respect to other ESE projects. There are three diesel generators of 80kVA, 100kVA and 300kVA in Hakha town to supply electricity for limited areas in dry seasons.

Total project cost was 3.38 million USD (in 1994). Monthly income varies between 4,000,000 to 7,500,000 Kt. Major Issues of this hydro-project are

- Bearings failure about 4 or 5 times within this project lifespan
- The rectifier diodes fusing at least 5 times per year
- There is no properly designed silting tank and turbines have minor damages due to hitting with stones



Dongvar Mini Hydro Power Project

Dongvar project is situated 12 miles northern from the Hakha town. There are two 200kW Francis turbines installed in 1984 supplied from Austria and another single 200kW Francis turbine installed in 2013 supplied from China. At initial stage the electricity has been supplied to 5 villages including part of Hakha town. Now it is applies only to 2 villages. The balance 3 villages have received electricity from the national grid a 10 month ago from the Hakha town electrification project. At present only 72 HH get electricity and maximum demand is less than 30kW. According to Hakha town officers, they have been maintained as a standby power sources for the town. In case of national grid fails, it is expected to connect and give supply to Hakha town. But, there is no such a failure of national grid reported. The head race channel of this project is 10,000 ft long and constructed in steep terrain. There are not enough intermediate settling basins, culverts to small drain running the rivulet under the channel or channel crossings to flow rivulet over the channel. So in rainy seasons turbine had to be switch off considerable time for cleaning the channel. For dry season (5 months per year) this hydro-project can be run about 3 to 6 hours only.

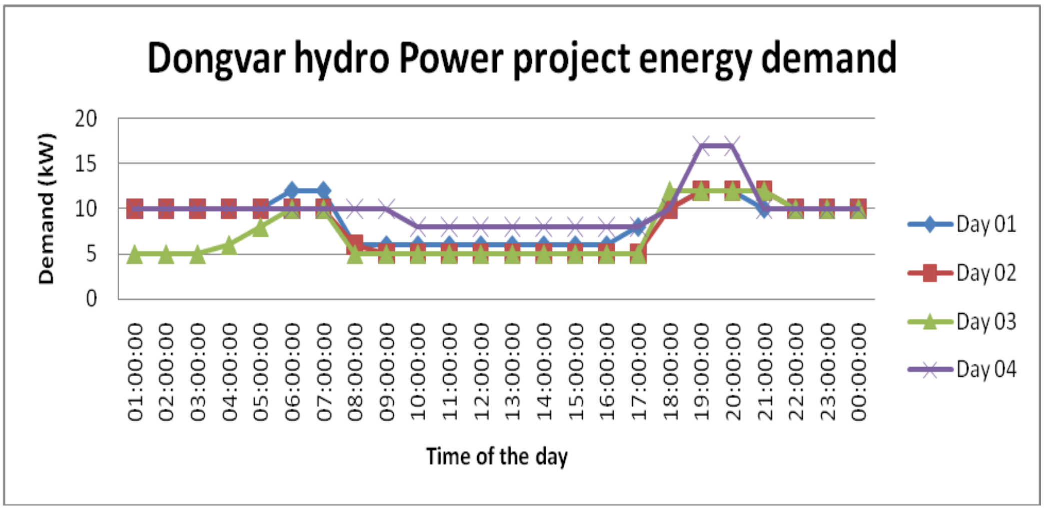
One Francis turbine out of two old versions had been stopped for bearing replace. Trash rack in forebay has damaged over few years and so these turbines regularly struck with foreign matters coming from water. Fortunately early installed two turbines involutes' (housings) have openings lids and the debris can be removed manually. But recently installed turbine does not have such openings. So it cannot be run until repairing the trash rack. However it is recommended to repair the damaged trash rack as soon as possible to avoid serious damaged to the turbines. Automatic control systems of both old turbines are not functioning and have to control manually. There is lever mechanism for the both turbines to operate the hydraulic systems. Further it is better if it could install 30kW impulse (pelton/turgo) turbine for this site instead of a 200kW Francis turbine (installed in 2013). Then it can cater over the year for the present little numbers of beneficiaries. This HPP also has some regular failures such as;

Water seals replacement of 2 times per year

Bearing replacement of 1 time per year

Present monthly income is 250,000ks and direct expenses is (70,000x6 =) 420,000 for 6 operators. Project cost is 10.32 million kt or 2.28million USD.

Following graph shows the energy demand of four days. Daily demand fluctuates between 5kW to 17kW. Further maximum load is 8.5% of the rated power since numbers of benefishries has reduced up to 72HH.


Dongvar hydro Power project energy demand
Demand (kW)
20
15
10
5
0
01:00:00
02:00:00
03:00:00
04:00:00
05:00:00
06:00:00
07:00:00
08:00:00
09:00:00
10:00:00
11:00:00
12:00:00
13:00:00
14:00:00
15:00:00
16:00:00
17:00:00
18:00:00
19:00:00
20:00:00
21:00:00
22:00:00
23:00:00
00:00:00
Time of the day
Day 01
Day 02
Day 03
Day 04

3. Annex Village Hydro power project

Mong In HPP

Mong Invillage situated 9.5 Miles from the Pindaya town. Initially there was a propeller turbine (Power Pal) modal which was developed by monks to get power for a monastery. Project location is 300 m away from the 11kV line and less than 1km from the LT transformer. Now monastery has electricity from the national grid and villages has requested from local government to develop a hydro project and supply electricity for a 60 HH. Then government (DRD) has allocated total project cost Ks 5,000,000 for this project and offered for the tender to Sea Pelicon Co. Ltd. However, supplying electricity to this village from the nearest transformer by extending LT line would be better than developing this project.

On the day we visited, it was the first test running. Generated maximum voltage was 200 V and maximum power was 900 W at 180 V. This can supply only 15 W per house. Among the 60 beneficiaries 19 numbers of committee members have been selected for operations and maintenances. Yet it has not been decided monthly charge for electricity. Distribution line has been completed. Presently all houses use candle to light up their homes. About 100 to 120 candles are used per month for each house. Following picture shows partially completed turbine.

Mong In HPP

Houses are 1 miles from the site and over head distribution line had completed with 16 mm ACSR cable. Used engine oil barrel has been used as the penstock. However they have planned to concrete in later.

Owe Kong Hydro power project

This project developer and the owner is mr. U Nyein Min. This is situated 10 miles from Pindaya town. It has started in 1990 with a small turbine for grain crushing and to get electricity for own house. Later it had been gradually developed for his milling system and to supply the electrical power to neighbours for over 20 year period. Mills are run in day time as his own business but electricity sharing with 80 numbers of neighbours. At present although national grid has reach to this village most people do not expect get electricity from the national grid.

Owe Kong HPP

There are two propeller type (powerpal) turbines interconnected with a belt drive system. Currently this power uses for followings applications.

1.80 houses electrify at night time

2. Oil expeller (Approximately 6kW)

3. Grain crusher (Maize)

4. Rice mill

All agricultural products are purchased from the village and processed product are sent to market though his trucks.

These machines run according to availability of raw materials and 5 to 10 numbers of labours are working every day. According to the owner, all equipment and distribution cost are about Ks. 80,000,000.00. But the owner does not have a cost break down. A 20kW 3 phase synchronous generator has been coupled to the system to get electricity at night. Total output power could not be measured in the inspected moment since maize crusher was running at that day.Electricity charging rate of this project is,

One florescent bulb (2 or4 feet) 1,000/=(10 HH)

Two florescent bulbs 2,500/= (70 HH)

TV/Audio set 1,000/= (there are 50 units)

5W lamp for religious activity free

Owner has the capacity for regular O &M activity. Within the last 24 years it has used about 5 generators. Generator replacing cost is not a big issue for the owner. Total distribution line length is 2 miles. At present owner has started to replace concrete poles in behalf of wooden poles. He has made a steel form work and filling concrete while vertically mounting in the pit. This is very hard and costly practice.

Ming In Hydro power Project I

Ming In HPP is situated 12 miles from the Pindaya town and it's a fully funded project of the DRD. Developer is Sea Pelicon Co.Ltd. which has develop Mong in project   Total project cost is 5,000,000 and developed in 2012. There were 80 numbers of household in early stage in this HPP. 100kVA transformer has been installed in 10 months ago in this village but LT distribution line had not been laid. But 12 HH of them get national grid electricity recently by paying both distribution and service line cost.

Pelicon Co. Ltd Company has installed and tested another two turbines in this site. The power output was very little and not enough for 80HH as observed. As a result present turbine has been installed. It seemed that this turbine could be designed without any knowledge of hydro turbine.

According to the villagers, government had installed and energized the transformer from the national grid but did not lay the distribution lines. So few lanes of villages have get to gather and paid huge money for the distribution and service lines for electricity. The other side villagers do not have money and yet use the hydro power project.

Turbine of Ming In HPP

This project has been recommended only for lighting for all houses. Monthly revenue of the project is between Ks 90,000 and 100,000 and beneficiaries are not aware of the consequences of this income.

Ming In Hydro power II

Ming In village has abandoned the hydro power project and run solar systems which were donated in 1996 by UNDP. Designed power of hydro project was 30kW (power pal turbine) and a 450W solar system for a health center. This hydro project has been running until mid of 2014. In the mid of 2014 national grid has reached the village and all people has shifted to national grid. Now hydro project has been abandoned. This project had faced lot of failures and that is why all people gave up the project soon. Health centre refrigerator is yet running with solar system.

Ming In Hydro power Project III

One lady who lives very closely to above mentioned UNDP project has invested for a hydro power project in 1990s. Basically she runs rice mill, oil expeller and grain crusher while generating electricity for her own consumption. That project also developed step by step over 20 years and few turbines have been removed due to poor performances. Presently her industry runs with a water wheel. She does not have idea on total project cost and does not maintaining O & M records.

Water wheel turbine interview the owner by ESE engineer

ThaPyayKone HPP

This project situated 20miles from Yardsok city. Deigned capacity is 10kW and total project cost 6,000,000 and it was fully funded by DRD It has 10kW propeller (Powerpal) turbine and actual output is 3.8kW. One of the main short comings in this project is considerable head lost in the head race channel. By correct design, it can double the power out. It has to be invested about 75m low pressure penstock in behalf of present earth channel to achieve that extra power.

There are 73 nos. of households and monthly total electricity charge is 219,000 in Myanmar kyat (for 1H.H = 3000 kyat). The commissioned year is February, 2014. Each house uses two tube bulbs. Some families use solar system with inverter to watch TVs.

ThaPyayKone HPP

Myosoe HPP

Myosoe HPP situated 6 miles from Yardsok town. It has 2 numbers of 7kW propeller turbines (Power Pal), and one 3kw turbine. The project cost is approximately 6,000,000 in Myanmar Kyat and DRD contributed the total project cost. There are 130 nos. of household and monthly total electricity charge is 390,000 in Myanmar Kyat (for 1H.H=3,000 kyat). This project commissioned in February, 2014. These two turbines have separate distribution lines.

This 3 kW turbine which has been used over ten years, expecting to use this small turbine in dry seasons.

TaungGyi HPP

TaungGyi has 50kW HPP which has been developed by a medical officer Mr. U Tun Min in 2004. He has studied such a project in Shan state and it has been copied. Further this is the only project which used “Pump as Turbine” technology. This project has three transformers 50kVA for step up and another two numbers of 20kVA each to step down at two clusters. Gross head is about 42feet and used welded engine oil barrels as the penstock. Total project cost at the construction period was Ks. 22,000,000 and total amount is collected from the beneficiaries. ESE has given technical support to construct the HT line free of charge. Further nobody does know the voltage of HT line. HT and LT lines lengths are about 3 miles each. Total numbers of households are 200 in four villages of two clusters. This project takes the water from irrigation tank which constructed in marshy land. According to the developer there is no water stream connected to this tank and rain water and spring water are used instead.

This project has been temporary stopped due to generator burnt 4 months ago. Further it has burnt 4 times as major failures within last 10 year life. Lightning strikes and penstock blast and water flashing in to generator were the reasons to burn so many times. Now these beneficiaries use domestic hydro units, solar panel and candle to light up. At the time of the functioning this project it has collected 3,000 average amounts from the beneficiaries. All income and expenses are managed by the developer.

Project access road not used over last four months

By discussing with the developer and active villagers, it is understood that everybody hasbeen tired with failures.

Pan Oo Taung HPP

NangHow reservoir has been constructed to supply drinking water to Pyin Oo Lwin town and irrigate farm lands. It is situated 10 miles from Pyin Oo Lwin town. 10kW turbine has been installed in 2002 and supply electricity to one village of 50 HH. In 2011 it has constructed a 75kW HPP to supply electricity for Pan Oo Tang village which is situated 1.5 miles from the power house. Then it has supplied electricity for another 220 HH. Total project cost was 60,000,000/= and Mandalay region government has given 10,000,000/= loan for one year period without interest. They have settled the loan within the first year of commissioning. Further only four families have not get electricity from this project that live within the coverage area. They have solar lighting system.   According to available document this project distribution line cost shows below.

1.5miles HT line

Material Cost = 5,666,200/-

Labour Cost = 1,624,000/-

Total 7,290,200/=

Unit cost 4,860,000 per mile

3.0 miles LT line

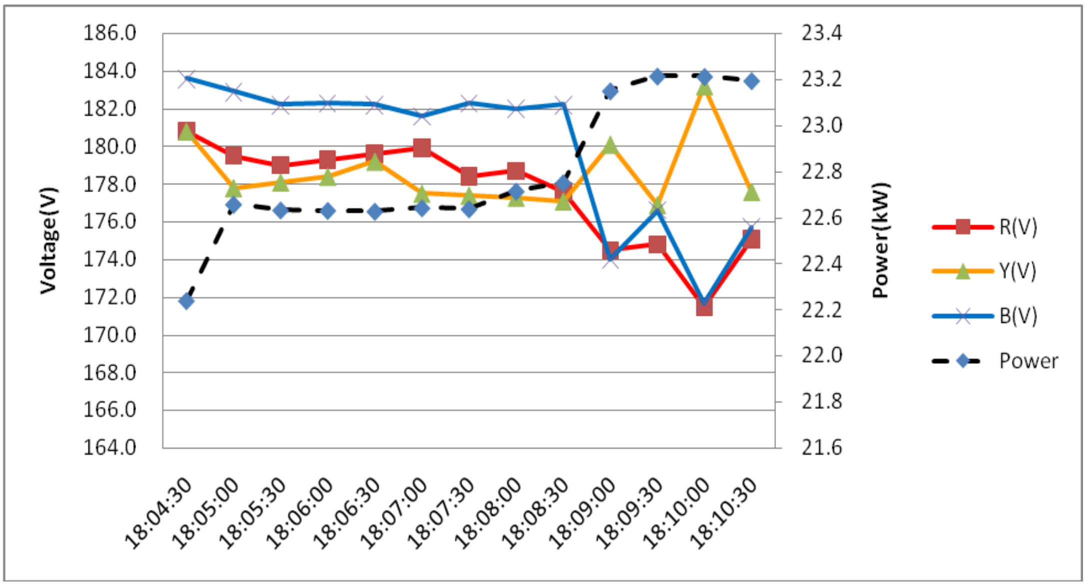
Material Cost =2,712,150/-

Labour Cost =2,381,000/-

Total cost =5,093,150/=

Unit cost =1,697,716 per mile

This project equipment manufacturer and designer is U Htun Min. As of the other project, this project also does not have a controlling system and the operator adjusts the sluice in the reservoir about 200ft away from the power house. According to the reservoir water level, operator determines the opening height of the gate. In case of operator observes low intensity of bulbs, the gate is been opened further. But they do not go to power house or observe the meters. This project can be run 24 hours only 6 month per year and the balance of the year running time depend on available water amount. Tailrace of the power house connected to the irrigation channel. Following graph shows the power generation at 7.00 pm.



Pan Oo Tang HPP each phase and total power demand at 7.00pm

Monthly income is about 400,000/= and manage by a committee of 10 members. For a new connection 100,000/= is charged as connection cost. Electricity bill is paid by all beneficiaries on time. At present they have been doing a lot of village development works from the income of HPP. Two teachers salary (50,000 per each), free of electricity for the school, school and road development are the main activities performed with the income of HPP.

As the major problems with in the 4 years life are transformer burnt once by lightning, turbine breaks 3 times due to hard wood and steel pieces come through the penstock.

TaungChae HPP

This is the HPP which has been selected for **Micro Hydro and Decentralized Renewable Energy for Myanmar"** workshop field visit. This project developer is U Sai HtunHla who developed the Pan Oo Taung HPP. There are two turbines of 50kW and 100kW rated capacities and commissioned in 2004 and 2007 respectively. The 100kW turbine is used during the peak time (6pm to 11pm) and the rest of the night 50 kW turbine is used till 6am. There are 250 nos. of HH and electricity is sold to an office/workers camp nearby for K250, 000 a month. Ks 2500/= charges from each HH per month. Households in addition pay in total K50, 000 a month to developer for the plant. They are not aware on length of repayment. The monk at temple is responsible for collecting money and other donations and organizing township people to contribute their time. The developer designed the power plant, civil works and supplying of the equipment. Construction materials such as sand, gravel, wood, were contributed by township.

Interest rates from local banks are 1.2% per month fixed rate with balloon payment due at end of one year. Immovable assets valued at 150% of loan amount required. Loan call is rolled over as needed. This is for developers. Interest rates for households is much higher at 4% a month flat rate Following table shows details of cost breakdown of project cost project in 2004.

30 kW generator with pulley	1	740,000.00
50kW Generator	1	2,875,000.00
Penstock 24"	1	2,500,000.00
30kW HT transformer	2	2,800,000.00
All other costs of the turbine supplier		10,087,074.00
Total cost		19,002,074.00

Laouk Lon hydro power project

This project situated 12miles from Hakha town. This project has been developed by UNDP in 2005. Designed capacity was 10kW. In 2011 another local donor has replaced all electromechanical equipment and increased the power output upto 20kW with 4,400,000/=. The total numbers of beneficiaries has been increased from 60 to 140. Machine manufactured and supplied from Mandalay but few villages who met did not have further details of them. According to 2011 renovated cost, the total project cost is 7,000,000/=. This project tariff rates is;

1 bulb 100/=

TV 500/=

Each house has 3 to 5 numbers of bulbs and there are 90 numbers of TVs in this village. Monthly income of the hydro power project is about 100,000. However this income is not enough to repair and additional amount had to be collected many times. All houses use 5w and 10W incandescent bulbs only and they cannot bear the high cost for energy efficient bulbs. Further all bulbs directly connected to the line without any switch throughout the day.

Electricity is supplied for 4 months without water shortage. The other 8 months turbine running time is dependent upon availability of water. However in dry season they can get electricity at least 4 hours per day. According to the operator they are suffering a lot of technical problems and that is shown in the following table

Kalay private hydro power project

This project location situates 15 km from kalay town. The developer, manufacturer and owner of this project are Mr. U win Soe .There are 66 numbers of HH. This is situated in a very populated area in kalay town of Magwe state. Designed power is 75kW and actual power output is 35kW. Project is operated by a person from nearby house. System frequency vary from 35Hz to 60Hz. Voltage is varying from 150V to 350V. Bearings fail 2 times per year. Project head is 20ft and flow is over 2 cubic meters per second. It has been constructed in 1,000 ft long and 8x2 ft cross sectioned channel for this project. 2008

There is no control system and the voltage and the frequency are fluctuating regularly. That may be according to workshop machinery on/off and loading /unloading.

Electrical energy tariff is,

1 bulb	2,500ks
2 bulbs	5,000Ks
TV/video set	12,000 Ks

Over 9 months per year, this HPP is running 24 hours but in dry season it's running time depends upon water availability. Electricity is supplied for the owner's workshop which is 4 miles away from the power house. Construction period was 2006 to 2008 and project cost was approximately Ks 100,000,000.00. A 2,000,000ks has been received from the state government. Owner does not have the breakdown of project cost. At the very early period of this project, one generator has been burnt due to low numbers of customers/demand and voltage increasing. Operator monthly salary is Ks. 50,000.00.

4. Annex Hydro power services provider's details

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Hydro Turbine Manufacturing
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Kalay Township
073 30155, 30155, 303062
09250860597

Mr. U win Soe's hydro power machine manufacturing workshop has been started by present owner's father in law. After death of the founder, U Win Soe is continuing the job. Pelton, cross flow, Kaplan (Power pal) arethe type of turbine manufacturing. Because of his kay town is the main access to Chin state, which has high hydro potential and low electrification rate this workshop has demand for turbine. Pelton bucket samples have been collected from English colonial era turbines and few sizes of propeller turbine have been purchased from market and being copied.. Over 1,000 turbines have been manufactured within last two decades. Highest demand type of turbine is the Pelton from Chin state. He is not using any scientific methods for designing turbine for specific site. FNDP (Pvt) Ltd turbines are also manufactured in this workshop.

His workshop runs with his own 50kW hydro project which is 4miles away from the workshop. There is a separate 400V three phase line from power house to workshop. Standby diesel generator (10kVA) is also there. All other workshop owners of this industrial zone use individual diesel generators since the national grid has not extend to this industrial zone.

This work shop has very old lathe machines, drill and milling machine. Operators have less knowledge on precision and systematic operations. Casting facility is also available for cast ion and bronze in this workshop.

Khinmynmung
Chaiman
FNDP (Pvt) Ltd

Falam

Chin state

FNDP (Pvt) Ltd is involving in Solar, Hydro energy sectors as well as Building contraction. They are manufacturing 7.5kW to 50kW range hydro turbine. Within last 15 years it has completed 55 nos. off grid hydro project. Their all projects are in Chin state where very steep mountain region. According to Mr. Khinmynmung they have installed Pelton and cross flow turbines only. Average machinery cost for 15kW to 30 kW rage project is 3,000,000/=. They are using tube and gauge method and current meter to measure head and flow respectively. They do not have idea on load controlling methods of hydro power projects. His turbines are manufactured by U Win Soe (Shwe Yaw) workshop in Kalay.

FNDP (Pvt) Ltd is registered supplier of solar home system for government projects. Solar charge controller is manufacturered by themelf. Unfortunately that controller has blocking diode and indicator bulb only. Then it leads to reduce the life time of battery drastically.

FNDP (Pvt) Ltd manufactured solar controller

LwinOhyoRtaw (Willium)

Sea Pelican Co. ltd

39th Road, 54th x 55th Streets

Mandalay

Mayanmar

Thargymdy91@gmail.com

0943036988/ 0949300088/ 09402511988

Sea Pelican Co. ltd is a government registered contractor for buildings, road and bridge etc. Very recently they have entered in to hydro power sector. But there is no any person who has studied hydro power technology. It could be seen two HPP developed by this organization and it has not practiced any scientific approach.

U Sai HtunHla

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Lashio Town
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Sai HtunHla is a mechanical engineer and this company involves fulltime in hydro power sector. Equipment's manufacturing, feasibility study and other services are provided for hydro power sector since 1982. About 140 projects have been completed up today and sites are in 6 states of Myanmar. He was met at the hydro power workshop organized by REAM and one of the visited projects"Pan Oo Tang " was developed by himself where machines had been supplied by this company. This company manufacture 3 kW to 300kW range turbine of pelton, Turgo, cross flow, propeller, Francis and tabular turbines.Their main technical constraints are hydro power controllers and bearing. At present they do not use controlling system for HPP. Average bearing life time is 6 months.

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Mr. U KhunKyaw has 30 years working experiences in hydro power sector and completed over 100 projects. Cross flow, propeller and Pelton turbines are manufactured. Hismaximjumdesigned capacity is extending up to 100kW. His project is also designed to run constant load due to lack of knowledge of the controllers. Further he has not received any hydro power project from theh government for his 30 year hydro power development carrier.

U Khun Aung Myo
Managing director,
KhunFharaBwar Construction Company and Win-Thet-di Hydro Power Production Company
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Mr. U Khun Aung Myo is a civil Engineer and involves in building construction and hydro power development sectors. He has designed and manufactured 15 nos. of turbines and theircapacity isvarying within 5kW to 90kW range. Propeller, Francis and cross flow are the types of turbines which had been used in the above sites. He also does not have control technology and bearing failure issues of his machines.

5. Annex : Energy demand of government HPP

Var HPP project energy demand

Var HPP project energy demand										
Time	Power(kW)									
	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day
01:00:00	100	110	105	115	100	110	100	100	100	100
02:00:00	100	110	105	115	100	110	100	100	100	100
03:00:00	100	110	120	115	100	110	100	100	100	100
04:00:00	100	110	120	115	100	110	100	100	115	100
05:00:00	140	175	165	155	130	160	130	105	130	140
06:00:00	280	305	300	240	250	280	220	130	270	280
07:00:00	400	420	430	400	380	420	400	225	380	410
08:00:00	320	340	340	360	310	325	400	380	250	340
09:00:00	260	280	250	310	240	200	300	380	265	265
10:00:00	240	220	230	260	220	220	220	340	200	220
11:00:00	220	220	200	240	190	220	160	280	200	220
12:00:00	220	220	200	200	200	200	175	270	180	200
13:00:00	220	200	215	140	195	220	250	210	180	200
14:00:00	220	195	225	140	220	220	280	170	240	210
15:00:00	240	250	260	165	240	240	290	190	280	260
16:00:00	300	290	320	150	295	280	320	200	300	315
17:00:00	280	290	320	350	320	300	300	340	340	395
18:00:00	290	290	360	340	340	320	320	345	400	345
19:00:00	280	300	360	300	355	360	340	360	355	300
20:00:00	240	280	300	280	320	300	320	320	320	280
21:00:00	240	240	280	240	280	260	270	280	280	240
22:00:00	180	180	200	280	180	175	200	200	190	170
23:00:00	120	130	140	140	140	130	140	140	135	115
00:00:00	110	100	120	100	120	100	120	120	100	100
Maximum demand (kW)	400	420	430	400	380	420	400	380	400	410
Daily energy demand (kWh/day)	5200	5365	5665	5250	5325	5370	5555	5385	5410	5405

Laivar HPP project energy demand

Time	Power(kW)			
	Day 01	Day 02	Day 03	Day 04
00:00:00	180	200	200	160
01:00:00	180	200	200	160
02:00:00	180	200	200	160
03:00:00	180	200	200	160
04:00:00	180	200	200	160
05:00:00	180	200	200	160
06:00:00	400	400	340	410
07:00:00	440	460	460	460
08:00:00	440	430	440	460
09:00:00	420	260	200	340
10:00:00	280	220	220	200
11:00:00	310	160	180	170
12:00:00	310	160	130	230
13:00:00	300	260	120	320
14:00:00	300	260	360	340
15:00:00	280	380	450	440
16:00:00	220	440	480	440
17:00:00	340	440	480	440
18:00:00	320	440	470	420
19:00:00	400	440	440	410
20:00:00	480	420	420	440
21:00:00	370	250	340	360
22:00:00	260	230	210	280
23:00:00	190	160	190	240
Maximum demand	480	460	480	460
Daily energy demand(kWh)	7140	7010	7130	7360

Donvar HPP project energy demand

Time	Power(kW)			
	Day 01	Day 02	Day 03	Day 04
01:00:00	10	10	5	10
02:00:00	10	10	5	10
03:00:00	10	10	5	10
04:00:00	10	10	6	10
05:00:00	10	10	8	10
06:00:00	12	10	10	10
07:00:00	12	10	10	10
08:00:00	6	6	5	10
09:00:00	6	5	5	10
10:00:00	6	5	5	8
11:00:00	6	5	5	8
12:00:00	6	5	5	8
13:00:00	6	5	5	8
14:00:00	6	5	5	8
15:00:00	6	5	5	8
16:00:00	6	5	5	8
17:00:00	8	5	5	8
18:00:00	10	10	12	10
19:00:00	12	12	12	17
20:00:00	12	12	12	17
21:00:00	10	12	12	10
22:00:00	10	10	10	10
23:00:00	10	10	10	10
00:00:00	10	10	10	10
Maximum demand(kW)	12	12	12	17
Daily energy demand (kWh)	210	197	177	238