CHAPTER 3 DEVELOPMENT PLAN OF NAM LAN PROJECT

SH-02 The Nam Lan Rural Electrification Project in Northern Shan

3.1 The Project Area

Nam Lan is located 60 km to the south of Hsipaw Township in the Northern Shan, which consists of 11 quarters and 5 surrounding villages. The population of Nam Lan is 12,229 and the total number of households is 2,082 as of September 2001 as shown in Table 3.1.1. A map of Nam Lan is shown on Figure 3.1.1.

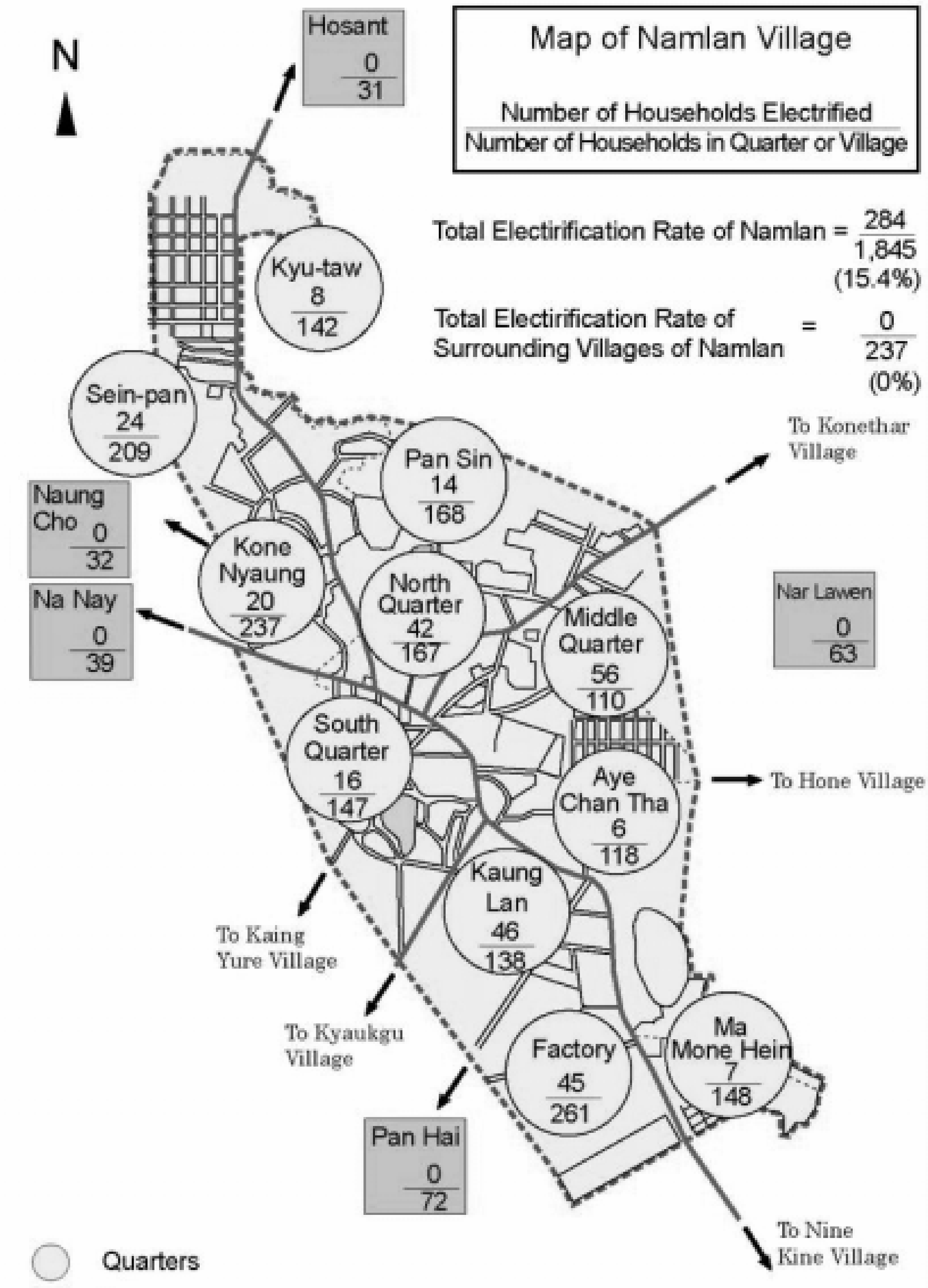
Nam Lan is designated as a municipal township under Hsipaw Township, since it has adopted the quarter administration system to govern populations exceeding 10,000.

Table 3.1.1 Population and Number of Households in Nam Lan

Quarter/Village Tract		Population	Number of household	Electrified household	Electrification ratio (%)
No.	Name				
Q1	Plant Station	1,519	261	45	17.2
Q2	Kaung Lan	873	138	46	33.3
Q3	Pan Sin	851	168	14	8.3
Q4	Down Town	640	110	56	50.9
Q5	Northern Part	954	167	42	25.1
Q6	Southern Part	1,312	147	16	10.9
Q7	Kone Naung	1,378	237	20	8.4
Q8	Sein Pan	1,377	209	24	11.5
Q9	Que Taw	916	142	8	5.6
Q10	Aye Chan Ta	576	118	6	5.1
Q11	Ma Mone Hein	651	148	7	4.7
	Sub-total	**11,047**	**1,845**	**284**	**15.4**
V1	Nar Lawan Village	295	63	0	0.0
V2	Pan Heigh V.	398	72	0	0.0
V3	Naung Cho V.	148	32	0	0.0
V4	Na Nay V.	167	39	0	0.0
V5	Hosant V	174	31	0	0.0
	Sub-total	**1,182**	**237**	**0**	**0.0**
	Grand Total	**12,229**	**2,082**	**284**	**13.6**

Source: Field Survey by JICA Study Team

The electrification ratios in Nam Lan in 2001, which are quoted from the MEPE's statistics, are 15.4% in the 11 quarters and 0% in the 5 villages, or an average of 13.6%. A diesel generator with a nominal capacity of 160 kW was installed in 1994 and has been used by the MEPE to supply electricity to the quarters usually from 18:30 to 21:00 each day.



Source: JICA Study Team

Figure 3.1.1 Map of Nam Lan

The actual electrification ratio in Nam Lan including miscellaneous power sources is estimated at about 19% consisting of 284 households supplied by the MEPE, 100 households by private diesel generators, and 5 pico hydros, according to the interview surveys.

The electricity use in Nam Lan can be divided into 4 categories; 1) household use, 2) public use, 3) business use, and 4) industrial use. The public facilities consist of 10 temples, 1 pagoda, 1 hospital, 1 clinic, 1 high school, and 9 primary schools. The commercial facilities are 3 restaurants and 2 guesthouses in the quarters.

There are a number of cottage industries in Nam Lan that are running diesel generators for their power supply. Accordingly, the main demands expected for electricity use in Nam Lan would be the home lighting during night-time, and the cottage industries during daytime.

Existing industries in Nam Lan are 18 rice mills, 6 oil mills, 2 sawmills, 3 tofu manufacturing shops, 3 noodle mills, 5 furniture manufacturing shops, 5 ironworks including car repair shops, 2 battery charging stations (BCS) (excluding 9 other private home-use SHS), and 25 water pumps.

Table 3.1.2 shows the average income, expenditure, and saving level of both non-electrified and electrified households surveyed in Naung Mon and Na Ya Ma villages near Lashio in the Northern Shan. The average annual income in the non-electrified village is K218,600, while that in the electrified village is K389,800. It is likely that the income difference comes from business sales (29% in the electrified village, and 2% in the non-electrified village).

Table 3.1.2 Income, Expenditure, and Saving Level in Northern Shan

(K/year/household)

Household Account	Northern Shan State	
	Non-electrified	Electrified
1. Income	218,600	389,800
2. Expenditure	174,300	363,500
3. Saving	44,300	26,300

Source: Field Survey by JICA Study Team

3.2 Needs and Demand for Electrification

1) Village Socio-economic Survey

According to the village socio-economic survey conducted for 430 households in the Northern Shan including Nam Lan from May to June 2001, the priority of basic living needs in the households are ranked as i) health, ii) electricity, iii) money, iv) education, and v) food. Electricity is ranked at 2nd highest, while villagers of the electrified villages in the Northern Shan gave a different order of priorities in their daily life, i) health, ii) money, iii) electricity, iv) food, and v) job.

The survey result also shows the preference for power sources of the local people; i) firewood, ii) small hydropower, iii) grid electricity, iv) kerosene, and v) diesel generator. The survey suggests that the local people in non-electrified villages desire stable and continuous electricity supply.

2) Power Demand Forecast

The electricity demand in Nam Lan was forecast in the following manner:

$$P_D = P_H + P_P + P_B + P_I \quad \cdots\cdot(1)$$

$$P_x = n_x W_x C_x A_x / 1,000 \quad \cdots\cdot(2)$$

where,
- P : Electricity demand in kW, where suffix H denotes household, P for public, B for business, and I for industry
- n_x : number of consumers of x sector;
- W_x : Unit consumption of x sector in Watts
- C_x : Ratio of concurrent use of x sector in peak time
- A_x : Affordability ratio of x sector.

It should be noted that the unit consumption of each sector was assumed according to the field survey as presented in Table 3.2.2.

The electricity demand during night-time per household in Nam Lan is estimated at 120 W in total, based on three lights of 90 W (30 W x 3), one small radio of 10 W, one TV of 60 W for 50% of the households, and a ratio of concurrent use of 0.9.

For further night-time demand in future, it is anticipated that 15% of households will have 600 W-class electric cookers. According to the survey results, the village people listed a rice cooker as the next most desirable appliance after lighting. The future estimated night-time demand of 160 W per includes the demand for rice cookers in the future.

Some households may not be able to access electricity due to their low income. The field survey suggested that the cut-off line would be drawn at an annual income of K 100,000 as shown in Table 3.2.1.

Table 3.2.1 Percentage of Households with Annual Income > K 100,000

(%)

Description	Southern Shan	Northern Shan	Kachin	Average
Non-electrified villages	86	82	93	87
Electrified villages	89	93	94	92
Average	87	84	93	88

Source: JICA Study Team

Table 3.2.2 Estimated Power Demand Forecast in Nam Lan

Source : JICAStudy Team

Customer	Number of Custo-mer	Step	Night						Daytime					
			Unit Con-sumption Watt	Sim-ulta-neous %	Unit Con-sumption Watt	Acce ssibi lity %	Estimat-ed Power Demand kW	Sub-total kW	Unit Con-sumption Watt	Sim-ulta-neous %	Unit Con-sumption Watt	Acce ssibi lity %	Estimat-ed Power Demand kW	Sub-total kW
1.Household	2,082	1-1	130	90%	120	93	232.4	232.4	130	15%	20	93	38.7	38.7
		1-2	220	70%	160	93	309.8	309.8	220	20%	50	93	96.8	96.8
2. Public														
2.1 Street Light	16		400	50%	200	100	3.2		400	0	0	100	0.0	
2.2 Temple & Pagoda	11		2,000	30%	600	100	6.6		2,000	40%	800	100	8.8	
2.3 Hospital	1		230	70%	160	100	0.2		230	50%	120	100	0.1	
2.4 Clinic	1		310	70%	220	100	0.2		310	50%	160	100	0.2	
2.5.1 H.School	1		6,200	0	0	100	0.0		6,200	20%	1,240	100	1.2	
2.5.2 M.School	0		1,640	0	0	100	0.0		1,640	20%	330	100	0.0	
2.5.3 P.School	9		380	0	0	100	0.0		380	20%	80	100	0.7	
Sub-total								10.2						11.0
3. Business														
3.1 Restaurant	3		3,185	30%	960	100	2.9		3,185	30%	960	100	2.9	
3.2 Guest House	2		4,905	50%	2,450	100	4.9		4,905	30%	1,470	100	2.9	
Sub-total								7.8						5.8
4. Industry														
4.1 Rice Mill	18		5,000	0	0	100	0.0		5,000	80%	4,000	100	72.0	
4.2 Oil Mill	6		5,000	0	0	100	0.0		5,000	80%	4,000	100	24.0	
4.3 Powder Mill	0		5,000	0	0	100	0.0		5,000	80%	4,000	100	0.0	
4.4 Sugarcane Processing	0		5,000	0	0	100	0.0		5,000	80%	4,000	100	0.0	
4.5 Saw Mill	2		10,000	0	0	100	0.0		10,000	80%	8,000	100	16.0	
4.6 Paper Mill	0		5,000	0	0	100	0.0		5,000	80%	4,000	100	0.0	
4.7 Tofu Mf'g	3		4,000	0	0	100	0.0		4,000	80%	3,200	100	9.6	
4.8 Noodle Mf'g	3		7,000	0	0	100	0.0		7,000	80%	5,600	100	16.8	
4.9 Furniture	5		5,000	0	0	100	0.0		5,000	80%	4,000	100	20.0	
4.10 Iron Work	5		4,000	0	0	100	0.0		4,000	80%	3,200	100	16.0	
4.11 BCS	2		1,500	0	0	100	0.0		1,500	80%	1,200	100	2.4	
4.12 Weaving	0		5,000	0	0	100	0.0		5,000	80%	4,000	100	0.0	
4.13 Water Pump	25		200	0	0	100	0.0		200	80%	160	100	4.0	
Sub-total								0.0						180.8
5. Total														
5.1 1-1+2,3,4								250.3						236.4
5.2 1-2+2,3,4								327.8						294.5
6. Gross Total														
6.1 1-1+2,3,4	Including 5% of transfer loss							270	Incl. 5% transfer loss					250
6.2 1-2+2,3,4	Including 5% of transfer loss							350	Incl. 5% transfer loss					310

The power demands in Nam Lan are estimated by adding 5% distribution loss as follows:

Power demand at the current level : Daytime demand 250 kW

	:	Night-time demand	270 kW
Power demand at the 2nd step (future)	:	Daytime demand	310 kW
	:	Night-time demand	350 kW

The breakdown of the estimate is shown in Table 3.2.2.

3) Willingness to Pay

Willingness to pay for the initial connection fee is estimated at K6,000 in the non-electrified villages, and K23,000 in the electrified villages according to the social survey in Northern Shan. However, the actual cost for the electrification was K32,600.

Meanwhile, willingness to pay for the monthly electricity tariff is estimated at K410 per month in the non-electrified villages, and K680 in the electrified villages according to the survey.

The above level for willingness to pay at K410 – 680 is quite high compared with the current the MEPE tariff, which is lower than K50/month for an average household. That shows the strong desire for electrification of the villagers.

3.3 Development Concept

The development concept for the Nam Lan mini-hydro scheme is summarized as follows:

(1) The Nam Lan mini-hydro scheme aims at the rural electrification of the Nam Lan municipal township consisting of 11 quarters and 5 surrounding villages, which includes 2,082 households and local industries with an electrification demand of 270 kW in night-time and 250 kW in daytime respectively.

Hosang Chaung (May 2001)

(2) Hosang Chaung, which is the main stream to be utilized for the hydropower generation, has a firm discharge of 0.25 m^3/s in the dry season. Hosang Chaung originates from a spring; hence a stable flow is expected throughout the year. The hydro-potential of Hosang Chaung is estimated at 110 kW, harnessing the head of 69.5 m and a discharge of 0.25 m^3/s.

Nam Pankan Chaung (Sep. 2001)

(3) There are several streams running between the site and the Nam Lan. A part of the river discharge in two streams among them, Nam Pankan Chaung and Kyutaw Chaung, can be diverted to Hosang Chaung to meet the forecast demand of 270 kW, though the irrigation water requirements on the downstream reaches should be assured.

Kyutaw Chaung (Sep. 2001)

(4) The irrigation water supply should have priority for the water utilization in principle, thus the available water for the power generation will be the remaining river flows after taking the irrigation water. However during the initial stage of the irrigation period or in a drought year, the available power discharge may be insufficient, even if the river flow from Nam Pankan Chaung and Kyutaw Chaung is diverted to Hosang Chaung. In this a case, the power facilities will be operated by selecting an optimum generating pattern

according to the available discharge.

(5) The power generation of the Nam Lan mini-hydro scheme is of run-of-river type with a daily regulating capacity by using a head pond, which is required to secure the minimum power demand in night-time when the available river flow is below the design turbine discharge of 0.65 m^3/s.

(6) The construction of the Nam Lan mini-hydro scheme will be divided into 2 phases. Phase-1 is the construction of the power facilities from the Hosang intake to the powerhouse with 160 kW x 2 units and the distribution line. Phase-2 includes the construction of the diversion channels from Kyutaw Chaung to Nam Pankan Chaung, and from Nam Pankan Chaung to Hosang Chaung. Phase-1 construction is scheduled to be implemented as a pilot project in this study from 2002 to 2003, while Phase-2 will be completed by the local people. The construction materials for Phase-2 could be procured in Nam Lan or Hsipaw with the funds from the initial access fee and the electricity tariff after commissioning of Phase-1. Figure 3.3.1 show the general plan of Phase-1, and Figure 3.3.2 shows the general layout including phase-2.

(7) The Nam Lan scheme is of a significant importance for promoting rural electrification in Myanmar with the following objectives:

a) To supply stable and continuous 24-hour electricity for using mini hydro
b) To improve the living standards of the village through lighting, security, hygiene, education, and communication
c) To raise the production of local industries
d) To promote the rural electrification as a model village in terms of management and operation initiated by VEC
e) To contribute to the MEPE’s financial balance through avoiding diesel fuel costs

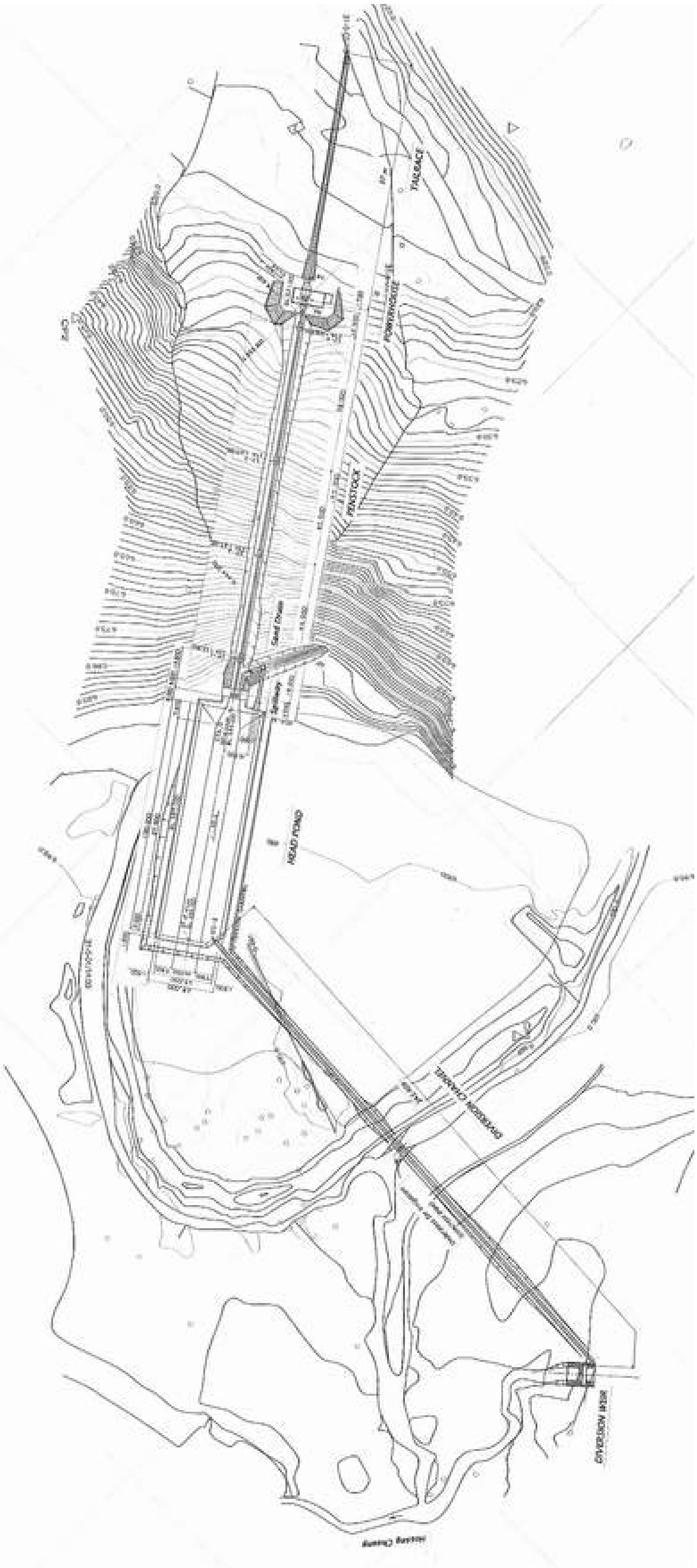
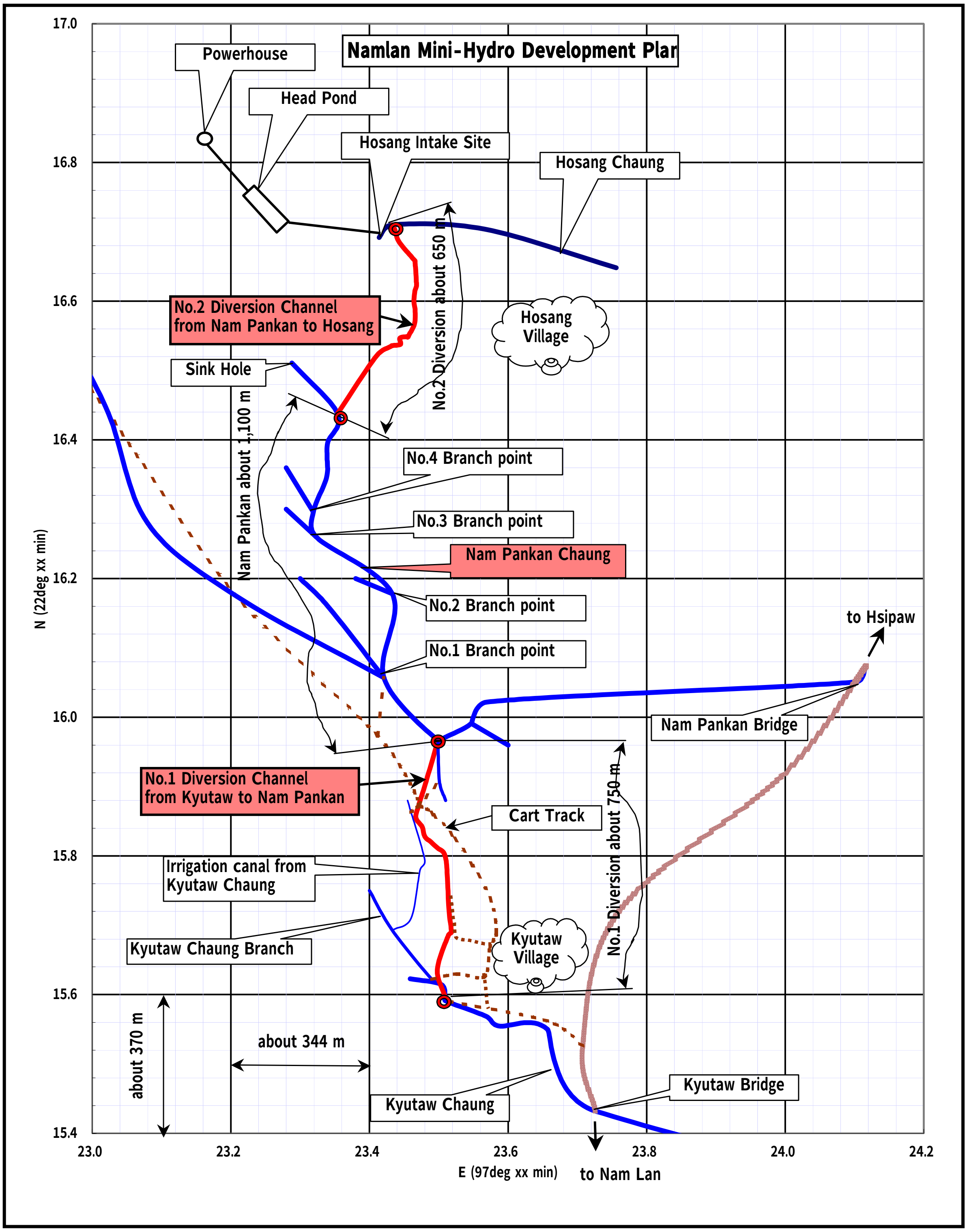


Figure 3.3.1 General Plan of Nam Lan (Phase-1)

Source: JICA Study Team



Source: JICA Study Team

Figure 3.3.2 General Layout of Nam Lan Scheme

3.4 Basic Design and Cost Estimate

3.4.1 Introduction

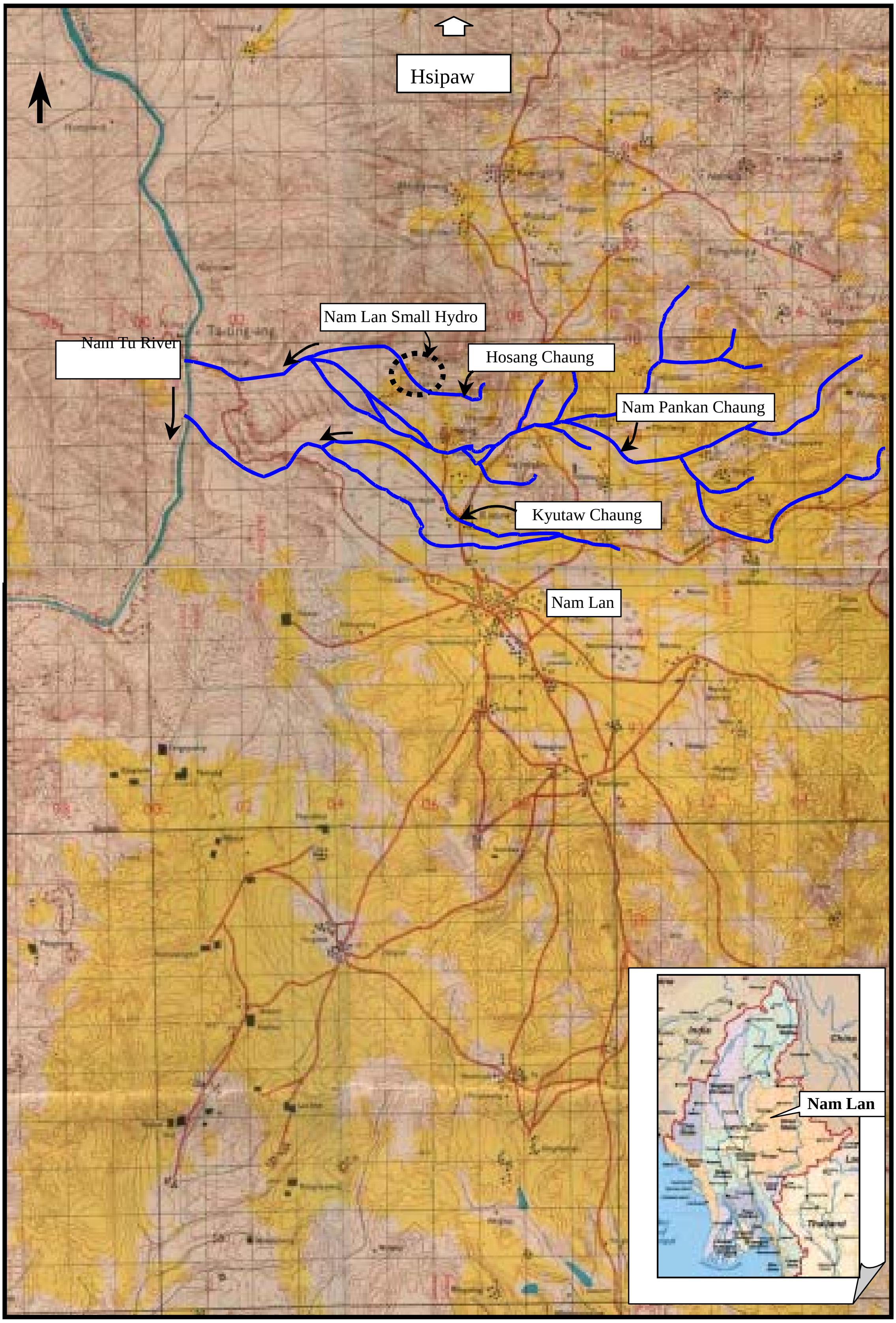
The Project site is located in Hosang village, about 4 km to the north-northwest of Nam Lan as shown on Figure 3-4.1. The Project will produce hydropower of 320 kW harnessing the gross head of 69.5m of Hosang Chaung and the firm discharge of 0.65m^3/s coming from Hosang Chaung, Nam Pankan Chaung, and Kyutaw Chaung to meet an electricity demand of 270kW in Nam Lan. These streams flow to the west, and eventually join with the Nam Tu River.

The Project area is around N22°17′ - E97°23′ at EL. 620 m ~ EL. 700 m on the Shan Plateau. The annual rainfall at Hsipaw was 1,300 mm on average from 1990 to 2000. The rainy season usually starts from May and ends in October during which the rainfall reaches about 88% of the annual total.

Hosang Chaung has a catchment area of 1.1 km^2 at the intake site. It originates from a spring in the mountains near Hosang village, discharging a relatively stable flow of 0.25 m^3/s even in the dry season. Nam Pankan Chaung (catchment area 52.5 km^2) and Kyutaw Chaung (catchment area 18.8 km^2) run in parallel with Hosang Chaung at an interval of approximately 1km as shown on Figure 3.4.1. A part of the river flow from Kyutaw Chaung and Nam Pankan Chaung, provided the irrigation demand flow is assured, could be diverted to Hosang Chaung by constructing open channels of about 750 m long from Kyutaw Chaung to Nam Pankan Chaung, and about 650 m long from Nam Pankan Chaung to Hosang Chaung. This work is planned in Phase-2, for which the detailed design of the diversion channels needs to be done based on the topographic survey.

The existing farm road branched from the National Road Route 44 running from Hsipaw to Loilem will be available for the access road through Hosang village down to the Powerhouse by reforming it over a stretch of about 2.5 km.

Phase-1 construction covering the main structures from the intake to the powerhouse and the distribution line to Nam Lan will be commenced in 2002 as a pilot project in this study. The construction period is estimated at about 4 months for the preparatory works including the access road, and 12 months for the main works.



Source: JICA Study Team

Figure 3.4.1 Location Map of Nam Lan Mini Hydro

3.4.2 Hydrology

1) Hydrological Data Collected and Measured

The following hydrological data were collected:

- Monthly rainfall data at Hsipaw from Jan/90 to Jun/01
- Daily rainfall data at Hsipaw from 01/Jan/55 to 31/Dec/97 and from 01/Jan/99 to 10/Sep/01

As no discharge data were available in the concerned basins, the Study Team carried out the following measurements:

- Discharge measurement at Hosang Chaung on 08/Feb/01 (1 day)
- Discharge measurement at Hosang Chaung from 20/May to 03/Jun/01 (15 days)
- Discharge measurement at Hosang Chaung, Nam Pankan Chaung, and Kyutaw Chaung twice a week from 17/Sep/01, ongoing

The measurement results are shown in Table 3.4.1.

2) Available Discharge

The lowest discharge of Hosang Chaung is estimated at 0.25 m^3/s for the following reasons:

- The discharge measured on 8 February 2001 by the Study Team was 0.25 m^3/s.
- The lowest discharge measured from 20 May to 3 June 2001 was 0.25 m^3/s.
- The flow of the Hosang Chaung originates from a spring in the Hosang Mountains, and the flow rate is considered stable throughout the year.
- There was fine weather for at least 3 days before the measurement on 25 May 2001.

As for the Nam Pankan Chaung and the Kyutaw Chaung, the firm discharges have not been confirmed yet, though the discharge measurement commenced, in cooperation with the village people, in September 2001. Accordingly it is essential to continue the discharge measurement on these streams to confirm the firm discharges in the dry season. At this stage, it was assumed that the base flow of the Nam Pankan Chaung and the Kyutaw Chaung would be the same as the Hosang Chaung; 0.25 m^3/s.

In order to assess the pattern of power generation over a year, depending on the available discharge and the irrigation water supply, the monthly mean discharges of three streams were estimated assuming that the river discharge could be interpolated from the monthly rainfall pattern at Hsipaw from 1990 to 2001. The monthly mean discharges estimated are shown in Table 3.4.2.

Table 3.4.1 Discharge Measurement Record for Nam Lan Mini Hydro Scheme

Date of Measurement	Hosang		Kyutaw	Nam Pan Kaung
	Gauge Reading (m)	Discharg (m^3/s)	Discharg (m^3/s)	Discharg (m^3/s)
08 February 2001	-	0.25		
Ave.		**0.25**		
20 May 2001	—	0.31	—	—
21 May 2001	—	0.25	—	—
21 May 2001	—	0.26	—	—
22 May 2001	—	0.29	—	—
22 May 2001	—	0.30	—	—
23 May 2001	—	0.30	—	—
23 May 2001	—	0.30	—	—
24 May 2001	0.13	0.29	—	—
24 May 2001	0.13	0.28	—	—
25 May 2001	0.13	0.26	—	—
25 May 2001	0.13	0.25	—	—
26 May 2001	0.13	0.33	—	—
26 May 2001	0.13	0.33	—	—
27 May 2001	0.13	0.34	—	—
27 May 2001	0.13	0.33	—	—
28 May 2001	0.12	0.31	—	—
28 May 2001	0.12	0.31	—	—
29 May 2001	0.13	0.30	—	—
29 May 2001	0.13	0.30	—	—
30 May 2001	0.14	0.31	—	—
30 May 2001	0.34	0.50	—	—
31 May 2001	0.13	0.35	—	—
31 May 2001	0.13	0.35	—	—
Ave.		**0.31**		
01 June 2001	0.14	0.30	—	—
01 June 2001	0.14	0.30	—	—
02 June 2001	0.14	0.37	—	—
02 June 2001	0.14	0.36	—	—
03 June 2001	0.17	0.44	—	—
03 June 2001	0.17	0.44	—	—
Ave.		**0.37**	—	—
17 September 2001	—	0.50	1.00	1.74
18 September 2001	—	—	1.15	—
21 September 2001	—	0.48	0.72	1.07
24 September 2001	—	0.44	0.70	1.26
28 September 2001	—	0.45	0.69	1.23
Ave.		**0.47**	**0.85**	**1.32**
01 October 2001	—	0.49	0.87	1.60
05 October 2001	—	0.53	0.82	1.43
08 October 2001	—	0.53	0.69	1.20
12 October 2001	—	0.51	0.97	1.40
15 October 2001	—	0.50	0.78	1.02
19 October 2001	—	0.46	0.61	1.19
22 October 2001	—	0.52	0.48	1.14
26 October 2001	—	0.50	1.36	2.76
29 October 2001	—	0.48	0.61	1.72
Ave.		**0.50**	**0.80**	**1.50**
27 November 2001	—	0.39	0.50	1.04
28 November 2001	—	0.36	0.45	—
30 November 2001	—	0.40		0.94
Ave.		**0.38**	**0.48**	**0.99**
03 December 2001	—	0.38		0.92
07 December 2001	—	0.31		0.99
10 December 2001	—	0.36		0.94
14 December 2001	—	0.32		0.84
17 December 2001	—	0.34		0.69
21 December 2001	—	0.34		0.97
24 December 2001	—	0.34		0.99
28 December 2001	—	0.33		0.84
31 December 2001	—	0.33		0.97
Ave.		**0.34**		**0.91**
Ave. (Total)		**0.44**	**0.71**	**1.24**

Source: Measured by JICA Study Team

Table 3.4.2 Estimated Monthly Discharge

Month	1	2	3	4	5	6	7	8	9	10	11	12	Remarks
Mean Rainfall (1990-2001)	4	16	47	49	172	226	227	225	175	123	59	15	Rainfall at Hsipaw
Hosang	0.25	0.26	0.27	0.27	0.34	0.37	0.37	0.36	0.34	0.31	0.28	0.26	Base flow =0.25m3/s
Kyutaw	0.26	0.30	0.41	0.42	0.84	1.03	1.03	1.03	0.85	0.68	0.45	0.30	Base flow =0.25m3/s
Nam Pankang	0.27	0.35	0.54	0.55	1.31	1.64	1.65	1.64	1.33	1.01	0.61	0.34	Base flow =0.25m3/s
Total	0.75	0.76	0.77	0.77	0.84	0.87	0.87	0.86	0.84	0.81	0.78	0.76	

Source: Measured by JICA Study Team

3) Water Supply for Irrigation

In the downstream basins of the three streams, paddy fields are developed. Accordingly, the irrigation water supply must be maintained during the irrigation period. The paddy field areas of the 3 stream basins are as follows:

i) Hosang Chaung 32.4 ha (80 acre)
ii) Nam Pankan Chaung 34.8 ha (86 acre)
iii) Kyutaw Chaung 47.8 ha (118 acre)

Paddy irrigation needs approximately 1.0 m^3/s of flow for 1,000 ha on average. Considering losses for transportation, operation, etc., a peak discharge of 0.1 m^3/s for irrigation supply was estimated for each river basin from May to July, and 0.05 m^3/s from August to October.

4) Probable Flood

A probable flood of 100-year return period was estimated as follows:

	Catchment (km^2)	Rainfall intensity (mm/hr)	Flood peak (m^3/s)
Hosang Chaung at Intake	1.1	40.3	8.6
Hosang Chaung at Powerhouse	2.5	39.4	19.2

It is likely that the flood flow will be inundated in the paddy fields upstream of the intake site, taking into account the topographic features along Hosang Chaung, though a peak discharge of 8.6 m^3/s is estimated at the intake.

5) Maximum Discharge on Nam Pankan Chaung and Kyutaw Chaung

The maximum discharges to flow on Nam Pankan Chaung and Kyutaw Chaung were estimated to be 11.9 m^3/s and 6.6 m^3/s respectively at the diversion points, under the conditions of river-bed slope of 1:500, roughness of 0.037, which were converted from the measured discharges.

3.4.3 Topographic Survey

A topographic survey was carried out at the site of 13.3 ha covering the intake to the powerhouse. Permanent control points were established at 3, and the mapping was done at a scale of 1:500 with 1m contour intervals.

This map covers the construction area of Phase-1. However, Phase-2 area needs to be surveyed along the route of the diversion channels from Kyutaw Chaung to Hosang Chaung via Nam Pankan Chaung (about 2 km long in total), prior to implementation of the design work.

3.4.4 Geology

Nam Lan area is covered by the several thousand-meter thick carbonate sequences known as the Shan Dolomite Group. It is divided into lower (Devonian) and upper (Triassic) Dolomite portions separated by a Permo-Carboniferous calcarious portion. In the Northern Shan State, the Shan Dolomite Group includes the Nwabangyi Dolomite formation and the Maymyo Dolomite formation.

The Nwabangyi Dolomite formation is characterized by an intensively dolomatized, shattered and brecciated carbonate sequence, which is at least 2,500 - 5,000 m thick and contains the following facies types:

- Thin bedded foraminiferal limestone facies
- Laminated and turbiditic facies
- Sedimentary breccia facies
- Light and dark gray, fine-grained limestone facies

Overlying the Shan Dolomite Group are the Mesozoic rocks of the Namyau Group, which includes Tati Limestone, Hsipaw Rod Beds and Pangno Evaporites (Upper Triassic-Jurassic). The Namyau Group is usually diachronously superjacent on the Nwabangyi Dolomite formation. The Namyau Group commences with bedded limestone and differs from the Nwabangyi Dolomite formation through the reddish colors. The joint occurrence of carbonates, clastic materials, evaporates and the microfossils indicate that the Namyau Group is built up of sediments deposited in a shallow shelf surrounded by arid regions. The following sedimentation pattern can be deduced from the observations made so far.

- The Triassic platform carbonates continued to form in the lowest Jurassic as well.
- More often a change from marine calcareous to dominantly continental, mainly clastic sedimentation occurred in the lower and middle Jurassic.
- Marine fossiliferous intercalations were deposited in this clastic-terrigenous

series.

- Continental red bed formed during the uppermost Jurassic to Cretaceous.

Though the Nam Lan area is covered predominantly by the Shan Dolomite Group of rock, the Hosang village area is covered by Namyau Group of rock. The cragged limestone hills around the village are buff colored with reddish tinted limestone, used in burning lime. On the cart track to the spring from Hosang, the contact between this limestone and the overlying purple shale and fine sandstone layers can be seen. The test pit No.1 (near BP of anchor block No. 1) site is located on a step like bench, which is about 1.8 m lower than the nearby field. This topographic difference is probably due to unstable conditions. Therefore the head tank is to be constructed on the higher step about 15 m away from the test pit No. 1. In the test pit No. 2 (middle of penstock), the top blackish soil and tufa are only 0.8 m thick followed by a yellowish brown and purplish clay layer of 1m, which is the weathering product of the shale. From 1.7 m to 2.1 m are highly weathered thinly bedded and closely jointed purplish shales, which can be excavated manually. From 2.1 m to 4.5 m highly to moderately weathered shales are encountered. It can be classified as C_{ML} class of foundation.

At the power station site (test pit No. 3), the top soil and completely weathered shale are only 1 m thick. The shale is stiff and easy to excavate. From 1.0 m to 2.1 m level, some boulders are found among the weathered shales. The boulders are sandstones, which are from the interbedded sandstone layers. Between 2.1 m and 4.5 m there are moderately weathered thin-bedded purplish shale and gray fine sandstone having the formation class of C_M. About 4.5 m from this pit, hard, dense fine grained grayish sandstone with faint reddish tint crop out. This sandstone band is also interbedded with purple shales of the Namyau Group. About 60 m to the south of the power station site, banded buff color with reddish tint limestone is exposed. Cave like hollows can be seen at the foot of the limestone scarp. The texture of this limestone and those of the limestone crags of the village are the same. There are many large boulders and blocks of the tufa scattered near the farmer’s hut on the downstream side of the power station site. They were all brought down to the site by a topping failure of the scarp. A few circular failures on both slopes in the valley upstream of the gauge site were also observed. They are located in a purple shale area.

The proposed pond area is a flat land covered by dark gray clayey soil with some shells. From the topographic features, it can be estimated that there may be a thin layer of tufa overlying the purple shales found as those of test pit No. 2 and No. 3 and those found near the water gauging site. There will be no foundation problems. The pond foundation can be placed directly upon the purple shales and sandstones.

With regard to the diversion weir and the diversion channel, no major geological problems are anticipated to such small-scale structures. The head pond is located on the flat area. A test pit No.1 excavated at the edge of the flat area indicates that the area is underlain by tufa at least to a depth of 4.5 m (15 ft). Although the tufa is poorly consolidated, it will have a sufficient bearing capacity for the designed head pond.

A small-scale potential landslide area about 50 m wide x 50 m long was observed at the upper half of the slope near test pit No.1. Because the landslide mass is located on the top of the slope, it may slide down when a heavy rainfall occurs. This reactivation could take place during construction when the area may be disturbed. Further to the above portion, the lower half of the slope is located on a gently sloping landslide (or talus deposits). Though this gently sloping landslide is unlikely to be reactivated under natural conditions, excavation of the toe area for the powerhouse may possibly induce a reactivation of the landslide.

On the other hand, two test pits No.2 and No.3 were excavated along a line about 20-30 m to the left side of the above slopes. Both test-pits encountered bedrock at shallower depths (1.65 m deep at No.2, 2.1 m deep at No.3).

From these observations above, it is recommended that the penstock and powerhouse be located along the line of TP-2 and TP-3.

3.4.5 Basic Planning for Power Generation

1) Power Output

The power facilities are designed as an isolated local power system to supply electricity to Nam Lan covering the demand of 270 kW, by collecting the river flows from Hosang Chaung, Nam Pankan Chaung, and Kyutaw Chaung. The base flows are estimated at 0.25 m^3/s each, while the discharges at Nam Pankan Chaung and Kyutaw Chaung in the dry season need to be confirmed in the coming dry season.

A power scale of an isolated local power system is generally determined so as to cover the demand of the target area, based on the firm discharge available in the dry season to secure a dependable power output throughout the year.

The gross head was set at 69.50 m from the topographic conditions, and the effective head was calculated at 68.80 m as shown on the Appendix C-4:

Crest level of Head Pond	EL. 689.00 m
Full supply water level in Pond	EL. 688.00 m

Minimum operation level in Pond	EL. 686.00 m
Turbine center elevation	EL. 622.00 m
Powerhouse ground elevation	EL. 621.00 m
Tail water level	EL. 618.50 m
Flood water level in the stream	EL. 616.00 m
Gross head	688.00 - 618.50 = 69.50 m
Head loss	0.684 m
Effective head	69.50 - 0.684 = 68.82 m

The design discharge was determined to be 0.65 m^3/s based on the firm discharges in the three streams, taking into account the diversion losses:

Hosang Chaung	0.25 m^3/s
Nam Pankan Chaung	0.20 m^3/s
Kyutaw Chaung	0.20 m^3/s
Total discharge	0.65 m^3/s

The efficiencies of the turbine and generator were estimated based on past experience of the same class of equipment and information from the manufacturers:

Turbine	0.815
Generator	0.900
Combined efficiency	0.815 x 0.900 = 0.733

The installed capacity was estimated as follows:

P = 9.8 x 68.8 x 0.65 x 0.733 = 321 ≒ 320 kW (160 kW x 2 units)

2) Power Generation Simulation

In order to cope with potential drought in the dry season and the irrigation period when the available discharge may be less than 0.65 m^3/s, a head pond with a capacity of 5,000 m^3 was planned to regulate the river flows for peak power generation.

A simulation study, assuming several patterns of drought and irrigation water supply was conducted to assess the power generation and the pond volume as shown in the Appendix C-3. The following is a summary of the study:

- Simulation of the daily power generation was done for 12 levels of available discharge, ranging from 0.05 m^3/s to 0.60 m^3/s at intervals of 0.05 m^3/s. For the annual power generation, the following 3 cases of typical flow regimes were examined:

i) Hosang Chaung only (dry season 0.25 m^3/s ~ rainy season 0.50 m^3/s)

ii) Hosang Chaung(0.25-0.50 m^3/s) + Nam Pankan Chaung (0.20-0.50 m^3/s)

iii) Hosang (0.25-0.50 m^3/s) + Nam Pankan (0.20-0.50 m^3/s) + Kyutaw (0.20-0.50 m^3/s)

- The daily power generation could be divided into 6 patterns as follows:

① Q > 0.65 m^3/s	:	2 units base operation (320 kW) over 24 hours
② 0.65 > Q > 0.40 m^3/s	:	1 unit base over 24 hours + 2 units peak during night/day
③ 0.40 > Q > 0.30 m^3/s	:	1 unit from 5:00 to 24:00 + 2 units peak at night
④ 0.30 > Q > 0.20 m^3/s	:	1 unit in day + 2 units peak at night
⑤ 0.20 > Q > 0.10 m^3/s	:	2 units peak at night
⑥ 0.10 m^3/s > Q	:	1 unit at night

- Discharge measurement devices will not be installed in the Project, however the inflow discharge into the pond can be calculated by monitoring the water level in the pond through the pressure gauge to be installed in the powerhouse. The calculation method is as follows:

$$\frac{dV}{dt} = \frac{dV}{dH} \cdot \frac{dH}{dt} = S(H) \cdot \frac{dH}{dt} = (Q_{in} - Q_{out})$$

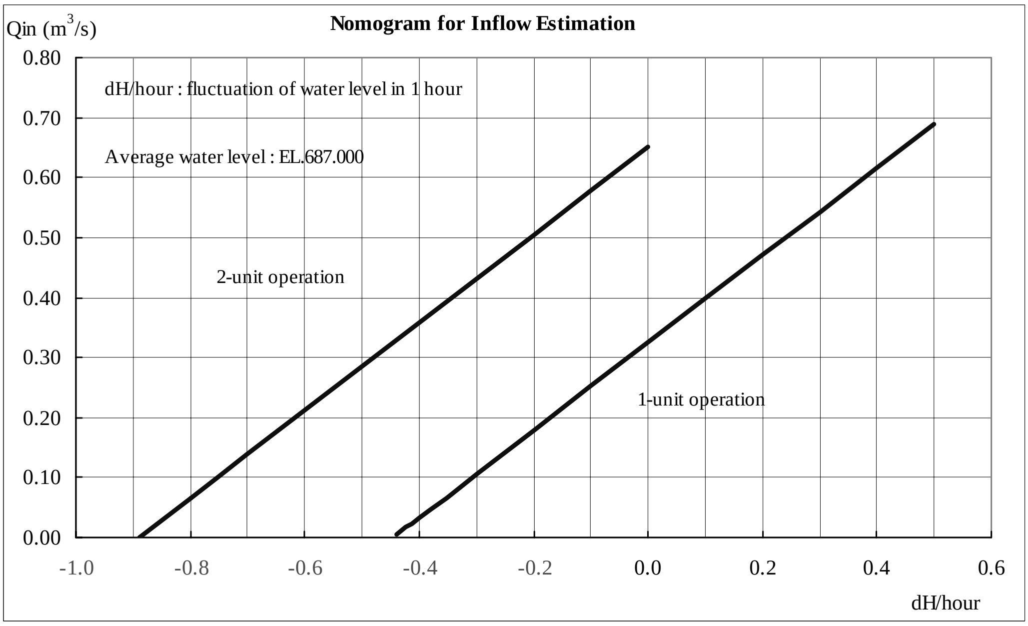
$$\frac{dH}{dt} = \frac{(Q_{in} - Q_{out}) \cdot 3{,}600}{S(H)} = \frac{(Q_{in} - Q_{out}) \cdot 3{,}600}{\{25 + (H - 686)\} \cdot \{100 + (H - 686)\}} = \frac{(Q_{in} - Q_{out}) \cdot 3{,}600}{(H - 661) \cdot (H - 586)}$$

$$Q_{in} = \frac{dH}{dt} \cdot S(H) / 3{,}600 + Q_{out} = \frac{dH}{dt} \cdot (H - 661) \cdot (H - 586) / 3{,}600 + Q_{out}$$

Where,

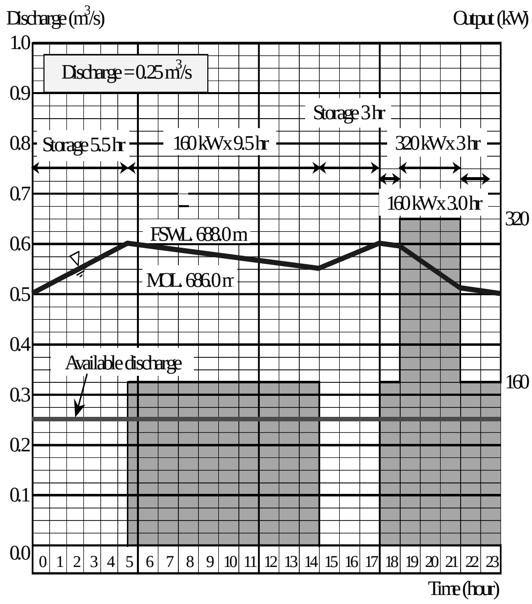
dH/dt	:	fluctuation of water level (m/hour)
H	:	water level in the pond (m)
Q_{in}	:	inflow into the pond (m^3/s)
Q_{out}	:	discharge to the turbine (m^3/s)

The above equation can be illustrated as follows:



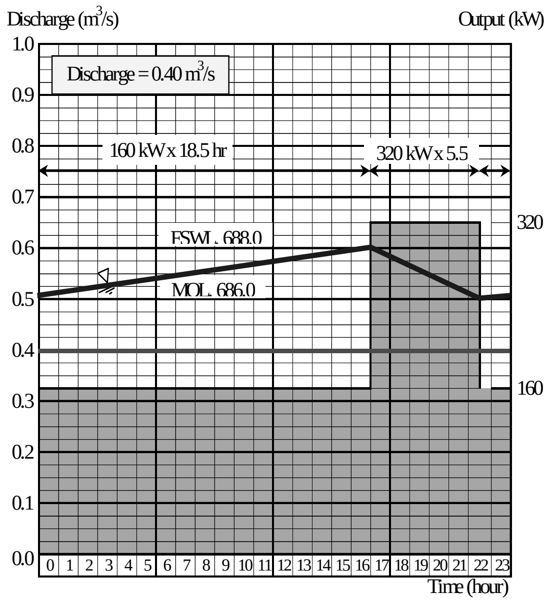
Source: Estimation by JICA Study Team

- In Phase-1 operation or when the available discharge is less than 0.65 m^3/s that is a design discharge for continuous power generation at 320 kW, an appropriate operation pattern for the power generation should be adopted according to the available discharge and the priority of the power demands. In such cases, the power output needs to be controlled by the turbines utilizing the storage capacity of the pond.
- In Phase-1 operation, the available discharge is expected to be 0.25 m^3/s in the dry season and 0.40 m^3/s at a maximum in the rainy season (river flow 0.50 – irrigation requirement 0.10 = 0.40 m^3/s). When the discharge is 0.25 m^3/s, 320 kW operations from 19:00 to 22:00, and 160 kW operations from 5:30 to 15:00 and from 18:00 to 24:00 would be available. When the discharge is 0.40 m^3/s, 320 kW operations from 17:00 to 22:30, and 160 kW operations for 24 hours would be available.



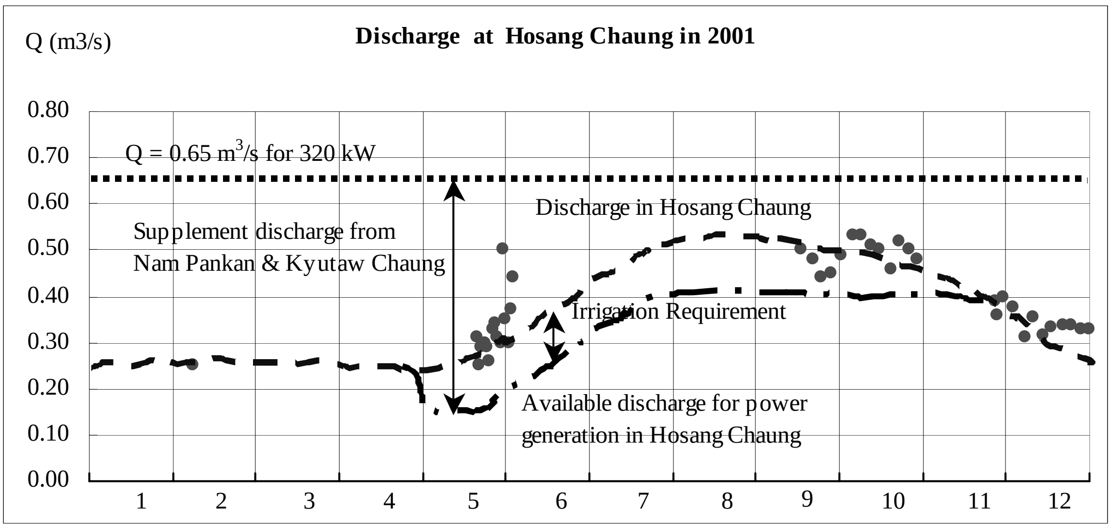
- After completion of Phase-2 construction, 320 kW power generation is expected for 24 hours except in a drought year or during the initial stage of the irrigation period from May to June.

- Paddy irrigation in Nam Lan normally starts in the beginning of May and ends in October, with the more water required in May ~ July. The rainy season usually begins at the end of May, so the available river water for power generation might be insufficient depending on the flow conditions especially in May and June.



- In the rainy season, for instance in September 2001, 0.44-0.50 m^3/s at the Hosang Chaung, 1.07-1.74 m^3/s at the Nam Pankan Chaung, and 0.69-1.15 m^3/s at the Kyutaw Chaung were measured, In such conditions, 24-hour operation with a full capacity would be possible irrespective of the irrigation requirements.
- Assuming that the discharges in the 3 streams are equal: 0.25 m^3/s in the dry season, and 0.32 m^3/s in the rainy season, 24-hour full power operation would be available throughout the year. Annual energy generation is estimated at about 2.6 GWh.

The basic operating patterns for the power generation of the Nam Lan mini hydro and that of during drought are shown in the figure below.



Source: Plan by JICA Study Team

3.4.6 Design of Civil Structures

1) Layout

The main components of the civil structures consist of a diversion weir, diversion channels, head pond, penstock, powerhouse and tailrace. The diversion channels comprises 3 parts; i) about 750 m from Kyutaw Chaung to Nam Pankan Chaung, ii) about 650 m from Nam Pankan Chaung to Hosang Chaung, and iii) 242 m from Hosang Chaung to the head pond.

The general layout is shown in Figure 3.3.2 in which the main structures from the weir to the powerhouse and the distribution line is constructed in Phase-1, and No.1 diversion channel from Kyutaw Chaung to Nam Pankan Chaung and No.2 diversion channel from Nam Pankan Chaung to Hosang Chaung are constructed in Phase-2.

The irrigation water supply will have priority in the river water use in principle, which is to be discussed further in the VEC, and the river flow after deducting the discharge required for the irrigation will be available for power generation. A simple gate will be provided at the diversion point at Kyutaw Chaung to release the river flow for the irrigation supply into the main stream and the surplus water for the power generation into No.1 diversion channel.

Nam Pankan Chaung has a complicated channel system including many branches and confluences for the irrigation of the basin. To divert the discharge from Nam Pankan Chaung to Hosang Chaung, the flow needs to be diverted into the right side branch of Nam Pankan Chaung, which is the nearest to Hosang Chaung, down to the beginning point of No.2 diversion channel. Accordingly simple gates need to be provided at the junctions in Nam Pankan Chaung between the outlet of No.1 diversion channel and the inlet of No.2 diversion channel. It is noted that the local people have been managing to distribute the river flows for the irrigation supply by blocking the junctions. No.2 diversion channel leads the flow from Nam Pankan Chaung to the upstream point of the diversion weir at Hosang Chaung. Prior to the implementation of Phase-2 construction, the detailed design for the diversion channels should be completed based on the topographic survey covering the project area.

The river flows collected from the three streams are led through No.3 diversion channel (242.4 m long) to the head pond at the flat area on the top of the penstock slope, and then led to the powerhouse through the penstock pipe (182 m long). The water released from the turbine is eventually discharged through the tailrace channel (97 m) long to the river located downstream of the powerhouse.

2) Diversion Weir

The Hosang Chaung is branched into many irrigation canals to supply the river water to the paddy fields nearby. Therefore the diversion weir was planned at the section upstream of these branches. The river outlet facility is provided with a weir to release the flow required for the irrigation supply to the downstream basin. No. 2 diversion channel coming from the Nam Pankan will be connected to Hosang Chaung at the upstream point of the diversion weir.

The diversion weir is designed to safely release the peak discharge of 8.6 m^3/s (100-year probable flood) over the spillway, and to release the irrigation water through the river outlet. The river outlet has a sluice gate (manual type 1.0 m wide x 1.0 m high), which will be operated as the sand flush gate as well.

The inlet of No.3 diversion channel (1.2 m wide x 1.5 m high) is located at the right bank of Hosang Chaung just upstream of the weir. When the river outlet is closed, the river flow below 0.79 m^3/s will enter the diversion channel without spilling over the weir. When the discharge exceeds 0.79 m^3/s, the water level in front of the weir rises above the weir crest level and the overflow from the weir begins.

An inlet gate (manual type, 1.0 m wide x 1.5 m high) is provided at the entrance of the No.3 diversion channel, which should be closed during the maintenance work for the waterway as well as during floods to avoid an excessive inflow of sediments to the pond. In case the inlet gate is not closed during a 100-year flood, the overflow from the weir will be 5.6 m^3/s, and the inflow into the channel will be 3.0 m^3/s at WL. 692.66 m, which is the design flood discharge for the pond.

The flushing of sediment deposited upstream of the weir will be made through the river outlet with a flow capacity of 4.6 m^3/s (inside velocity 4.6 m/s) at WL. 691.80 m.

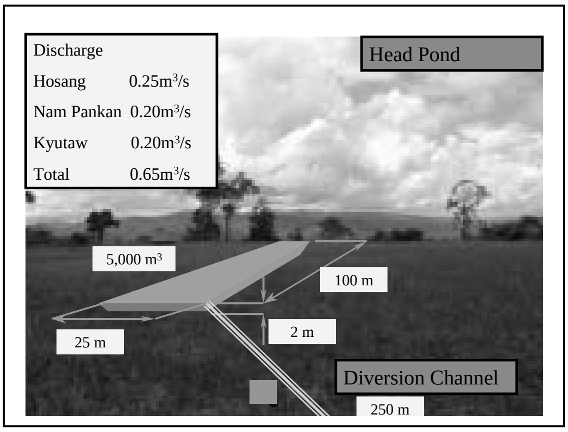
The diversion weir is designed to be safe during normal, seismic and flood conditions. The riverbed and both abutments adjacent to the weir are protected by gabion and wet rubble masonry walls.

River diversion work is required during the construction scheduled from Nov. 2002 to Aug. 2003, which will be done by excavating an open channel detouring the weir site. The river diversion channel will be a rectangular section with 1.0 m bottom width x 1:0.5 side slopes x 1.0 m deep to pass a design discharge of 0.60 m^3/s for the river diversion for which the uniform depth is calculated at 0.69 m (velocity 0.65 m/s) under the conditions of roughness coefficient of 0.035 and river-bed slope 1:500.

The power water is led through No. 3 diversion channel (1.0 m wide x 1.0 m deep x 242.4 m long) from Hosang Chaung to the head pond. The depths of the flow are calculated at 0.27 m for 0.65 m^3/s in a normal operation, and 0.84 m for 3.00 m^3/s in a 100-year flood under the conditions of roughness coefficient 0.015 and channel slope 1:74.19.

No.3 diversion channel crosses the existing irrigation canal on the way to the pond where a ϕ1.0 m concrete pipe is provided under the diversion channel.

3) Head Pond



The head pond is located on the flat area of the hill to regulate the flow to the turbine when the available discharge is below 0.65 m^3/s.

The pond has a capacity of 5,000 m^3 with dimensions of 25 m wide x 100 m long x 2 m deep. The crest elevation of the pond is set at EL. 689.00 m, full supply water level at EL. 688.00 m, minimum operation level at EL. 686.00 m, and bottom elevation at the downstream end at EL. 684.20 m.

The pond shape is selected to be slender with a bottom slope of 1:55 for ease of maintenance. Sediment deposited in the pond will be flushed through the sand drain gate (manual type, 60 cm x 60 cm) provided at the downstream end of the pond. The spillway with a 2 m wide overflow weir is provided at the level of FSWL 688.0m to discharge excessive inflow. The pond is lined with wet rubble masonry for surface protection, leakage prevention, and easy maintenance for sand flushing.

The sand drain gate is provided at EL. 684.20 m, which is 1.5 m below the sill level of the penstock inlet. The sand drain gate has maximum discharge capacity of 2.3 m^3/s at FSWL. 688.00 m. However, the gate should only be operated under a water level less than EL. 685.70 m to avoid sediment inflow into the penstock and to provide security at the outlet against jet flow The outflow is calculated at 1.0 m^3/s (velocity 2.8 m/s), and a ϕ0.6 m steel pipe, 11.2 m long, is connected to the sand drain gate to release the muddy water into the sand drain channel.

The spillway's function is to release any excessive flow into the pond. The maximum design flood into the pond is calculated at 3.0 m^3/s during 100-year flood when the inlet gate is not closed. The spillway has a concrete rectangular section 2.0 m wide x 1.0 m deep at the entrance, and is narrowed to a 1.0 m wide section with a slope of 1:10.

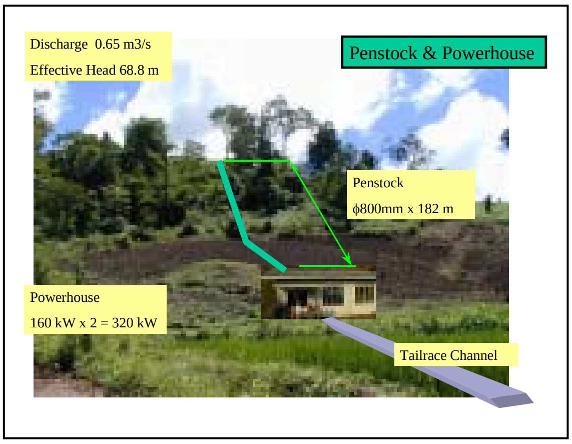
4) Penstock

An unstable mass about 50 m wide x 50 m long at the upper slope and a talus deposit at the lower slope have been identified at the area adjacent to the right side of the existing waterfall during the site reconnaissance. The penstock route was located in the relatively stable area to avoid loosening or sliding due to heavy rain or excavation work during construction.

Judging from the test pit conditions excavated at 3 locations along the penstock route, stable foundations for the anchor blocks are at 1.5-2.0 m below the ground surface.

The inlet structures of the penstock are located at the downstream end of the pond. Trashracks 3.0 m wide are provided on the inlet sill at EL. 685.70 m. The center elevation of the penstock pipe inlet is set at EL. 685.20 m (= MOL. 686.00 m - ϕ 0.8 m).

The ϕ800 mm diameter of the penstock pipe was selected based on the average range of practical application. The total length of the penstock is 182.038 m long, of which 178.485 m long is ϕ800 mm pipe with 3.553 m of ϕ400 mm pipe after the bifurcation. The penstock is longitudinally bent at 4 anchor blocks and supported by 23 saddle piers. The spacing of the anchor blocks was designed to be around 50 m to provide stability against overturning, sliding, and foundation settlement for which the stability calculations are attached in Appendix C-5.



5) Powerhouse

The powerhouse is located at the end of the penstock slope on a stable foundation at EL. 621.0 m, higher than the paddy field level of EL. 619.0 m-EL.617.0m. The tail water level is set at EL. 618.5 m, taking into account the flood water level at EL. 616.0 m in the stream down the tailrace, which corresponds to 100-year probable flood with a peak discharge 20 m^3/s.

The floor elevation of the powerhouse is set at EL. 621.15 m, while the outdoor ground elevation is at EL. 621.00 m. The substructure below EL. 621.15 m is made with reinforced concrete, and the superstructure above EL. 621.15 m is built with wood. The floor size is 13 m wide x 6 m long to accommodate 2 units of turbines, generators (220kVA - 160kW x 2), dummy load heaters, control panels and 11 kV cubicle. The power water is discharged through the turbines into the draft tube pit provided below the powerhouse floor, which links with the tailrace channel protected with wet masonry (97 m long and a slope of 1:27). One unit of the main transformer (250 kVA – 400 V/11kV) is placed on the concrete slab at EL. 621.15 m adjacent to the powerhouse.

3.4.7 Hydro-mechanical Equipment

1) River outlet

A river outlet gate of 1.0 m wide x 1.0 m high is provided with the diversion weir to release the irrigation water to the downstream basin of Hosang Chaung. The river outlet gate functions as the sand flushing gate to flush out the sediments deposited upstream of the weir. The gate is operated by manual hoisting device.

2) Inlet gate

An inlet gate of 1.0 m wide x 1.5 m high is provided at the entrance of the diversion channel to cut off the inflow into the pond during maintenance and floods. The gate is operated by manual hoisting device.

3) Trashracks

One set of trashracks is provided at the inlet of the penstock to prevent injurious matter from intruding into the penstock and turbines. The trashracks are 3m wide and are set at an inclination of 1:0.3 to be approximately 3.45 m in slant height.

4) Sand drain gate

A sand flush gate of 0.6 m wide x 0.6 m high is provided at the downstream end of the head pond to flush the sediment. The gate is operated by manual hoisting device.

5) Steel penstock

One line of penstock of 800mm in diameter and 178.5 m long extends from the head pond to the lower horizontal portion, at which it bifurcates into two branch pipes of 400mm in diameter and 3.6 m long towards each turbine respectively.

The current design data for the hydromechanical equipment to be provided are summarized in Table 3.4.3.

Table 3.4.3 Major Design Data of the Hydromechanical Equipment

Items	Major Design Data
1) River outlet gate	Quantity: 1set Width: 1.0 m Height:1.0m Design Head : 3.0m
2) Inlet gate	Quantity: 1set Width: 1.0 m Height:1.5 m Design Head : 1.8m
3) Trashracks at head pond	Quantity: 1set Width: 3m Slant Height: Approx. 3.45m(1:0.3)
4) Sand drain gate at head pond	Quantity: 1set Width: 0.6m Height:0.6m Design Head : 3.8m
5) Penstock	Dia. : 800mm (Main pipe)to 400mm(Branched pipe) Length : 182.038m Max. Static Head: 66m

Source: Design by JICA Study Team

3.4.8 Electrical Works

1) Planning of Power Distribution Facilities

a) Design Wind Pressures

The MEPE's standard design wind pressure will be applied to the following facilities:

- Electric conductor and wire : 40 kg/m^2
- Cylindrical structure like electric pole : 30 kg/m^2
- Insulation and fixtures : 60 kg/m^2

b) Conditions for Sag Calculation

The conductor sag will be calculated based on the following conditions:

- The design maximum conductor temperature including temperature rise due to electric current is set at 75ºC, which consists of an assumed maximum atmospheric temperature of 40ºC and electric temperature rise of 35ºC.
- Although such probability is very low as the design maximum wind

speed takes place concurrently at the time of the design minimum temperature, the design minimum conductor temperature is set at 10ºC at the design maximum wind speed.

- EDS (normal tensile stress) will be calculated for a conductor temperature of 25ºC without any wind.
- Safety factor for the conductor is set to be higher than 2.5 under the conductor temperature of 10ºC and the design maximum wind speed against ultimate break strength, and higher than 4.0 for EDS.
- The maximum sag to determine the height of conductor supports above ground is to be that under the design maximum conductor temperature and no wind.

c) Design Safety Factor

- For structures, electric poles, and other supporting auxiliaries	2.5 against ultimate strength under the maximum design load
- For the maximum operating tensile stress of conductor	2.5 against ultimate break tensile strength
- For insulators under the design maximum load	2.5 against break strength
- For foundation under the combined maximum loads which could concurrently operate on structures	2.5 against compressive strength and pulling out resistance

d) Height of Supports

The height of the bottom conductor cross arms is determined taking account of the following ground clearances, maximum conductor sag (under 75ºC conductor temperature) and length of insulator sets.

According to the MEPE standards, the minimum clearances of distribution line conductors are as follows:

	11 kv	L.V.
- Ground clearance		
Crossing area of roads and streets	6.0 m	5.7 m
Open area not approachable by vehicle	5.7 m	5.4 m
Cultivated areas, paddy field	5.1 m	4.5 m
- Clearance for		
Line and trees	2.0 m	1.0 m

Line and building or structures ....2.4 m   1.2 m

11 kV line and low tension line ....1.0 m

11 kV line and 11 kV line ....0.6 m

400 V line and 400 V line ....0.3 m

The pole lengths for 11kV and low tension lines are as follows:

11 kV and LV. Supports

Clearance	11 kv Line Type of Support		Low Voltage Line Type of Support	
	A, B, BA C, D (m)	A, B, BA (m)	A, B, BA, C, D (m)	
Minimum conductor height above ground	6.0	5.7 (5.1)	5.7 (5.4)	4.5
Sag of conductor	0.5	0.5	0.5	0.5
Distance from cross arm to top of pole	0.25	0.25	0.25	0.25
Foundation depth of pole below ground	1.5	1.5	1.4	1.4
Allowance of conductor height above ground	0.75	0.05 (0.65)	0.15 (0.45)	0.35
Total pole length	9.0	8.0	8.0	7.0

11 kV Supports with L.V. Lines

Clearance	11 kv – Supports Type A, B, BA, C & D (m)	
Minimum conductor height above ground (400V line)	5.7	4.5
Sag of conductor	0.5	0.5
Distance between 400V cross arms	0.7	0.7
Distance from 400V cross arm to 11 kv cross arm	1.0	1.0
Distance from 11 kv cross arm to top of pole	0.25	0.25
Foundation depth of pole below ground	1.7	1.5
Allowance of conductor height above ground	0.15	0.55
Total pole length	10.0	9.0

Source: Design by JICA Study Team

e) Construction Method of Distribution Facilities

A combined total of 873 concrete poles will be hauled and unloaded by a truck equipped with a crane. Hole excavation and pole electric works will be done manually. Stringing work of the distribution lines will be carried out using an adjustable height working deck car.

f) House Connection

House connection works to the domestic consumers from the low tension lines will be undertaken by the Myanmar side.

2) Planning of Equipment

Table 3.4.4 presents a list of equipment and materials, which will be procured under the Project:

Table 3.4.4 Procurement Plan of Equipment

No.	Equipment	Unit	Quantity	Remarks
1	Generating equipment	unit	2	160 kW turbine, 3 phase synchronous type, generating voltage 400 V, power factor 0.80
2	Controller	set	2	Dummy load type governor, capacity 220 kVA
3	Main transformer	unit	1	Outdoor type, 0.4/11 kV, 500 kVA
4	Switchgear panel for distribution	set	1	Indoor type, 11 kV, 400 A, with automatic re-closure circuit and space heater
5	River outlet gate	nos	1	1.0 m wide x 1.0 m high
6	Inlet gate	nos.	1	1.0 m wide x 1.5 m high
7	Sand drain gate	nos.	1	0.6 m wide x 0.6 m high
8	Penstock	m	182	ϕ800 : 178.5 m, ϕ400 : 3.6 m
9	Concrete pole for medium voltage distribution line	nos.	347	Pole length 8m, 9m and 10m, including insulators and cross arms for 11 kV and low tension line
10	Concrete pole for low voltage distribution line	nos.	526	Pole length 7m and 8m, including insulators and cross arms for low tension line
11	Distribution transformer	unit	3	3ϕ, 200 kVA, 11 kv/400-230V
12	Distribution transformer	unit	2	3ϕ, 50 kVA, 11 kv/400-230V
13	Medium voltage distribution line	km	34	11 kV, 3-phase 3-wire, ACSR 35mm^2, 11.3 km × 3
14	Low voltage distribution line	km	84.4	400-230 V, 3-phse 4-wire, single-phase 3-wire and single-phase 2-wire systems, low tension line in some sections will be arranged on 11 kV line poles, house service wire connecting works will be undertaken by Myanmar side
15	Meter, breaker, case, and house connection wire	set	2,100	Only procurement
16	Street light	set	50	Fluorescent lamp, to be fixed to line poles

Source: Planning by JICA Study Team

a) Type of Turbine

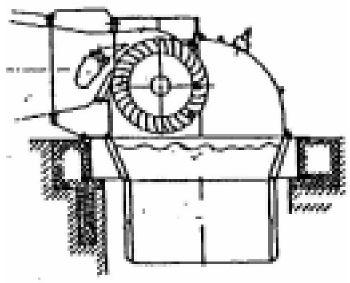
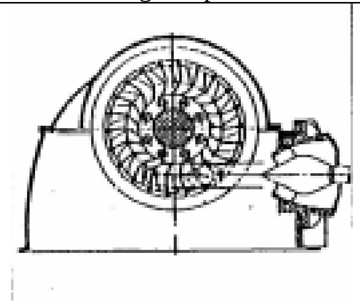
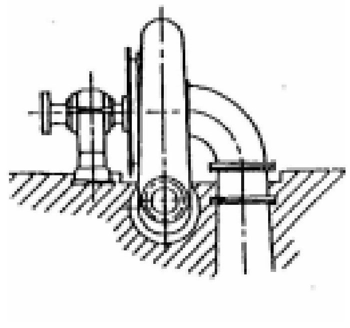
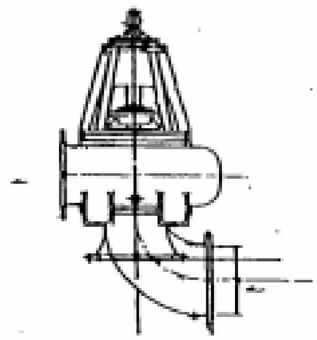
On the basis of the net head of 68.8m and turbine discharge of 0.325 m^3/s of the Project, the following five turbine types are considered; Crossflow, Pelton, Turgo-impulse, horizontal-shaft Francis and Reversed pump turbine. Pelton and Turgo-impulse turbines are classified as impulse turbines. In the case of the head and discharge of the Project, the rated speed of a Pelton turbine is lower than that of a Turgo-impulse turbine and this increases not only the generator size but also the total cost for a Pelton turbine. Accordingly, the Pelton turbine was discarded from further examination of the turbine types.

i) Comparison of Turbine Type

Table 3.4.5 presents a comparison of the four candidates for turbine type, listing advantages and disadvantages, and other features.

The most popular turbine type among the existing mini hydro plants is Crossflow. Although the applicable head range of Crossflow turbines is in general 5-100m, it can be difficult in practice to maintain durability of 26 or more thin runner blades due to stress concentration on the turbine blades when the head exceeds 30-60 m, and cross flow turbines are not usually applied to such high head. Economic life of runner is also short at 3 years with mild steel. One of the main reasons for runner damage is inflow of debris into the turbine, and complete trap of debris is quite difficult. For these reasons, the Crossflow turbine type was also discarded as a candidate for the Project, which aims at easy operation and maintenance and relatively high durability (that is, high sustainability).

Table 3.4.5 Comparison of Turbine Type (1/2)

No.	Items	Unit	Crossflow	Turgo-Impulse	Horizontal Shaft Francis	Reversed Pump
1	Illustration					
2	Output range	kW	50-1,000	100-10,000	500-5,000	
3	Discharge range	m^3/s	0.1-10	0.2-8	0.65-18	
4	Head range	m	5-100	25-300	15-300	
5	Max. turbine efficiency	%	79	85	86	78
6	Rev. speed	rpm	680	750	1,000	1,000
7	Past experience in Myanmar		Many but improvement in design and manufacturing is needed.	Not known, probably few	Many but larger scale.	Probably none as reversed pump. Many irrigation pumps exist and provide experience of O&M.
8	Overall assessment		Not suitable to this high head. Durability would be critical since a small-sized runner (narrow and short blades and shaft in particular) prerequisite for high speed runner, has to carry a big power (160-320 kW) and receives stress concentration.	Suitable. Applicable to variable discharge and can maximize the utilization of available water. Revolution speed is lower than Francis but structure is simpler than Francis. It is characterized by high efficiency at partial load and can be operated even at 10% of the maximum turbine discharge (2 nozzles).	Suitable. If fixed guidevane with dummy load governor type is adopted and discharge is constantly available, the structure can be simpler and the cost lower. In the case of fixed guidevane, certain loss of water is inevitable as the characteristics of dummy load governor. Efficiency lowers at partial load.	Applicable only if the maximum turbine discharge is constantly available or multiple numbers of turbines are installed to facilitate discrete adjustment of station output by unit control. A dummy load governor is prerequisite and incurs certain loss of water as the characteristics of dummy load governor.

Source: Arranged by JICA Study Team

Table 3.4.5 Comparison of Turbine Type (2/2)

No.	Items	Unit	Crossflow	Turgo-Impulse	Horizontal Shaft Francis	Reversed Pump
9	Features		1. Practical revolution speed is the lowest among the four. 2. Equipment and erection costs are low. 3. Simple structure of turbine 4. Draft head may not be utilized if priority is given to the simplicity. 5. Max. efficiency is lower than others. Efficiency at partial load can be improved by splitting runner into two if head is low to allow wide width of runner for splitting. 6. Weak against cavitations and sand abrasion under high head due to high stress concentration on the turbine blades. 7. Runner lifetime is about 3 years with mild steel and 10 years with stainless steel in general. 8. Debris countermeasures incl. mesh screen are needed to secure the efficiency and to avoid vibration due to clogging of runner blades.	1. Revolution speed can be set higher compared to Pelton, resulting in a smaller size and lower cost of generator. However, the speed is low compared to Francis. 2. Application head is in the border ranges of horizontal Pelton and horizontal Francis. The Namlan falls in the center of Turgo application rage. 3. Simple structure 4. Erection cost is lower than Francis. 5. Gross dimension of turbine is large compared to others and occupies more floor space. 6. Draft head cannot be used for power generation. 7. Although max. efficiency is lower than Pelton by 1-3%, efficiency at partial load is higher. 8. Several installations in Japan.	1. Revolution speed can be higher than others, resulting in a smaller size and lower cost of generator. 2. Less convenience in maintenance due to complicated operating mechanism of guidevane except for fixed type. 3. Fixed guidevane with dummy load type is simple in structure. 4. Draft head can be utilized effectively. 5. Advantageous for constant output operation due to the highest max. turbine efficiency among others. On the other hand, disadvantageous for partial load operation due to lower efficiency at partial load. 6. Fixed guidevane type cannot adjust discharge and has to stop operation when available discharge is lower than rated.	1. A standard pump design can be applied since it will use a pump as a turbine by reversing the rotation direction of pumps. 2. Simple structure of turbine 3. Low turbine efficiency due to the use of a pump as a turbine. It needs to be operated at rated output and, therefore, an operation with a dummy load is prerequisite. 4. Turbine cannot adjust discharge and has to stop operation when available discharge is lower than rated.

Turgo-impluse turbines have relatively complicated inlet structures, and has such O&M issues as a nozzle may be clogged with debris that has passed through trashracks. Such debris, if clogged, needs to be cleared from hand-hole. Although the actual installation number of this type of turbine in Myanmar is not known, it would be rather new type. Its generator cost is higher compared to that of Francis due to its lower revolutionary speed. Turgo-impluse turbines can adjust the turbine discharge in accordance with the load fluctuation and can continue operation even at 10% of the maximum turbine discharge (with 2 nozzles) when the available water reduces in the dry season. Turgo-impluse turbines have a high efficiency even at partial load. Therefore, if partial load operation is frequent, the Turgo-impluse turbine will best suit the Namlan.

Conventional Francis turbines with horizontal shafts operated by cooperatives in mountainous regions have had O & M problems due to their complicated structure in the controlling mechanism of the guidevane. In addition, the output and design discharge of the Project are slightly out of the general application range of Francis turbines and need careful design. However, it can adjust the output and save the water like Turgo-impulse but unlike the reversed pump turbine. The efficiency at turbine design discharge is the highest among the four. It has so many applications. Therefore, if the full load operation is dominant where water is abundant and station is connected to a grid with larger power stations, the Francis turbine will best suit. However, this is not the case.

If a Francis turbine with a fixed guidevane and a dummy load governor is adopted, the features becomes similar to those of a reversed pump turbine: simple structure, full use of available head including draft head, operable only with rated discharge. In terms of weight that is a price index, the reversed pump turbine is lighter, but in terms of efficiency Francis is superior. However, under the given turbine scale of the Project, a Francis is probably less economic than the reversed pump turbine.

Based on the comparison above, the reversed pump turbine was employed for the design of the Project for its simplicity in structure and durability (sustainability). However, if the recent cost levels of the Turgo impulse turbines are taken into consideration, the Turgo impulse turbines would be competitive with the reversed pump turbine in terms of cost and will be superior in such site where partial load operation is frequently required and the river water drops below the maximum turbine discharge in the dry season.

ii) Advantages and Disadvantages of Dummy Load Governor

Since the reversed pump turbine has no discharge control mechanism, it will, under an isolated operation such as the Project, need a constant-discharge constant-output operation using a dummy load governor. The dummy load governor, which is applicable also to other turbine types, has the following advantages: ① There will be no water hammer in the penstock since there is no variation in the turbine output; ② Since the turbine can be continuously operated at rated discharge, the development of cavitation in the structure will be minimized.

On the other hand, the dummy load governor has the following disadvantages: ① It cannot follow the variation in the available discharges and partial load operation because there is no discharge control mechanism; ② In the case of regulating pond or reservoir type plant, it will cause spilling of excess water during off-peak load time (irrelevant to the Project which is of run-of-river type); ③ Since it cannot automatically stop the turbine in the case of an accident, the turbine will continue rotation until the inlet valve or intake gate is manually closed and the generator needs to be designed for long periods at its no-load revolutionary speed; ④ In this instance, the operator must get to the power station as quickly as possible (can be judged since there will be power cut) and should take countermeasures according to the manual; ⑤ It always has to waste certain power as heat in order to secure the governor function to meet a load increase in particular.

iii) Potential Power Cuts in Dry Season

As mentioned in the foregoing paragraphs, because of the lack of the discharge control mechanism, the reversed pump turbine will need unit control (to reduce the number of operating generating units so that a total turbine discharge becomes equal to or less than the available discharge) or a special regulating inlet valve for adjustment of the turbine discharge when the river flow falls below the design discharge of the turbine. In the case of the Project, generating equipment of 160 kW × 2 units will be installed, but no special inlet valve for discharge control will be provided for economic reasons. Accordingly, when the available discharge falls below the design discharge of turbine (0.325 m^3/s), power generation will have to be stopped. When the available discharge becomes less than the design discharge in the dry season, one of the two generating units should be stopped. In this situation, consumers should be asked to reduce electricity use at night-time, or load shedding will have to be applied on a village by village basis.

b) Design Conditions of Generation and Distribution Equipment

The generation and distribution equipment will be designed in accordance with the following design criteria:

- The design head of the turbine is 68.8m, and the design discharge is 0.325m^3/s as shown below assuming a combined efficiency of this size at

0.733 (subject to minor changes by tenderer's offer).

$$P = g\,\eta\,Q_t\,H_e$$
$$= 9.8 \times 0.733 \times 0.325 \times 68.8$$
$$= 160 \text{ kW}$$

- Normal water level of head tank	:	EL. 688.00 m
- Normal water level of tailrace bay	:	EL. 818.50 m
- Rated head of turbine	:	68.8 m
- Rated capacity of generator	:	220 kVA
- Distribution voltage	:	11 kV

c) Equipment Planning for Generating Facilities

The following equipment will be provided in the power station:

i) Turbine

- discharge and head : 0.325 $m^3/s \times 68.8m$
- type : reversed pump turbine
- rated output × unit : 160 kW × 2 units
- rated speed : 1,000 rpm
- type of governor : dummy load governor

ii) Generator

- type : 3 phase, AC synchronous generator horizontal-shaft, drip-proof type
- rated output × unit : 220 kVA × 2 units (power factor 0.8)
- rated voltage : 400 V
- frequency : 50 Hz
- rated speed : 1,000 min^{-1}
- method of cooling : self cooled, open type
- type of excitation system : brushless type

iii) Transformer

- type : outdoor use, 3-phase oil-immersed natural-air-cooled system with off-circuit tap-changer.
- rated voltage : High-voltage side 11 kV
  Low-voltage side 400 V
- rated capacity : 500 kVA
- frequency : 50 Hz
- number : 1 unit

- cooling system : oil-immersed self-cooling type

iv) 11 kV metal enclosed cubicle
- type : indoor use, metal enclosed cubicle type
- rated voltage : 11 kV
- rated circuit breaker : 12 kV, 600 A, 12.5 kA
- number of feeders : 1 circuit

v) Low voltage switchgear
- type : indoor use metal-enclosed switchgear
- nominal voltage : 400 V

If the Turgo impulse turbine is adopted in place of the reversed pump turbine, the features of the turbines and generators will be as follows:

i) Turbine
- discharge and head : 0.65 $m^3/s \times 68.8$ m
- type : Turgo impulse turbine
- rated output × unit : 370 kW × 1 units
- rated speed : 750 min^{-1}
- type of governor : CPU governor

ii) Generator
- type : 3 phase, AC synchronous generator horizontal-shaft, drip-proof type
- rated output × unit : 450 kVA × 1 units (power factor 0.8)
- rated voltage : 400V
- frequency : 50 Hz
- rated speed : 750 min^{-1}
- method of cooling : self cooled, open type
- type of excitation system : brushless type

d) Planning for Power Distribution Facilities

i) 11 kV distribution line

The 11 kV distribution line between Nam Lan power station and five (5)-distribution transformer stations is designed so that route length of line is about 11.3 km long along the existing low-tension lines and access road to Nam Lan power station.

The following materials will be provided in the 11 kV distribution line.

- system : A.C. three-phase, three-wires

-	line voltage	:	11 kV
-	route length	:	11.3 km
-	support	:	concrete pole (average pole intervals = 40m)
-	conductor	:	ACSR (Aluminum Conductor Steel Reinforced) of 35 mm^2
-	insulator	:	Pin insulation and disc. type suspension insulator (hall-socket type)

ii) Distribution Transformer Stations

The distribution transformer Stations are designed as two (2)-50 kVA stations and three (3)-200 kVA stations for supply power to the approximately 2000 households.

The following equipment will be provided in the each distribution transformer station.

- Distribution transformer

-	type	:	three-phase, oil immersed natural-air-cooling system with off-circuit tap-changer, outdoor-use, installation on concrete-foundation		
-	rated capacity and	:	50 kVA	2 units	
	unit number	:	200 kVA	3 units	
-	rated voltage	:	High voltage side	:	11 kV
			Low voltage side	:	400-230 V
-	insulation level	:	for 11 kV site		
			full-wave lightning impulse		
			1.2 × 50 micro-second		90 kV
			power-frequency for one minute		28 kV
			for 400V side		
			power-frequency for one minute		2.5 kV
-	impedance voltage	:	for 200 kVA		3%
			for 50 kVA		2%
-	vector symbol	:	Dyn 11		
-	neutral	:	brought out for grounding directory		
-	frequency	:	50 Hz		

- Load breaker disconnecting switch

- type : outdoor use, three-pole, single throw, manually gang operating type, and installation on the poles
- rated voltage : 12 kV
- rated insulation level : 75 kV
- rated normal current : 600 A
- rated breaking current : 600A
- rated frequency : 50 Hz

● Drop-out fuse switch

- type : Porcelain-insulator, cartridge fuse type, outdoor use, single-pole, hook operated type
- rated voltage : 12 kV
- continuous rated current : 100 A
- interrupting current rating : 12.5 kA
- rated frequency : 50 Hz

● Lightning arrester

- rated voltage : 14 kV or more
- nominal discharge current : 10 kA

● Distribution box

For each transformer, a distribution switch box is provided complete with a molded case circuit breaker (MCCB), and all fixing materials to the poles.

- type : steel plates with key locked front door,

outdoor use
- voltage : 400V
- no. of MCCB in switch box : for 200 kVA transformer

one (1) main switch	600 V, 350 A
five (5) sub switches	600 V, 150 A

: for 50 kVA transformer

one (1) main switch	600 V, 100 A
three (3) sub switches	600 V, 50 A

iii) Low Tension Lines

The low-tension lines, 400 V-230 V, three-phase four (4)-wires system, are designed for supply power to eleven (11) quarters of Nam Lan villages and five (5) satellite villages so that the route length is about 28 km long along the existing lines and the access road to the five (5) satellite villages.

The following materials will be provided in the low tension lines.

- system	:	three-phase, four-wire	: 8.6 km
		single-phase, three-wire	: 6.0 km
		single-phase, two-wire	: 13.4 km
- route length	:	28 km	
- support	:	concrete pole (average pole intervals = 40 m)	
- conductor	:	HDCC (Hard-Dram Copper Stranded Conductor), HDCC-38 mm^2, for main circuit HDCC-22 mm^2, for main circuit HDCC-8 mm^2, for lighting circuit	
- insulators	:	pin insulator and shackle insulator	

Survey and soil investigation of the route of the 11 kV and low-tension lines above have not been carried out to date.

The route map for 11 kV line is shown on Figure 3.4.2 and the route map for 400-230 V line is shown on Figure 3.4.3.

e) Other Equipment

i) The other equipment will be selected using criteria such as machine reliability, ease of O & M and repairs, availability of spare parts, and procurement in Myanmar in principle.

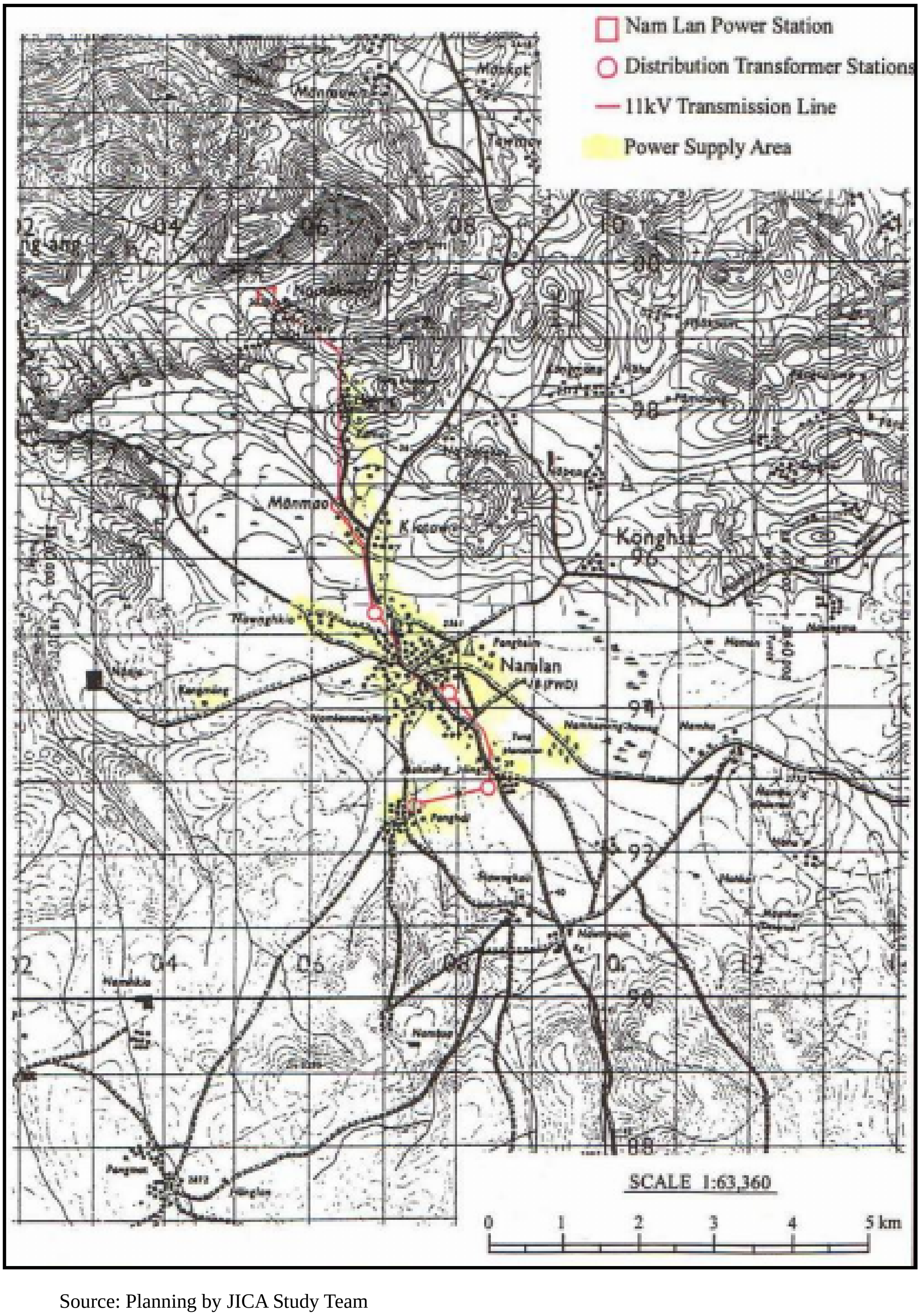
ii) The streetlights will be fluorescent type of less than 100 W each.

iii) Spare parts will be provided to secure the smooth operation of the power station and distribution facilities. The spare parts for the Project are selected based on the following criteria with reference to Society of Electric Cooperative Research, Volume 19, No.2, Japan:

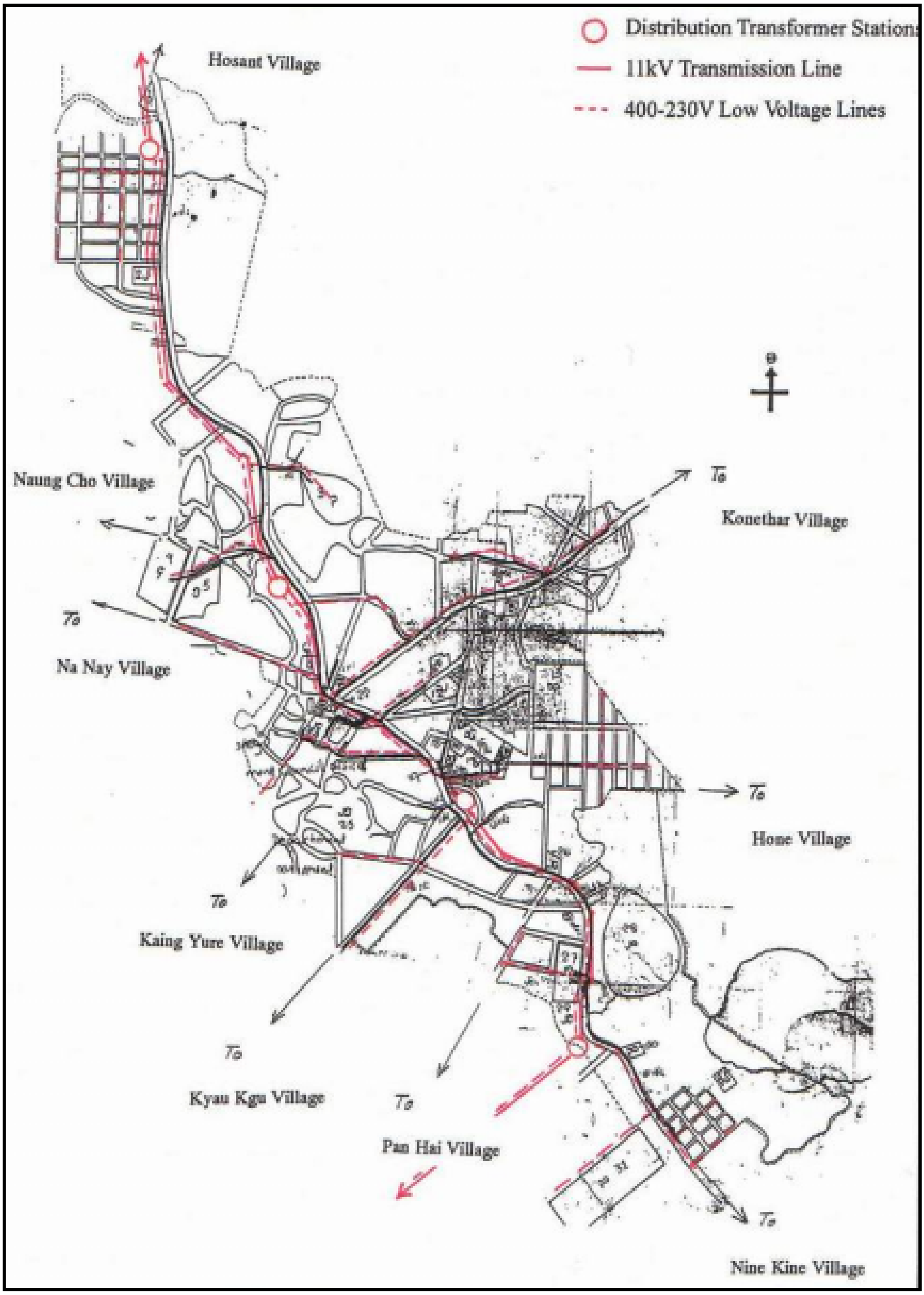
- Essential principal parts which sooner or later problems, such as bearings.
- Essential principal parts which are liable to erosion and corrosion, such as runners, sleeves, etc.
- Small but essential parts for electrical circuits, such as measuring instruments, fuses, indicator lamps,
- Wearing parts such as shaft sealing materials,
- Specially designed parts which will need a special order for procurement and a significant lead time for site delivery, such as runners and heaters for the dummy load governor.

- Those parts which are required to be periodically replaced, such as packing, grease oil, etc.

Since the Project site is located in a remote are and it will take time to get delivery of spare parts, and since the funds available for overhauls will be limited in the first few years of the operation, the quantity of these spare parts are set with the aim of ensuring continuous operation as long as possible, for at least 2 years without the need for additional spare parts.



Source: Planning by JICA Study Team



Source: Planned by JICA Study Team

3.4.9 Cost Estimate

The construction cost for the Project was estimated based on the following conditions:

(1) The civil works are to be executed by local contractor(s) in Myanmar under the supervision of the MEPE, in accordance with the specifications and the Conditions of the Contract to be prepared by the Study Team.

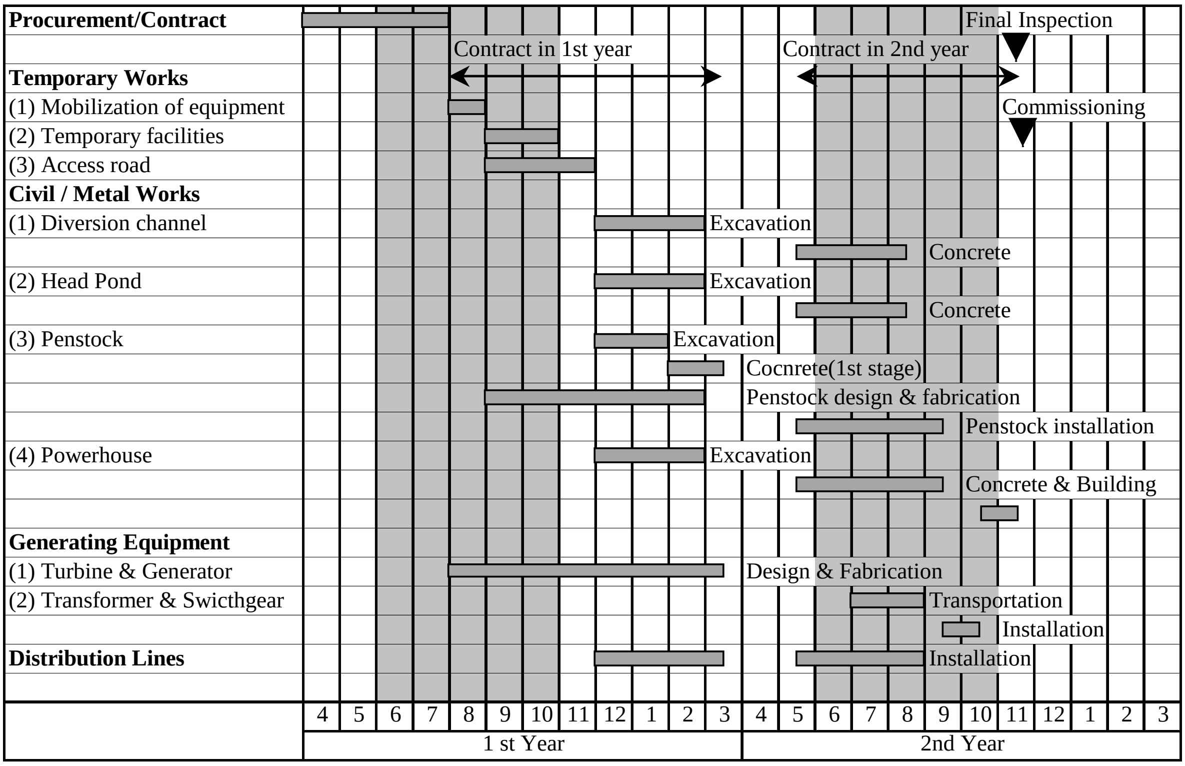
(2) The unit prices for the civil works are worked out based on the actual prevailing range of the cost of the hydropower construction in Myanmar, referring to the general construction costs in international biddings.

(3) The generating equipment such as turbines, generators, governors and control panels are assumed to be procured in Japan, while the other equipment will be procured in Myanmar.

The construction cost for the Project was estimated at about US$ 1,200,000 based on the above conditions.

3.3.10 Construction Schedule

The construction schedule for the Nam Lan mini hydro scheme was estimated based on the detailed design.



Source: Planning by JICA Study Team

Figure 3.4.4 Construction Time Schedule

3.4.11 Further Investigations

Further investigations listed below are required for Phase-2 construction as well as for suitable operation by the VEC:

Item	Contents
Topographic survey	along the diversion channel route with 1/2,000 in scale
Discharge measurement	Continuous discharge measurement in Nam Pan Chaung, Kyutaw Chaung, and Hosang Chaung

3.5 Economic, Financial, and Environmental Aspects

3.5.1. Economic Aspects

The Nam Lan Mini hydro Project is expected to supply electricity for 24 hours a day for a total of 2,082 households. Therefore, the economic benefit of electricity could expand beyond that of lighting. Other benefits include those of domestic industry and heat for cooking.

At the first step of Nam Lan project, the demand at night is estimated to be 270 kW and at daytime 250 kW; however, the demand is expected to expand to 350 kW at night-time and 310 kW at daytime. If the power is to supply electricity from 6 am to 10 pm for 16 hours (night-time 8 hours and daytime 8 hours), the total generation will be (350 kW + 310 kW) x 8 hours x 30 days = 158 MWh/month for a total of 2,082 households. Therefore the potential of the Nam Lan system will reach to 76 kWh/hh/month or more. This potential exceeds the demand for lighting.

In fact, the daytime demand is expected to be from domestic industries. The existing industries in the Nam Lan RE project area, Northern Shan, are; 1) rice-mills, 2) oil-mills, 3) furniture makers, 4) ironworks (black smith), 5) tofu factories, 6) noodle factories, 7) a sawmill, 8) BCS, and 9) water pumps. Among these, the consumption of rice-mills is largest, followed by oil-mills and furniture. This is the typical industrial demand in the highland agricultural area. From the point of rural electrification, the generated electricity should be used in order to maximize the operating revenue.

The total electric power consumption is estimated to be about 310 kW at daytime. The total consumption from 8 a.m. to 4 p.m. is 310 x 8 = 2,480 kWh/day. Because industries use mechanical power directly from diesel engines, the actual power required by diesel engines would be smaller. Assuming motor efficiency of about 86% (average standard motors of 15HP), the required energy input would be 2,480 x 0.86 = 2,133 kWh/day. To provide this amount of electricity by diesel engine the required diesel oil is 213 gallon = 2,133 kWh / 10 (kWh/gallon of diesel) with efficiency of about 20%. The monthly cost is about 213 x 30 = $ 6,390/month. Because there are about 50 such domestic industries, it is about $127/month/industry.

Because the economic benefit of light is about $1-$2/hh/month the total economic benefit from lighting will be about $ 2,000 to $4,000 per month. The total benefit will exceed $8,390 to $ 10,390/month. It is about $4.0 to $5.0/hh/month on average.

Table 3.5.1 shows the calculation of the financial and economic analysis. Knowing that the capital cost of Nam Lan project is about $1.20 million with a project life of 50 years, the Economic Internal Rate of Return (EIRR) was calculated as 10.3% with an economic benefit of $5.0/month/hh.

3.5.2 Financial Aspects

The financial benefit is determined by the actual amount of money paid for electricity. In practice, it is a matter of tariff and consumption. In our survey, the household night-time power demand would be about 350 kW/2082 = 168 watt at maximum. The night-time consumption from 6 p.m. to 10 p.m. will be less than 4 hours x 168 W = 0.67 kWh/day/hh. The residential daytime demand is estimated to be about one fifth of the night-time demand so that the total residential demand would be 0.67 + 0.67/5 = 0.8 kWh/day/hh or 24 kWh/month/hh. With present the MEPE tariff, the monthly residential payment would be K25 (fixed fee) + 24 x K2.5/kWh (energy fee) = K85 or about $0.17/month/hh.

The daytime domestic industrial users are about 50 for a total demand of 2.3 MWh/day. On average they use 46 kWh/day or 1,380 kWk/month/user. With present the MEPE tariff the monthly payment would be K2.5 (under 50 kWh) x 50 kWh +10Kyats (under 200 kWh) x 150 kWh + K25 (above 201 kWh) x 1180 = K31,125 or $62.3/month/hh for domestic industrial users. The total of all 50 users is calculated as 50 x $62.3 = $3,115/month. The household average is $3115 / 2082 = $1.5/month/hh. Combined with the night-time payment the average payment per household would be 0.17 + 1.5 = $1.67/month/hh. This is at a level of a half to one third of the economic benefit. The total consumption is 0.8 kWh/day/hh x 2082 + 2.3 MWh/day = 4 MWh/day or 120 MWh/month or about 60 kWh/month/hh. The monthly total payment is $0.17 x 2082 + $3,115 = $3,468. The unit price is 3468 / 120,000 = $0.029/kWh.

In the comparison of economic benefit, both the night-time users and daytime users pay far less than the economic value. There is a clear distinction, however, in that the night-time users are small in terms of consumption but large in the number of customers, whereas the industrial users consume large amount but are small in the number of customers.

In consideration of this, the annual fee, which differs between night-time only users and daytime users in terms of contract renewal or member-ship fees of the village electrification committee or association, may be worth. For example, the annual membership fee could be $10 for night-time only users (users of

50kWh/month or less) in addition to the MEPE tariff and $50 for daytime users (Users of 50 kWh/month or more). In this case the average annual fee is (10 x 2082 + 50 x 50)/2082 = $11.2/hh/year.

The Table 3.5.1 shows the calculation of the Financial Internal Rate of Return of this case. The FIRR is a positive rate of 1.25%. In the current Nam Lan project the FIRR is still positive at about 1.17%, even without annual fees due to the relatively high average tariff. The large demand of industries and the progressive tariff for their consumption contributed to the higher average tariff than the Heho project.

Table 3.5.1 Financial and Economic Analysis

Assumptions

Discount Rate%	10.0%	Construction Cost $	1,200,000
Consumption kWh/hh/month	60	O & M Cost (% of Construction Cost)	1.0%
No. of Household	2,082	Fuel Cost $/year	0
Financial Benefit (Tariff $/kWh)	0.029		
Annual Fee $/hh (1st Year Only)	10		

Financial Benefit $/Year = (Initial Fee x No.HH + Tariff ($/kWh) x Consumption (kWh/hh/month) x No.HH x 12 month) x Discount Factor

Economic Benefit (WTP $/month) 5

Economic Benefit $/Year = WTP ($/month) x No.HH x 12 month x Discount Factor

Results:				
	Financial Net Benefit	-759,941	FIRR	1.25%
	Economic Net Benefit	28,672	EIRR	10.30%

		Benefit ($, 2001 constant)				Cost ($, 2001 constant)				
Year	Discount factor	Financial Benefit (Present Value)	Economic Benefit (Present Value)	Accumulated Financial Benefit (Present Value)	Accumulated Economic Benefit (Present Value)	Capital Investment (Construction)	O&M Cost	Fuel Cost	Total Cost (Present Value)	Accumulated Cost (Present Value)
1	0.91	58,447	113,564	58,447	113,564	1,200,000	12,000	0	1,101,818	1,101,818
2	0.83	35,927	103,240	94,375	216,803		12,000	0	9,917	1,111,736
3	0.75	32,661	93,854	127,036	310,658		12,000	0	9,016	1,120,751
4	0.68	29,692	85,322	156,728	395,980		12,000	0	8,196	1,128,947
5	0.62	26,993	77,565	183,721	473,545		12,000	0	7,451	1,136,399
6	0.56	24,539	70,514	208,260	544,059		12,000	0	6,774	1,143,172
7	0.51	22,308	64,104	230,568	608,163		12,000	0	6,158	1,149,330
8	0.47	20,280	58,276	250,848	666,439		12,000	0	5,598	1,154,928
9	0.42	18,436	52,978	269,284	719,417		12,000	0	5,089	1,160,017
10	0.39	16,760	48,162	286,045	767,579		12,000	0	4,627	1,164,644
11	0.35	15,237	43,784	301,282	811,363		12,000	0	4,206	1,168,850
12	0.32	13,852	39,803	315,133	851,166		12,000	0	3,824	1,172,673
13	0.29	12,592	36,185	327,726	887,351		12,000	0	3,476	1,176,149
14	0.26	11,448	32,895	339,173	920,247		12,000	0	3,160	1,179,309
15	0.24	10,407	29,905	349,580	950,151		12,000	0	2,873	1,182,182
16	0.22	9,461	27,186	359,041	977,338		12,000	0	2,612	1,184,794
17	0.20	8,601	24,715	367,642	1,002,052		12,000	0	2,374	1,187,168
18	0.18	7,819	22,468	375,460	1,024,520		12,000	0	2,158	1,189,326
19	0.16	7,108	20,425	382,568	1,044,946		12,000	0	1,962	1,191,288
20	0.15	6,462	18,569	389,030	1,063,514		12,000	0	1,784	1,193,072
21	0.14	5,874	16,881	394,905	1,080,395		12,000	0	1,622	1,194,693
22	0.12	5,340	15,346	400,245	1,095,741		12,000	0	1,474	1,196,168
23	0.11	4,855	13,951	405,100	1,109,692		12,000	0	1,340	1,197,508
24	0.10	4,414	12,683	409,514	1,122,374		12,000	0	1,218	1,198,726
25	0.09	4,012	11,530	413,526	1,133,904		12,000	0	1,108	1,199,834
26	0.08	3,648	10,481	417,173	1,144,385		12,000	0	1,007	1,200,840
27	0.08	3,316	9,529	420,489	1,153,914		12,000	0	915	1,201,756
28	0.07	3,015	8,662	423,504	1,162,576		12,000	0	832	1,202,588
29	0.06	2,740	7,875	426,244	1,170,451		12,000	0	756	1,203,344
30	0.06	2,491	7,159	428,736	1,177,610		12,000	0	688	1,204,032
31	0.05	2,265	6,508	431,000	1,184,118		12,000	0	625	1,204,657
32	0.05	2,059	5,917	433,059	1,190,035		12,000	0	568	1,205,226
33	0.04	1,872	5,379	434,931	1,195,413		12,000	0	517	1,205,742
34	0.04	1,702	4,890	436,633	1,200,303		12,000	0	470	1,206,212
35	0.04	1,547	4,445	438,180	1,204,748		12,000	0	427	1,206,639
36	0.03	1,406	4,041	439,586	1,208,789		12,000	0	388	1,207,027
37	0.03	1,278	3,674	440,864	1,212,463		12,000	0	353	1,207,380
38	0.03	1,162	3,340	442,027	1,215,803		12,000	0	321	1,207,701
39	0.02	1,057	3,036	443,083	1,218,839		12,000	0	292	1,207,993
40	0.02	961	2,760	444,044	1,221,599		12,000	0	265	1,208,258
41	0.02	873	2,509	444,917	1,224,108		12,000	0	241	1,208,499
42	0.02	794	2,281	445,711	1,226,389		12,000	0	219	1,208,718
43	0.02	722	2,074	446,432	1,228,463		12,000	0	199	1,208,917
44	0.02	656	1,885	447,088	1,230,348		12,000	0	181	1,209,098
45	0.01	596	1,714	447,685	1,232,062		12,000	0	165	1,209,263
46	0.01	542	1,558	448,227	1,233,620		12,000	0	150	1,209,412
47	0.01	493	1,416	448,720	1,235,036		12,000	0	136	1,209,549
48	0.01	448	1,288	449,168	1,236,324		12,000	0	124	1,209,672
49	0.01	407	1,171	449,575	1,237,494		12,000	0	112	1,209,785
50	0.01	370	1,064	449,946	1,238,559		12,000	0	102	1,209,887

Source: Analyzed by JICA Study Team

3.5.3 Environmental Aspects

The CO_2 emission due to the National Grid is estimated to be about 0.00128bbl/kW or 0.00128 x 156 (litter/bbl) x 0.85 (kg/litter) = 0.170 kg/kWh. Providing that each household consumes 60 kWh/month/hh, with household numbers of 2,000, the total CO_2 emission in one year is calculated to be 0.170 (kg/kWh) x 60 kWh x 2,000 x 12 month = 245 ton of carbon equivalent. For lighting, an average household consumes about one gallon of kerosene or diesel oil per month. The annual CO_2 emission that can be saved through electrification is 3 kg/hh/month (coefficient: 0.821 Mt-C/Mtoe) of carbon equivalent. For 2,000 households for one year it will be 3 x 2,000 x 12 = 72 ton of carbon equivalent.

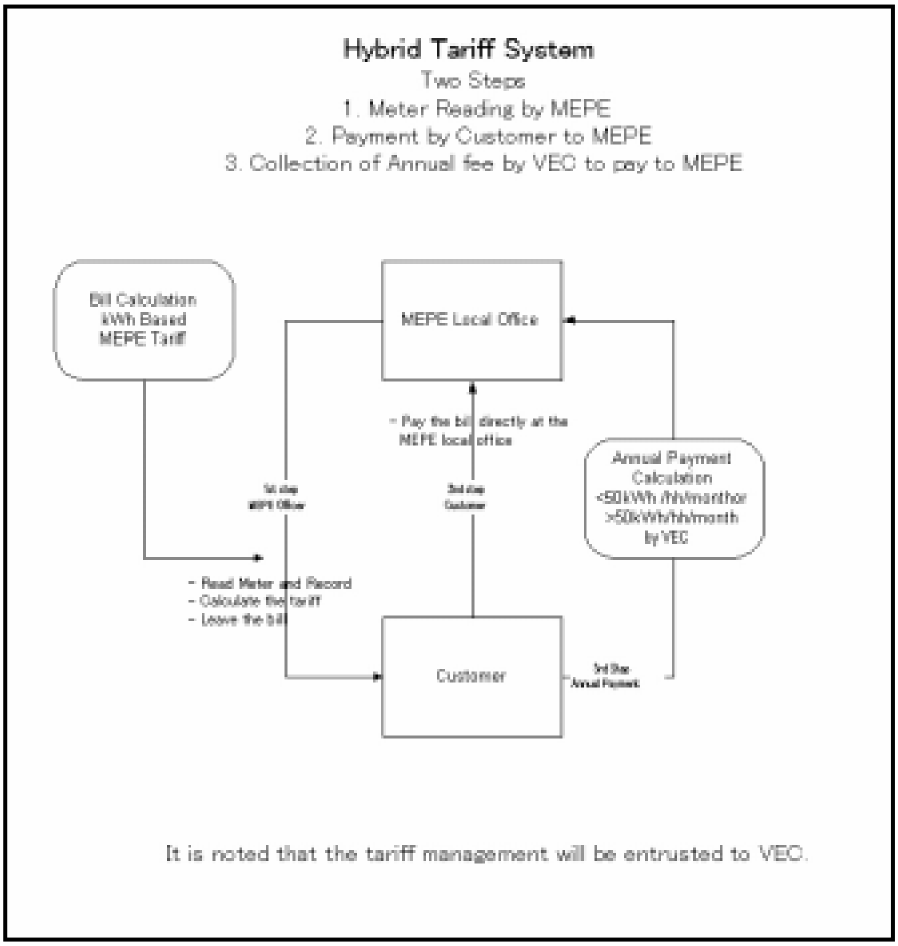
3.6 Tariff System and Accounting

3.6.1 Tariff System

The suggested tariff system is a hybrid of the MEPE tariff plus an annual fee for the renewal of a contract that ensures the supply of electricity on a 24-hour basis. In this example, these two types of payments are a monthly tariff and an annual payment to the VEC. (see Figure 3.6.1)

3.6.2 Accounting System

Accounting is integrated into billing. The billing or money collection is by three steps. The MEPE staff read the meter of each customer and calculate the bill based on the MEPE tariff at the site and leave the bill there. Then the customer visits the MEPE local office to pay the bill. The annual fee will be collected by the VEC based on the initial contract of the night-time user or daytime user. The staff of the VEC may collect money from each customer, then pay annually to the MEPE or the Department of Rural Electrification.



Source: Proposal of JICA Study Team

Figure 3.6.1 Tariff System