No.

Japan International Cooperation Agency (JICA)

Ministry of Electric Power
Myanma Electric Power Enterprise
Union of Myanmar

The Study on Introduction of Renewable Energies in Rural Areas in Myanmar

Final Report

Volume 5 Main Report
Development Plan of Priority Projects

September 2003

Nippon Koei Co., Ltd.
Institute of Energy Economics Japan

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MYANMA ELECTRIC POWER ENTERPRISE
MINISTRY OF ELECTRIC POWER
UNION OF MYANMAR

STUDY ON INTRODUCTION OF RENEWABLE ENERGIES IN RURAL AREAS IN MYANMAR

FINAL REPORT

VOLUME 5

MAIN REPORT

DEVELOPMENT PLAN OF PRIORITY PROJECTS

SEPTEMBER 2003

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
INSTITUTE OF ENERGY ECONOMICS, JAPAN

NIPPON KOEI CO.,LTD.
Consulting Engineers

September 2003

To Mr. Takao KAWAKAMI
President
Japan International Cooperation Agency (JICA)
Tokyo, JAPAN

Dear Sir,

Letter of Transmittal

We are pleased to submit herewith the Final Report of the Study on Introduction of Renewable Energies in Rural Areas in Myanmar. The report reflects opinions and views of the Myanma Electric Power Enterprise and other organizations concerned in Myanmar, as well as Japanese government organizations concerned.

In view of the power supply conditions in Myanmar—severe shortages have been experienced even in the capital city Yangon—we propose in our conclusions that renewable energy be extensively introduced in the rural areas by utilizing local technology existing and available in Myanmar. We hope and believe these *Guidelines*, *Manuals*, *Development Plans*, and *Database* will be useful and employed in the implementation, operation and maintenance of rural electrification projects, both *Government Schemes* and *Village Schemes*, for sustainable improvement of the level of rural electrification that would contribute to rural poverty alleviation and reduction of the urban-rural divide in Myanmar.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of Economy, Trade and Industry, Japan for extensive support and cooperation.

We also wish to express our deep gratitude to the Ministry of Electric Power, Department of Electric Power, and Myanma Electric Power Enterprise for the cooperation extended to our study team throughout the field surveys and studies in Myanmar.

Very truly yours,

Akio KATAYAMA, Team Leader
The Study on Introduction of Renewable Energy
in Rural Areas in Myanmar

Nippon Koei Co., Ltd.
Institute of Energy Economics, Japan

THE STUDY ON INTRODUCTION OF RENEWABLE ENERGIES
IN RURAL AREAS IN MYANMAR

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ABBREVIATIONS

Organizations

DEP, DOEP	Department of Electric Power of MOEP
DHP	Department of Hydroelectric Power of MOEP
GOM/SPDC	Government of Myanmar/State Peace and Development Council
GOJ	Government of Japan
ID	Irrigation Department of Myanmar
IOE	Institute of Economics of Myanmar
ITC	Irrigation Technology Center, Irrigation Department
JICA	Japan International Cooperation Agency
MADB	Myanma Agricultural Development Bank
MAPT	Ministry of Agricultural Products and Trade
MEC	Myanmar Economic Commission
MELC	Myanma Electric Light Co-operative Society Ltd.
MEPE	Myanma Electric Power Enterprise
MPBANRDA	Ministry for Progress of Border Areas and National Races and Development Affairs
MOC	Ministry of Cooperatives
MOE	Ministry of Energy
MOEP	Ministry of Electric Power
MOST	Ministry of Science and Technology
NEDO	New Energy & Industrial Technology Development Organization, Japan
SPICL	Sein Pann Industrial Production Co-operative Limited
USDA	Union Solidarity and Development Association (an NGO)
VEC	Village Electrification Committee
VPDC	Village Peace and Development Council
VWSDC	Village Water Supply Distribution Committee
YIE	Yangon Institute of Economics
YIT	Yangon Institute of Technology

Economics, Finance

ATP	Ability to Pay
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
IRR	Internal Rate of Return
WTP	Willingness to Pay

Unit

kVA	kilo Volt ampere
kWh	kilo-Watt-hour
MWh	Mega-Watt-hour (10^3 kWh)
K	Currency unit of Myanmar (Kyat)
toe	Tons of oil equivalent (10^7 kcal)
US$, $	Currency unit of USA (US dollar)
Yen	Currency unit of Japan (Yen)

Others

BCS	Battery Charging Station
FS	Feasibility Study
HRD	Human Resource Development
IPP	Independent Power Producer
MP	Master Plan
NGO	Non Governmental Organization
OJT	On-the-Job-Training
O&M	Operation and Maintenance
R&D	Research and Development
RE	Rural Electrification
SHS	Solar Home System

Exchange Rates

US$ 1.00 = K500 = Yen 120 (May 2001)
US$ 1.00 = K1,000 = Yen 120 (May 2003)
unless otherwise specifically noted

CHAPTER 1 PROSPECTIVE PROJECTS FOR RENEWABLE ENRGY

1.1 Investigation on Renewable Energies

1.1.1 Small Hydropower

There are 39 small hydropower stations installed by MEPE, out of which 30 are currently in operation. In addition, there are numerous pico hydro available in the market being installed and operated by the villagers. There are local manufactures of small penstocks, small gates, transformers and concrete poles, as well as the know-how of NGOs and VECs to operate and collect tariff.

There is high potential of small hydro, especially in the mountainous areas of Shan Plateau and Chin Mountains. Small and mini hydro (100 ~ 10,000kW) would be operated by MEPE and are preferable in view of their larger scale. Pico hydro (<10kW) is advantageous in the sense of short lead time and low cost, and because they can be installed and operated by the villagers' self-help.

1.1.2 Photovoltaics and Wind Power

There are many battery charging stations (BCS) in Myanmar, but only a limited amount of solar BCS and two installation of wind power. The two existing wind powered BCSs are both hybrid systems with solar power installed by Karamosia, a Japanese NGO. There is stock of local technology in battery charging and recycling, but the solar panels are foreign products.

The advantage of solar power and wind power is the quick installation and easy maintenance, whilst the prominent disadvantage is the high initial cost for the equipment. Although the output of solar and wind power can fluctuate, the different components of the hybrid system can complement one another making output more stable. Solar power is suitable in the Central Dry Zone as solar pumps and as BCS in remote areas.

1.1.3 Biomass Power

There are examples of large scale biomass steam turbines in ricemills and local technology of a rice husk gas engine. The former is not suitable for RE, but the latter is already being installed in some areas, namely Ayeyarwady Division.

The rice husk gas engine makes best use of local technology and rice husks in the paddy growing areas. The advantages of the rice husk gas engine are the short lead time and the low initial investment. If a sufficient amount of rice husk can be secured annually, stable energy can be supplied cheaply.

1.2 Formulation and Selection of Priority Development Projects

1.2.1 Formulation and Selection of Priority Development Projects

1) Selection and Planning of Small Hydropower Scheme for Rural Electrification

The selection of potential sites for small hydropower schemes was conducted first by requesting hydropower engineers of MEPE to select fifteen (15) schemes from MEPE's list of 150 potential small hydropower sites that they consider feasible. 150 potential small hydropower sites are shown in Figure 1.2.1 and listed in Appendix - E. The list was further shortened to nine (9) schemes by analyzing past study reports and maps, and by interviewing hydropower engineers of MEPE who have actually been to the site. Out of these schemes, the Study Team conducted site reconnaissance of seven (7) schemes, as depicted in Figure 1.2.2, and for the two (2) sites that seemed most feasible, topographic survey, discharge measurement, and test pitting were conducted through subcontracted works by local subcontractors. These are the candidate projects SH-01 ~ 07 shown in Table 1.2.1.

During the field inspection, there were opportunities to visit five (5) existing small hydropower stations as shown in Figure 1.2.3. Serious sediment problem and the malfunctioning of the turbine/generator controller were the most prominent problems common to all hydropower stations visited. Up until now, 39 small hydropower stations have been constructed by MEPE, out of which 30 are presently in operation. The grave importance of timely rehabilitation of these small hydropower stations was confirmed also by the concerned staff of MEPE. This rehabilitation project is presented as RH-01 in Table 1.2.1.

On the other hand, there is also a significant need for a MEPE Engineer Training Center, which train engineers in the field of planning, design, construction, O&M of hydropower stations and transmission lines, and repair of turbines, etc. This capacity building project is presented as CB-01 in Table 1.2.1.

2) Selection and Planning of Biomass Gas Engine Scheme for Rural Electrification

It is judged that the introduction of the rice husk gas engine being manufactured by a local private company since 1995 is appropriate for rural electrification in the paddy growing areas and in semi-urban areas with rice mills.

However, the use of the rice husk gas engine for rural electrification has only recently been begun, and its operation by VECs is not yet well established. Therefore, it is deemed necessary to conduct a model project (BM-01) to solve the problematic issues concerned with their management, as well as to demonstrate the performance of the system to the public, before the implementation of the three rural electrification projects presented as BM-02 ~ 03 listed in Table 1.2.1. These three projects use rice husk and solar power, both available nearly throughout the whole of Myanmar, as the energy source. It is necessary to make a specific rural electrification plan based on the availability of materials, data of the location and the number of households in un-electrified villages in each State / Division.

3) Replacement of MEPE Diesel Generators by Rice Husk Gas Engines

The above-mentioned rice husk gas engines are small scale schemes to electrify individual villages, but the possibility to use biomass to replace the 456 units of diesel generators (525 units including standby units) operated by MEPE in the rural areas can also be considered. In order to replace all 65 MW of MEPE- owned diesel generators by rice husk, assuming unit consumption of 2.5 kg/kWh, about 300,000 tons (65 MW x 1,000 kW x 5 hr/day x 365 days x 2.5 kg/kWh) of rice husk will be necessary. Since the amount of rice husk being produced annually in Myanmar is in the vicinity of 3.5 million tons, the necessary amount is only 8.6% of the total produced amount. Therefore, there is a possibility to replace the diesel generators by rice husk gas engine. Also, the total electricity generated annually by the diesel units is approximately 120 GWh, and assuming unit cost of diesel fuel to be US$1.00/gallon and generation to be 10 kWh/gallon, it amounts to a saving of US$12 million in fuel cost, which is more than double the capital requirement of US$5 million per annum to electrify 166 Village Tracts a year.

- The unit generation cost of the rice husk gas engine manufactured by MIC is about US$400 ~ 800/kW. (In the case of Younetalin Village in Ayeyarwady Division, K4,000,000 x 2.0 / K350/$ / 35 kW = US$650 (Coefficient 2.0 is adjustment to compensate for the fact that distribution lines were constructed free of charge by MEPE, that the gasifier itself was procured at a specially low price since it was the first shipment, and that the engine was provided by the DPDC)
- When an existing diesel engine of 100s kW deteriorates and needs replacement, it is possible to introduce several small-scale rice husk gas engines and to operate them simultaneously when necessary. Otherwise, it is also possible to supply electricity to the different quarters individually from each of the rice husk gas engines.

1.2.2 Selection of Priority A Projects

Since CB-01 MEPE Capacity Building Project does not directly lead to rural electrification, it was excluded from the selection to be considered separately. The other 14 schemes composed of seven (7) hydropower schemes, four (4) biomass schemes, two (2) solar-wind BCS schemes and the rehabilitation of small hydropower plant were evaluated according to the Selection Criteria described in the Guidelines. These schemes were ranked in classes Priority A, B and C according to the points acquired.

The seven (7) schemes that ranked as Priority A, including CB-01 MEPE Capacity Building Project, are listed below.

SH-01 The Inle Lakeshore Rural Electrification Project in Southern Shan (8 MW)
SH-02 The Namlan Rural Electrification Project in Northern Shan (320 kW)
SH-06 The Gangaw Rural Electrification Project in Magway Division (1.2 MW)
RH-01 The Rehabilitation Project of Small Hydropower Stations in Myanmar
CB-01 MEPE Capacity Building Project
BM-01 The Model Villages for Rural Electrification with Rice Husk Gas Engine and BCS
BM-04 The Pilot Project for Diesel Substitute of MEPE Power Plants for Rural Electrification

1.2.3 Selection of 3 Priority Development Projects

Out of these seven (7) candidate projects, one scheme each of MW-class, 100s kW-class, and 10s kW-class is to be selected as Priority Development Projects. Although RH-01, CB-01 and BM-04 have high priority, because they aim at rehabilitation, training or replacement they were excluded from the selection of the three Priority Development Projects.

Of the remaining Priority-A Projects, the MW-class schemes are SH-01 and SH-06. Of the two schemes, SH-01 The Inle Lakeshore Rural Electrification Project in Southern Shan was selected as the Priority Development Plan because 1) SH-01 acquired higher points, 2) the target population exceeds 150,000, and 3) the scheme can contribute to the conservation of water quality of Inle Lake as well as the conservation of upstream forest land by serving as substitution for wood/charcoal.

As for the 100s kW-scale and the 10s kW-scale schemes, the only schemes ranked Priority-A are SH-02 The Namlan Rural Electrification Project in Northern Shan and BM-01 The Model Villages for Rural Electrification with Rice Husk Gas Engine and BCS respectively, and so they were selected as the Priority Development Projects. Eventually the following 3 schemes were selected as Priority Development Projects:

SH-01 The Inle Lakeshore Rural Electrification Project in Southern Shan (8 MW)
SH-02 The Namlan Rural Electrification Project in Northern Shan (320 kW)
BM-01 The Model Villages for Rural Electrification with Rice Husk Gas Engine and BCS

For SH-01 The Inle Lakeshore Rural Electrification Project in Southern Shan and SH-02 The Namlan Rural Electrification Project in Northern Shan, basic design was conducted based on the data from topographic survey, discharge measurements and test pitting. On the other hand, further study in the field of economic/financial analysis and social survey, namely electricity demand and WTP was also conducted based on the data acquired from the subcontracted village social survey. The basic design for SH-01 scheme is described in Chapter 2, and the detailed design for SH-02 is shown in Chapter 3.

For BM-01 The Model Villages for Rural Electrification with Rice Husk Gas Engine and BCS, the exact location of the project site was selected through additional field inspections trips. A Development Plan was formulated including the funding plan for the project. Details of the Development Plans are shown in Chapter 4.

1.2.4 Selection of Pilot Project

SH-01:Nam Lan Mini Hydro Scheme (320 kW) was selected as the Pilot from the following reasons:

1) A priority project of 100 kW class or 2 priority projects of 100 kW and 10 kW classes are to be selected from the 3 priority projects as Pilot Project(s).
2) Small/mini hydro is one of the most potential and practical renewable power sources for the rural electrification in Myanmar. The Nam Lan Scheme aims at electrification of about 2,000 households with 24-hour power generation by means of the stable water resources. The Nam Lan Scheme is suitable foe the Pilot Project in many aspects in power source, development scale, technical feasibility, economic aspect, etc. Further sustainable development in the rural electrification by renewable energy is expected through a technology transfer to MEPE and VEC, formulation of the model village initiated by VEC, and participation of the local inhabitants during the construction and the operation of the Pilot Project.
3) The Rice Husk Gas Engine Schemes are feasible by the local NGOs in Myanmar, which will be promoted to implement in cooperation with the NGOs under Grass-roots Grant of EOJ.

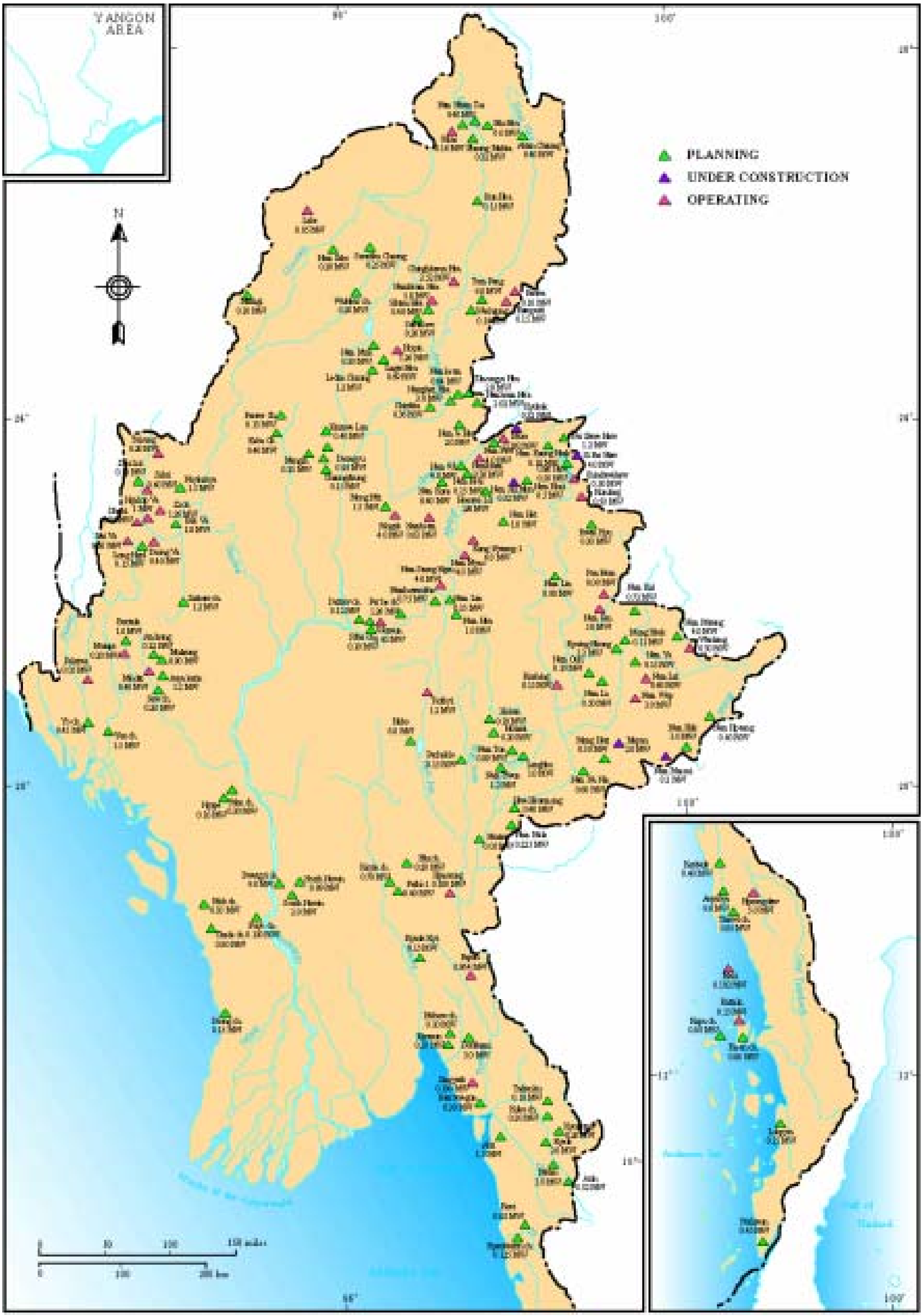
1.3 Prospective Projects for Renewable Energy

The prospective projects for promotion of rural electrification in Myanmar by means of the renewable energy were selected through the Selection Criteria of the Guidelines. These projects are selected as Priority-A and –B, and expected to implement at an early date. The prospective projects are listed in Table 1.2.1 and shown in Figure 1.3.1. The outline of the projects is summarized in Appendix-A: Project Sheets.

Table 1.2.1 List of Prospective Projects

No.	Title	State	Type
SH-1	The Inle Lakeshore Rural Electrification Project	Shan (S)	Hydro
SH-2	The Nam Lan Rural Electrification Project	Shan (N)	Hydro
SH-3	The Parhe Rural Electrification Project	Shan (N)	Hydro
SH-4	The Nam Kone Chaung Rural Electrification Project	Shan (N)	Hydro
SH-5	The Mong Ping Rural Electrification Project	Shan (E)	Hydro
SH-6	The Gangaw Rural Electrification Project	Magway	Hydro
SH-7	The Dawai Rural Electrification Project	Taninthayi	Hydro
BM-1	The Model Villages for Rural Electrification with Rice Husk Gas Engine and Solar BCS	Yangon	Biomass
BM-2	The Project for Promotion of Rural Electrification with Rice Husk Gas Engine	Ayeyawady	Biomass
BM-3	The Project for Promotion of Rural Electrification with Rice Husk Gas Engine and Solar-Wind BCS	Kachin	Biomass
BM-4	The Pilot Project for Diesel Substitute of MEPE Power Plants	Whole Myanmar	Biomass
SW-1	The Project for Promotion of Rural Electrification with Solar-Wind BCS	Kachin	Solar-Wind
SW-2	The Project for Promotion of Rural Electrification with Wind BCS	Magway	Wind
RP-1	Rehabilitation of Small Hydropower Stations in Myanmar	Whole Myanmar	Hydro
CB-1	Hydropower Capacity Building Project	-	Hydro

An outline of each project is summarized in Appendix-A.

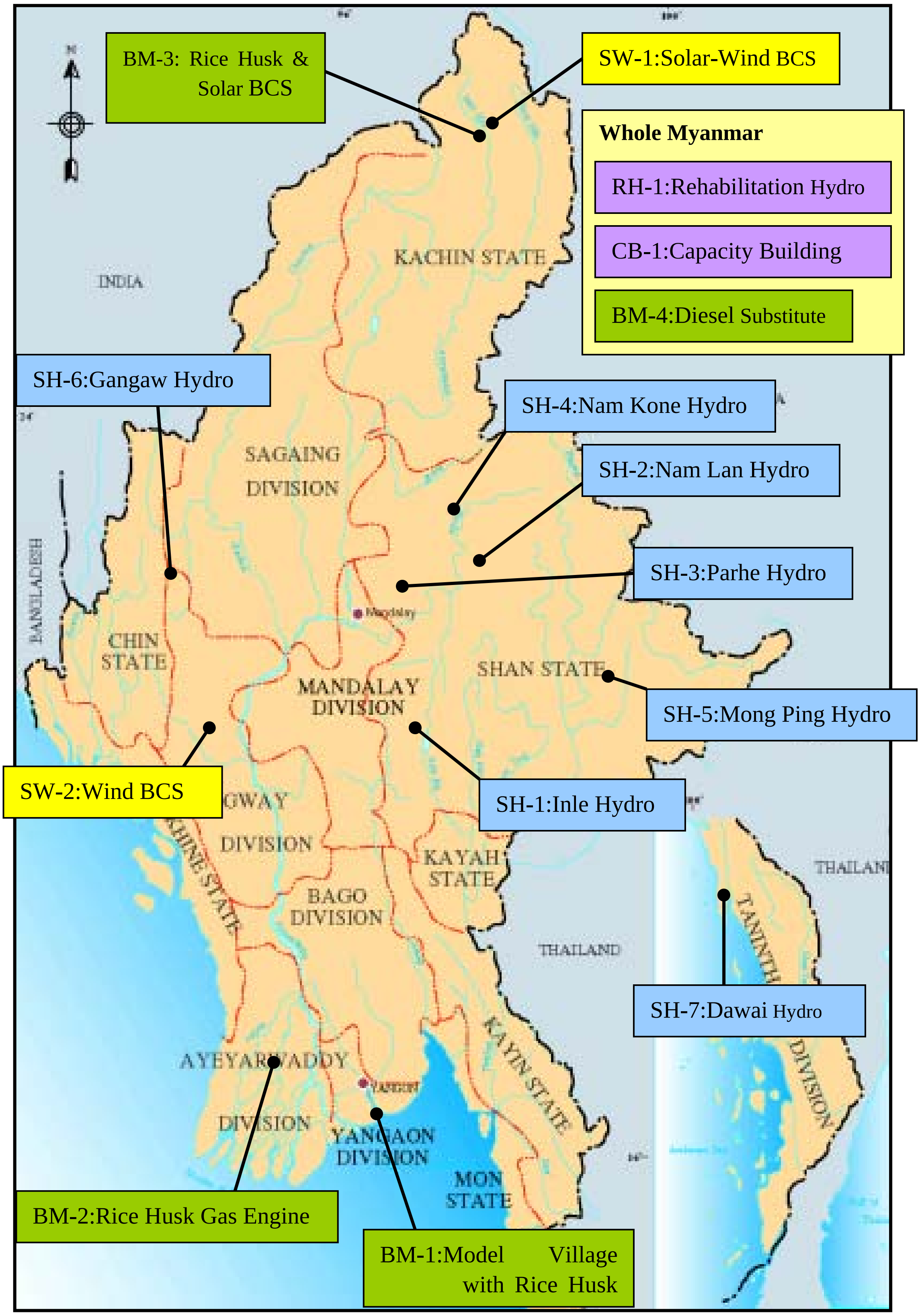


Source: MEPE, Compiled by JICA Study Team

Figure 1.2.1 Potential Small Hydropower Site in Myanmar(< 10 MW)

Source: MEPE, Compiled by JICA Study Team

Figure 1.2.2 Potential Hydropower Sites and Existing Hydropower Stations Investigated



Source: JICA Study Team

Figure 1.3.1 Location Map of Prospective Projects

CHAPTER 2 DEVELOPMENT PLAN OF HEHO PROJECT

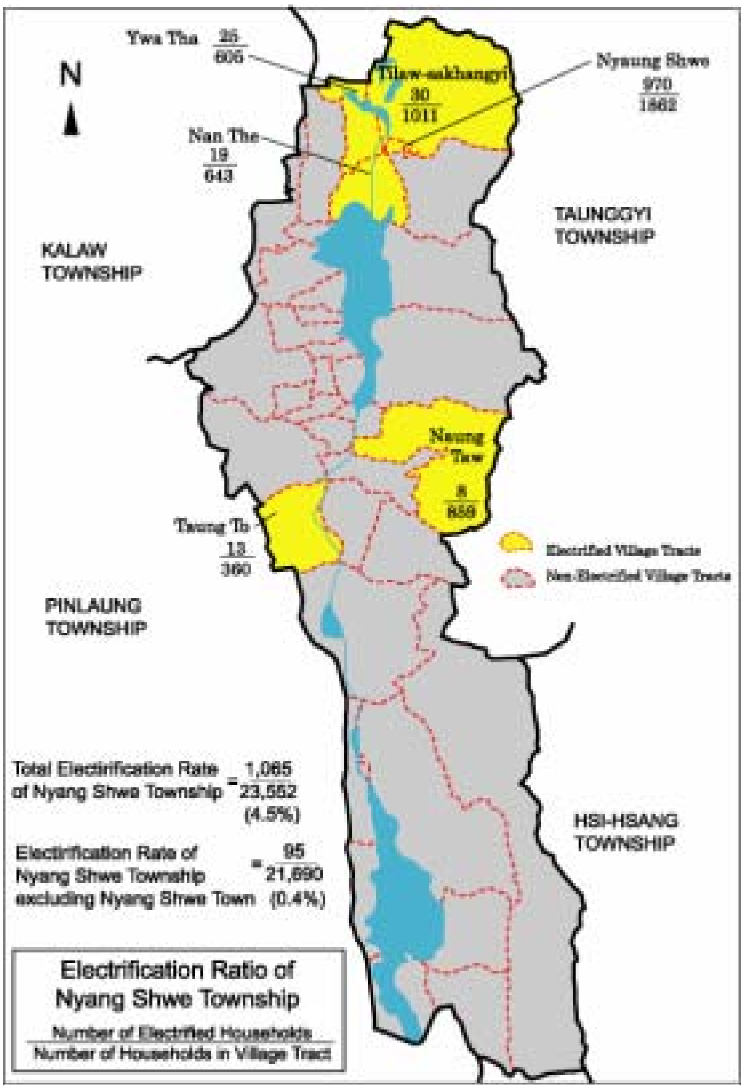
SH-01 The Inle Lakeshore Rural Electrification Project in Southern Shan

2.1 The Project Area

The project site is located on the Negya Chaung River that flow west to east through the plains located to the south of Heho (approximately 160 km to the south-southeast of Mandalay) The Negya Chaung eventually flows into the Inle Lake located in Nyang Shwe Township, which is the target area for electrification.

The administrative center of Nyang Shwe Township is Nyang Shwe Town with 1,862 households and a population of 12,500. In the township there are 408 villages grouped into 35 village tracts around the Inle Lake as well as around the Mobye Dam Reservoir. The east bank of the Inle Lake is Special Region No.6, where the Pao people reside. The total population of the township is 153,000, and the total number of households is 23,552 as shown in Table 2.1.1.

The electrification rate in the whole of Nyang Shwe Township is 4.5%, but the electrification rate solely of the 35 village tracts, excluding Nyang Shwe Town, is only 0.4% as shown in Figure 2.1.1.



Source: JICA Study Team

Figure 2.1.1 Electrification Ratio of Nyang Shwe Township

Table 2.1.1 Population and Number of Household in Nyang Shwe Township

Quarter/ Village Tract	Quarter/Village Tract Name	Population	Number of Household	Electrified Household	% Electri-fication	Note
Q1	Kan Thar	2,559	274	180	65.7	
Q2	Thar Si	1,257	183	100	54.6	
Q3	Nan Dar Won	3,826	606	150	24.8	
Q4	Myo Htae (Down town)	879	133	140	105.3	
Q5	Win	1,113	175	100	57.1	
Q6	Nanpan	976	172	100	58.1	
Q7	Mingalar	658	101	80	79.2	
Q8	Minele	1,278	218	120	55.0	
	Sub-total	12,546	1,862	970	52.1	
VT1	Nan Thae	4,396	643	19	3.0	
VT2	Kyung Kyi	4,069	630		0.0	
VT3	Linn Kinn	4,234	639		0.0	
VT4	Kaung Htaing	2,889	443		0.0	
VT5	Lat Maung Kawe	2,077	324		0.0	
VT6	Taung Po Gyi	3,195	476		0.0	
VT7	Taung Chae	5,438	954		0.0	
VT8	Mine Thauk	5,883	922		0.0	
VT9	Ywar Thar	3,948	605	25	4.1	
VT10	Hti Law	7,097	1,011	30	3.0	
VT11	Min Chaung	5,360	1,405		0.0	
VT12	Nan Pan	4,760	803		0.0	
VT13	Tone Lae	3,526	578		0.0	
VT14	Ta Paye Pin	6,246	1,024		0.0	
VT15	Ngarphae Chaung	3,003	493		0.0	
VT16	Ywar Ma	4,365	705		0.0	
VT17	Thar Lay	5,099	304		0.0	
VT18	Taung Tho	3,637	360	13	3.6	
VT19	Kyuk Tai	1,837	278		0.0	
VT20	Naung Taw	7,023	859	8	0.9	
VT21	Inn Yar	4,477	810		0.0	
VT22	Kyae Paw Kon	6,170	980		0.0	
VT23	Inn Tein	3,593	363		0.0	
VT24	Inn Kyan	4,989	756		0.0	
VT25	Inn Paw Kore	5,567	942		0.0	
VT26	Ta Lae Oo	5,626	920		0.0	
VT27	Sa Kar	2,593	337		0.0	
VT28	Lone Kan	2,212	312		0.0	
VT29	Pont Mu	5,033	795		0.0	
VT30	Linlan Myauk	1,370	224		0.0	
VT31	Ban Pyin	3,547	582		0.0	
VT32	Inn Tan	1,627	235		0.0	
VT33	Mine Pyo	2,566	370		0.0	
VT34	Yae Pu	1,757	226		0.0	
VT35	Lin Lan Taung	1,245	205		0.0	
	Sub-total	140,454	21,690	95	0.4	
	Grand Total	153,000	23,552	1,065	4.5	

Source: JICA Study Team

Table 2.1.2 shows the average income, expenditure, and saving level of both electrified and un-electrified households surveyed in Southern Shan. The average annual income for the electrified and the un-electrified areas are K310,000 and K240,000, respectively.

Table 2.1.2 Income, Expenditure and Saving Level in Southern Shan

(Kyat/Household/year)

Electrification Status	Southern Shan State	
	Un-Electrified	Electrified
1. Income	239,900	309,800
2. Expenditure	214,000	193,400
3. Saving	25,900	116,400
4. Donation	12,900	14,200

Source: JICA Study Team

2.2 Needs and Demand for Electrification

1) Power Demand Forecast

The use of electricity can be divided into four categories; 1) household use, 2) public use, 3) business use, and 4) industrial use. The type and number of each category are shown in Table 2.2.1.

The electricity demand in Nyang Shwe was forecast for the above four sectors in the following manner:

$P_D = P_H + P_P + P_B + P_I$ ････(1)

$P_x = n_x W_x C_x A_x / 1{,}000$ ････(2)

where, P : Electricity demand in kW, where suffix H denotes for 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 W

C_x : Ratio of concurrent use of x sector in the peak time

A_x : Affordability ratio of x sector.

It is noted that unit consumption of each sector was assumed according to the field survey as presented in Appendix B-1.

Table 2.2.1 Estimated Power Demand Forecast in Nyang Shwe Township

Object	Number of Object	Step	Nighttime: Unit Consumption Watt	Simultaneous %	Unit Consumption Watt	Accessibility %	Estimated Power Demand kW	Sub-total kW	Daytime: Unit Consumption Watt	Simultaneous %	Unit Consumption Watt	Accessibility %	Estimated Power Demand kW	Sub-total kW
1.Household	23,552	1-1	130	90%	120	87	2,458.8	2,458.8	130	15%	20	87	409.8	409.8
		1-2	220	70%	160	87	3,278.4	3,278.4	220	20%	50	87	1024.5	1024.5
2. Public														
2.1 Street Light	416		400	50%	200	100	83.2		0	0%	0	100	0.0	
2.2.1 Temple	220		2,000	30%	600	100	132.0		2,000	40%	800	100	176.0	
2.2.2Pagoda	236		2,000	30%	600	100	141.6		2,000	40%	800	100	188.8	
2.3 Hospital	3		350	70%	250	100	0.8		350	50%	180	100	0.5	
2.4 Clinic	6		310	70%	220	100	1.3		310	50%	160	100	1.0	
2.5.1H. School	6		6,200	0%	0	100	0.0		6,200	20%	1,240	100	7.4	
2.5.2 M.School	12		1,640	0%	0	100	0.0		1640	20%	330	100	4.0	
2.5.3 P.School	205		380	0%	0	100	0.0		380	20%	80	100	16.4	
Sub-total								358.9						394.1
3. Business														
3.1 Restaurant	5		3,185	30%	960	100	4.8		3,185	30%	960	100	4.8	
3.2 Hotel	36		7,000	80%	5,600	100	201.6		7,000	70%	4,900	100	176.4	
Sub-total								206.4						181.2
4. Industry														
4.1 Rice Mill	39		5,000	0%	0	100	0.0		5,000	80%	4,000	100	156.0	
4.2 Oil Mill	4		7,000	0%	0	100	0.0		7,000	80%	5,600	100	22.4	
4.3 Powder Mill	3		5,000	0%	0	100	0.0		5,000	80%	4,000	100	12.0	
4.4 Sugarcane Processing	58		5,000	0%	0	100	0.0		5,000	80%	4,000	100	232.0	
4.5 Saw Mill	6		5,000	0%	0	100	0.0		5,000	80%	4,000	100	24.0	
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	26		4,000	0%	0	100	0.0		4,000	80%	3,200	100	83.2	
4.8 Noodle Mf'g	0		7,000	0%	0	100	0.0		7,000	80%	5,600	100	0.0	
4.9 Furniture	0		5,000	0%	0	100	0.0		5,000	80%	4,000	100	0.0	
4.10 Iron Work	6		4,000	0%	0	100	0.0		4,000	80%	3,200	100	19.2	
4.11 BCS	11		1,500	0%	0	100	0.0		1,500	80%	1,200	100	13.2	
4.12 Weaving	4		5,000	0%	0	100	0.0		5,000	80%	4,000	100	16.0	
4.13 Water Pump	2		200	0%	0	100	0.0		200	80%	160	100	0.3	
Sub-total								0.0						578.3
5. Total														
5.1 1-1+2,3,4								3,024						1,563
5.2 1-2+2,3,4								3,844						2,178
6. Gross Total														
6.1 1-1+2,3,4	Including 5% of transfer loss							3,190	Incl. 5% transfer loss					1,650
6.2 1-2+2,3,4	Including 5% of transfer loss							4,050	Incl. 5% transfer loss					2,300

Source: The Study Team

The demand forecast for household use was calculated in two steps accounting for the increase in income and higher living standards due to electrification.

In the First Step, the electricity demand per household in Nyang Shwe Township during nighttime was estimated at 120 W in total at the current level in which three lighting of 30 W, one small radio of 10 W, and one TV of 60 W for 50% of the households, and the ratio of concurrent use (90%) were considered.

For the Second Step, the future nighttime demand was estimated by adding a 600 W-class electric cooker for 15% of the households, because survey results showed that the villagers listed a rice cooker as their second priority after lighting. Accordingly, the nighttime demand of 160 W per household was estimated..

Some households may not be able to access electricity due to their low income. Results of the field survey suggests that the threshold would be at a level of an annual income of K 100,000, and the percentage of the households with the ability to afford electricity is 87% in Southern Shan as shown in Table 2.2.2. This percentage was accounted for in the demand forecast.

Table 2.2.2 Household Affordability of Electricity (%)

Description	Shan South	Shan North	Kachin	Total
Un-electrified	86	82	93	87
Electrified	89	93	94	92
Average	87	84	93	88

Source: JICA Study Team

Assuming that demand in the other three sectors (public facilities, business and industry) remain unchanged, and adding 5% as distribution loss, the total power demand for all sectors was estimated as shown in Table 2.2.3.

Table 2.2.3 Summary Table for Power Demand Forecast(kW)

Situation	Consumer	Nighttime	Daytime
First step	Household (Step1-1)	2,459	410
	Public Institutions	359	394
	Business	206	181
	Industry	0	578
Total	Net Demand	3,024	1,563
Total Demand including 5% transfer loss		**3,200**	**1,700**

Situation	Consumer	Nighttime	Daytime
Second step	Household (Step1-2)	3,278	1,025
	Public Institutions	359	394
	Business	206	181
	Industry	0	578
Total	Net Demand	3,844	2,178
Total Demand including 5% transfer loss		**4,100**	**2,300**

Source: JICA Study Team

It is noted however, that the Second Step demand which adopts a 600 W-class rice cooker for 15% of the households, may be subject to the supply of the Project.

2) Willingness to Pay

Willingness to pay (WTP) for the initial connection fee is estimated at K 9,000 in the un-electrified villages and K10,000 in the electrified villages according to the social survey in Southern Shan.

Meanwhile, the willingness to pay for the monthly electricity tariff is estimated at K360 in both the un-electrified and electrified villages. With reference to the financial situation of the households shown in Table 2.1.2, the monthly amount seems to be affordable, although it is much higher than the average tariff of MEPE.

2.3 Development Concept

The development concept of the Heho Small Hydro Scheme is summarized as follows:

1) The Heho Small Hydro Scheme aims at the rural electrification of mainly Nyang Shwe Township including 23,552 households (population 153,000), but also the following options are conceivable:

Table 2.3.1 Development Option of Heho Small Hydro Scheme

	NyaungShwe Township around Inle Lake	Mobye	Heho Aungbang Pindaya	Grid Connection	Installed Capacity
Option-1	○	○		○	8MW
Option-2	○			○	8MW
Option-3	○		○		8MW
Option-4	○	○			4MW

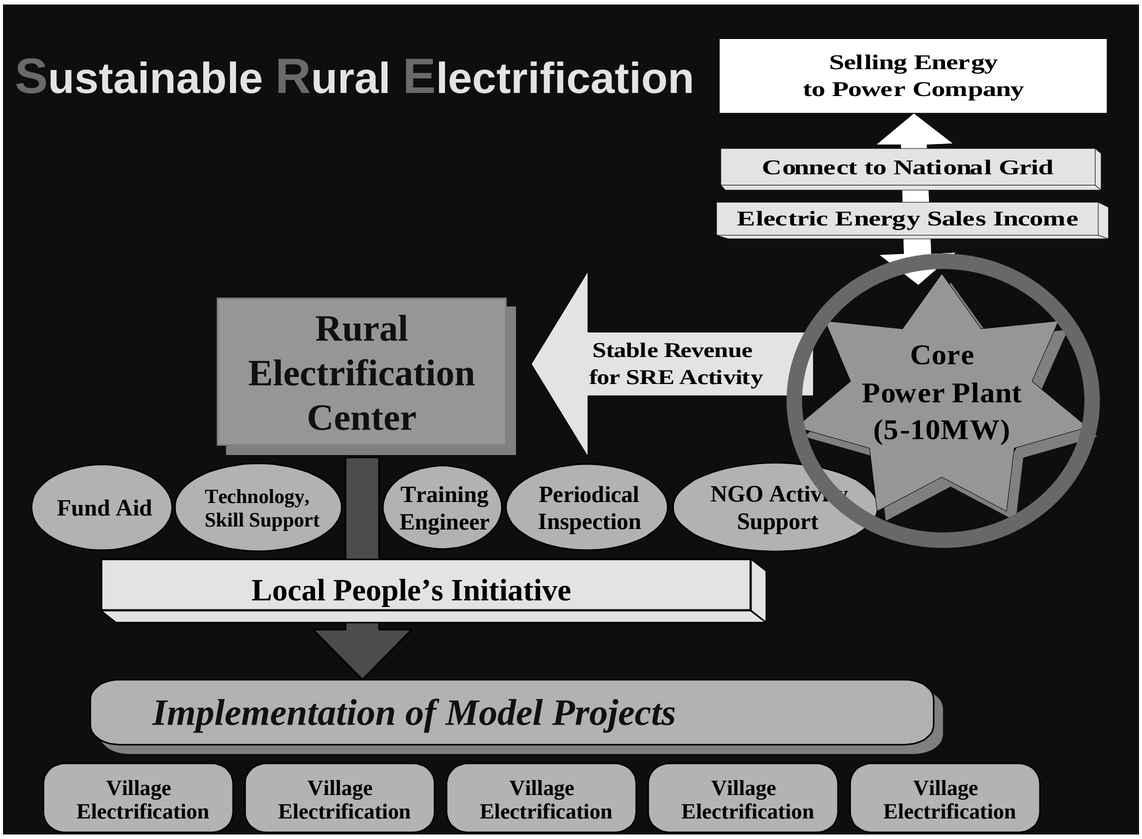
Source: JICA Study Team

In this Study, Option-1, which will distribute electricity to the whole Nyang Shwe Township and the surplus energy in the rainy season to the National Grid, was examined. For implementation of the Project, there is another option to supply the electricity to Southern Shan in combination with the existing Zauggyi I and II Power Station by separating these from the Grid.

2) For the development of the hydro-potential of Negya Chaung to the maximum extent, river channel storage by provision of gated structures on the intake weir is worth studying for the peak load operation during the dry season.

3) The Project is regarded as a model project for the small hydropower involving tunneling works that may be implemented by the MEPE workforce with assistance of foreign tunnel experts. This will pioneer small hydropower development with tunnel in Myanmar.

4) The Heho power station is expected to play a role as the Core Power Plant for the Sustainable Rural Electrification by selling the energy as illustrated on Figure 2.3.1.



Source: JICA Study Team

Figure 2.3.1 Concept of Sustainable Rural Electrification

The following benefits are expected by implementation of the Heho Scheme:

a) To supply electricity to the rural areas of Nyang Shwe Township where the present electrification ratio is only 0.4% for 21,690 households.

b) To improve the living standards of the villages to be electrified.

c) To raise the production of local industries.

d) To transfer tunneling technology.

e) To save the consumption of the imported fuel that contributes to the national economy.

f) To reduce the emission of carbon dioxide.

2.4 Basic Design and Cost Estimate

2.4.1 Introduction

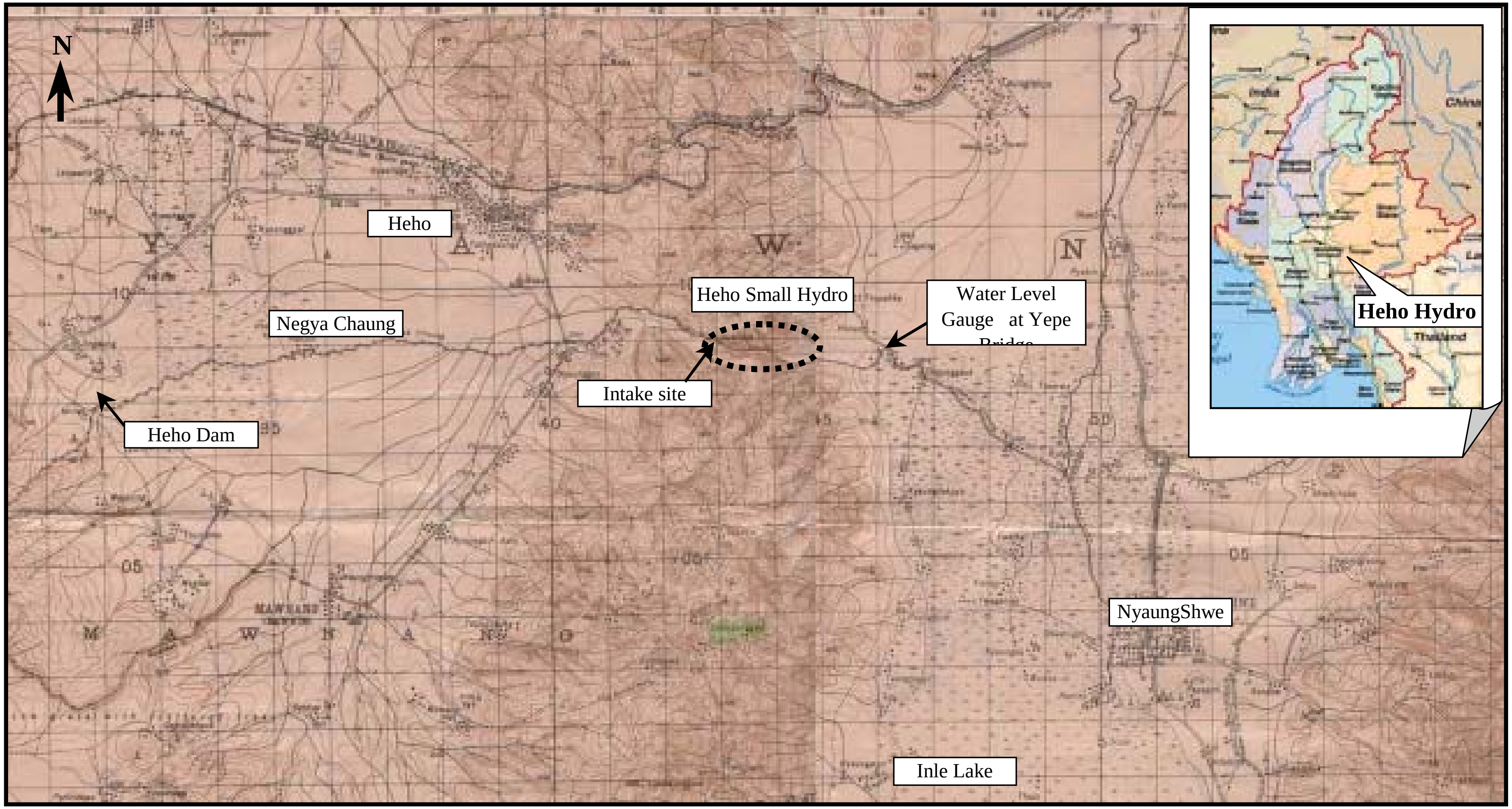
Heho small hydro project site is located 5 km to the southeast of Heho in Kalaw Township in Southern Shan. The Project aims at generating hydropower by harnessing a gross head of 229.0 m and an average discharge of 4.1 m^3/s of the Negya Chaung which runs through the midst of the Heho plain and Shwenyaung Valley, and eventually flows into the northern part of the Inle Lake.

The Negya Chaung has a catchment area of 249 km^2 at the proposed intake site just upstream of the cascades. The main source of the Negya Chaung are springs at the foot of Thigaungtaung. The Heho Dam located upstream of the Project site is an earth fill type dam with a capacity of 630,000 m^3 and was constructed to collect the spring flow to supply irrigation, but has no substantial function for flood control.

The location of the Project site is shown on Figure 2.4.1. The proposed intake site is located just upstream the of cascades of the Negya Chaung at N20 ° 42’ - E96 ° 51’. An existing farm road from Taunzaung village near Heho would be available for the access during and after construction to the intake site by reforming it for a stretch of about 3.5 km. For access to the powerhouse, reformation of a footpath of about 1km long to a motor road is required for construction and operation. The footpath branches from Heho-Kaungdaing Road running along the west side of the Inle Lake at Yeype Village.

There are two alternatives for the Project layout; 1) the left bank scheme, and 2) the right bank scheme. Both alternatives were equally examined in this Study through hydrological, geological, and topographic surveys. After thorough investigation and basic design of both plans, the right bank plan was selected due to its superior topographic and geological conditions.

It is recommended that discharge measurements of Negya Chaung be conducted continuously for the further study to be followed, since its flow fluctuates widely from season to season and from year to year. The Negya Chaung has a high potential for hydropower development, but the river water needs to be shared between irrigation use and the hydropower generation. Therefore, it is essential for the study to continue the measurement of the available discharge at the intake site.



Source: JICA Study Team

Figure 2.4.1 Location Map of Heho Small Hydro Scheme

2.4.2 Hydrological Analysis

1) Hydrological Data Collected and Measured

The following hydrological data were collected:

- Daily water level at Yeype Bridge on Kaungdaing Road from 4/Aug/98 to 22/Dec/01
- Monthly Inflow into Heho Dam from Jan/66 to Dec/71 (MEPE Report)
- Monthly Inflow into Heho Dam from Jan/96 to Jun/01 (MEPE Report)
- Daily Inflow into Heho Dam and Outflow from Heho Dam from 1/Jan/97 to 30/Jun/01(Irrigation Department)
- Daily Rainfall data in Heho from Jan/99 to Sep/01 (Irrigation Department)

The Study Team carried out the following measurements:

- Discharge measurement at Intake site
- (24/May/01 - 07/Jun/01, 20/Sep/01, 23/Nov/01)
- Discharge measurement at Yeype Bridge
- (28/Feb/01, 26, 30/May, 06, 07, 23/Jun, 19, 20/Sep/01, 23/Nov/01)

The measurement results are shown in Appendix-B2

2) Available Discharge

There is no gauging station on the Negya Chaung near the intake site. The inflow data into Heho Dam (upstream of the intake site) and the water level data at Yeype Bridge (1.5 km downstream of the powerhouse site) are the only available long-term data. The discharge at Yeype Bridge was obtained by converting the daily water level using a rating curve that was established based on the relationship between the water levels and the discharge measured as shown in Figure 2.4.2.

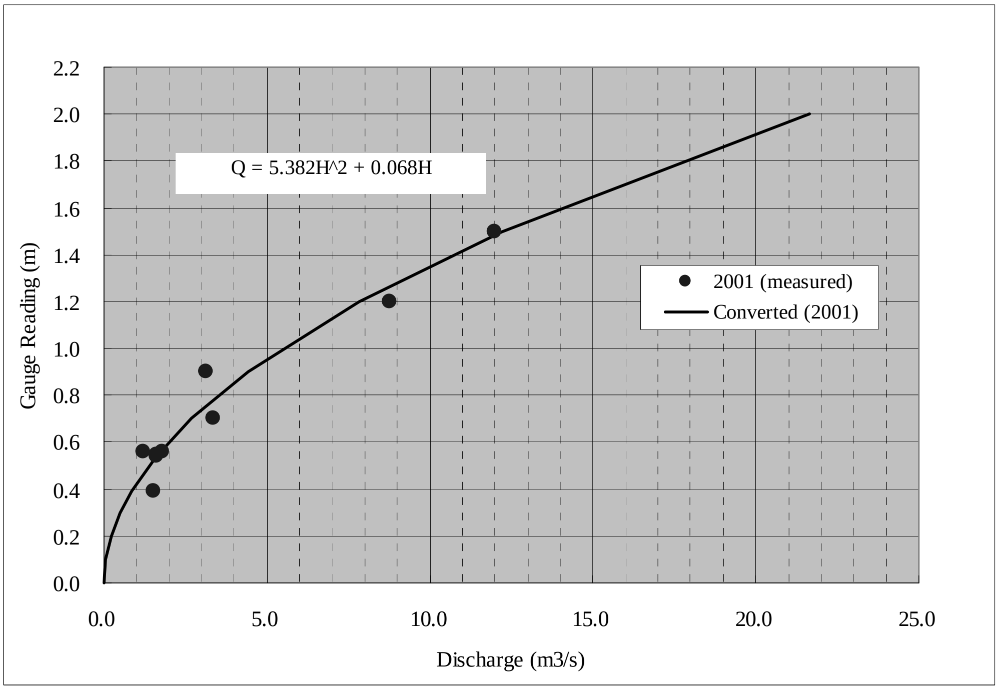
The average of inflow data of these two sites were computed as follows:

		Average discharge
Inflow into Heho Dam	1966-1971	4.25
	1996-2001	4.02
	1966-2001	4.14
Discharge at Yeype bridge	1998-2001	2.07

It can be seen from the above table that the average discharge at Heho Dam is double that of Yeype bridge. This phenomenon can be explained by the fact that the discharge record at Yeype bridge is only for three years, and during this period summer paddy was conducted as a trial causing the discharge especially in 2000 to decrease significantly.

The topographic condition shows that the catchment between the intake site and Yeype bridge is limited, and therefore the discharge record at Yeype bridge can be considered as available discharge for power generation. However it is important to take note that 2000 was an exceptional year, and that in the future, continuous discharge measurement at the intake site is prerequisite for the planning of the scheme.

For reference, the discharge rating curve at the intake site worked out from discharge measurement data and the flow duration curve at Yeype Bridge worked out from converted discharge data of 1999 and 2000 are shown in Appendix-B2.



Source: JICA Study Team

Figure 2.4.2 Discharge Rating Curve at Yeype Bridge

4) Design Flood

The design flood was examined by comparing the following methods:

Method-1: Calculation of a flood from probable rainfall of 100 year return period from observation records in the vicinity using the rational formula.

Method-2: Calculation of a flood from the maximum rainfall recorded in the vicinity by the rational formula.

Method-3: Calculation of a flood by converting the flood records in the vicinity by the ratio of catchment areas.

Method-4: Estimation of a flood by use of the Creager's curve.

Method-5: Calculation of a flood from the highest water level recorded at Yeype Bridge by using the rating curve based on water level and discharge measurements.

Method-6: Calculation of a flood from the highest water level at the Intake site calculated from the correlation of the water levels between Yeype Bridge and the Intake site and assuming uniform flow around the intake site

The results acquired by the six methods are shown in Table 2.4.1, whereas the calculation process is shown in Appendix-B2.

Table 2.4.1 Estimates of Maximum Flood by the Six Methods

Estimation Methods	Maximum floods (m^3/s)
1) Probable rainfall of 100 year return period	491
2) Recorded maximum rainfall	428
3) Flood records commensurate with catchment area	143
4) Creager's curve	660
5) Highest water level recorded at Yeype Bridge	21.7
6) Uniform flow at the Intake site	28.8

As shown the above, the six estimates vary over a wide range from the lowest at 21.7 m^3/s to the highest at 660 m^3/s.

Special characteristics of this area are responsible are as follows:

According to the discharge records between the inflow at Heho Dam and the discharge at Yeype during floods, there is a significant time lag, and this river has characteristics of slow rising and slow recession like a large river.

Swamps located upstream of the intake site would function as a reservoir, and the rapid changes observed in the water levels upstream of the intake site would have been absorbed. The downstream reaches then would only experience a change in the water level.

Therefore, at this stage of the Study it is thought that the methods 5) and 6) present more realistic values.

Finally, 29 m^3/s was adopted as the larger one to be conservative in determining the design flood at the intake site.

2.4.3 Topographic Conditions

The Shwenyaung Valley of Negya Chaung forms a deep ravine along the steep slopes of both banks. The topographic survey was carried out along both banks of the valley in June - July 2001, covering the Project areas of 132.7 ha on the left bank, and 53.6 ha on the right bank. Control points made of concrete were also established at three locations on the left bank. The mapping was made with a scale of 1:2,000 with 2 m contour intervals for the route selection of the waterway. In the detailed design stage of the Heho Small Hydro Scheme, the topographic survey of 1:500 scale will be required for the design of open structures such as intake, head tank, penstock, and powerhouse.

2.4.4 Geological Conditions

The geology of the Negya Chaung catchment area is covered by Paleozoic rocks and recent valley filled alluvial deposits. The rock groups found are (a)Shan Dolomite group, (b)Minbyataung group, and (c) Pindaya Group.

The Shan Dolomite group comprises of Nwabangyi formation, Thingaung taung formation, and Thisipin Limestone formation. Mibya taung group comprises of Nam Hsim formation, Wabya formation, and Linwe formation.

Pindaya Group Consists of Na-on, Wunbye and Lokpyin formations. The major rock types are brecciated limestones foraminiferal limestone facies, turbitic limestones, argillaceous limestones, cherty limestones, phacoidal limestones, shales, marls, sandstones, and laminated silty sandstones etc. Block faulting tilting and folding are rather intensive and erosion in the head reaches of some streams is very severe. The rolling hill areas are covered by terra rossa soil and in this area, the erosion is very intensive. Deeply eroded valleys have banks of over 40 feet in some places. In the flat area, swamps and lake deposits of dark gray silty clay with fresh water shells are observed. The alluvial fans and piedmont deposits are predominantly made up of yellowish brown clayey soil with rock pieces.

The Negya Chaung flows through the black alluvial soil and the drainage channels of the irrigated track drain into the Negya Chaung at a place about a mile from the fall. The black alluvial soil naturally slopes towards the main drainage or Negya Chaung. But in many areas close to the limestone hills, the alluvial soil slope towards the hill and the surface run off water sinks into the depressions or sink holes formed along the foot hills. Therefore, the proposal for constructing an impounding reservoir becomes out of the question. The leakage from the reservoir rim will be high and not possible to seal at reasonable cost.

1) Left Bank Scheme

At the project site the rock encountered are multicolor phacoidal limestones, argillaceous limestone, calcareous sandstone and buff color marl. The general strikes of these limestones are N-S to N20E and there are a couple of syncline and anticlinal folds between the Heho Plane and Shwenyaung valley. There are also strike faults and traverse faults across the ridge. A few circular and plane failures are also observed on the steep mountain slopes on either sides of the Negya Chaung.

Test pit No.1 is located at the intake portal site on the left bank of the Negya Chaung. From 0-2.5ft there is a top soil layer of dark brown silty clay with plant roots. From 2.5 to 7.0 ft there is slope wash materials of yellowish brown stiff clay, mixed with highly weathered limestone pieces between the 6 to 7 ft level. From 7 to 15ft is stiff clay, reddish yellow in color, slightly moist and very hard to excavate by hand tools. Highly weathered limestone pieces are found scattered at all levels indicating that the clays are developed from the slope wash materials. The clay becomes highly plastic after wetting. Phacoidal limestone outcrops are located about 50feet from this test pit on the higher slope. The bedding plane strikes N20 ° E and dips at high angle toward west. To open the tunnel portal, the location must be moved north from the test pit site. At the same time, the tunnel route seems to be oblique to the slope (not normal to the slope). Therefore, overburden thickness and asymmetry load at the portal area should be cross checked.

Test pit No.2 is only five feet deep and loose rock and weathered rock are found at 3.4ft level and from 4 feet to 5 feet the bedrock of limestone is encountered. It is not possible to dig with normal hand tools. The joints trend in a N-S direction with an 85^{o}dip towards the west. One set of joints is dipping east at 28^{o}. To have enough over head natural cover, the portal site should be moved towards the hillside.

There is a synclinal valley between the intake portal hill and the head tank site hill. The tunnel invert level must be lower than the valley floor and there must be enough rock cover. To meet these requirements the tunnel alignment must be moved to the west to avoid the valley crossing.

The Ordovician limestone exposed in the project area has a general trend in N-S to N20 ° E direction. The beds are generally thick (1 to 5ft). There is a large rock outcrop exposed at the proposed head tank site. A quick scanline survey of this exposed rock outcrop was made to estimate the rock quality designation (RQD) using the Priest and Hudson (1976) equations:

$$RQD = 100_e^{-0.1\lambda(0.1\lambda+1)} \text{…………………………..(1)}$$

With the values of λ in the range of 6 to 16/m, a good approximation to measure RQD values was found to be given by the linear relation

$$RQD = -3.68\lambda + 110.4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

The dip amounts are high, with a spacing of 0.65 ft to 2ft; the joint surfaces are rough and undulating to rough and stepped and generally dry or just moist. The uniaxial compressive strength (UCS) is estimated at between 70-110 kPa, these parameters give the rock mass rating of 60 to 80% which indicate good rock for tunneling.

The cohesion of the rock can be taken as between 250-350 kPa and friction angles as 35-40. Spot bolting and shotcreting will be necessary in the synclinal axis area.

The tentative head tank site has rock outcrops exposed all over the area. There will be no foundation bearing or stability problems at the site. Similarly, the test pit No.3 at the anchor block site will have rock foundation at 5 ft below the surface.

The upper half of penstock is located on a fairly steep slope. In the middle of the slope, a linearly continuous cliff is identified. The cliff elongates about 400 m across the slope. Compared to the slope up the cliff, a slightly gentler slope is observed down the cliff. Those indicate that the landmass down the cliff is a product of a large-scale mass movement (landslide) delineated by the cliff where a geologically weak band such as a fault zone may be located. A landslide mass in general lost its soundness due to disturbance. Although a test pit (TP-3) encountered a highly weathered and jointed ‘bedrock’, it is possibly a rock blocks in the landslide mass. The landslide mass, because of its fairly steep slope gradient, is likely to be reactivated by heavy rainfalls or earthquakes. Construction of the penstock on the landslide is not recommended.

The lower half of the penstock is to be buried in a rather gentle slope consisting of unconsolidated talus deposit. A test pit (TP-4) did not encounter bedrock down to 4.5 m below the ground surface. If the landslide mentioned above should reactivate, the slide mass will load pressing forces to the upper part of the talus deposits, which may result in a deformation of the talus deposits. Location a penstock structure in the talus is therefore not recommended.

At the power station site, test pit No.5 was excavated to 15 ft in depth. The overburden soil and reddish silty clay were found to a depth of 8.5 ft. Below this level 3 feet of highly weathered siltstone closely jointed, with yellow color, moist and stiff. It is followed by moderately to slightly weathered yellowish white siltstone to the final depth of 15 ft. The rock is dry and dense, very hard to excavate by hand tools.

Close to this test pit and in the stream banks phacoidal limestone and sandy limestones are exposed. There is no groundwater in the test pit and dry siltstone will form the foundation rock for the proposed powerhouse.

In the study of the proposed reservoir area, many depressions and sinkholes are observed along the contact between the alluvial soil and the reservoir rim rock outcrops.

The diversion weir should be sited on the upstream side of the gauging site, where the stream bed level is higher than the fall area. In this place, the height of the weir will be less than the fall area site.

The pondage area will be on the left bank in the vicinity of the gauging site. The top soil will be about 10 to 12 feet thick and probably follow by tufa or the clayey slope wash materials as the foundation.

Log data and photographs of the test pits are shown on Appendix B-5.

2) Right Bank Scheme

Test pit No.1 near the gauging station is entirely in the alluvial deposit. The five gray ashy color silty paleo-soil layers are noted in this test pit, suggesting that there are at least six times of deposition of eroded tuffaceous sediment and a break in deposition. During these break in deposition, gray ashy solid layers are developed. These paleo-solid layers are found as horizontal bed (at least in the test pit). The tuffaceous sand layers in between these paleo-solid layer are soft and relatively with little or no cohesion but poorly cemented. Excavation by hand tools is easy. The groundwater level at 14 feet is probably equal to that day's stream level. It will be very helpful to find out the direction of groundwater and the groundwater movement by installing a couple of shallow piezometers. There are chances of underground flow towards the fault zone located at the foot of the mountain range (indicated by sink holes or depressions). Therefore the leading canal between the diversion structure and intake portal of the tunnel should be lined with concrete. Similarly, the pond formed by the construction of the diversion structure should be lined with clay blanket or geo-textile.

The upstream portal is located at the sub-montane of a steep slope. Excavation in unconsolidated materials will be minimal and the tunnel portal can be aligned normal to the slope.

The downstream portal and the regulation pond are located on a steep hillside. Smooth sloping and steep gradient suggest that bedrock will be available at a shallow depth. The tunnel portal and the larger part of the regulation pond can be constructed on the bedrock. Small-scale excavation may be necessary for construction of the portal and the pond. Due to the possible thin decomposed material on the slope surface, no slope instabilities are anticipated.

The penstock will be located on a steep slope below the regulation pond. No features indicating slope instabilities are observed. Bedrock foundation will be available at a shallow depth. No particular geological problems on the steep slope are identified. Down the slope, the penstock will cross the influx of a fairly large valley. At this point, debris deposits are identified. As this type of debris will recur when heavy rainfalls, the penstock structure should be protected from such possible debris flow.

Test pit No.2 is located in a sugar cane plantation. The soil and boulders/ pebbles indicated that the site is on slope wash materials. At the bottom of the test pit, a layer of closely packed limestone boulders are observed. Probably the bouldery small stream on the south of the pit once flow over the pit area before shifting to its current alignment. A small spring located on the west indicates that there is a lineament along the stream direction. The site may be shifted on to the spur north of the test pit. The spring identified upstream of the test pit seems to be sacred to the villagers. The spring is considered to flow out through the debris deposit as saphenous water flow. Disturbance (such as excavation) of the debris deposit at the influx area may adversely affect the spring.

Test pit No.3 is located on the left bank of a stream flowing into the Negya Chaung. Close to the pit and in the stream bed, there is a fall and secondary lime crust covers all the outcrops. There is no chance of founding the powerhouse on sound bed rock at this test pit site because the pit bottom is still higher than near by stream bed. Absence of the groundwater table in the pit support this view. If the site be shifted towards west for about 20 meters, the powerhouse will be on the limestone bedrock. But the stability of the slope of the mountain on the west should be studied. The bending tree up on that slope indicated that there is some shallow soil creeps on this steep slope. Some precautionary measures like benching and stabilization of nearly cut faces with rock bolts etc. should be considered.

Log data and photographs of the test pits are shown in Appendix B-5.

2.4.5 Comparison of Left Bank Scheme and Right Bank Scheme

Topographic survey was conducted for both the left bank scheme (132.7 ha) and the right bank scheme (53.6 ha). Based on the topographic map of scale 1:2,000 (contour interval 2 m) produced, basic design of the both schemes were conducted. The basic design of the two scheme are shown in the Drawings section of this report, whereas a comparison of the salient features are shown below.

		Left Bank Scheme	Right Bank Scheme
Conduit length	(m)	35.79	38.28
Tunnel length	(m)	944.77	1,218.48
Penstock length	(m)	766.43	771.46
Full supply water level at intake	(m)	1,134.00	1,134.00
Full supply water level at head tank	(m)	1,132.75	1,132.62
Powerhouse ground elevation	(m)	918.00	906.00
Turbine center level	(m)	917.13	905.05
Tailwater level	(m)	915.53	902.95
Flood water level of Negya Chaung	(m)	914.00	901.00
Gross head	(m)	218.47	228.95
Head loss	(m)	5.43	5.07
Effective head	(m)	213.04	223.88
Installed capacity	(MW)	8.0	8.0
Design discharge	(m^3/s)	4.5	4.3

By adopting the monthly mean discharge near Heho Dam as the maximum design discharge of the Project, generation of 8MW is possible. Under this condition, the basic design of both the alternatives was conducted.

The right bank scheme has a tunnel length approximately 270 m longer than the left bank scheme, but it has the topographic advantage of having more head. Other than this, there are no major differences in the aspects of hydraulics and design between the two schemes. However, on the hill of the penstock of the left bank scheme, there exists a large landslide, whilst for the right bank scheme no such geological problem was observed.

In view of the above, the right bank scheme was selected in this Study as being more feasible.

2.4.6 Basic Planning for Power Generation

Although basic planning was conducted for both the right bank scheme and the left bank scheme, only the results of the right bank scheme, that is considered more feasible, will be explained in this report.

1) Power Output

The power facilities have been designed in consideration of the possibility of connection to the National Grid which extends in the Project area by the 66kV line running between Kalaw and Taunggyi. Accordingly, the installed capacity was studied not only to meet the demand in the target areas but also to feed surplus energy to the Grid.

The gross head for the right bank scheme was set at 228.95 m from the topographic conditions, and effective head was calculated to be 223.88 m as shown in the Appendix B-3.

A maximum design discharge of 4.3 m^3/s was adopted at this stage of the Study for the following reasons:

a) To develop the hydro-potential of the Negya Chaung in the rainy season to the maximum feasible extent by providing 2 units of 4.0 MW turbine which corresponds to the discharge slightly higher than the monthly mean discharge of 4.2 m^3/s near the Heho Dam from 1966 to 1971 and from 1996 to 2001.

b) To meet the demand of the target area of 3.2-4.0 MW even in the dry season by 1 unit operation with river channel storage.

c) To utilize the river discharge ranging from the average to the drought discharge for efficient power generation.

The combined efficiency of 0.85 was applied based on the standard efficiency for 5 ~ 10 MW-class turbines and generators:

Turbine	0.89
Generator	0.96
Combined efficiency	0.89 x 0.96 = 0.85

The installed capacity was estimated as follows:

P = 9.8 x 223.87 x 4.3 x 0.85 = 8,000 kW (4,000 kW x 2 units)

2) Power Generation

Simulation for power generation was conducted assuming two conditions; i) run-of-river operation and ii) river channel storage using daily regulating operation during the dry season. The calculation of power generation is shown in Appendix B-4.

a) Run-of-River Operation

The run-of-river operation was studied as shown in the following table. The calculation output for Case-1 is shown in Figure 2.4.3.

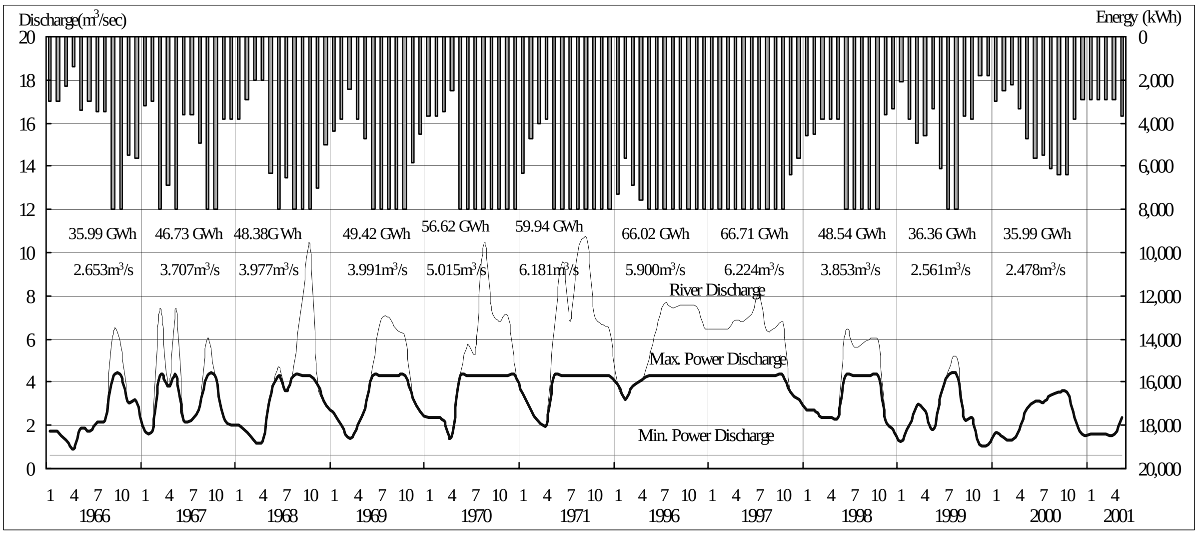
Case-1

Discharge data	Monthly mean discharge measured near Heho Dam from 1966 to 1971, and from 1996 to 2001
Average output	5,712 kW
Annual energy	47.6 GWh
Plant factor	67.8%

Case-2

Discharge data	Daily discharge measured at Yepe Bridge from Aug. 1998 to Sep. 2001
Average output	3,137 kW
Annual energy	26.3 GWh
Plant factor	37.3%

Notes : Max. turbine discharge : 4.3 m^3/s for 2 units
Min. turbine discharge : 0.645m^3/s for 1 unit (2.15 x 30%)



Source: JICA Study Team

Figure 2.4.3 Calculation of Power Output (Case-1)

It is noted that:

i) Discharge measurement at the intake site is required over several years in order to elaborate the study by assessing the available discharge for the power generation.

ii) The irrigation water consumption and the inflow from the tributaries between the Heho Dam and the intake site were not considered in Case-1.

iii) The experimental trial for the special crops in the Heho Plain was conducted in the year 2000, which resulted in drying up of the Negya Chaung flow.

b) River Channel Storage Operation

The river storage operation, which will generate the peak power during the dry season to supply the target area with electricity commensurate with the demand, was studied based on the following conditions:

i) The river storage operation is limited only for the dry season from November to April when no floods are anticipated.

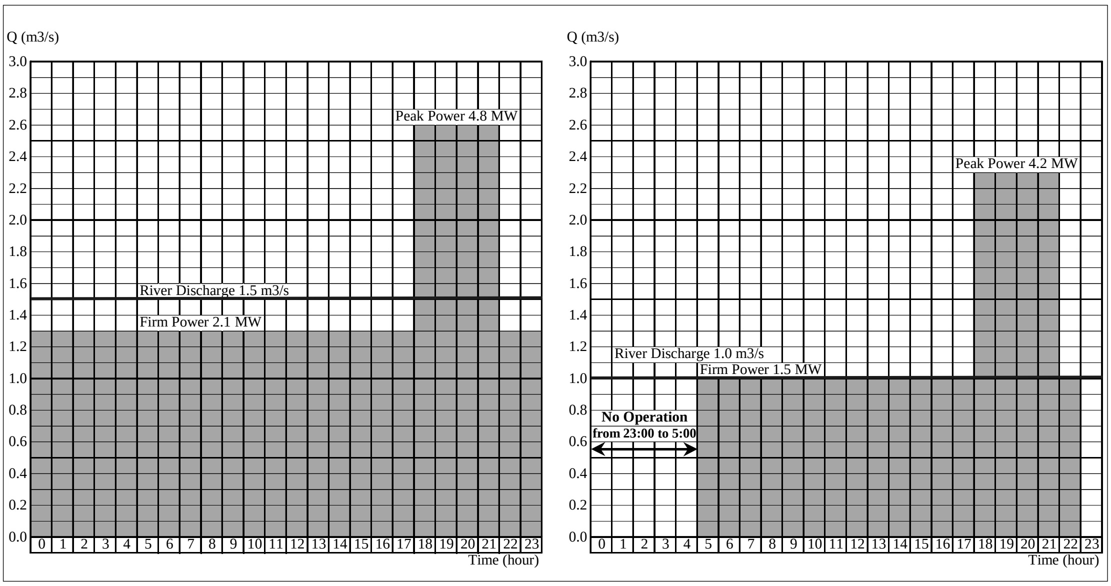
ii) The gates 2.0 m high on the intake weir are to be operated to regulate the river discharge. The river storage volume was calculated to be 18,800 m^3 assuming the river slope of 1/500 and width of 12m.

The following table shows the outcome of the study:

River Flow (m3/s)	Firm Power			Peak Power		
	Q_{firm} (m3/s)	Output (kW)	Duration	Q_{peak} (m3/s)	Output (kW)	Duration
1.5	1.28	2,100	22:00 ~ 18:00	2.59	4,800	18:00 ~ 22:00
1.2	0.98	1,500	22:00 ~ 18:00	2.29	4,200	18:00 ~ 22:00
1.0	1.00	1,500	5:00 ~ 18:00	2.31	4,000	18:00 ~ 22:00

It can be seen that power output of 4.0 MW for 4-hour peak and 1.5 MW for firm power is possible even with the discharge of 1.0 m^3/s in the dry season.

The power generation pattern under river channel storage operation is shown in Figure 2.4.4, whereas the calculations are shown in Appendix B-4.



Source: JICA Study Team

Figure 2.4.4 Power Generation Pattern under River Channel Storage Operation

2.4.7 Design of Civil Structures

1) Layout

The main components of the civil structures consist of intake, de-silting basin, headrace tunnel, head tank, penstock, powerhouse, and tailrace channel. Judging from the topographic and geological conditions formed along the Shwenyaung Valley, it was concluded that a tunnel-type headrace is indispensable for the Project An open-type headrace channel would not be practically feasible along the steep and deep valley as it would require large-scaled rock excavation.

Two alternative layouts for the Project were examined to compare the feasibility:

a) Alternative - A : Left bank plan

Gross head	:	218 m
Headrace Tunnel length	:	945 m
Penstock length	:	766 m

b) Alternative - B : Right bank plan

Gross head	:	229 m
Headrace Tunnel length	:	1,218 m
Penstock length	:	771 m

After thorough investigation, the right bank scheme was selected as being more feasible as described in Sub-section 2.4.5. Therefore, although design of civil structures were conducted for both schemes, only that of the right bank scheme will be introduced in this report.

2) Intake

The intake is located just upstream of the beginning of the Negya Chaung Falls. The intake consists of a movable weir, sand flushing gate adjacent to the weir, inlet of waterway, de-silting basin with sand flushing gate, side spillway, and river outlet. The features of each structure are as follows:

Movable weir	Fixed weir 3.0 m high x 10m wide	
	Fixed weir crest elevation 1,134.00 m	
	Gate 2.0 m high x 5.0 m wide x 2 nos.	
	Gate crest elevation	1,136.00 m
	Full supply water level	1,134.00 m (gate opened)
	Full supply water level	1,135.50 m (gate closed)
	Flood water level	1,137.00 m (design flood of 28m^3/s)

Sand flushing gate	2.0 m high x 2.0 m wide to flush out sediments in front of intake structures, gate sill EL. 1,130.79 m.
Inlet	Rectangular shape 4.0 m wide x 1.7 m deep under FSWL with a velocity of 0.63 m/sec. Skimmer wall, trash racks, and intake gate 2.0 m wide x 2.0 m high are equipped.
De-silting basin	Rectangular shape 6.0 m wide x 22.5 m long x 2.5 m deep under FSWL deducting the sedimentation, with minimum velocity of 0.21 m/sec. Side spillway 14.5 m length, crest EL. 1133.900 m
Intake conduit	Rectangular shape 2.0 m wide x 2.0 m high x 36.5 m long, 1.45 m deep under FSWL with a velocity of 1.48 m/sec.

3) Headrace Tunnel

The headrace tunnel is a free-flow-type with D-shaped section. Concrete lining would be adopted in principle, which may be substituted by shotcrete depending on the rock conditions encountered. The main features of the headrace tunnel are summarized below:

Tunnel	Concrete lined, 2.0 m high x 2.0 m wide x 1,218 m long D-shape section (upper circular, lower rectangular section) Slope 1:1,000 Normal water depth of 1.58 m under Q = 4.3m^3/s and n = 0.016

4) Head Tank

The head tank is provided at the location between the headrace tunnel and the penstock for adjustment against load fluctuation having a capacity of 272 m^3 to supply water for about 1 minute. It has a function also for sand trapping and flushing. The location was selected on a ridge with stable rock foundation to give the best positioning for the penstock alignment.

The increase in water level at the head tank due to the water hammer effect can be avoided by controlling the deflector on the Pelton turbines. Therefore, the spillway of the head tank was omitted in the design.

5) Penstock

ϕ1,500 mm diameter of penstock pipe was selected at this stage from the averaged range for practical application. One line of penstock of 1,500 mm diameter 771 m long extends from the head tank to the lower horizontal portion. Then it bifurcates into two branch pipes of ϕ700mm diameter towards each of the turbines with the length of 12 m each. The upstream section 396 m long is of an exposed type supported by anchor blocks at the bend, and by saddle piers at 6 m interval.

At the point where the hill makes a transition from steep to gentle, the penstock crosses an influx of a fairly large valley and there is also a spur on the right bank of the penstock line. From these topographic conditions, in order to avoid damage from possible debris deposits and landslides triggered by heavy rainfall, the lower section of the penstock 375 m long was designed as an embedded type.

6) Powerhouse

The powerhouse is located at the end of the penstock slope at EL. 906.00 m on the stable foundation near the downstream end of the Negya Chaung Falls. The tail water level is set at EL. 902.95 m, taking into account the flood water level at EL. 901.00m estimated from the trace of the flood observed on 13 August 2001.

The powerhouse accommodates 2 units of the generating equipment of 4.0 MW each. The outdoor switchyard adjoining the powerhouse accommodates 2 units of transformers (5 MVA - 33/11kV), and switchgears (33 kV x 1, 11 kV x 4).

The concrete tailrace channel, with a rectangular shape 2.0 m wide extending for a length of 28 m, will direct the water discharged from the turbines back to the Negya Chaung.

2.4.8 Hydro-mechanical Equipment

1) Movable weir

Two sets of gates 2.0 m high and 5.0 m wide will be provided above the fixed weir for river channel storage during the dry season.

2) Intake trashrack

One set of trashrack will be provided at the intake piers covering the whole intake opening with 4.0 m wide and 5.7 m high to prevent matter injurious from intruding the de-silting basin.

3) Intake gate

One set of intake gate 2.0 m high and 2.0 m wide will be provided to control the discharge required for power generation and to maintain the intake facilities and de-silting basin.

4) Scouring sluice gate

A scouring sluice gate will be provided on the left side of the intake weir to flush the sediment and/or floating debris through the weir. The gate will be operated by manual hoisting device. The dimension of the gate is planned as 2.0 m wide and 3.0 m high.

5) Sand flushing gate at de-silting basin

A sand flushing gate 1.0 m wide and 1.0 m high will be provided at the bottom of the de-silting basin to flush the sediment for maintaining the basin. The gate will be operated by manual hoisting device.

6) Trashrack at the head tank

One set of trashrack will be provided at the inlet of the penstock to prevent matter injurious from intruding the penstock and turbines. The trashrack, having a width of 6.0 m will be set at an inclination of 1:0.3, having approximately 3.7 m in slant height.

7) Sand flushing gate at head tank

A sand flush gate of 0.8 m width and 0.8 m height will be provided at the bottom of the head tank to flush the sediment. The gate will be operated by a manual hoisting device after stopping power generation.

Current design data for the hydro-mechanical equipment to be provided are summarized in Table 2.4.2.

Table2.4.2 Major Design Data of the Hydromechanical Equipment

Items	Major Design Data
1)Penstock	Dia. : ϕ1,500mm (main pipe) to ϕ700mm (branched pipe) Length :Approx. 771m Max. Static Head: 228.95m Water Hammer:30% of Max. Static Head (assumed)
2) Movable weir gates with hoist	Quantity: 2 sets Width: 5m Height: 2m
3)Trashrack at intake	Quantity: 1 set Width: 4 m Slant Height: Approx. 5.9 m (1:0.25)
4)Intake gate	Quantity: 1 set Width:2 m Height:2 m Design Head : Approx. 4.7 m
5)Scouring sluice gate	Quantity: 1 set Width:2 m Height:3 m Design Head : Approx. 3 m
6)Sand flushing gate at de-silting basin	Quantity: 1 set Width:1 m Height:1 m Design Head : Approx. 7.4 m
7)Trashrack at head tank	Quantity: 1 set Width: 6 m Slant Height: Approx. 3.70 m (1:0.3)
8)Sand flush gate at head tank	Quantity: 1 set Width: 0.8 m Height:0.8 m Design Head : Approx. 4 m

Source: JICA Study Team

2.4.9 Electrical Works

1) Power Distribution System

Electric power for the Project area will be supplied from the Heho Hydroelectric power station. The power in the Project area will be distributed to the 400-230 V, three-phase-4-wires system through an 11 kV/400 V distribution transformer and 33/11 kV substation. A schematic diagram of the power distribution system for the Project area is illustrated in Figure 2.4.4.

2) Electric Power Demand Forecast

The relationship among generating capacity, maximum power demand and losses of lines is shown below:

Generating capacity of Heho Power Station = Maximum power demand in Project area + Losses of Lines

3) Electricity Facilities

The major electricity facilities needed to supply electricity to the Project area are shown in Tables 2.4.3 to 2.4.6.

Table 2.4.3 Electricity Facilities for the Power Station

	Description	Q'ty
i)	Generating equipment including auxiliary equipment and materials.	2 units
ii)	11 kV Switchgear Cubicle	4
iii)	11 kV House Service Cubicle	1
iv)	Diesel Engine Generating Equipment including Auxiliary Equipment	1
v)	Control Panel	5
vi)	Main Transformer Rated Capacity : 5 MVA Rated voltage : 11/33 kV	2
vii)	33 kV Switchgear	1 lot
viii)	Miscellaneous Materials	1 lot

Table 2.4.4 Transmission and Distribution Lines

	Description	Q'ty
i)	Power Conductor	
	ACSR - 240 mm^2	280 km
	ACSR - 80 mm^2	87 km
	ACSR - 35 mm^2	700 km
	HDCC - 22 mm^2	1,160 km
	HDCC - 8 mm^2	390 km
ii)	Concrete Pole	
	12 m pole, 33 kV line use	2,500 Nos
	10 m pole, 11 kV line use	5,900 Nos
	8 m pole, 4 V line use	13,000 Nos

Description	Q'ty
iii) Insulator and Fitting	
Pin type insulator, 33 kV use	8,000
Suspension insulator set, 33 kV use	2,700
Pin type insulator, 11 kV use	18,700
Suspension insulator set, 11 kV use	6,400
Pin insulator, L.T. use	52,000
Shackle insulator, L.T. use	8,000
iv) Other Materials	1 lot

Table 2.4.5 Substations

Description	Q'ty
i) 4,500 KVA Substation - 4,500 KVA Transformer – 1 Rated voltage : 33/11 kV - 33 kV Switchgear, 1 cct - 11 kV Switchgear, 4 ccts	2 station
ii) 1000 KVA Substation - 1000 KVA Transformer – 1 Rated voltage : 33/11 kV - 33 kV Switchgear, 1 cct - 11 kV Switchgear, 4 ccts	2 station

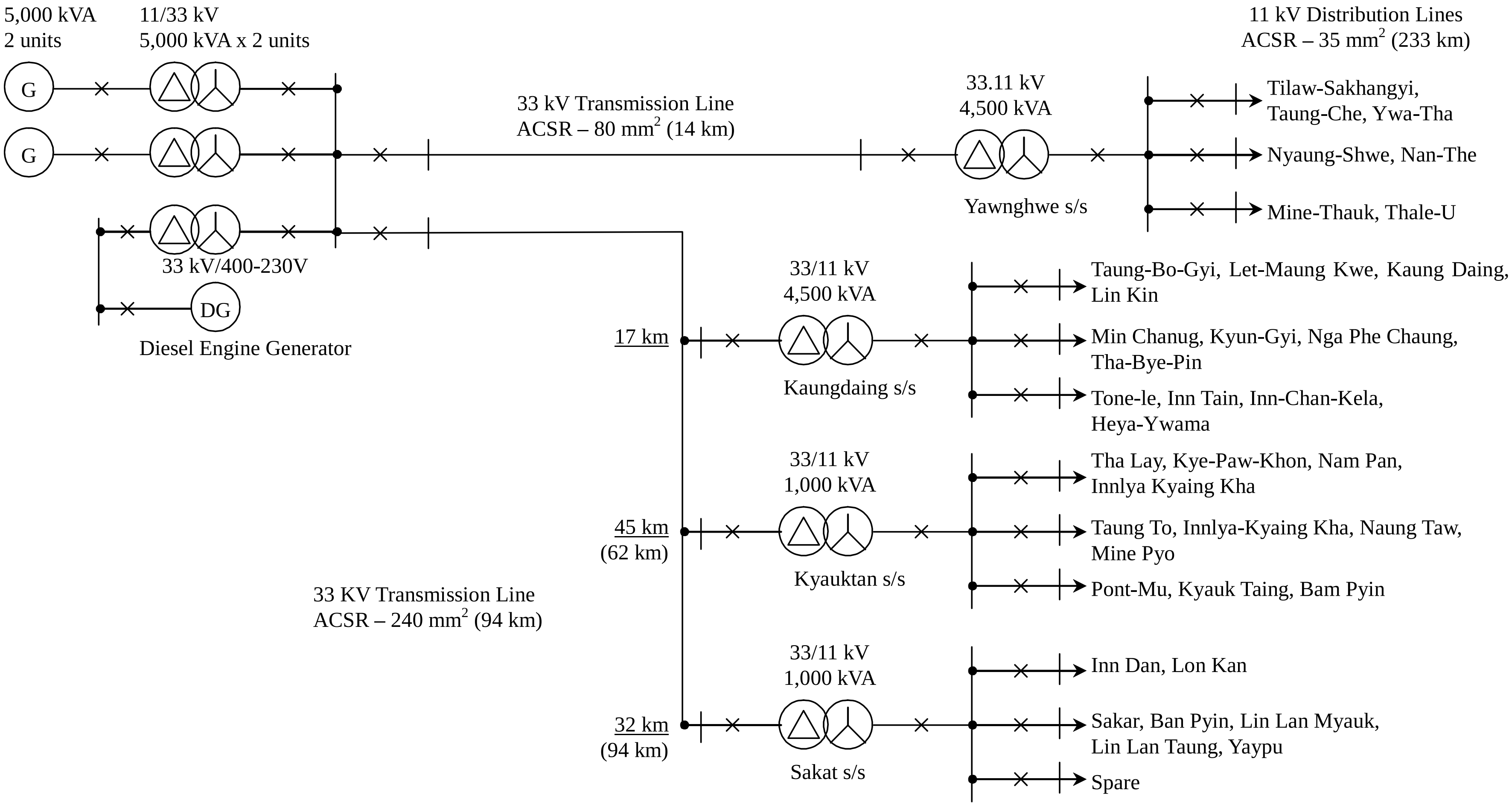
Table 2.4.6 Distribution Transformer Stations

Description	Q'ty
i) Distribution Transformer Capacity : 50 kVA~250 kVA Rated voltage : 11 kV/400-230 V	40 Nos
ii) 11 kV Switchgear 1 cct	40 Nos
iii) Distribution Box Rated Voltage : 600 V MCCB, Main : 1 Nos NFB : 4 Nos	

Consumer Connection Cable 1 lot

Lighting Fixture for Outdoor 1 lot

Figure 2.4.5 Power Distribution System



Source: JICA Study Team

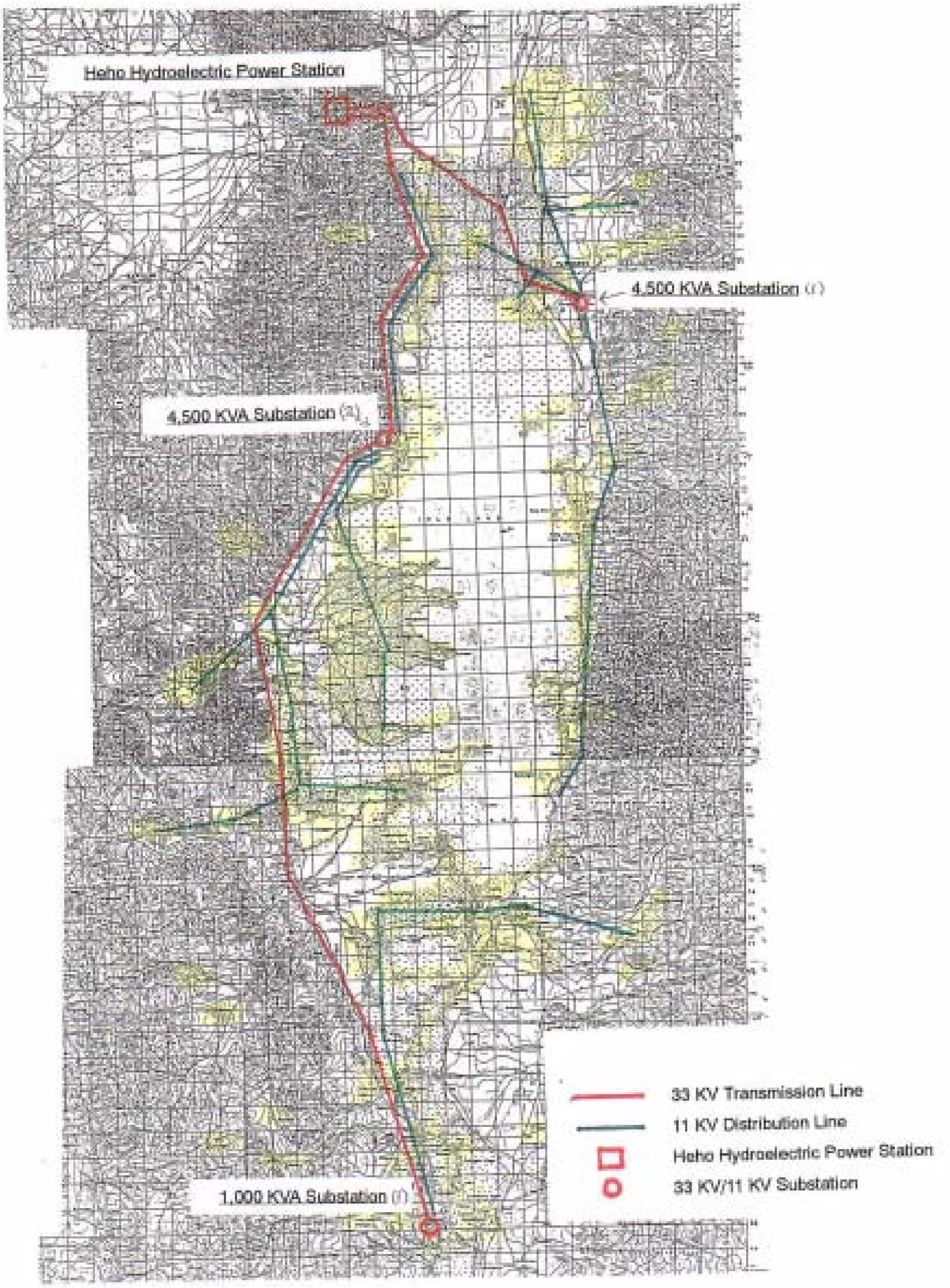
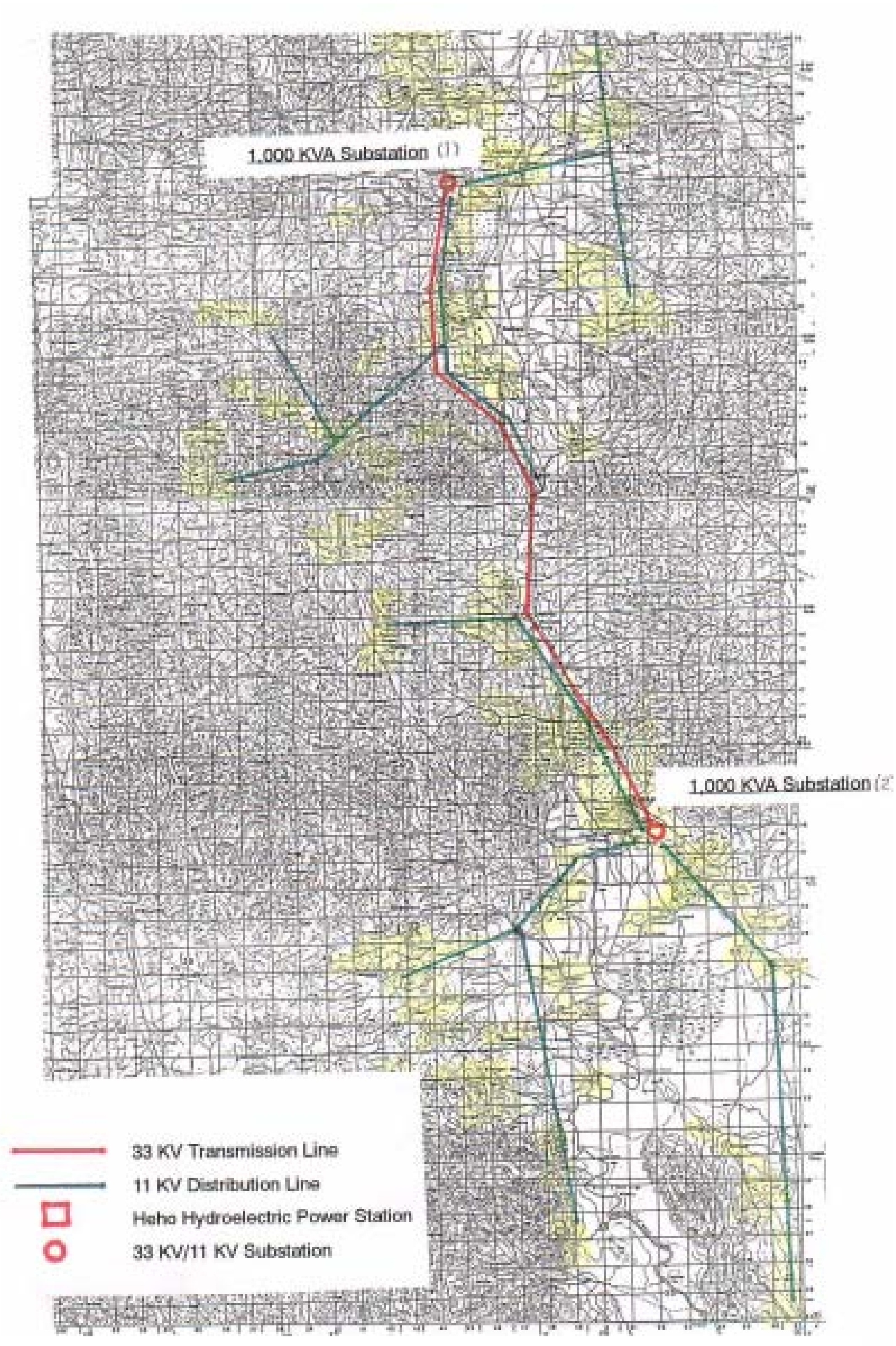


Figure 2.4.6 Route Map of 33kV Transmission Lines between Heho Power Station and 33/11kV Substations (1/2)



Source: JICA Study Team

Figure 2.4.7 Route Map of 33kV Transmission Lines between Heho Power Station and 33/11kV Substations (2/2)

Table 2.4.7 Supply List of Equipment and Materials

	Q'ty	Myanmar	Japan	Other
1. Heho Power Station				
i) Turbine	2 units	-	○	-
ii) Generator	2 units	-	○	-
iii) Governor Cabinet	2	-	○	-
iv) Generator Control Panel	2	-	○	-
v) Main Valve	2	-	○	-
vi) 11 kV Switchgear Cubicle	4	-	○	-
vii) House Service Cubicle	1	-	○	-
viii) Diesel Engine Generator Set	1	○	-	-
ix) Diesel Engine Control Panel	1 unit	○	-	-
x) Control Panel	5	-	○	-
xi) 5 MVA Transformer 33/11 kV	2 units	○	-	-
xii) 33 kV Switchgear	1 lot	○	-	-
2. 33 kV, 11 kV and L.T. Lines				
i) Conductor, ACSR, 240 mm^2	280 km	○	-	-
ACSR, 80 mm^2	86	○	-	-
ACSR, 38 mm^2	700	○	-	-
HDCC, 22 mm^2	1,160	○	-	-
HDCC, 8 mm^2	390	○	-	-
ii) Concrete Pole, 33 kV use	2,500 Nos	○	-	-
11 kV use	5,900	○	-	-
400 V use	12,960	○	-	-
iii) Insulator, 33 kV Pin Insulator	8,000	○	-	-
33 kV Suspension Insulator	2,700 sets	○	-	-
11 kV Pin Insulator	18,700	○	-	-
11 kV Suspension Insulator	6,400 sets	○	-	-
L.T. Pin Insulator	52,000	○	-	-
L.T. Shackle Insulator	8,000	○	-	-
iv) Other Materials	1 lot	○	-	-
3. Substation				
i) 4,500 KVA Substation	2 units	○	-	-
4,500 KVA Transformer 33/11kV		○	-	-
33 kV Switchgear (1 ccA)		○	-	-
11 kV Switchgear (4 ccAs)		○	-	-
ii) 1,000 KVA Substation	2 units	○	-	-
1,000 KVA Transformer 33/11kV		○	-	-
33 kV Switchgear (1 ccA)		○	-	-
11 kV Switchgear (4 ccAs)		○	-	-
4. Distribution Transformer Station				
i) 50~250 KVA Transformer 11 kV/400V	40 units	○	-	-
ii) 11 kV Switchgear (1 cct)	40	○	-	-
iii) 400 V Switchgear	40 sets	○	-	-
5. Consumer Connection Cable	1 lot	○	-	-
6. Lighting Fixture	1 lot	○	-	-

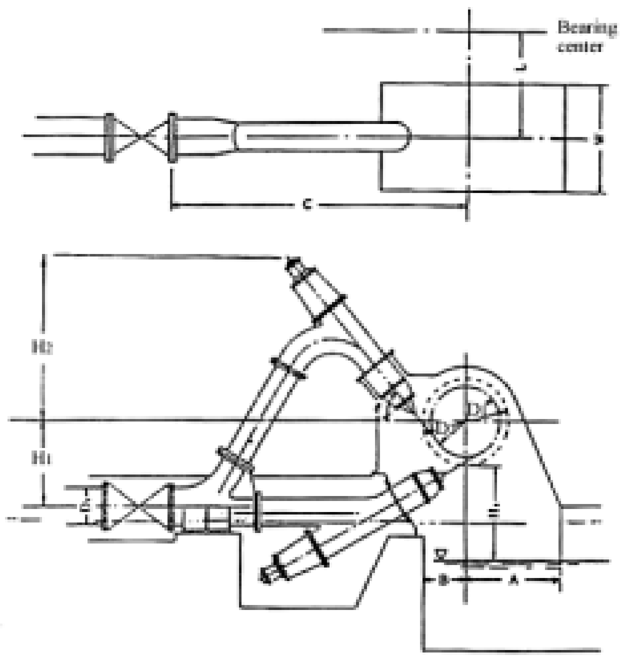
Source: JICA Study Team

4) Selection of Water Turbine

Two turbine types are possible for the planned head H_e = 223.88 m and discharge Q_{max} = 4.3 m^3/s. These are horizontal axis Pelton turbine and horizontal axis high speed impulse turbine (Turgo). The rated features and basic dimensions of these turbines are obtained for the comparison as presented below:

a) Pelton turbine

	Description	Alternative esignA	Alternative Design B
i)	Rated features of turbine		
	● Efective head	224 m	224 m
	● Max. turbine discharge	4.3 m^3/s	4.3 m^3/s
	● Max. output	8,100 kW	8,100 kW
	● Revolution speed	500 min^{-1}	428.5 min^{-1}
	● Specific speed Ns	26.0 m-kW	22.3 m-kW
	● Type	HP 1R2Nx2	HP 1R2Nx2
ii)	Basic dimensions		
	● Runner diameter (pitch circle)	1100 mmφ	1300 mmφ
	● Max. diameter of one jet	147 mmφ	147 mmφ
	● Diameter of shaft	300 mmφ	320 mmφ

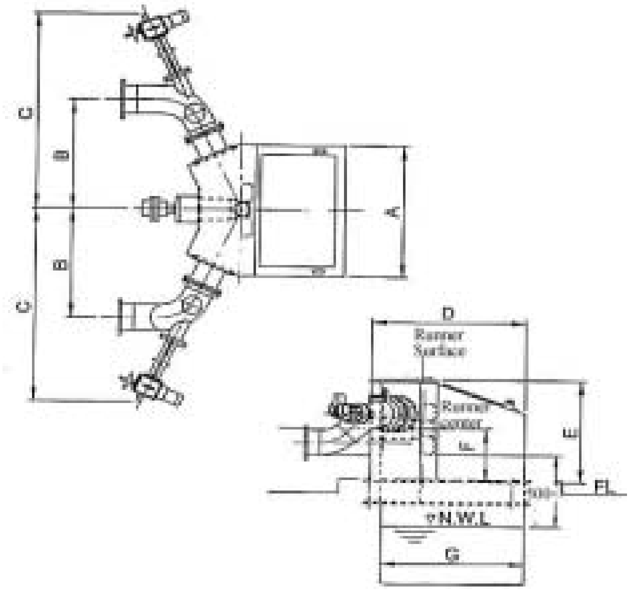


Model	D_1	D_2	A	B	C	Ds	H1	H2	W	L
C	1000	1285	1700	785	3950	525	1320	2200	1120	820
D	1000	1310	1760	830	525	590	1390	2300	1250	890
E	1000	1340	1820	880	660	660	1480	2500	1400	990

Figure 2.4.8 Basic Dimensions of Pelton Turbine

b) Turgo impulse turbine

Description		Features
i)	Rated features of turbine	
	● Effective head	224 m
	● Max. turbine discharge	4.3 m^3/s
	● Max. output	8,000 kW
	● Revolution speed	750 min^{-1}
	● Specific speed Ns	55 m-kW
	● Type	HT 1R2N
ii)	Basic dimensions	
	● Runner diameter (pitch circle)	860 mmϕ (outer diameter 1300 mm)
	● Max. diameter of one jet	210 mmϕ
	● Diameter of shaft	400 mmϕ



(Unit:mm)

Runner Diameter	A	B	C	D	E	F	G	Bend tube diameter
300	1300	1100	1800	1500	1000	550	1000	250
330	1400	1200	2000	1500	1100	550	1000	300
360	1400	1200	2000	1500	1100	550	1000	350
400	2100	1350	2200	1800	1200	600	1300	400
440	2100	1350	2200	1800	1200	600	1300	450
480	2200	1400	2300	1900	1200	650	1400	500
530	2600	1700	2800	2400	1300	780	1700	550
580	2600	1900	3000	2600	1400	780	1800	550
640	2900	2000	3200	2800	1500	860	1900	750
710	3100	2300	3400	3200	1800	1000	2200	800
780	3400	2600	3800	3500	1900	1100	2500	850
860	3800	2800	4000	4000	2100	1150	2800	900
940	4300	3400	4500	4100	2200	1200	2900	1000
1040	4600	3400	5200	4500	2400	1400	3200	1100
1140	5000	3600	5500	4900	2700	1500	3400	1200

Figure 2.4.9 Basic Dimensions of Turgo Turbine

As may be observed in the rated features of the two turbines above, Turgo impulse turbine is more advantageous in view of:

- Simplicity of its structure;
- Lower cost of its electric equipments owing to the higher turbine revolution speed at 750 min^{-1}, which facilitates direct coupling with such generator that has 8 poles and is generally manufactured.

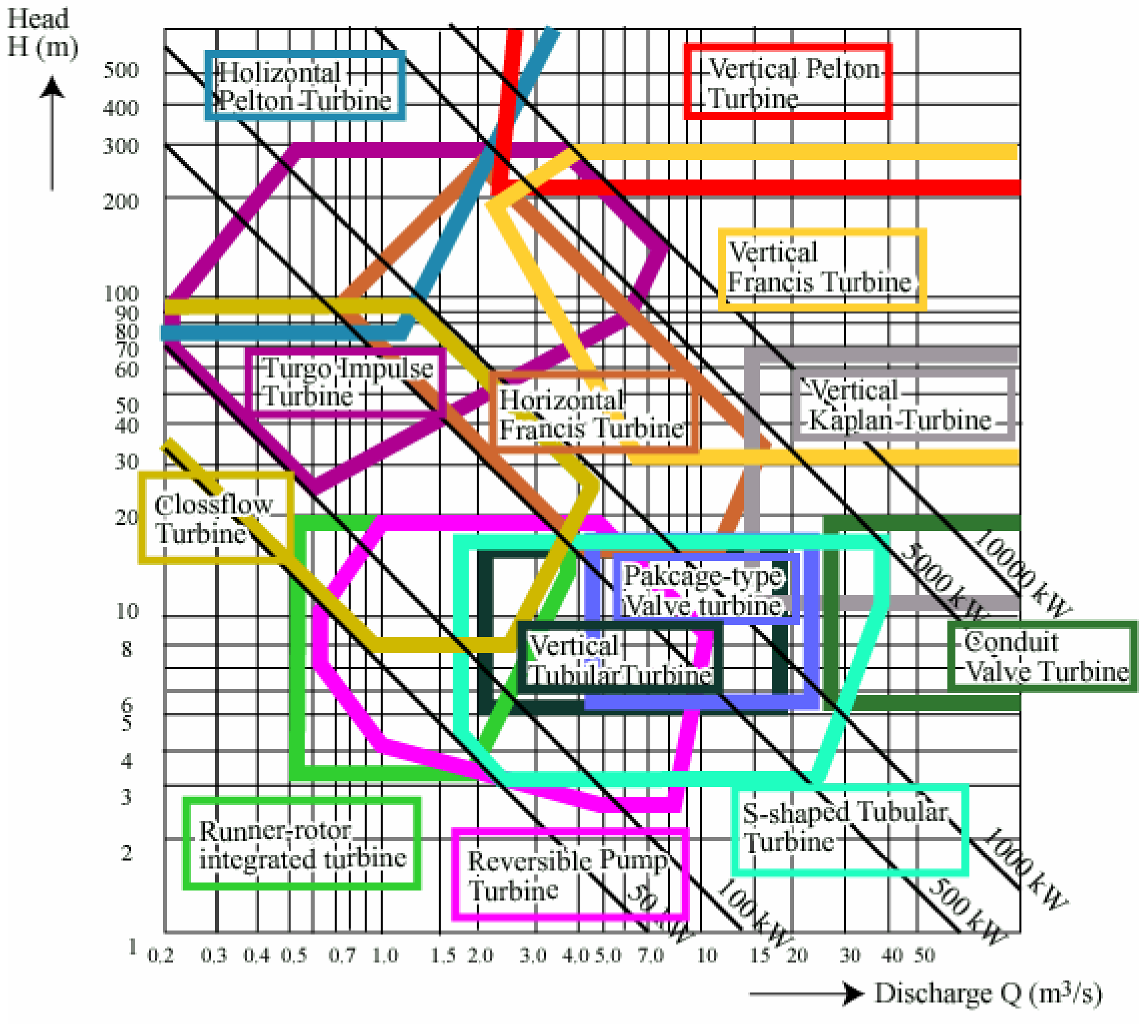


Figure 2.4.10 Applicable Range of Turbine

2.4.10 Cost Estimate

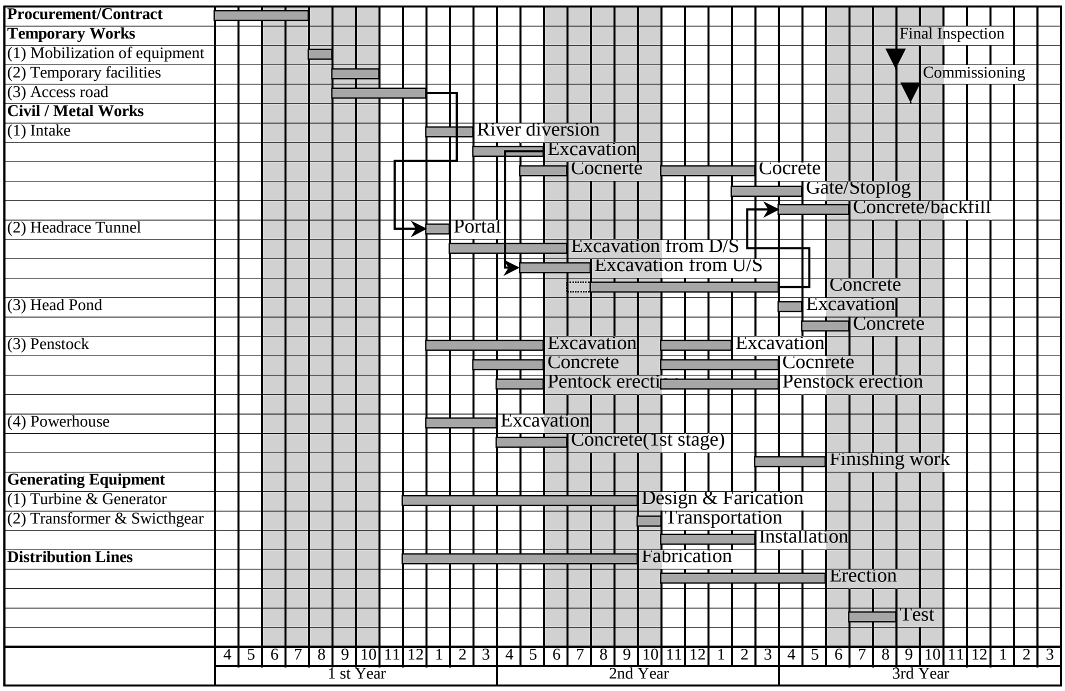
The construction cost for the Project was roughly estimated at a a total of about US$ 20,300,000, assuming that the civil works are to be executed by the local contractor(s) in Myanmar, and the generating equipment is to be procured in Japan.

The Project is divided into 2 phases, in which Phase-I consists of 1 set of turbine and generators (4 MW) distributing electricity only to the northern half of Inle Lake. The construction cost for Phase-I was roughly estimated at about US$ 9,082,000 as shown below.

Item	Amount (US$)
Civil Works	4,671,000
Steel Penstock	430,000
Gate and Trashracks	20,000
Turbine and Generator	2,000,000
Transformer and Switchgears	495,000
Distribution Lines	1,466,000
Phase-I Total	**9,082,000**

2.4.11 Construction Schedule

The tentative construction schedule for the Heho Small Hydro Scheme was estimated based on the basic planning, which should be elaborated through the detailed design.



Source: JICA Study Team

Figure 2.4.11 Construction Schedule

2.4.12 Further Investigations

To promote the Heho Small Hydro Scheme towards implementation, further investigations listed below are required:

Item	Investigation / Study
Discharge measurement	Continuous discharge measurement at intake site on the Negya Chaung
Topographic survey	1/500 scale topo-map for intake, head tank, penstock, and powerhouse areas for the detailed design

2.5 Economic, Financial and Environmental Aspects

2.5.1 Economic Aspects

The Heho hydropower project is expected to supply electricity for 24 hours a day. Therefore, the economic benefit of electricity could expand beyond that of lighting. Other benefits include those of domestic industry and heat for cooking.

In fact, the average monthly household consumption of one of the surveyed villages (Theley village) receiving power from the National Grid of the Inle Lake area is 100 kWh. The demand for lighting would be much smaller, since this demand includes those for cooking and for some domestic industries like gold smith, black smith and workshops. The survey suggests the demand for cooking heat, especially for rice cooker is high. In this area, because the costs of charcoal and firewood are almost two dollars (K900) for one month per household, the economic benefit of electricity for cooking could be almost two dollars.

From the survey, the daytime power demand for industries is estimated to reach 578 kW or 0.025 kW/hh with 23,552 households. The total consumption from 8 a.m. to 4 p.m. is 578kW x 8hr = 4.6 MWh/day. Because industries use the mechanical power directly from diesel engine, the actual power required by diesel engine would be smaller. Assuming motor efficiency of about 86% (average standard motors of 15HP), the required energy input would be 4.6 x 0.86 = 4.0MWh/day. To provide this amount of electricity by diesel engine the required diesel oil is 400 gallon = 4.0MWh / 10 (kWh/gallon of diesel) with efficiency of about 20%. The monthly cost is about 400 x 30 = $12,000/month (or $0.5/month/hh on average).

In total, the economic benefits of electricity, including lighting ($1-$2/month/hh), cooking ($2/month/hh), and domestic industry ($0.5/month/hh) could reach $3.50 ~ $4.50/month/hh on average.

This estimate shows that there is enough daytime capacity for more industrial users. Considering that the capacity of Heho project can accept two to three times more industrial, the economic benefit could be increased about $0.5-$1.0 to make the total benefit by about $4.00-$5.50/month/hh. Table 2.5.1 shows the calculation of financial and economic analysis. Knowing that the capital cost of Heho project is about $20 million with a project life of 50 years, the Economic Internal Rate of Return (EIRR) was calculated as 5.99% with an economic benefit of $5/month/hh.

2.5.2 Financial Aspects

The financial benefit is determined by the actual amount of money paid for electricity. In practice, it is the matter of tariff and consumption. In our survey, the household nighttime power demand would be 220 watt maximum. The nighttime consumption from 6 pm to 10 pm will be less than 4 hours x 220 watt = 0.88 kWh/day/hh or 26.4 kWh/month/hh. With present MEPE tariff, the monthly payment would be K25 (fixed fee) + 26.4 x K2.5/kWh (energy fee) = K 91 or about $0.18/month/hh.

The daytime domestic industrial users are about 160 for the total demand of 4.6MWh/day. On average they use 28.75 kWh/day or 861 kW/month/user. With the present MEPE tariff the monthly payment would be K 2.5 (under 50 kWh) x 50 kWh +K 10 (under 200 kWh) x 150 kWh + K 25 (above 201 kWh) x 661 = K18,150 or $36.3/month/hh for domestic industrial users. The total of all 160 users is calculated as 160 x $36.3 = $5,808/month. The household average is 5808 / 23552 = $0.25/month/hh. Combined with the nighttime payment the average payment per household would be 0.18 + 0.25 = $0.43/month/hh. This level is one tenth of the economic benefit. The total consumption is 0.88 kWh/day/hh x 23552 + 4.6 MWh/day = 25.3 MWh/day or 760 MWh/month or 32 kWh/month/hh. The monthly total payment is $0.18 x 23,552 + $5,808 = $10,047. The price is 10,047 / 760,000 = $0.013/kWh.

Industrial demand is the key to the MEPE tariff system. The 24 hour supply has the potential to increase the daytime users. If it could double the industrial users, the monthly payment will increase another $5,808 or total $15,855. The unit price will come close to $0.2 {15855 / (760,000 + 4,600 x 30)} with average consumption about 40 kWh/month/hh. The Table 2.5.1 shows the calculation of Financial Internal Rate of Return of this case. The FIRR is negative at -8.34%. This can be made positive by increasing the consumption from 38 kWh/month/hh to 100kWh/month/hh or by increasing the average tariff level from $0.02 to $0.05. Namely, if the current tariff level could be increased two to three times, the financial prospects would be much better.

Table 2.5.1 shows the calculation of financial and economic cost and benefit.

Table 2.5.1 Financial and Economic Cost and Benefit

Assumptions				
Discount Rate%	10.0%		Construction Cost $	20,263,853
Consumption kWh/hh/month	40		O & M Cost (% of Construction Cost)	1.0%
No. of Household	23,552		Fuel Cost $/year	0
Financial Benefit (Tariff $/kWh)	0.02			
Initial Fee $/hh (1st Year Only)	20			
Financial Benefit $/Year = (Initial Fee x No.HH + Tariff ($/kWh) x Consumption (kWh/hh/month) x No.HH x 12 month) x Discount F				
Economic Benefit (WTP $/month)	5			
Economic Benefit $/Year = WTP ($/month) x No.HH x 12 month x Discount Factor				
Results: Financial Net Benefit	-17,760,858		FIRR	-8.34%
Economic Net Benefit	-6,419,985		EIRR	5.98%

		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	633,763	1,284,655	633,763	1,284,655	20,263,853	202,639	0	18,605,901	18,605,901
2	0.83	186,859	1,167,868	820,622	2,452,522		202,639	0	167,470	18,773,371
3	0.75	169,872	1,061,698	990,493	3,514,220		202,639	0	152,245	18,925,616
4	0.68	154,429	965,180	1,144,922	4,479,400		202,639	0	138,405	19,064,021
5	0.62	140,390	877,436	1,285,312	5,356,837		202,639	0	125,823	19,189,844
6	0.56	127,627	797,669	1,412,939	6,154,506		202,639	0	114,384	19,304,228
7	0.51	116,025	725,154	1,528,964	6,879,660		202,639	0	103,986	19,408,213
8	0.47	105,477	659,231	1,634,441	7,538,891		202,639	0	94,532	19,502,746
9	0.42	95,888	599,301	1,730,329	8,138,192		202,639	0	85,939	19,588,684
10	0.39	87,171	544,819	1,817,500	8,683,011		202,639	0	78,126	19,666,810
11	0.35	79,246	495,290	1,896,746	9,178,301		202,639	0	71,024	19,737,834
12	0.32	72,042	450,264	1,968,788	9,628,564		202,639	0	64,567	19,802,401
13	0.29	65,493	409,331	2,034,281	10,037,895		202,639	0	58,697	19,861,098
14	0.26	59,539	372,119	2,093,820	10,410,013		202,639	0	53,361	19,914,459
15	0.24	54,126	338,290	2,147,947	10,748,303		202,639	0	48,510	19,962,969
16	0.22	49,206	307,536	2,197,152	11,055,839		202,639	0	44,100	20,007,069
17	0.20	44,733	279,578	2,241,885	11,335,417		202,639	0	40,091	20,047,160
18	0.18	40,666	254,162	2,282,551	11,589,579		202,639	0	36,446	20,083,606
19	0.16	36,969	231,056	2,319,520	11,820,636		202,639	0	33,133	20,116,739
20	0.15	33,608	210,051	2,353,128	12,030,687		202,639	0	30,121	20,146,860
21	0.14	30,553	190,956	2,383,681	12,221,643		202,639	0	27,383	20,174,243
22	0.12	27,775	173,596	2,411,456	12,395,239		202,639	0	24,893	20,199,136
23	0.11	25,250	157,815	2,436,707	12,553,054		202,639	0	22,630	20,221,766
24	0.10	22,955	143,468	2,459,662	12,696,521		202,639	0	20,573	20,242,339
25	0.09	20,868	130,425	2,480,530	12,826,947		202,639	0	18,703	20,261,042
26	0.08	18,971	118,568	2,499,501	12,945,515		202,639	0	17,002	20,278,045
27	0.08	17,246	107,790	2,516,747	13,053,305		202,639	0	15,457	20,293,501
28	0.07	15,678	97,990	2,532,425	13,151,295		202,639	0	14,052	20,307,553
29	0.06	14,253	89,082	2,546,679	13,240,378		202,639	0	12,774	20,320,327
30	0.06	12,957	80,984	2,559,636	13,321,361		202,639	0	11,613	20,331,940
31	0.05	11,779	73,622	2,571,415	13,394,983		202,639	0	10,557	20,342,497
32	0.05	10,709	66,929	2,582,124	13,461,912		202,639	0	9,597	20,352,095
33	0.04	9,735	60,844	2,591,859	13,522,756		202,639	0	8,725	20,360,820
34	0.04	8,850	55,313	2,600,709	13,578,069		202,639	0	7,932	20,368,752
35	0.04	8,046	50,285	2,608,755	13,628,354		202,639	0	7,211	20,375,962
36	0.03	7,314	45,713	2,616,069	13,674,067		202,639	0	6,555	20,382,517
37	0.03	6,649	41,558	2,622,718	13,715,625		202,639	0	5,959	20,388,477
38	0.03	6,045	37,780	2,628,763	13,753,404		202,639	0	5,418	20,393,894
39	0.02	5,495	34,345	2,634,258	13,787,749		202,639	0	4,925	20,398,819
40	0.02	4,996	31,223	2,639,254	13,818,972		202,639	0	4,477	20,403,297
41	0.02	4,541	28,384	2,643,795	13,847,357		202,639	0	4,070	20,407,367
42	0.02	4,129	25,804	2,647,924	13,873,160		202,639	0	3,700	20,411,067
43	0.02	3,753	23,458	2,651,677	13,896,619		202,639	0	3,364	20,414,431
44	0.02	3,412	21,326	2,655,089	13,917,944		202,639	0	3,058	20,417,489
45	0.01	3,102	19,387	2,658,191	13,937,331		202,639	0	2,780	20,420,269
46	0.01	2,820	17,624	2,661,011	13,954,956		202,639	0	2,527	20,422,796
47	0.01	2,564	16,022	2,663,575	13,970,978		202,639	0	2,298	20,425,094
48	0.01	2,331	14,566	2,665,905	13,985,543		202,639	0	2,089	20,427,183
49	0.01	2,119	13,242	2,668,024	13,998,785		202,639	0	1,899	20,429,081
50	0.01	1,926	12,038	2,669,950	14,010,823		202,639	0	1,726	20,430,808

Source: JICA Study Team

2.5.3 Environmental Aspects

There may be an idea to electrify cooking at semi-urban households in the regions such as Kalaw, Aungban, Heho, Shwe Nyaug, and Nyang Shwe, but only during the rainy season when there is a large excess of power, through the introduction of a strategic power tariff. This aims at reducing the demand for firewood and charcoal in the semi-urban households. The demand for charcoal has reportedly caused denudation of the Upper Balu Chaung Basin on the west bank of the Inle Lake in particular causing eutrophication of the lake.

Because the energy source is hydropower, it can contribute to reducing CO_2 emission. In the National Grid, fossil fuel used in 1999-2000 for the generation of 4 million GWh (83% of the total 4.79 million GWh). Assuming the thermal efficiency of 38.1% (or 2250kcal/kWh--Japan's case) the total energy is 4 million GWh x 2250 kcal = 9,000 trillion kcal. In crude oil this is equivalent to 9,000/9250 (litter/kcal) = 973 billion litters or 973/159 (litter/bbl) = 6.12 billion bbl. Therefore the consumption of fossil fuel to supply the Grid is about 6.12/4,790 = 0.00128 bbl/kWh. This means that at least 0.00128 bbl of crude oil equivalent for each kWh generated. The CO_2 emission is estimated at about 0.00128(bbl) x 159 (litter/bbl) x 0.85 (kg/litter) x 0.837 (Mt-C/Mtoe) = 0.145 kg/kWh (coefficient: 0.837 Mt-C/Mtoe). Assuming each household consumes 50 kWh/month/hh with 20,000 households, then the total CO_2 emission in one year is 0.145 x 30 x 20,000 x 12 = 1,044 ton of carbon equivalent. For lighting, an average household consumes about one gallon of kerosene or diesel oil. The annual CO_2 emission, which can be saved, is 4.54 (litter/gallon) x 0.8 (kg/litter) x 0.821 (Mt-C/Mtoe) = 3 kg/hh/month or 36 kg/hh/year (coefficient: 0.821 Mt-C/Mtoe) of carbon equivalent. For 20,000 households for one year it will be 3 x 20,000 x 12 = 720 ton of carbon equivalent.

The total annual saving of CO_2 by the Heho hydropower project will reach about 1044 + 720 = 1764 ton or more of carbon equivalent.