Chapter 10

Small Hydropower Development

10-1 Rural Electrification by Small Hydro

Formulation of Small Hydropower (S/H) Development Plan for Vientiane and Borikhamxay provinces is one of the main objectives of this study. There are many examples of small hydropower development in developing countries for rural electrification. The technology necessary for small hydro plants ranging from 20kW to 100kW, which are suitable for rural development, has been mature. As for smaller size plants, called mini- or micro-hydro, basically the same technology can be applied.

The economic feasibility of hydropower depends largely on natural conditions such as topography or water discharge. As a characteristic of hydropower, the initial investment is quite large and, therefore, needs a long time for cost recovery. This problem makes small hydro development difficult to realize on a commercial basis, which is similar to solar power development. In case of hydropower, people can use alternate current (AC) and many electrical appliances so that they benefit much more compared with a solar system. In theory, average fee of hydro power should be higher than that of solar power to reflect the advantage of hydro. However, it was made clear in this study that villagers in the remote areas of Laos people can only pay about $2.00 every month for electricity. This is a very tough condition for hydro development because the initial investment of typical small hydro is quite large. It is requested to search for potential small hydro sites with this point in mind.

Small hydro development requires skilled contractors who undertake the construction work of main structures such as weir, channel and power house. Also electrical/mechanical equipment such as turbine, generator and controller requires custom design. Even after commissioning, special knowledge and skill are necessary for the maintenance of hydro equipment. As operators, educated experts are required, which is a tough condition for rural villages. There are many examples where poor maintenance caused fatal damage to the equipment of village hydropower.

10-2 Small Hydropower Development in Laos

There are many small villages scattered in mountainous areas of Laos. Small hydropower is viewed appropriate as a source of electricity supply for those small villages in remote areas. Considerable number of survey reports have been published regarding the hydropower potential in the Mekong basin and it is commonly understood, among the nations in the Mekong region, that the hydropower potential in Laos is estimated to be 13,000MW, which is equivalent to the potential in the Mekong mainstream down-reach of Yunnan province of People's Republic of China. The already deprived hydropower resource in the Lao tributary of the Mekong is only about 620MW: Selabam(5MW), Nam Ngum(150MW), Xeset (45MW), Theun Hinboun(210MW), Houay Ho(150MW), and Nam Leuk(60MW). In addition, according to MIH, only 37 small hydropower stations with a total capacity of about 6MW have been developed, and two small hydropower plants with a total capacity of 1,400kW are under construction. Thus, only 5% of the hydropower potential in Laos has been exploited so far. Table 10-2-1 shows developed small hydropower plants in Laos.

Table 10-2-1 Developed small-hydropower

No.	Project Name	Location		Capacity. (kW)	Year of Completion
		District	Province		
1	Nam Boun	Bountai	Phongsali	110	1996
2	Nam Leu	Namtha	Loungnamtha	46.2	1994
3	Houay Khiboan	Long	Loungnamtha	50	1998
4	Nam Pa	Loungphrabang	Loungphrabang	16	1998
5	Nam Dong	Loungphrabang	Loungphrabang	1,008	1970
6	Nam Et	Viengthong	Houaphanh	100	1988
7	Nam Long	Sopbao	Houaphanh	20	1989
8	Nam Soplong	Sopbao	Houaphanh	24	1989
9	Nam Hang	Samnua	Houaphanh	6	1994
10	Nam Soy	Samnua	Houaphanh	12	1994
11	Nam San	Samtai	Houaphanh	110	1995
12	Nam Peun	HouaMuang	Houaphanh	36	1986
13	Nam Poun 1	Viengxai	Houaphanh	96	1994
14	Ban Sop Ma	Kham	Xiangkhouang	55	1995
15	Nam Tain	Kham	Xiangkhouang	75	1995
16	Nam Poui	Khoun	Xiangkhouang	24	1986
17	Nam Poung	Khoun	Xiangkhouang	5	1995
18	Nam Ka1	Phaxai	Xiangkhouang	12	1987
19	Nam Ka2	Phaxai	Xiangkhouang	81	1995
20	Nam Ka3	Phaxai	Xiangkhouang	6	1995
21	Ban Nong	Khoun	Xiangkhouang	40	1995
22	Ban Tan 1	Khoun	Xiangkhouang	5	1994
23	Ban Tan 2	Khoun	Xiangkhouang	8	1995
24	Nam Chat	Mokmai	Xiangkhouang	100	1995
25	Houay Saloi	Nong	Savanakhet	75	1996
26	Nam Ham	Boten	Xaignabouri	90	1992
27	Nam Khoun	Bountai	Phongsali	5	1996
28	Houay Kha	Bountai	Phongsali	5	1996
29	Nam Phao	Khamkeut	Borikhamxay	1,600	1995
30	Nam Ko	Xai	Oudomxay	1,500	1996
31	Nam Poun 2	Viengxai	Houaphanh	48	1994
32	Nam Noun	Nale	Loungnamtha	30	1999
33	Muangphoun Dam	Phoun	Xaisomboun	200	1999
34	Houay Champi	Pakxong	Champasak	40	1985
35	Houay Men	Xamnua	Houaphanh	24	1994
36	Nam Mong	Nambak	Loungphrabang	70	2000
37	Nam Sat	Viengthong	Houaphanh	250	2000
	Total Capacity	---	---	5,973.2	---

Source : Department of Electricity MIH ; as of August 2000

In Laos it is expected that many 20kW-class attractive hydro sites can be found near the foot of mountains. This size of hydropower is appropriate for electrifying one village. But if the site is too far from the village center, it is not economically viable. Also, if the site is located in an area where the grid is to be extended, its development should be avoided. Therefore, really attractive sites may be limited.

10-3 Inventory of Small hydropower sites

This study originally aimed at composing an inventory of potential small hydropower sites with a capacity of less than 500kW in Laos. It turned out that the Lao government is investigating some potential sites as shown in Table 1-3-1 and Table 1-3-2. Planning stages of the listed sites vary. However, it is confirmed that systematic inventory survey on potential small hydro sites has not been conducted in Laos.

Table 10-3-1 Planned mini-hydro sites

Project name	Location (District, Province)	Capacity (kW)	Remark
Nam Khouang	Xamtai Dist., Luang Phrabang	200	
Nam Pa 2	Phonxai Dist., Luang Phrabang	70	
Nam Sing	Sing Dist., Luang Namtha	200	
Houyahop	Viengkham Dist., Luang Phrabang	100	
Nam Pok	Samphan Dist., Phonsaly	200	
Nam Kheio	Paktha Dist., Bokeo	150	
Tadnammeng	Mueng Dist., Bokeo	150	
Nam Nga	Mai Dist., Phonsali	100	
Total capacity	---	**1,170**	---

Table 10-3-2 Planned small-hydro sites

Project name	Location (District, Province)	Capacity (kW)	Remark
Nam Boun 2	Boun Dist., Phonsaly	1,500	
Nam Ngao	Beng Dist., Phonsaly	2,000	
Nam Beng	Beng Dist., Oudomxay	1,500	
Tadsalen	Xepon Dist., Savannakhet	3,200	
Nam Hao	Vienxay Dist., Houaphan	5,000	
Nam Ngay	Phonsaly Dist., Oudomxay	1,000	
Nam Ham 2	Boten Dist., Xayabouly	2,000	
Nam Sim	Vienxay Dist., Houaphan	2,700	
Nam Huang	Vienkhoun Dist., Houaphan	1,200	
Nam Ou 1/2	Ngao Ou Dist., Phonsaly	500	
Nam Ngon	Houayxay Dist., Bokeo	460	
Nam Ka	Kham Dist., Xiengkhouan	800	
Tad Xienleu	Bualapha Dist., Kahmmoune	860	
Nam Phouang	Dokghung Dist., Sekon	400	
Nam Yang	Viengtong Dist., Borikhamxay	450	
Total capacity	---	**23,570**	---

Source : DOE of MIH (As of September 2000)

10-4 Small Hydropower Resource

10-4-1 Meteorological stations and Rainfall

Laos can be divided into three regions: northern, central and southern Laos. Major meteorological station in each region would be Luangprabang station for northern, Vientiane station for central, and Savannakhet station for southern Laos. Since the target area of this study is Vientiane and Borikhamxay provinces, which are located in the central region, the main meteorological station is Vientiane station. Table 10-4-1 shows a comparison of rainfall data since 1978. In addition to the data from the three leading meteorological stations, data from Vangvieng station in Vientiane province and from Kengkouan station in Borikhamxay province are referred to. This table indicates that the central region has the heaviest rainfall in Laos. The additional data from Vangvieng and Kengkouan reaffirm that high precipitation prevails in the target area of this study.

Table 10-4-1 Annual rainfall data (mm)

Year	Luang Prabang	Vientiane Muni.	Savanna Khet	Vangvieng	Kengkouan
1978	1,608	1,987	1,681	x	x
1979	1,343	1,301	1,236	x	x
1980	1,559	2,291	1,636	x	x
1981	1,932	1,922	1,381	x	x
1982	1,222	1,642	1,491	x	x
1983	1,385	1,369	1,321	x	x
1984	1,080	1,637	1,710	x	x
1985	1,093	1,254	1,205	x	x
1986	1,087	1,723	1,384	x	x
1987	1,036	1,668	1,454	x	x
1988	1,196	1,643	1,134	1,962	x
1989	1,409	1,681	1,489	2,814	x
1990	1,642	1,552	1,714	3,843	x
1991	1,064	1,331	1,539	3,023	2,205
1992	1,230	2,033	1,379	2,872	1,397
1993	1,162	1,468	1,115	3,142	1,921
1994	2,280	1,801	1,527	3,384	-
1995	1,617	2,020	1,342	3,699	2,521
1996	1,601	1,756	1,938	4,001	1,675
1997	1,180	1,600	1,335	3,512	
Average	1,386	1,684	1,451	3,225*	1,944*

N.B.: 1. Average value at Vangvieng is for 10 years since 1988

2. Average value at Kengkouan is for effective 5years since 1991

Source: Meteorological Dept., Ministry of Agriculture-Forestry

10-4-2 Small Hydropower Potential in Vientiane Province

Vientiane province is divided into 10 districts such as Vangvieng, Kasi, Fuang, etc. This study revealed that Vangvieng and Kasi districts would be recommendable as candidate districts for small hydropower development. Both districts have typical topography of relatively steep slopes behind major activity areas. MIH local office in Vientiane province, Department of Industry and Handicrafts (DIH), suggested that Fuang district, located in the mid-west of the province, could also be one candidate. However, it may require more than 10 hours by 4WD vehicle from Vientiane to the district even during the dry season due to poor road conditions. To conduct site investigations in the district seemed difficult. Therefore, Fuang district was eliminated from case study. Selected candidate small hydro sites in the two districts, through map studies on 1/100,000 topo-maps and site investigations, are as follows . (See Figure 10-6-1)

(1) Candidate sites in Vangvieng district

①<Houay Sing>

- Catchment Area at Intake Point : 5.7km²
- Recipient Community(s) : Ban Nalao
- Number of Households : 82
- Minimum Discharge : 0.1 m³/s (as of Feb. 1999, by eye)
- Gross Head : 20m (based on 1/50,000 map)
- Composite Efficiency : $\eta = 0.6$
- Minimum Output : 10kW
- Maximum Output : 15kW

② <Nam Lao>

- Catchment Area at Intake Point : approx. 7km²
- Recipient Community(s) : Ban Nadouan
- Number of Households : 96
- Minimum Discharge : 0.1m³/s or less(by eye)
- Gross Head : 20m(based on 1/50,000 map)
- Composite Efficiency : $\eta = 0.6$
- Minimum Output : 10kW
- Maximum Output : 20kW

(2) Candidate site in Kasi district

<Nam Kheng>

- Catchment Area at Intake Point : approx. 25km^2
- Recipient Community(s) :Ban Phonsavat & Ban Nongbouatone
- Number of Households : 113
- Minimum Discharge :0.28m^3/s(as of Feb. 1999, with HIROI-propeller)
- Gross Head : 30m(based on 1/100,000)
- Composite Efficiency : $\eta = 0.6$
- Minimum Output : 40kW
- Maximum Output : 50kW

10-4-3 Small-Hydropower Potential in Borikhamxay Province

Borikhamxay province is located to the east of Vientiane, and divided into 6 districts such as Pakxan, Pakkading, Borikhan, etc. This study revealed that Kamkeut and Viangthong districts would be recommendable as candidate districts for small hydropower development. Besides these two districts, the Borikhan district administrator recommended Borikhan district, northern area of the province near the Snake Mountains. However, since there is no access road for vehicles beyond the Snake Mountains, Borikhan district was screened-out from case study. Selected candidate sites in the two districts, through map studies on 1/100,000 topo-maps and site investigations, are as follows. (See Figure 10-6-1)

(1) Candidate site in Kamkeut district

<Nam Phouan>

- Catchment Area at Intake Point : 5.7km^2
- Recipient Communities : Ban Tonsan & Ban Kammouan
- Number of Households : 147
- Minimum Discharge : 0.07 m^3/s (as of Feb. 1999, HIROI-propeller)
- Gross Head : 27m(based on 1/50,000 map)
- Composite Efficiency : $\eta = 0.6$
- Minimum Output : 10kW
- Maximum Output : 20kW

(2) Candidate sites in Viangthong district

①<Nam So>

- Catchment Area at Intake Point : approx. 201km²
- Recipient Community(s) : Ban Sopso
- Number of Households : 88
- Minimum Discharge : 0.2～0.3 m³/s (as of Feb. 1999, by eye)
- Gross Head : 37m(based on 1/100,000 map)
- Composite Efficiency : $\eta = 0.6$
- Minimum Output : 40kW
- Maximum Output : 60kW

②<Nam Ngom>

- Catchment Area at Intake Point : approx. 284km²
- Recipient Community(s) : Ban Phondou
- Number of Households : 117
- Minimum Discharge : 0.5～0.6 m³/s (as of Feb. 1999, by eye)
- Gross Head : 27m(based on 1/100,000 map)
- Composite Efficiency : $\eta = 0.6$
- Minimum Output : 75kW
- Maximum Output :95kW

10-5 Zoning

10-5-1 Zoning Criteria

The target zones for small-hydropower development in the target districts of Vientiane and Borikhamxay provinces were selected referring to EdL's electrification plan and other criteria. Basic zoning criteria in this study are:

- **the area where grid extension will not be realized in the coming decade**
- **the area with comparably easy accessibility**
- **the area located at more than 8 km distance from the existing or planned grid**

Based on the result from the cost estimation for the case study, transmission system construction in Laos would cost approximately $10,000/km. Therefore, in general, grid extension would be more economical in areas where the distance from the grid terminal is less than 8km.

Note *) : Average unit construction cost is estimated at approximately $5,000/kW, including survey & design works and the transformer/transmission system. When the minimum size of households in the planned area is 100 with unit demand of 150W/household, the required minimum installed capacity would be 15kW and the project cost would be about $80,000. This is almost equal to the cost of extending the grid for 8 km.

and

- **the direct distance between the location of the powerhouse and the nearest accessible road should be within 2km**

When the direct distance between the powerhouse and the nearest accessible road is more than 2km, it would require a significant amount of extra cost for a temporary road and transmission line.

10-5-2 Basic Data

Basic data for the selected zones and candidate sites were provided by EdL. The status of local electrification as well as the electrification plan by EdL and/or MIH composed the base in combination with some statistical information on number of rural households and official topographical maps of 1:50,000 or 1:100,000.

10-5-3 Zoning

(1) Electrified and to-be-electrified area

The necessary information was provided by EdL and/or local MIH offices (DIHs). It was foreseen that the planned areas for future electrification would be limited to the vicinity of grid transmission lines along major national roads.(See Appendix)

(2) Target areas for S/H development

Target areas for S/H development were selected on topo-maps of 1:100,000 under the above conditions (See Appendix).

10-6 Small-Hydropower Pilot Projects (Case Study)

10-6-1 Strategy

In this study, the basis of Master Plan for Small Hydropower Development was considered as follows:

① The Electricity Law in Laos liberalized small power (under 100kW) development. Local authorities such as provincial government or district administration are responsible for such development.

② Given the financial difficulties of local authorities, use of local materials and skills should be encouraged as much as possible. Also, ease of maintenance should be carefully examined. This would contribute to reducing investment cost and shorter construction period.

③ In the past, small hydro develop projects, with capacity of less than 100kW, in Southeast Asia ended up with unit cost of around $3,000/kW. This study is aiming to achieve the unit cost of $3,000/kW as well. In cost analysis, current unit prices of work items in Laos are taken into account.

10-6-2 Basic Plan

Among the selected candidate sites in the two targeted provinces, one study site for each province was selected with accessibility mainly in mind. Then, basic design work followed. The outline of selected study sites is as follows.

(1) Vientiane province

The selected stream of Houay Sing is located at a distance of approximately three hours by 4WD vehicle from Vientiane. In the wet season the site is inaccessible due to poor road conditions. Ban Nalao, the planned recipient community, is located very close to the candidate site and had 82 households (1998). The planned facility comprises a 15kW(minimum 10kW) generation system and a low-voltage distribution line of approximately 780m between the power plant and the community.

(2) Borikhamxay province

Ban Tonsan and neighboring Ban Kammouan, located near the river Nam Phouan, were selected as the candidate locations. The area is located at a distance of about five hours by 4WD vehicle from Vientiane. The area is also the source of the river Nam Theun. The number of recipients in the two villages is 147 households (1998). The planned facility comprises a 20kW (minimum 10kW) generation system, due to flow conditions, and a low voltage distribution line of approximately 3.7km connecting the power plant and the two recipient communities.

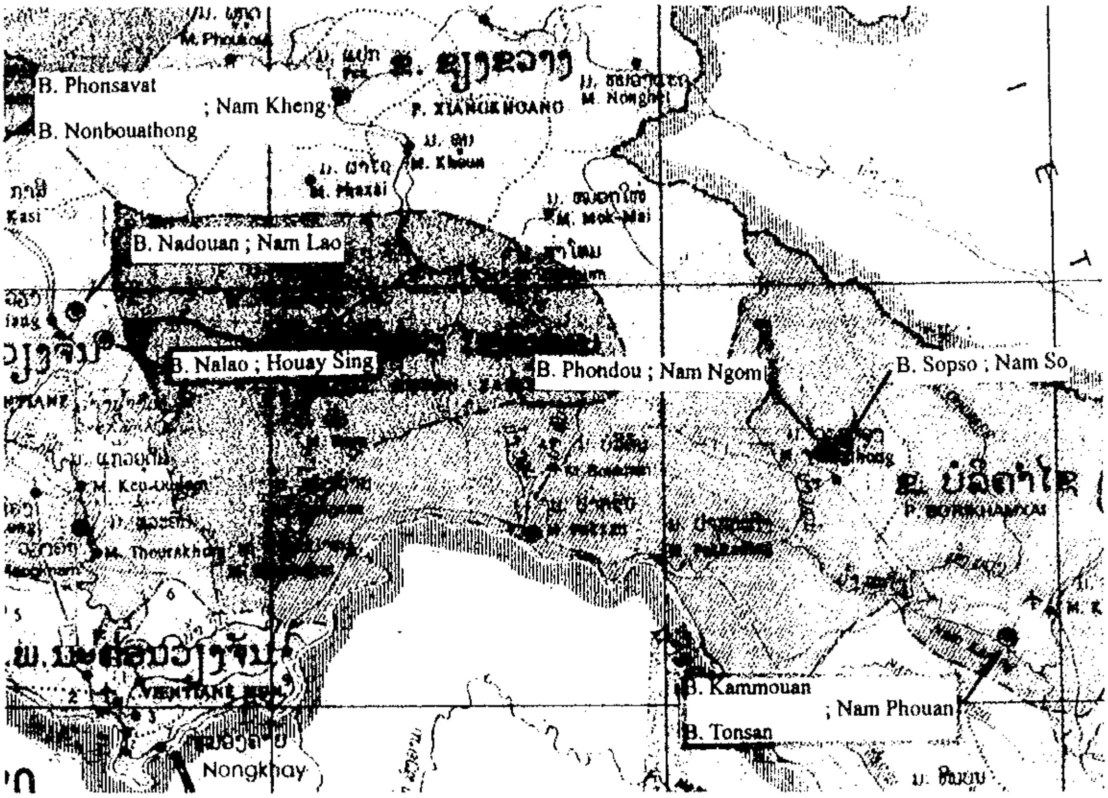


Figure 10-6-1 Location of pilot project sites

10-6-3 Basic Design

Basic design works for the two study sites were undertaken and the outcome will be the basis for the cost estimation. The design took into consideration the use of local materials and skills as much as possible, as well as the need for easy maintenance. (See Appendix)

10-6-4 Cost Estimation

Based on the basic design, the total direct costs were calculated by multiplying each work item with its unit cost and adding the figures together. Project costs were derived by calculating overhead costs, which were assumed not to exceed 10% of the direct costs. Unit costs for materials and work items were based on actual prices in Laos (researched by EdL) or domestic market prices in Japan when unavailable in Laos.

(1) Cost Estimation for pilot projects

1) Houay Sing Project(Vientiane Province) ; installed capacity- 15kW

•Civil Works	: $37,900-
•Equipment Installation	: $23,000-
•Low voltage distribution line (780m)	: $4,800-
•Additional Works	: $5,900-
•Cost for Direct Works(Subtotal)	: $71,600-
•Overhead(within 10% of subtotal)	: $7,100-
Grand Total	: $78,700-
•Unit Project Cost per kW	: **$5,250 /kW**

2) Nam Phouan Projcet(Borikhamxay Province) ; installed capacity- 20kW

•Civil Works	: $34,700-
•Equipment Installation	: $23,000-
•Low voltage distribution line (3.7km)	: $26,100-
•Additional Works	: $9,500-
•Cost for Direct Works(Subtotal)	: $93,300-
•Overhead(within 10% of subtotal)	: $9,200-
Grand Total	: $102,500-
•Unit Project Cost per kW	: **$5,130 /kW**

(2) Evaluation of unit project cost

Analyzing the outcome from the above-mentioned case study projects, the following findings could be introduced. In the case of installed capacity of around 20kW, the costs for civil works and power generating equipment are almost the same or constant regardless of site conditions, and the major controlling factor of project cost would be the transmission/distribution line. When looking at the derived Unit Project Costs per kW, installation for a 20kW (or approx. 20kW) system with a 2km distribution line would cost approximately $5,000/kW. Of that, $3,700/kW is to be spent on civil works and equipment. The $5,000/kW figure exceeds by about 65% the targeted unit cost of $3,000/kW. Considering the current situation for material supply in Laos, one can observe that most domestically utilized industrial products are imported from abroad. Moreover, the design of maintenance-free projects might lead to rather expensive civil structures.

10-7 Ten-year Development Plan (Master Plan)

It is difficult to formulate a long-term small-hydro development plan taking into account site conditions, because potential hydro sites have not been fully investigated so far. Therefore, only a conceptual frame work is discussed in this section.

10-7-1 Demand Forecast

(1) Category of users and appliances

To estimate demand for electricity in a typical remote village with 100 households, electric appliances and their usage hours need to be studied. For estimating unit demand per user in rural Laos, the following types of users and appliances are assumed. At the beginning of electrification, there will be limited number of appliances in village. Therefore, we need to take into account demand growth after the start of electricity supply. Also, we need to consider not only household demand but also demand at public facilities such as clinic and school. As for lighting, only fluorescent tube is assumed.

1) Household : 2 interior lights(20W) and 2 wall sockets(100W)
2) School : 2 interior lights(40W) and 2 wall sockets(100W)
3) Clinic : 2 interior lights(40W), 1exterior light(20W) and 2 wall sockets (100W)
4) Meeting Hall/Temple: 2 interior lights (20W), 1 exterior light (20W) and 1 wall socket (100W)
5) Small power : 2 rice mills(5kW) and 2 water pumps(200W)－per 100 H/H
6) Public lights : 20 lights (20W) for community road lighting－per 100 H/H

(2) Unit Demand

We estimated peak electricity demand of a typical village during the daytime and nighttime in a day. Usage hours of each appliance were assumed as follows. To calculate the aggregate peak demand in a village, it is necessary to consider coincidental demand coefficient which shows probability of using same kind of appliances at peak time.

①Daytime Demand

Utility Category	Appliances Type	Quantity	Coincidental Demand Coefficient	Demand (W)	Notes
School	Interior light (40W)	2	1.0	80	
	Wall socket (100W)	2	0.7	140	
Clinic	Interior light (40W)	2	1.0	80	
	Wall socket (100W)	2	0.7	140	
Small Power	Rice mill (5kW)	2	1.0	10,000	
	Water pump (200W)	2	1.0	400	
Total	—	—	—	10,840	

②Nighttime Demand

Utility Category	Appliances Type	Quantity	Coincidental Demand Coefficient	Demand (W)	Notes
Household	Interior light (20W)	200	1.0	4,000	100H/H
	Wall socket (100W)	200	0.5	10,000	100H/H
Clinic	Interior light (40W)	2	0.8	64	
	Exterior light (20W)	1	1.0	20	
	Wall socket (100W)	2	0.6	120	
Meeting hall or Temple	Interior light (20W)	2	1.0	40	
	Exterior light (20W)	1	1.0	20	
	Wall socket (100W)	1	0.8	80	
Small Power	Rice mill (5kW)	2	0.0	0	
	Water pump (200W)	2	0.5	200	
Public lighting	Public light (20W)	20	1.0	400	
Total	—	—	—	14,944	

③Unit Demand

The maximum demand in this case is 14.9kW in the nighttime. And the averaged 'unit demand' becomes 150W/household.This figure seems a little big, but can be used as a design base to have a margin for future demand growth.

10-7-2 Basic principle

The following conditions are taken into account to make a ten year plan.

(1) Target year

The project period would be 10 years from 2001 to 2010; first 2 years for preparation work and subsequent 8 years for development.

(2) Target community and plant size

Considering the geography of Laos, basically we target individual village, not multiple villages, with about 100 households and a 15kW size mini-hydro plant, which corresponds to the village size.

10-7-3 Investment Cost Estimation

The ten year project period is divided into two phases: Phase-1 for survey and planning, and Phase-2 for development. This makes project planning and implementation simpler and easier.

(1) Candidate districts

Candidate districts proposed for the Master Plan were screened based on the before-mentioned criteria, such as size of community, status of electrification and future electrification plan and potential of small hydro, etc. Information on potential small-hydro sites was reviewed referring to 1:100,000 topo-maps. The selected candidate districts are as follows:

① Vientiane province
- -Vanvieng district
- -Kasi district

② Borikahmxay province
- -Khamkeut district
- -Vianthong district

(2) Candidate communities

The location of potential mini-hydro sites in the vicinity (within about 2km distance) of target communities is checked using 1:100,000 topo-maps and with information from DIH. As a result, in the four target district, 16 villages were selected for further investigation. The number of households as of February 1998, except for Houaynamyen and Somsaat, was only available. (See Table 10-7-1)

Table 10-7-1 Candidate communities for S/H Master Plan

Province	District	Community	H-H	Notes
Vientiane	Vangvieng	Houaynamyen	30	New Community, April 2000
		Keokouang	119	
		Nalao	82	
		Nakhoun	88	
		Phonsavang	86	
		Phonxay	40	
		Phonxou	94	
		Somsaat	43	New Community, April 2000
		Sub Total	582	
	Kasi	Phato	106	
		Phonthieng	87	
		Viengsamay	106	
		Sub Total	299	
		Total	881	
Borikhamxay	Kamkeut	Khammouane	105	Neighboring to Ban Tonsan
		Tonsan	42	Neighboring to Ban Khammouane
		Sub Total	147	
	Viangthong	Chomthong	163	
		Phondou	117	
		Vangphe	95	
		Sub Total	375	
		Total	522	

It is recommended that MIH/DOE concentrate their efforts on a limited number of projects, because they have limited knowledge and expertise in mini-hydro development. Starting one or two projects every year is reasonable. For estimating the capital requirements for the ten-year period, we selected 10 projects covering 11 villages, as primary development project sites. (See Table.10-7-2)

Table 10-7-2 Selected communities for S/H Master Plan

Province	District	Community	No. of HH	Notes
Vientiane	Vangvieng	Keokouang	119	
		Nalao	82	Pilot Plant
		Nakhoun	88	
		Phonsavang	86	
		Phonxou	94	
		Sub Total	469	
	Kasi	Phato	106	
		Phonthieng	87	
		Viengsamay	106	
		Sub Total	299	
		Provincial Total	768	
Borikhamxay	Kamkeut	Khammouane	105	Neighboring to Tonsan
		Tonsan	42	Pilot Plant
		Sub Total	147	
	Viangthong	Phondou	117	
		Sub Total	117	
		Provincial Total	264	

N.B.: Number of households is based on EdL information as of February 1998

(3) Cost Estimation for S/H Master Plan

The investment cost of each project was estimated based on the previous case study. The cost for survey and design work of each project in Phase-1 is assumed to be $20,000. The total investment required for the ten-year period turned out to be around $930,000. (See Table 10-7-3)

- Unit demand	150W/household
- Survey and Design cost	$20,000 (Preparation $500, Planning $3,000, Survey $1,500, Design $15,000)
- Unit construction cost	
Civil and power facilities	$3,700 / kW
Distribution Line	$8,000 / km

Table 10-7-3 Cost estimation for S/H Master Plan

Province District	Community	Households	Plant Capacity (kW)	Distribution. (km)	Cost	Notes
Vientiane						
Vangvieng	Keokouang	119	17.9	2.0	$102,300-	
	Nalao	82	12.3	0.6	$70,400-	
	Nakhoun	88	13.2	2.0	$84,900-	
	Phonsavang	86	12.9	2.0	$83,800-	
	Phonxou	94	14.1	2.0	$88,200-	
	Sub Total	469	70.4	8.6	$429,600-	
Kasi	Phato	106	15.9	2.0	$94,900-	
	Phonthieng	87	13.1	2.0	$84,500-	
	Viengxamay	106	15.9	2.0	$94,900-	
	Sub Total	299	44.9	6.0	$274,300-	
	Vientiane Total	**768**	**115.3**	**14.6**	**$703,900-**	
Borikhamxay						
Kamkeut	Khammouane	105	15.8			With Tonsan
	Tonsan	42	6.3	3.0	$125,800-	
	Sub Total	147	22.1	3.0	$125,800-	
Viangthong	Phondou	117	17.6	2.0	$101,200-	
	Sub Total	117	17.6	2.0	$101,200-	
	Borikhamxay Total	**264**	**39.7**	**5.0**	**$227,000-**	
	Two provinces Total	**1132**	**155**	**19.6**	**$930,900-**	

Note : Number of households is as of 1998 (EdL data)
Case study data of Nalao and Khammouane/ Tonsan are not used here.

The selected 10 candidate small-hydropower development projects will totally require approximately $931,000 for a total of 155kW installed capacity. The total number of households is 1,132. Unit project cost per household, therefore, is about $820.

10-7-4 Project Prioritization

Thus a total amount of $930,000 is required for the next ten years for developing small hydro sites in the two provinces. During Phase-1 of the ten-year period, detailed survey will be carried out on each site, and priority projects are to be decided based on set criteria such as economic feasibility, and urgency, etc. In Phase-2, the projects will be implemented based on the order of priority.

10-7-5 Economic Evaluation

Based on the estimated unit project cost, $820 per household, we studied user's payment, or electricity tariff. Other financial conditions used in the calculation are as follows.

- Discount Rate : 0.75%(soft loan through international aid)
- Depreciation Period : 30 years
- Salvage Value : 10% of total construction cost
- O&M Cost : 1% of total construction cost (from the next year of completion)

The result of simple cash flow analysis revealed that the monthly charge for a single household would be $3. Even with such a low interest loan, the monthly charge is more than the upper limit of $2.00 that rural users are willing to pay. This suggests that the government needs to consider providing subsidies to such small hydro projects in the early stage, and also cost reduction efforts by using simple design and domestic products should be made intensively. We strongly recommend that the government set target project cost of small hydro at less than $500 per household.

10-7-6 Investment Plan

Based on the total capital requirement of $930,000—$200,000 for planning and $730,000 for construction—the annual budget for the whole period can be estimated at $90,000 to $100,000. Thus, the necessity of securing approximately $100,000 annually to develop mini-hydro plants for rural electrification in the two provinces must be recognized.

Grants from foreign aid organizations are the most likely source of capital for mini-hydro development as well as for solar system development. However, the Lao government needs to provide funds for the survey stage, which may not be covered by grants. In this case, it would be possible to use the funds to be created by collecting fees from solar system users, because solar and mini-hydro development has the common goal of promoting rural electrification. With such measures, the rural mini-hydro development can be accelerated. At the same time, it is important to train local technicians so that they can provide inspection and maintenance services of mini-hydro facilities, because good maintenance is the key to success in case of rural mini-hydro development. Developing a separate training program would be indispensable and, therefore, should be seriously considered.

Appendix

Attachment List

Photovoltaic Power Generation

1.Solar Insolation and Precipitation in the Lao.P.D.R

2. Flow Chart of Solar-based Rural Electrification Project

3.Socio-economic survey Sample Survey Forms (Baseline/Monitoring/Impact Survey)

4.Lease Contract Forms (Draft) of Photovoltaic System (SHS,BCS)

5.Operating Instruction of Photovoltaic systems for users (SHS,BCS)

6.Installation and maintenance manual for Solar Home Systems

Small-hydropower Generation

1.Electrified and planned area / Candidate area for small-hydropower in two targeted provinces (Zoning)

2.Layout / Drawings (Houay Sing Project)

3.Layout / Drawings (Nam Phouan Project)

4.Table 10.1(1) Unit prices for Civil works in Laos

5.Table 10.1(2) Unit prices for Transmission System Construction in Laos

6.Table 10.2(1) Houay Sing Project Work Item Calculation Sheet

7.Table 10.2(2) Nam Phouan Project Work Item Calculation Sheet

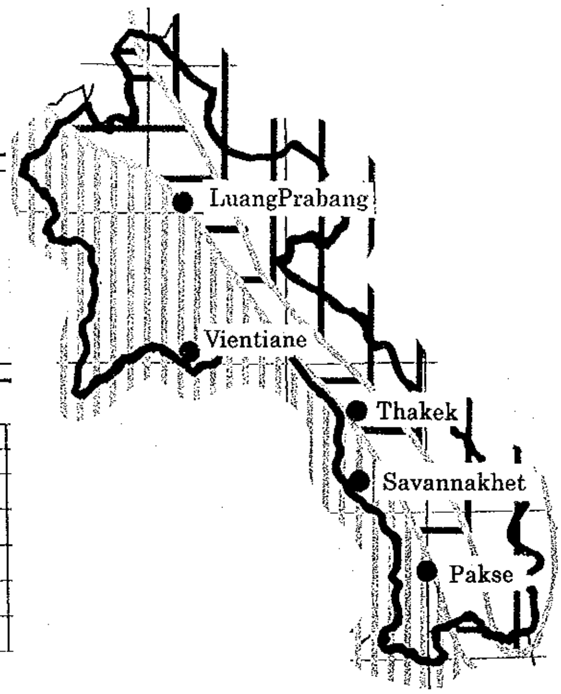
8.Table 10.3(1) Houay Sing Project Cost estimation

9.Table 10.3(2) Nam Phouan Project Cost estimation

Solar Insolation in Lao PDR(kWh/m2/day)

	LuangPrabang	Vientiane	Savannakhet	Pakse	Thakek
January	4.1	4.8	5.1	5.3	4.5
February	4.6	4.7	5.0	5.2	4.7
March	5.2	5.4	5.6	6.0	4.8
April	5.5	5.6	5.9	5.7	4.8
May	5.6	5.5	5.8	5.8	4.9
June	4.7	4.9	4.9	4.6	4.3
July	4.6	4.9	5.1	4.8	4.3
August	4.7	4.6	4.7	4.6	4.3
September	4.8	4.6	4.7	4.5	4.6
October	4.6	5.0	5.2	5.1	5.0
November	4.0	4.7	4.9	5.1	4.6
December	3.7	4.7	4.8	4.9	4.9
Average	4.7	5.0	5.2	5.1	4.6

		Solar cal/sq·cm/day
High	Rank5	>400
↑	Rank4	350~400
	Rank3	300~350
	Rank2	<300
Low	Rank1	

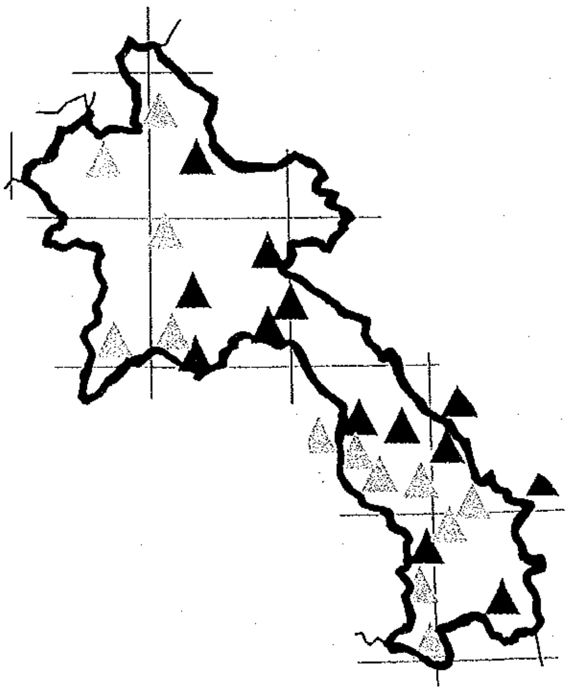


Solar Insolation in Lao P.D.R

UNIT: mm/y

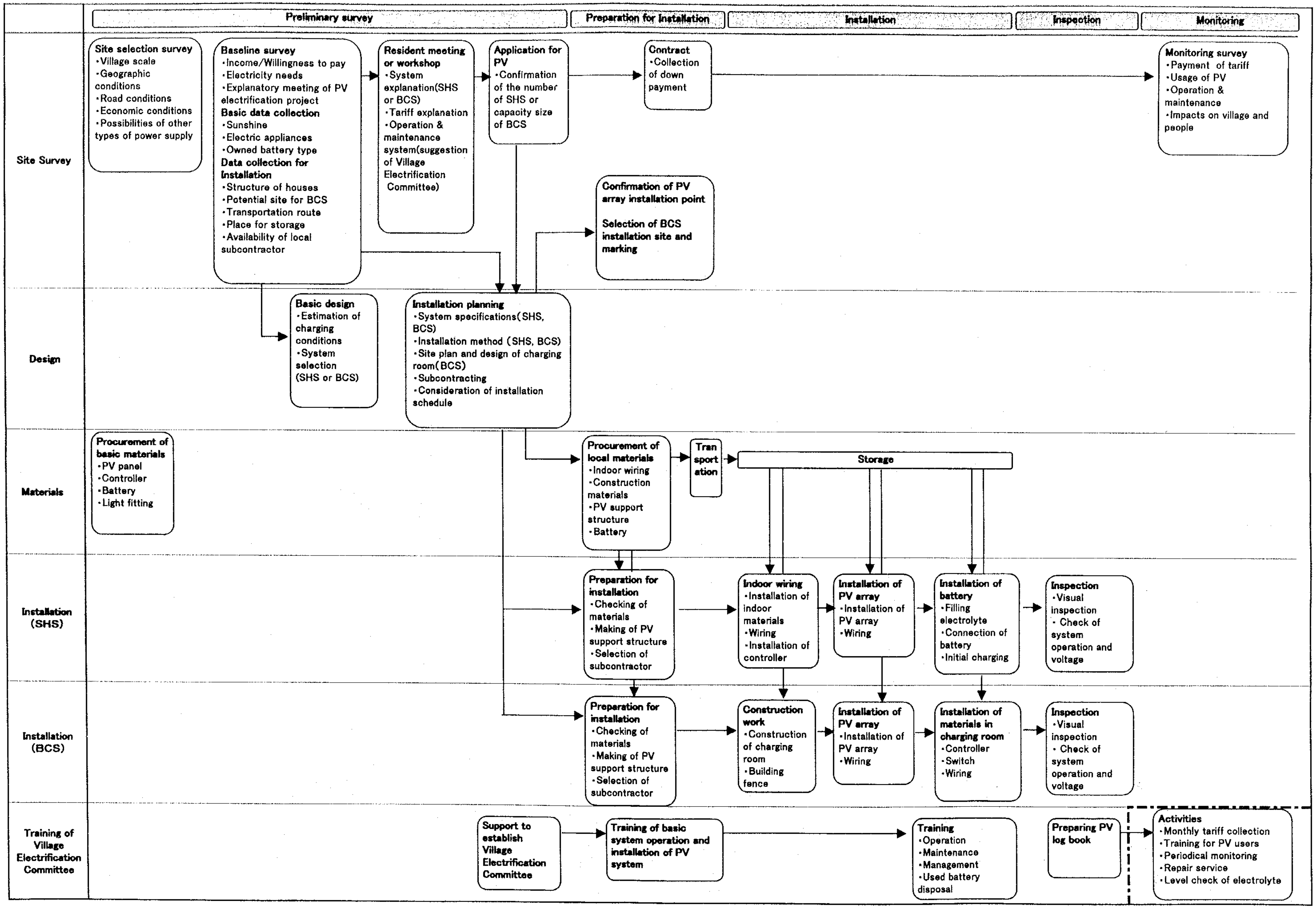
MARK	Range of Q
▲	3000≦Q
▲	2000≦Q<3000
▲	1600≦Q<2000
△	1000≦Q<1600
▲	Q<1000

Q = Yearly Precipitation



Precipitation in Lao P.D.R

Flow Chart of Rural Electrification by Solar System



Sample Survey Form

House No.	
Village name	
Date	
Surveyor	

Socio-economic baseline Survey (Questionnaire I)

1.House No. ______ 2.Name ______________________ 3.Age ____________

4.Number of Family member: _________ 5.Number of rooms: _______________

6. Roofing materials ☐metal sheet ☐bamboo/straw fiber7.Occupation____________

8. How much is cash income? ______________Kip/year

9.Source of cash income;

☐From Agriculture__________ kip/year, Crop name _________________

☐From selling Livestock____________kip/year

Livestock name (sold)	Livestock number(sold pieces)	Selling price(kip/head)

☐From selling fish_____________kip/year

How many kg of fish you sell?____kg/week, price_____________kip/ kg

☐Weaving/textile______kip/year, number of textile to sell_____pieces /year

Price________kip

☐Handicraft_________kip/year, What do you produce?______________

Number of pieces to sell_____pieces/year, Price___________kip

☐Rice mill_________kip/year, Price of milling __________kip/kg

☐Repair shop___________kip/year, What do you repair?____________

☐Commerce______________kip/year What kind of shop? ☐restaurant, ☐ retail, ☐kerosene oil, ☐barber, ☐tailor, ☐trader, ☐others_____

☐Service____________kip/year, What kind of service? : ☐teacher, ☐ farming for somebody ☐wood cutting, ☐transportation, ☐constructor, ☐others______

☐Others_____________kip/year, What do you do?________________

10.Total Living expense______________kip/year 11.Saving ___________kip/year

12.What do you own?

12.1 Field______ rai,_______ha

12.2 boat with engine___pieces, price_____kip, when did you buy?____Year

12.3 boat without engine___pieces, price___kip, when did you buy?____Year

12.4 car_____pieces, price__________kip, when did you buy?____Year

12.5 motorcycle____pieces, price________kip, when did you buy?____Year

12.6 bicycle______pieces, price__________kip, when did you buy?____Year

12.7 cow ______heads

12.8 buffalo ______heads

12.9 pig ______heads

12.10 well ______, pump______, rice mill______

12.11 others ________________

13.Type of lighting : ☐kerosene lamp, ☐gas lamp, ☐candle, ☐others

14.Using time of lighting per day?___________hours

15.1 Fuel cost of Kerosene: price/litter________kip, _____litter per month?

15.2 Fuel cost of Gas :price/litter________kip, _____litter per month?

16.Do you have a battery? ☐Yes, ☐No, if yes how many?_________Pieces

17.Do you have a diesel generator? ☐Yes, ☐No, if yes what purpose? ☐light, ☐rice mill, ☐TV, ☐water pump, ☐lighting for business, ☐refrigerator, ☐others

Price of generator ___________kip: When did you buy? ______year

<u>For battery owners</u>

18. Battery size____ Ah 19. Battery price _______kip 20. Battery Life______year

21. What kind of appliances do you use? ☐light__pcs, ☐TV__pcs,

☐radio___pcs, ☐fan___pcs, ☐others_________

22.How many times do you charge a battery per month? _________ times /month

23.Battery Charge price____________kip/time

24.How do you manage money for buying a new battery?_________________________

<u>25.For TV owners;</u>

25.1How many hours do you watch TV a day?____hours 25.2 TV capacity____W

26.For electric light owners;

26.1Type of lamp : ☐Bulb____pcs, ☐Fluorescence_______pcs

26.2How many hours you use a light a day? _________hours

26.3What wattage is a light?_______W

<u>For new solar battery systems</u>

27.When new solar battery systems comes, what so you expect?

☐To use (☐TV, ☐Radio, ☐Light, ☐Fan, ☐Others_________)

☐To work more (what work), ☐To study more, ☐to be safe night ☐others _____

28.How much capacity do you expect for new battery? _____Ah

29.How much are you willing to pay monthly for new solar electricity supply?

______________ kip/month

30.New solar battery systems require initial investment. How much can afford to pay for new system? _____________Kip

Sample Survey Form

Socio-economic Survey (Questionnaire II)

No.	
Village.	
Date.	
Surveyor	

Name ______________________ Age ________ Occupation __________
Income ____________________kip/year Field Area ______________________

1. Application : Solar Home System 55W _____, Solar Home System 110W _____,
   Battery Charge Station 50-70Ah Battery _____,
   Battery Charge Station 120Ah Battery _____.
2. Why did you choose the system?
   Price _____, Service hour _____, Convenience _____, Suggestion _____,(from who?)
3. What do you want to use electricity for?
   Lamp _____, TV _____, Radio _____, Fan _____, Others _____
4. What to you except the electricity?
   Study _____, Work _____, Better Light _____, Reading _____, Less Struggle _____,
   Wife _____, Others _____,
5. Family size? _____
6. How many school children do you have? Boy _____, Girl _____
6-1. Number of each category : Primary _____, Secondary _____, High school _____,
   Others _____
7. What is your educational level?
   Never attended school _____, Primary _____, Secondary _____, High _____,
   College _____, University _____
8. Life cycle

Head of Family

0 6 12 18

Spouse

0 6 12 18

Child

0 6 12 18

Child

0 6 12 18

Sample Survey Form

PV system users monitoring sheet1

Name ______________________

House No.	
Village	
Date	
Surveyor	

1 PV system ☐ BCS ☐SHS(50W) ☐SHS (100W) ☐Others( )

2 Battery size ☐ 50~70Ah ☐120Ah ☐Others ( )

3 Battery number ☐ 0 ☐ 1 ☐ 2 ☐more than 3 ( )

4 How do you prepare money for down payment?

☐Selling something

→ What did you sell?

☐Crops→ What ?( ) How many ? ( ) How much price( )

☐Livestock→ What ?( ) How many ? ( ) How much price?( )

☐Handicraft→What ?( ) How many ? ( ) How much price?( )

☐Wood→ How many? ( ) How much price?( )

☐Others( ) → How many? ( ) How much price?( )

☐From ordinary income

☐Savings

☐Borrowing from others ( )

5 What do you think of affordability on down payment?

impossible | very difficult | difficult | not difficult | easy

6 What do you think of inflation adjustment of monthly payment?

☐Acceptable ☐ depend on scale ☐non-acceptable ☐others

7-1 What kind of appliances do you have?

☐TV ☐radio ☐cassette recorder ☐lighting ☐others( )

7-2 Do you plan to buy new appliances?

☐TV ☐radio ☐cassette recorder ☐lighting ☐others( )

8 Are you satisfied with the system you chose? ☐ Yes ☐ No

8-1 If your answer to #8 is No, which system do you like?

☐BCS ☐SHS(50W) ☐SHS(100W) ☐Others( )

9 Remark

Sample Survey Form

PV system users monitoring sheet 2

Name__________House no.______ Village___________ Date____Surveyor

1 Is your PV system working well? ☐Yes ☐No If you have problems, what problems?:
☐Not charging well ☐Fluorescent light ☐Battery ☐Charging controller☐Others

2 What do you think of your PV system operation ? ☐Easy ☐Difficult.
If difficult, especially what?: ☐Changing Fluorescent light ☐Reading charge controller
☐Connecting battery ☐Cleaning panel ☐Checking distilled water ☐Others

3 Who checks distilled water of your battery?: ☐Yourself ☐Neighbor ☐VEC member ☐BCS operator

4 What service do you want to get from Village electrification committee?:
☐Users training ☐Selling spare-parts ☐ Advice to users ☐ Repair service ☐Others

5 Are you satisfied with the system you chose?: ☐Yes ☐No.
If no, what is problems? ☐Taking long time to charge ☐Cannot use expected electric appliances ☐ Others. If no, which system do you like? ☐ BCS ☐ SHS(50W) ☐ SHS (100W) ☐ Others( )

6 Do you charge another Battery(2nd, 3rd one or 6V one)? If yes, where do you charge?:
☐Your own SHS ☐Neighbor's SHS ☐BCS in town ☐BCS in the village☐others

7 Do you pay Monthly payment on schedule? ☐Yes ☐No.

8 What do you think about an amount of Monthly payment on your PV system?:
☐not payable ☐very expensive ☐expensive ☐not expensive ☐cheap

9 Dose your monthly living expense increase after PV installation?: ☐Yes ☐No. If yes, why?

10 Dose your income increase after PV installation?: ☐Yes ☐No.
If yes, why?:☐Night Handicraft ☐Night Weaving ☐Night fishing ☐Others( )

11 Did you cut any expense to pay PV expenses ?: ☐Yes ☐No.
If yes, what?: ☐Living expense ☐Educational expense ☐Expense for entertainment ☐Others ( )

12 Did you buy any new electric appliances after PV installation?: ☐Yes☐No: If yes, what did you buy?:
☐More Light ☐Radio ☐Cassette-recorder ☐TV ☐Fan ☐Others

13 Are you still buying kerosene, after PV installation?: ☐Yes ☐No.
If Yes, How many liters are you spending a month?
Now: (liters/month) (kip/litter), Before: (liters/month) (kip/litter)

14 Which is better for lighting in your house, PV system or Kerosene lamp?: ☐ PV ☐Kerosene lamp

14.1 What is better point for PV than Kerosene lamp?
☐Cost performance ☐Convenience ☐Saving time ☐Safety use ☐No smell ☐Status

14.2 What is better point for kerosene than PV? ☐Cost performance ☐Insects guard ☐Others

14.3 Which is better, SHS or BCS? ☐SHS ☐BCS.
Why? ☐Cost performance ☐Convenience ☐Saving time ☐Good service ☐Others

14.4 Which is better, charging battery in town or BCS? ☐ charging battery in town ☐BCS.
Why? ☐Cost performance ☐Convenience ☐Saving time ☐Good service ☐Others

Sample Survey Form

PV system users Impact survey sheet

Name___________ House no.______Village_____________Date Surveyor ______

1.Have your PV system been working well for past three months? 0.( ) Yes, ( )No If no, what problems? 1.( ) Not charging well, 2.( ) Fluorescent light, 3.( )Charging controller, 4.( ) Others ________

2.Are you satisfied with the system you chose? 0.( ) Yes, ( ) No.

2.1 If no, what are problems? 1.( )Taking long time to charge, 2.( )Cannot use expected electric appliances, 3.( )Others.

2.2 If no, which system do you like? 1.( )BCS, 2.( )SHS-50W, 3.( )SHS-100W, 4.( )Others

3.Do you have any electric appliances except 8W fluorescent lamp? 1.( )Yes, .( )No. If yes, please specify number into the table in question 3.

4.How many hours do you use electrical appliances on average? Please draw a line on a time zone you use it.

Electrical appliance	number	W	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	hour
Fluorescent lamp		8																									
Another fluorescent lamp																											
Radio-cassette																											
TV																											
Speaker																											

5.Did you buy any new electric appliances after PV installation? ( )Yes, 0.( ) No If yes, what did you buy? Please specify.

	Light	Radio cassette recorder	TV	Fan	Others
Total Number					
Bought past 1 year					

6.What is changed better in your life, after PV installation ?

1( )Cooking at night easier 2( )Working at night easier 3( )Studying at night easier 4( )Getting information from radio or TV 5( )Increasing income 6( )Getting safer at night(with light) 7( ) Saving energy expense 8( )Having fun under the light <What:8.1□Dinner time 8.2□Relaxing time 8.3□Chattering time 8.4 □Drinking time 8.5□Others ______)

6.1 What is best? __________________(Choose from 6)

7.Dose your income increase after PV installation? ( )Yes, 0.( )No. If yes, why? 1.( )Night Handicraft, 2.( )Night Weaving, 3.( ) Night fishing, 4.( )Others How much can you get income per month? ( )kip/month

If yes. Please ask detail .

8.What is changed worse in your life, after PV installation ?

1( )Sleeping time shorter (Reason:1.1☐Brightness of light 1.2☐TV watching time 1.3☐ Longer working time at night 1.4☐Others______) 2( )Increasing energy expense 3( ) Increasing living expense 4( ) Insects gathered more than before 5( )Villager's relationship worse <Reason:5.1☐Fee collection trouble 5.2☐VEC member's attitude 5.3☐Trouble between PV user and non-user 5.4☐Others > 6( )Village noisier <Reason: 6.1☐TV 6.2☐Cassette recorder 6.3☐Speaker 6.4☐ Karaoke 6.5☐People often come from outside village. 6.6☐Others ________>

9.Dose your monthly living expense increase after PV installation? 1.( )Yes, ( )No. If yes, how much? From ( )kip/month to ( ) kip/month.

If yes. Please ask detail .

10.Are you still buying kerosene for lighting, after PV installation? ( )Yes 0.( )No. If Yes, How many liters are you spending a month? Now: [liters/month] [price kip/litter], Before: [liters/month] [price kip/litter]

11.Do you charge another batteries past three month? 1( )Yes, 2( )No.

12.Do you charge other house's batteries at your house? 1( )Yes, 2( )No.

13.Do you think PV has improved your life ? 1( )Yes ( )No

14.Do you check your PV system periodically? 0.( )Yes, 1.( ) No. If yes,

14.1 how frequency? 1.( ) Every day, 2.( ) Once a week, 3.( )Once a month, 4.( )Others
14.2 have you found any problems by your check? 1.( )Yes, .( )No.

15.Have you wiped solar module? 1.( )Yes, ( )No.

16.Have the battery been filled water? 1.( )Yes, .( )No.

If yes, 16.1 who filled? 1.( )User, 2.( )Committee, 3.( )Others
16.2when and how many bottles?

	February	March	April	May
Number of bottle				

17.What can you do for sustainable PV using in the village ?

1( ) Take care of using PV 2( )Self maintenance 3( ) Trouble report to VEC 4( ) Payment on schedule 5( )Others

18.Does the electrification committee (VEC) maintain your PV system periodically? 1.( )Yes, 2( )No.

If yes, 18.1 how frequency? 1.( )Almost every day, 2. ( ) Once a week, 3.( )Once a month, 4.( )Others

18.2 what kind of service do they provide?

1( )Periodical check for PV. 2( )Appropriate fee collection. 3.( )User training and maintenance instruction. 3( )Filling water into battery. 4( )Cleaning of equipment. 5( )Repair services. 6( )Replacement services. 7( )Selling spare parts, 8( ) Keep contact with MIH. 9( )Others

19.What do you expect VEC to do for sustainable PV using in the village ?

1( )Periodical check for PV. 2( )Appropriate fee collection. 3.( )User training and maintenance instruction. 3( )Filling water into battery. 4( )Cleaning of equipment. 5( )Repair services. 6( )Replacement services. 7( )Selling spare parts, 8( ) Keep contact with MIH. 9( )Others

Solar Home System Lease Application Form (Draft)

Name ____
Village ____
ID ____

1. Type of Solar Home System (SHS)
   I, as Renter, apply for a

   ______55W system which includes one solar panel with mounting, one charge controller, one fluorescent lamp, one battery (70Ah), and standard cables and connections.

   ______110W system which includes two solar panels with mounting, one charge controller, one fluorescent lamp, one battery (120Ah), and standard cables and connections.

2. Down payment
   I agree to pay the following amount as a down payment. The down payment will be collected by a designated officer.

   ****** kip (55W system)---------*((70Ah local battery price equivalent))*
   ****** kip (110W system)--------*((120Ah local battery price equivalent))*

3. Monthly Charge
   I agree to pay the following amount every month. The monthly charge will be collected by the Village Electrification Committee (VEC) every month.

   ****** kip (55W system)
   ****** kip(110W system)

   The monthly charge may change due to inflation. Changes to the tariff will be announced two months in advance.

4. Warranty
   Battery, fluorescent lamp, indoor wiring, switch, and wall outlet are covered by a one-year warranty.

5. User's Liability
   I agree to replace at my expense the battery, fluorescent lamp, indoor wiring, switch, and wall outlet by myself after the one-year warranty period has expired. In the event the SHS is malfunctioning, the user shall notify the VEC.

6. Duration of Contract
   The term of this Lease is 20 years. After 20 years, the ownership of SHS will be transferred to the user. The user can purchase the SHS by paying the residual value at any time. Until this lease is terminated, the SHS shall remain the property of the Government, and the user is not allowed to sell or modify the SHS. In case the user wishes to terminate the lease before expiration, the user shall notify the VEC one month in advance and the user shall return the SHS to the VEC.

7. Failure of Payment
   In case the user fails to pay the monthly charge for two consecutive months, this Lease may be terminated

8. Relocation of the System
   In case of relocating the SHS, the user is responsible for the cost incurred.

9. Reduction of System Capacity
   In case the user wishes to reduce the capacity from 110W to 55W, the user shall notify the VEC one month in advance and return the solar panel to the VEC.

10. Government's Liability

The Government is responsible for installation, ordinary maintenance, and replacement of the charge controller and solar panel if they are faulty.

11. Transfer of Lease Contract

The user can transfer this lease contract to another user. The second user must notify the VEC immediately after the transfer is completed. In this case, the Government is not responsible for system installation.

All amounts charged under this Lease are nonrefundable.

The undersigned hereby applies to lease a Solar Home System. I HAVE READ THE ABOVE LEASE AS STATED AND AGREE TO BE BOUND BY THE TERMS AND CONDITIONS CONTAINED WITHIN. I ALSO CERTIFY THAT THE INFORMATION I HAVE PROVIDED IS COMPLETE AND ACCURATE.

Date:______________________________

Signature:____

For the second user (in case of transfer)

I agree to take over the system under the same lease conditions as the former user.

Date:______________________________

Signature:____

Date:______________________________

Signature:____

Battery Charge Station (BCS) Lease Service Application Form

The Village Electrification Committee (VEC) in ***"Name of Village"*** hereby applies for the battery charging service to be provided by the service agency (Government)..

1. Capacity of BCS

   The BCS consists of ** units. Capacity of one unit system is 165W.

2. Monthly charge

   The VEC agrees to pay ***** kip of monthly fee to the Service Agency (Government). The monthly leasing charge is subject to change due to inflation every year.

3. VEC's Liability

   In case a part of the BCS such as a PV module or charge controller is stolen, the VEC agrees to pay for the replacement.

4. Government's Liability

   In case of the BCS failure, the Government repairs or replaces the system without charge.

5. Termination

   The term of this Lease is 20 years. After 20 years, the ownership of BCS will be transferred to the VEC. In case the VEC wishes to terminate this contract, the VEC will notify the Government one month in advance. In case of failure to pay the monthly charge for two consecutive months, this contract may be terminated.

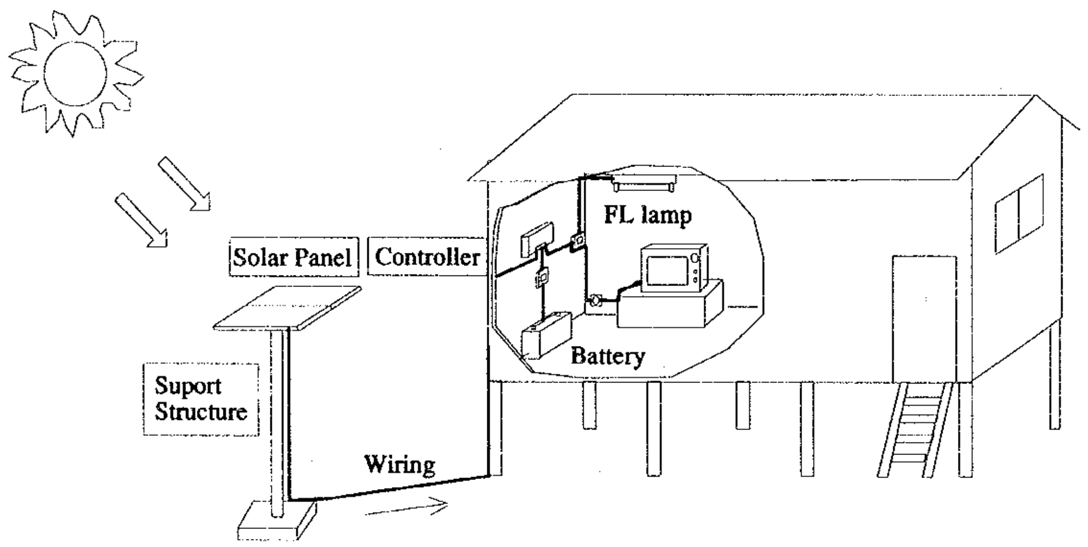
Date______________________________

Signature_________________________

Operating Instructions for Your Solar Home System

How the Solar Home System Works

*Under sunshine, the solar panel generates.
*The controller controls charging and discharging to protect SHS.
*The battery stores electricity for your use.



Equipment	Responsibility
Solar panel, Support structure, Controller	EDL/HPO
Battery, Fluorescent(FL) light, Switch, Wall outlet, Wiring	User

Switching On

1. Move main breaker to ON position.
2. Check LED 6 is on for five seconds.
3. This will connect the solar array and appliances to the battery.

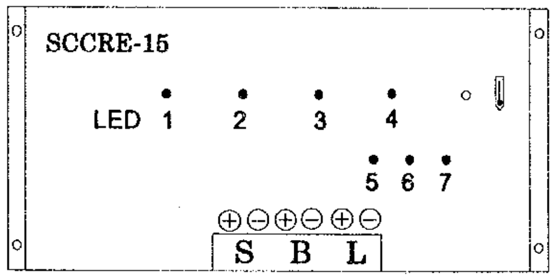
Switching Off

1. Turn off all appliances.
2. Move main breaker to OFF position. This will disconnect the solar array and appliances from the battery.

How to Use

*Plant trees and build should away from solar panel. The shade on the solar panel reduces the generating power from the solar panel.
*To save energy and to keep batteries life long, remember to turn off your lights on TV when they are not necessary.
*Be careful not to connect wires in reverse, because your appliance may be broken.
*Keep liquids and everyone, especially children, away from the controller, because the trouble may be caused.
*Keep fire away from battery, because a fire may be caused.

Controller



Controller

LED 1: Battery is low. The power supply to appliances is automatically cut, and the controller will only charge the battery.
LED 2: Battery is in normal condition. You can use appliances.
LED 3: Battery is almost fully charged.
LED 5: Solar panel connection is wrong.
LED 6: Switch on (lighting five seconds)
Battery problem (lighting long time)
LED 7: Battery connection is wrong.

How to Maintenan Your Solar Home System

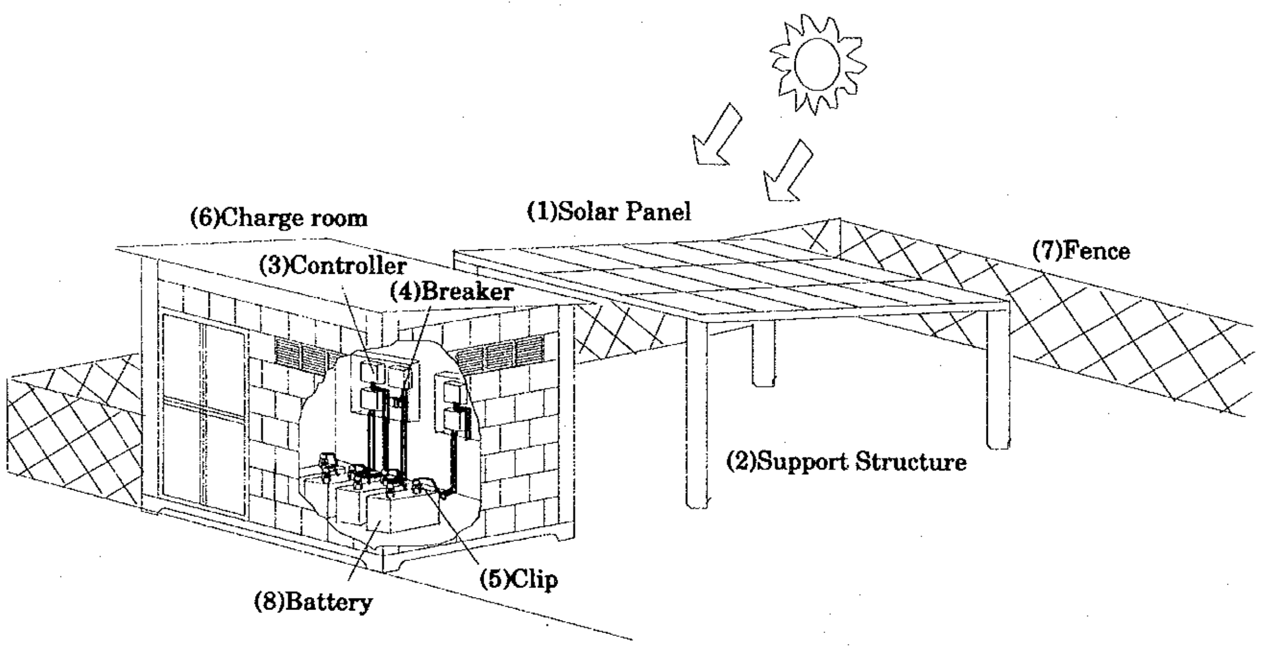
PV Array: *If the surface of solar panel is dirty, wipe and wash.
Battery: *Check acid level. If the levels is low, add distilled water only. Don't add well water and so on.
Wiring: *Check cables to secure tight connection.
*Check condition of the cable. (Damage, snapping, short etc.)

If you find any trouble in your system which you cannot deal with, please report to technician.

Operating Instructions for Battery Charge Station

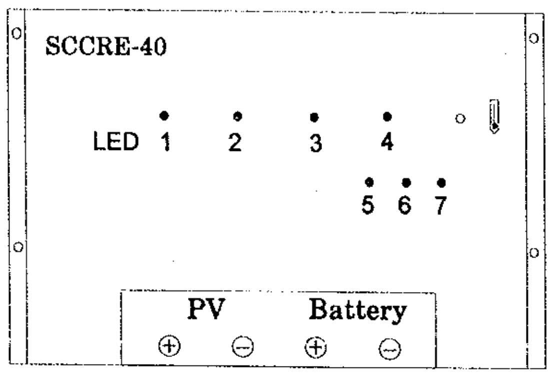
How the Battery Charge Station Works

*Under sunshine, the solar panel generates.
*The generated power is stored into the battery through the controller
*The controller controls overcharging to protect your battery.



Equipment	Responsibility
(1)Solar panel, (2)Support structure, (3)Controller	HPO
(4)Breaker, (5)Clip, (6)Charge room, (7)Fence	Management
(8)Battery	User

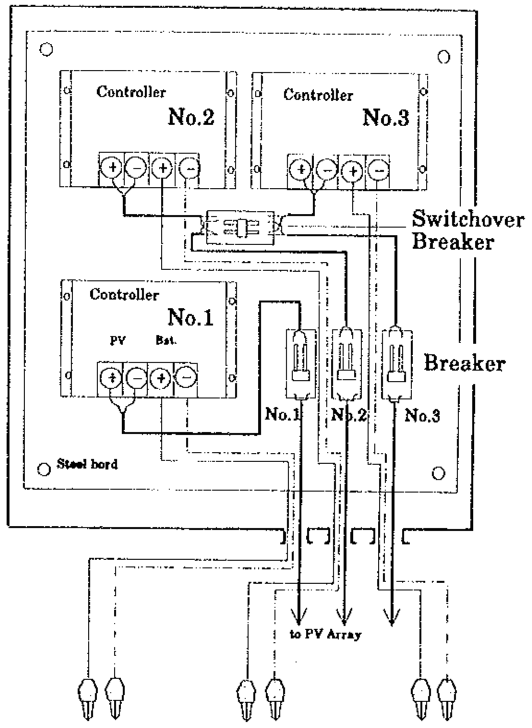
Controller



Controller

LED 1: Battery is low. (less than 12.5V)
LED 2: Battery is in normal condition. (more than 12.5V)
LED 3: Battery is almost fully charged.
LED 4: Battery is during charging.
LED 5: Solar panel connection is wrong.
LED 6: Switch on (lighting five seconds) Battery problem (lighting long time)
LED 7: Battery connection is wrong.

Charge Start (in case of using No.3)



Battery capacity: less than 80Ah

1. Connect battery.
2. Check LED 6 is on for five seconds, then LED 1 is on.
3. Check switchover breaker is neutral position
4. Move breaker (No. 3) to ON position.
5. Charge start

Battery capacity: more than 90Ah

1. Connect battery.
2. Check LED 6 is on for five seconds, then LED 1 is on.
3. Move switchover breaker to side B.
4. Move breaker (No. 3) to on position.
5. Charge start

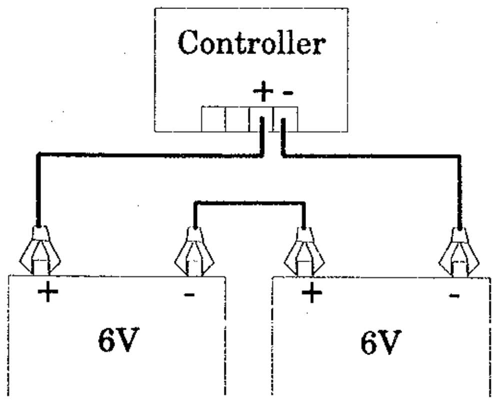
Charge Stop

1. Check LED 3 is on continuously. This means battery is full charge.
2. Turn off breaker.
3. When switchover breaker is used, move it to neutral position.
4. Take off battery.

How to Charge 6V Battery

1. Connect two 6V batteries in series.
2. Connect batteries to controller.
3. Charge start according above order.

Caution
*Don't connect batteries in parallel.
*Don't connect different batteries together.
*Batteries should be charged in the morning or in the evening.



Trouble shooting

Battery can't be charged fully.

Cause	Corrective action
1. Bad weather condition	Continue charging a battery next day.
2. Damage of PV module	Report to technician.
3. Dust of PV module surface	Clean PV module surface.
4. Connecting bad battery	Check battery. Report to user when battery is bad.
5. Loosen of connecting part	Tie bolts hardly or clean the connecting part.
6. Rust of clips	Remove the rust or exchange a clip.
7. Controller trouble.	Report to technician.
8. Damage of cable (cut, short)	Repair or exchange

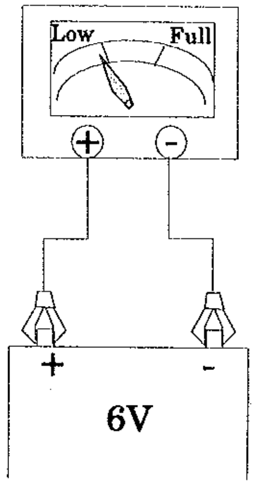
Controller doesn't operate.

Cause	Corrective action
1. Reverse connection of battery	Reconnect battery properbly.
2. Low Battery voltage	Check voltage. If voltage is low, let user know.
3. Open circuit or short	Check cable between PV array and battery.
4. Loosen of connecting parts	Tie bolts hardly.
5. Operating protective function	Restart controller.
6. Controller trouble.	Report to technician.

How to check battery

Check battery voltage when LED6 is lighting long time.

1. Connect voltage meter to battery.
2. Check voltage
   *Less than 8V   Battery is low. Battery can't be charged directly.
   *More than 8V   Check cable, clips and controller.



Check battery voltage after charging.

*More than 12.5V   Battery is full.
*Less than 12.5V   Battery is not full or battery is almost dead.

How to judge battery is almost dead.

Case1   LED2 and LED3 flush at the same time.
Case2   Charge interval become short.
Case3   Battery voltage is less than 12.5V after charging fully.

How to Maintenan Battery Charge Station

PV Array :   *If the surface of solar panel is dirty, wipe and wash.
Controller :   *Check condition of the controller. (Damage, state of installation, heat etc)
Wiring :   *Check cables to secure tight connection.
    *Check condition of the cable. (Damage, snapping, short etc.)
Clip :   *If the clip is made corrosion, polish or exchange new one.

If you find any trouble in the system which you cannot deal with, please report to technician.

THE STUDY ON
RURAL ELECTRIFICATION PROJECT
BY RENEWABLE ENERGY
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

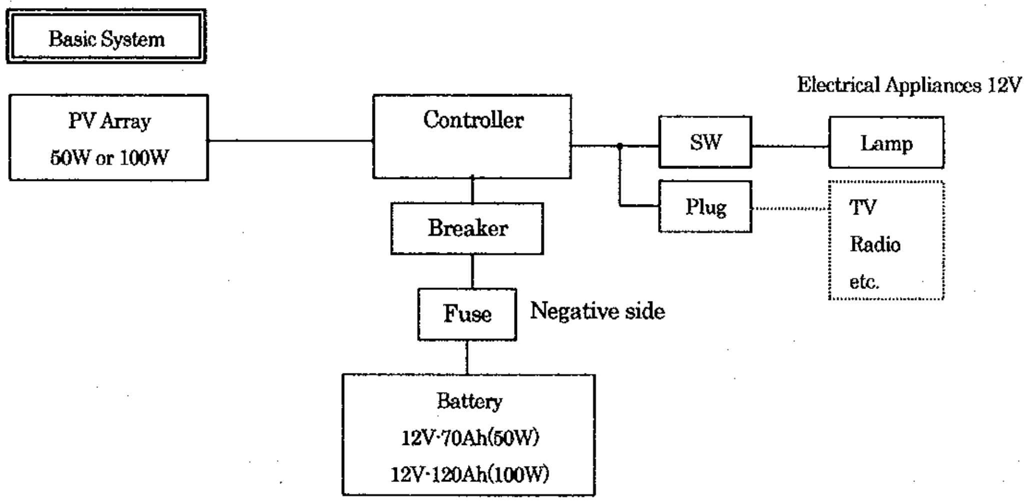
Installation and maintenance manual
for Solar Home Systems

1. Introduction

This manual provides installation and maintenance information on solar home systems. It focuses particularly on the systems installed by the Rural Electrification Division (RED) of the Ministry of Industry of Lao PDR, with assistance from JICA.

2. System Diagram

There are two types of solar home system, 50W and 100W.Basically, a solar home system consists of PV array, Controller, Battery, Breaker, Switch, Wall outlet and Lamp kit. Users can connect their own electrical appliances using the wall outlet. In Laos, many people use 6V batteries for various purposes. To allow people to charge these 6V batteries, and to allow charging of additional 12 volt batteries, the solar system has the option of extra-battery charging.



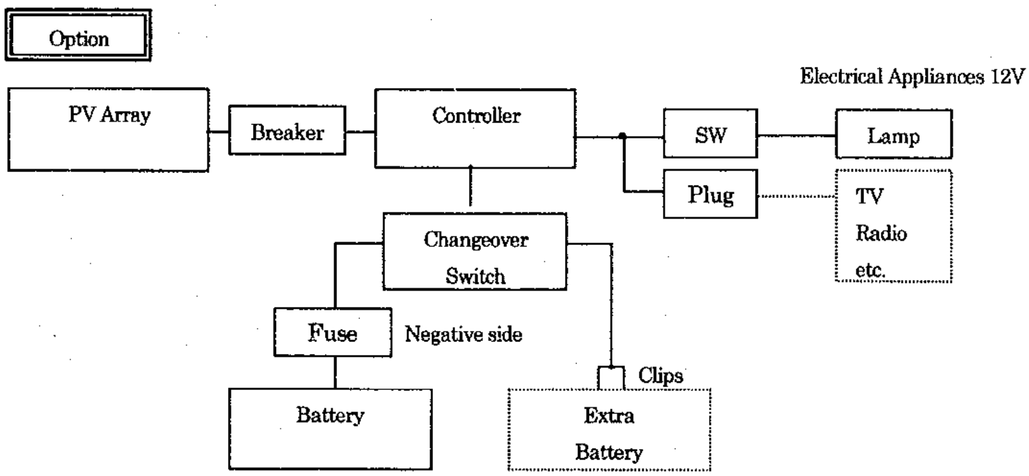


Figure 2-1 System diagram

Reference 2-1 Usable load for 50W system

Electrical Appliance	W	Case-1	Case-2	Case-3	Case-4	Case-6	Case-6	Case-7
Florescent Lamp	8	12		10	6		5	
Florescent Lamp	20		5			3		3
Radio & Cassette	5			4			4	2
B/W TV 14"	18				3	2	2	2

Reference 2-2 Useable load for 100W system

Electrical Appliance	W	Case-1	Case-2	Case-3	Case-4	Case-6	Case-6	Case-7
Florescent Lamp	8	24		11		8		6
Florescent Lamp	20		10		6		6	3
Radio & Cassette	5					6	5	4
B/W TV 14"	18			6	4	5	3	4

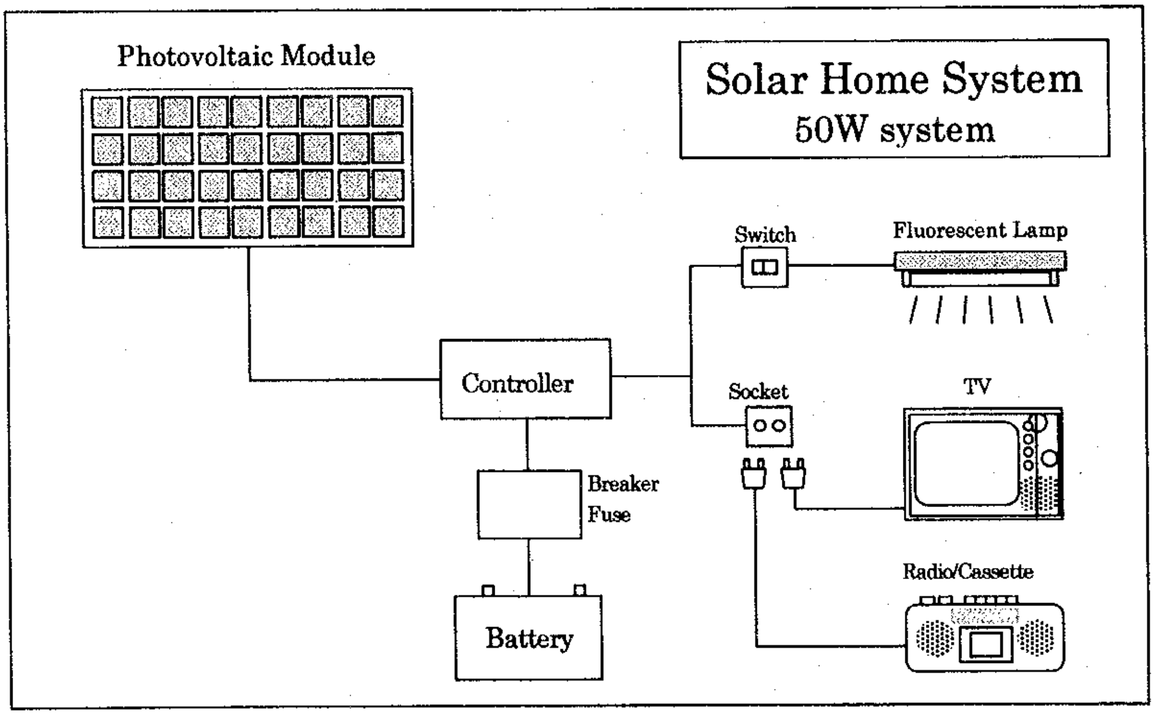


Figure 2-2 Image drawing

3. Equipment and materials

3.1 Main Materials

No.	Item	Specification	50W	100W
1	Photovoltaic module	Capacity : 50W Peak power voltage: more than 17V	1	2
2	Controller	Nominal voltage: 12V Through current: more than 10A (depend on current of peak load) Control: Overcharge & Over-discharge	1	
3	Battery	Type: Lead-acid Nominal voltage: 12V	70Ah (60-100 Ah)	120Ah (100-140 Ah)
4	Breaker*3 (Battery)	AC 240V – 30A 2P	1*1	
5	Fuse*4	Capacity : depend on controller	1	
6	Switch	AC 300V – 10A	1	
7	Plug	AC 300V – 10A	1	
8	Cable holder	Steel band & Nail	40	
9	Solderless terminal		2	
10	Protective cover		2	
11	Breaker (PV)	AC240V-30A 1P	1*2	
12	Changeover switch	AC300V-30A	1*2	
13	Clip	20A	2*2	

Notice *1: Basic system, *2: Optional system
*3: When the following conditions are satisfied, you may omit breaker.
· The breaker is provided with controller.
· A removable fuse is used.
*4: When a DC safety breaker is used, a fuse is not necessary.

3.2 Cable

No.	Location	Specification	Reference
1	PV array to Controller	Type : PVC/PVC 300V Size : $6mm^2$ x 2 cores (less than 10m)	3-1
2	Controller to Battery	Type : Flexible PVC 300V Size : $6mm^2$ x 2 cores (less than 3m)	3-2
3	Controller to SW & Plug	Type :Flexible PVC 300V Size : $2.5mm^2$ x 2 cores (less than 2m)	3-3
4	SW & Plug to Load	Type :Flexible PVC 300V Size : Depend on load current and distance	3-3

If controller senses battery voltage directly, the cable between controller to battery can be smaller.

Reference 3-1

System	Length of cable [m]														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
50W			1.25mm²				2.5mm²						4.0mm²		
100W	1.25mm²			2.5mm²			4.0mm²				6.0mm²			8.0mm²	

*Voltage drop is under 0.5V.

Reference 3-2

Current [A]	Length of cable [m]				
	1	2	3	4	5
5	1.25	2.5	4.0mm²		6
10	2.5	4	6		
15	4	6			

*Voltage drop is under 0.2V.

Reference 3-3

Current [A]	Length of cable [m]														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1															
2															
3		1.25mm²													
4															
5															
6							2.5mm²								
7															
8									4.0mm²						
9													6.0mm²		
10															

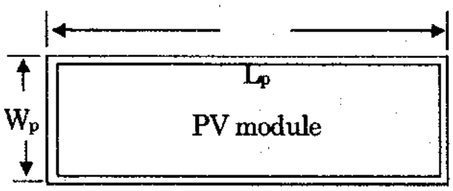
*Voltage drop is under 1.0V

3.3 Support Structure for PV modules

<Installation condition>

*Tilt Angle = Latitude of installing point * 1.1

(Reference 3-4)



*Direction = Face to south

(Recommendable range: ±30 degrees from south in the case of roof top type)

Reference 3-1

System	Length of cable [m]														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
50W	1.25mm²					2.5mm²				4.0mm²					
100W	1.25mm²		2.5mm²				4.0mm²				6.0mm²			8.0mm²	

*Voltage drop is under 0.5V.

Reference 3-2

Current [A]	Length of cable [m]				
	1	2	3	4	5
5	1.25	2.5	4.0mm²		6
10	2.5	4	6	8	
15	4	6	8		

*Voltage drop is under 0.2V.

Reference 3-3

Current [A]	Length of cable [m]														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1															
2															
3		1.25mm²													
4															
5															
6								2.5mm²							
7															
8										4.0mm²					
9														6.0mm²	
10															

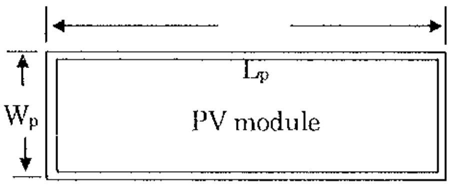
*Voltage drop is under 1.0V

3.3 Support Structure for PV modules

<Installation condition>

*Tilt Angle = Latitude of installing point * 1.1

(Reference 3-4)



*Direction = Face to south

(Recommendable range: ±30 degrees from south in the case of roof top type)

Reference 3-4 Tilt angle of PV array

Tilt angle [degrees]	City
17	Pakxe, Saravan
18	Savanakhet
19	Muang Khammouan,
20	Vientiane, Paxan, Muang Phon-Hong
21	Muang Xaignabouri, Xiangkhong
22	Louangphrabang, Xam Nua, Ban Houayxay
23	Moung Xay, Louang Namtha
24	Phongsali

1) Roof Top Type

No.	Item	Specification	50W	100W
1	Timber	40*80mm	L> W_p+200	L>W_p*2+300
2	Bracket	Steel plate 80*40*4mm	4	8
3	Nail	No 8	4	6
4	Screw		4	8
5	Bolt & Nut	Hex Bolt M6 * 20 & Nut	4	8

2) Pole Mount Type

No.	Item	Specification	50W	100W
1	Pole	Steel pole φ85 – H 3 m,	1	1
2	Support structure	Assembled with L type angle	1 set	1 set
3	Panel frame	L type steel angle 30*30*5mm	L=W_p	L=W_p*2
4	Bolt & Nut	Hex Bolt M6 * 20 & Nut	4	8
		Hex Bolt M10 * 20 & Nut	4	4
5	Concrete		0.06m^3	0.06m^3

3) Roof Pole Mount Type

No.	Item	Specification	50W	100W
1	Pole	Steel pole φ85 – H 2m,	1	1
2	Support structure	Assembled with L type angle	1 set	1 set
3	Panel frame	L type steel angle 30*30*5mm	L=W_p	L=W_p*2
4	U type band	Steel φ85	2	2
5	Bolt & Nut	Hex Bolt M6 * 20 & Nut	4	8
		Hex Bolt M10 * 20 & Nut	4	4
6	Nail	No 10	4	4

4. Installation of PV array

4.1 Mounting of PV array

1) Roof top type

Using this method, the PV module is installed on the roof.

1- Fix four brackets on the frame of PV module with bolts and nuts.

2- Install two timbers on the roof with nails.

3- (Connect two 50W PV modules to each other, in case of 100W system)

4- Check that the tilt angle is approximately correct, and if necessary modify the timbers to correct the angle.

5- Fix the PV modules on the timbers with screws.

6- Connect wire between PV module and controller.

Precautions:

* The distance between the PV module and roof should be more than 10cm (to regulate temperature of the modules)
* seal holes so that they are water-tight
*strengthen mounting in windy areas
*if the roof is not facing south, select the pole-type mount (recommendable range for roof mounting : ±30 degrees from south)

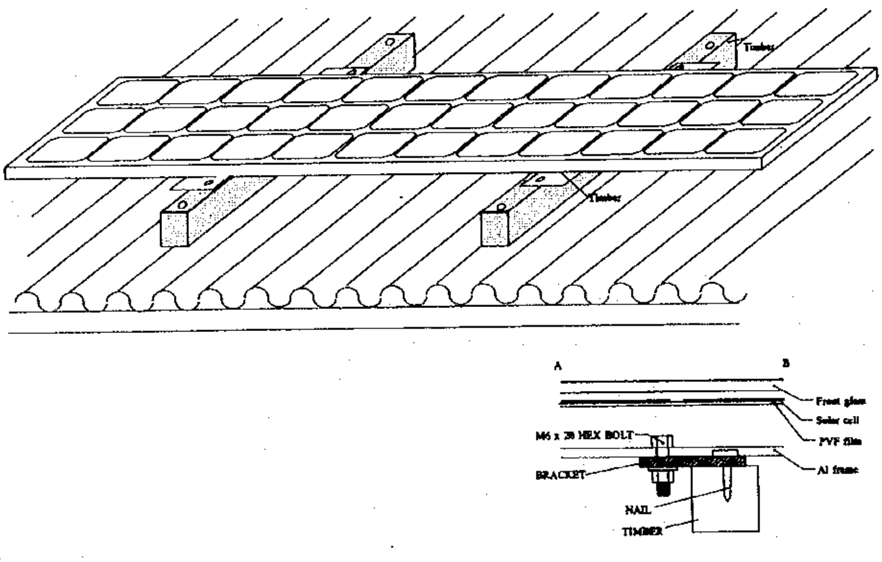


Figure 4-1 Drawing of roof- mounted PV array2) Pole mount type

2) Pole mount type

This is the method by which the PV module is installed on the ground using steel pole.

1- Assemble PV support structure with bolts and nuts
2- Mount PV panel frame to the support structure
3- Fix PV support structure at the correct tilt angle (see table of tilt angles) on the top of steel pole with nuts and bolts
4- Dig a hole of 300mm diameter and 500mm depth at selected place.
5- Set up a steel pole and adjust the direction of PV array to south
6- Fill up to 200mm deep of the hole with mud and gravel, and compress.
7- Fill up to 300mm deep of the hole with concrete.
8- Connect wire between PV module and controller.

Precautions

* build a fence around the PV array when it is installed at the side of road where animals or vehicles may hit the pole.
* lay the cable between the PV array and the controller underground when the distance is less than 3m. If the distance is more than 3m, connect the cable overhead.
*strengthen the installation in windy areas.

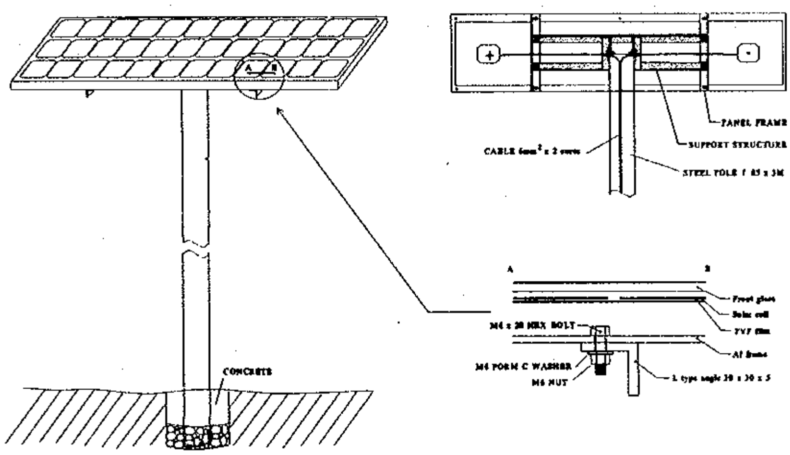


Figure 4-2 Drawing of pole-mounted PV array

3) Roof–pole mount type

Using this method, the PV array is mounted on a pole which is mounted on a major structural member of the house, such as a cross-beam or support column.

1- Assemble PV support structure by bolts and nuts.
2- Mount panel frame to the PV support structure by bolts and nuts.
3- Fix PV support structure at the correct tilt angle (see table) on the top of steel pole with nuts and bolts.
4- Fix the pole to the column of house with U bands, but do not tighten until you have finished adjusting the direction of the array.
5- Adjust the direction of PV array to south and fix the pole firmly.
6- Connect wire between PV module and controller.

Precautions

* seal holes for water-tightness *strengthen the installation in windy areas.

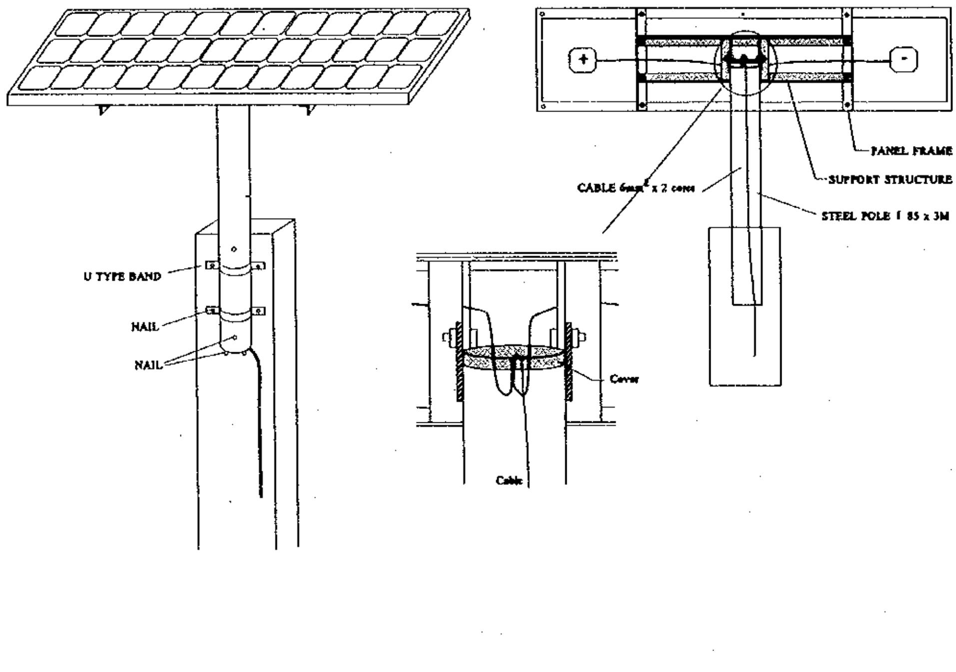


Figure 4-3 Drawing of PV array mounted (Roof pole type)

4.2 Wiring of PV array

1) Junction Box

There are one or two junction box(es) on the back of PV module. A cable should be connected to the terminal of junction box tightly.

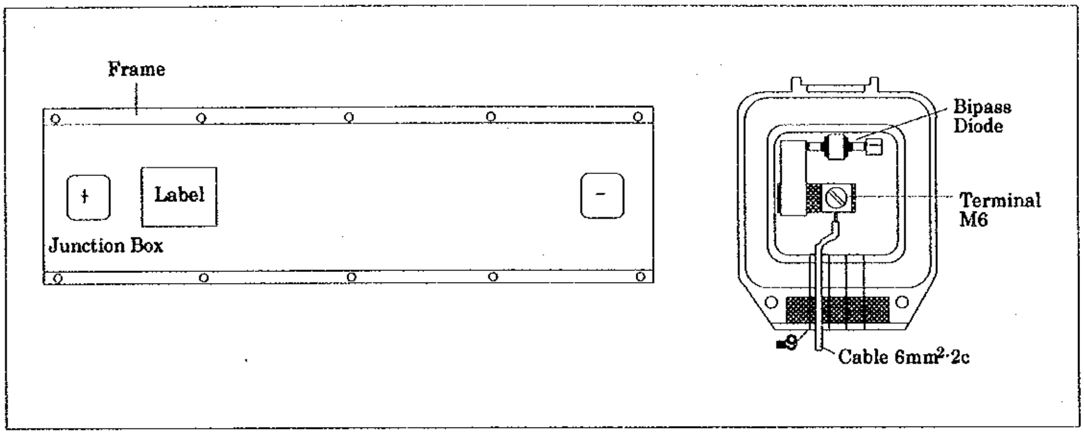


Figure 4-4 Junction Box (Example)

2) Module Connection

In case of 100W system, two PV modules are connected in parallel.

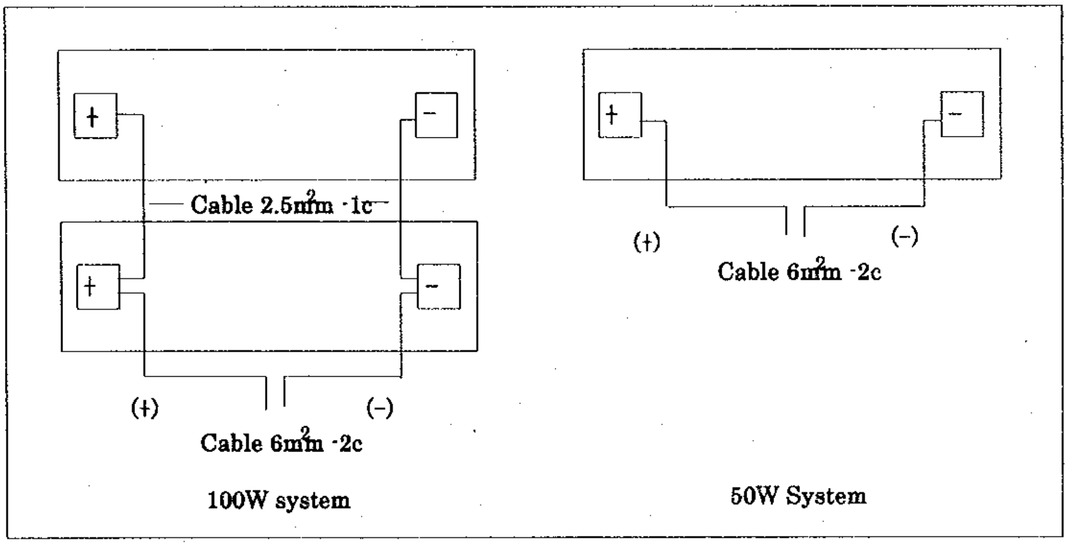


Figure 4-5 Connection of Modules

5. Indoor Wiring

5.1 Installation of indoor equipment

1) Controller

The controller should be installed firmly with screws or nails on a permanent major structural member of the house, such as a column or crossbeam. If it is impossible to install the controller directly on the column or crossbeam, a strong wooden back-board should be prepared and mounted firmly on a column or cross-beam

2) Fluorescent lamp

The fluorescent lamp should be installed on the crossbeam or ceiling in the center of room with screws or nails.

3) Breaker, switch and wall outlet

The breaker, switch and wall outlet should be assembled on a wooden back-board. This board should then be installed on a column with nails.

4) Fuse

The fuse should be connected between the negative terminal of the battery and the switch. The fuse can be either be a box-fuse mounted on the wood back-board or it can be an in-line fuse connected near the battery terminal.

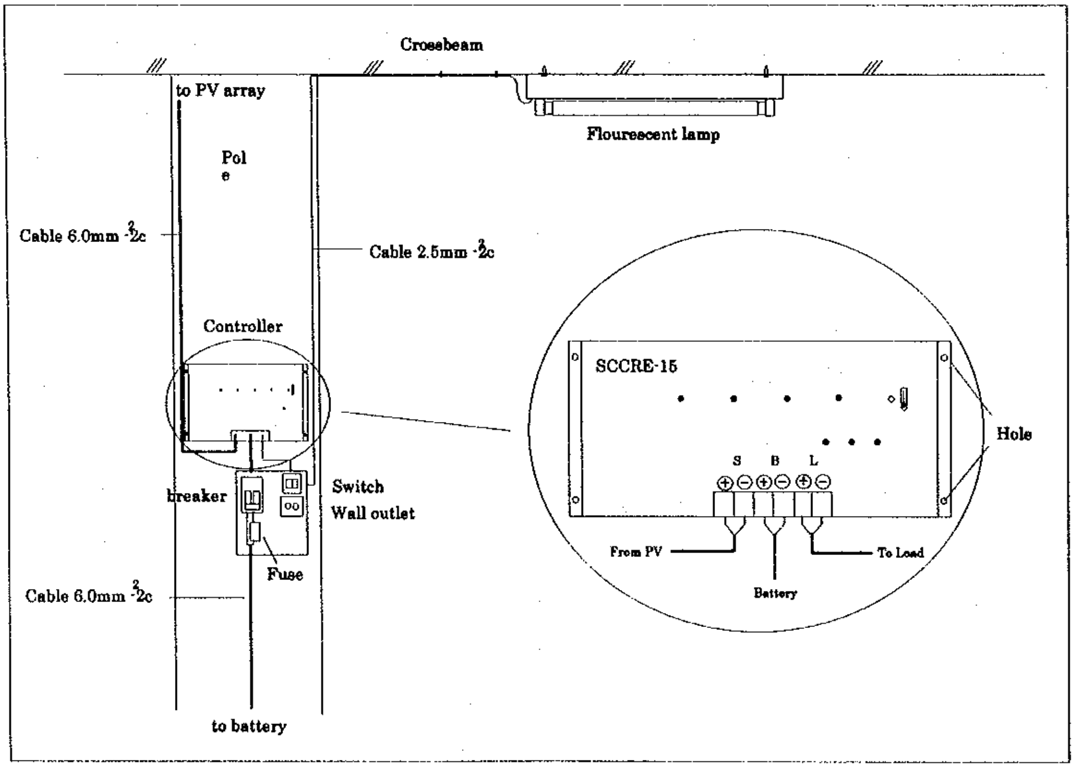


Figure 5-1 Installation drawing of the controller and other indoor equipment(Example)

5) Battery

The battery should be put on a flat floor. It requires good ventilation.

The controller and other indoor equipment should be installed following the advice given in the installation manual.

Item	Precautions
Controller	* install in a high place where children can't reach it and where the user can observe the indicator lamps * avoid any place where water is used or where it is likely to get wet from rain leaks, etc * avoid any place which receives direct sunlight or which experiences a high temperature * install on a place which is strong enough such as a pillar or crossbeam
Indoor equipment (Breaker, Switch, Outlet, Lamp, Fuse)	* install in places which are convenient for the user * avoid any places where water is used or which are likely to get wet from rain leaks
Battery	* install the battery on a floor strong enough to support it * avoid a place receiving direct sunlight or rising to a high temperature * ensure ventilation is good * lay cloth or paper underneath the battery * place the battery near to the controller

5.2 Wiring

Each cable should be laid out in the wiring route of shortest distance. The cable should be fixed with clips to the wall. The battery should be connected using solderless terminals. The terminals of the battery should be protected with covers. It is recommended to protect the terminals also with grease.

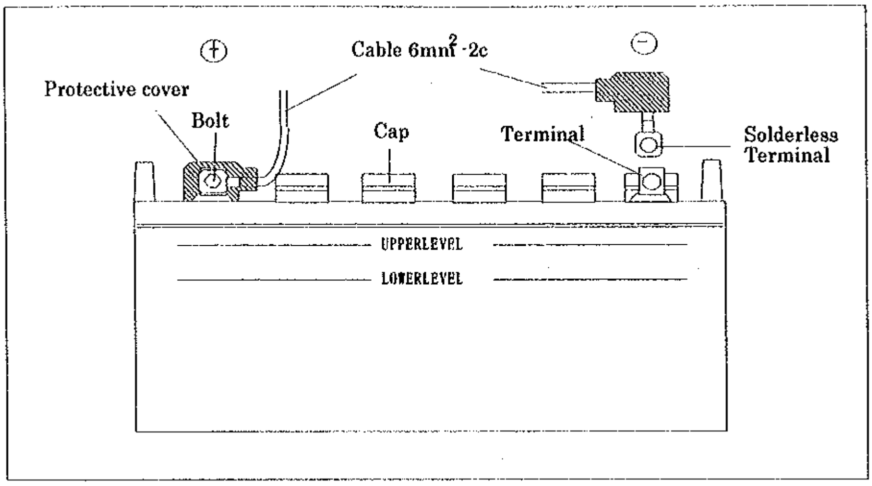


Figure 5-2 Connection of battery

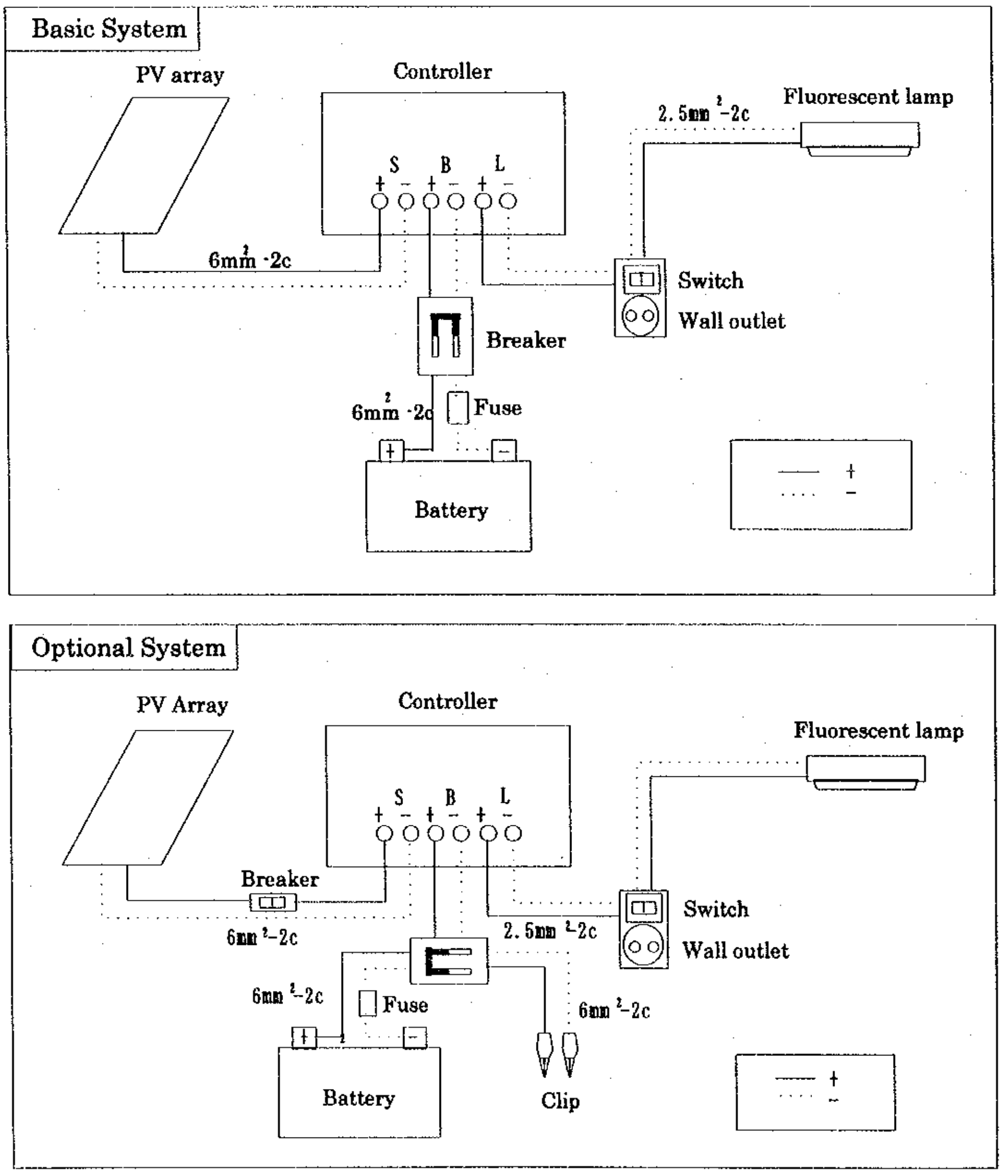


Figure 5-3 Wiring Diagram

5.3 Initial charge

1) Filling battery acid

When first charging a new battery with acid, fill to the lower level. *(The reason for doing this is that when the battery receives its initial charges the level in some cases rises due to trapped gas. If the battery is filled to the upper level initially, this rise in level causes the electrolyte to be blown out of the ventilators which can damage surroundings and cause anxiety. After a week or two this problem disappears).* After two or three weeks of operation of the battery, check the level and if necessary top it up with pure water to half way between the lower level and higher level.

2) Initial charge

To charge the battery for the first time, connect it to the PV system and allow it to charge from the solar panel without using any loads (household lights etc) until it gains full charge status. Usually two days of good sunshine is enough. If you are starting in a cloudy or rainy period, continue to charge for longer without loads, until full charge is indicated by the controller indicators or by a voltmeter check.

6. Inspection and maintenance of PV system

Regular inspection and maintenance of a PV system is needed to find problems early and to ensure system performance. Inspection and maintenance tasks as listed below should be carried out regularly by both the user and by the village electrification committee (VEC). If any problem is found, then in all cases appropriate measures must be taken immediately. If the user cannot fix the problem, he should report immediately to the VEC. If the VEC cannot fix the problem, they should report immediately to the authorized technician.

6.1 Weekly user inspection

The user should do a visual inspection every week, attending to every inspection point listed below. If any problem is found, user should undertake the maintenance tasks described in the table.

Inspection point	Maintenance task
Surface of PV module	*If the surface of the PV modules is dirty, wipe with wet cloth or wash with clean water. *If small articles such as leaves are on the PV module, they should be removed immediately.
Shading of PV module	*Check that there is no shading between 10 am and 3 pm. *Remove origin of shade (trim trees lightly, not heavily)
Battery liquid level	*Keep the liquid level between the upper and lower range. *Top up with distilled or pure water if necessary. NEVER add acid.
Battery terminal	*Keep the terminals clean. When the grease gets dirty, remove it, clean the terminals and dry them, then add new clean grease *Check for loose connections and if necessary tighten firmly.
Controller	*Keep the controller clean. * Check for loose connections and if necessary tighten firmly.
Fuse wire	*Ensure 10A fuse wire is in place.

If the following problems are found by the user during his weekly inspection, he should immediately report them to the VEC:

Inspection	Potential problems
PV array	Damage to PV module, support structure, or cable connections
Controller	Abnormal operation (wrong display, making noise, bad smell, high temperature, etc) Damage to controller
Fuse	Fuse blows. The reason must be found.
Cable	Damage to cable, use of incorrect cable sizes
System operation	"Battery isn't charged fully." " System stops often." etc.

6.2 Monthly VEC inspection

The VEC should inspect and maintain all the systems in the village every month. If any problems are found, the VEC should undertake the maintenance task listed in the table immediately. Also, the VEC should keep a record of problems and maintenance activities. The VEC should help the user to understand maintenance and guide him in taking care of his system.

1) Inspection and maintenance

Inspection point	Maintenance task
PV array	*If the direction or angle is changed, put back as before. *If the PV module is damaged, report to technician. *If the support structure is damaged, repair it, keeping the correct tilt angle the southward direction of the panel
Controller	*Check for loose connections and tighten firmly *If the controller operates abnormally, report to technician. *If the controller is damaged, report to technician.
Breaker	* Check for loose connections and tighten firmly
Fuse box	*If the fuse is blown, find out what caused it to blow, and take measures to avoid this happening again. Replace with correct type (standard 10A).
Cable	*If the cable is damaged, repair or replace.
User tasks	*Make sure the user is doing all tasks listed in 6.1.

See list of maintenance tools (Reference 6-1)

Reference 6-1 Maintenance tools

Description	
Hammer	Metric spanner (8, 10,13 mm)
Screwdrivers – large, medium, small	Pliers
Multi-meter	Insulation tape

2) Maintenance record

For effective system management, it is important that the VEC keeps a record of maintenance problems and activities. There must be a record of the following items kept for each house:

Battery liquid addition	*Date of liquid addition and a note as to how much added
Problem	*Date of problem and its details *Details of measures taken
Electrical appliance	*Type and power consumption (W) of electrical appliances

3) Guidance

Depending on the inspection and maintenance record, the VEC should help the users to understand inspection and maintenance tasks, and guide them in carrying out maintenance.

6.3 Troubleshooting by the VEC

If problems occur, the VEC should troubleshoot following the guidance in the table below. If a problem cannot be fixed immediately, the VEC should report to the authorized technician.

1) System stops often

Cause	Corrective action
1. Over-consumption, or bypassing of the controller	Guide user to reduce consumption. Explain that he must not bypass the controller. Bypassing damages the battery and causes frequent system stoppage due to low voltage
2. Bad weather	When it is rainy or cloudy, the user should use the system less. This is because there is less sunshine to charge the battery and therefore there is less power.
3. The battery is too small (its AH rating is lower than recommended)	Change to a battery with the recommended AH rating
4. There is a problem with the load (the load is everything connected to the output of the controller)	Check wire, switches, and appliances, and see if they are damaged or faulty. Repair them or replace them with good units.

2) No power from controller

Cause	Corrective action
1. The Battery voltage is too low (the controller over-discharge cut-off is operating))	Wait to recharge. Do not use loads until solar power brings the battery back up to full charge voltage
2. One of the wires is disconnected.	Check the cables between PV panel, controller and battery. Repair or replace.
3. Fuse blown or trip off	Find and remove the source of the fault, and then replace fuse or reset trip
4. A corroded or a loose connection	Clean the connecting parts. Re-connect and tighten securely with screwdriver.
5. Controller fault	Connect a good controller. If this test shows that the original controller was faulty, give it to the technician as he may be able to replace it.
6. Old or faulty battery	Connect a good battery. If this test shows the original battery was faulty, change to a good battery.

3) Power available for shorter period

Cause	Corrective action
1. Over-consumption, or bypassing of the controller	Guide user to reduce consumption. Explain that he must not bypass the controller. Bypassing damages the battery and causes frequent system stoppage due to low voltage
2. Battery may be at the end of its life.	After charging, check if battery voltage drops quickly. If so, replace battery.

4) Battery is not charged fully

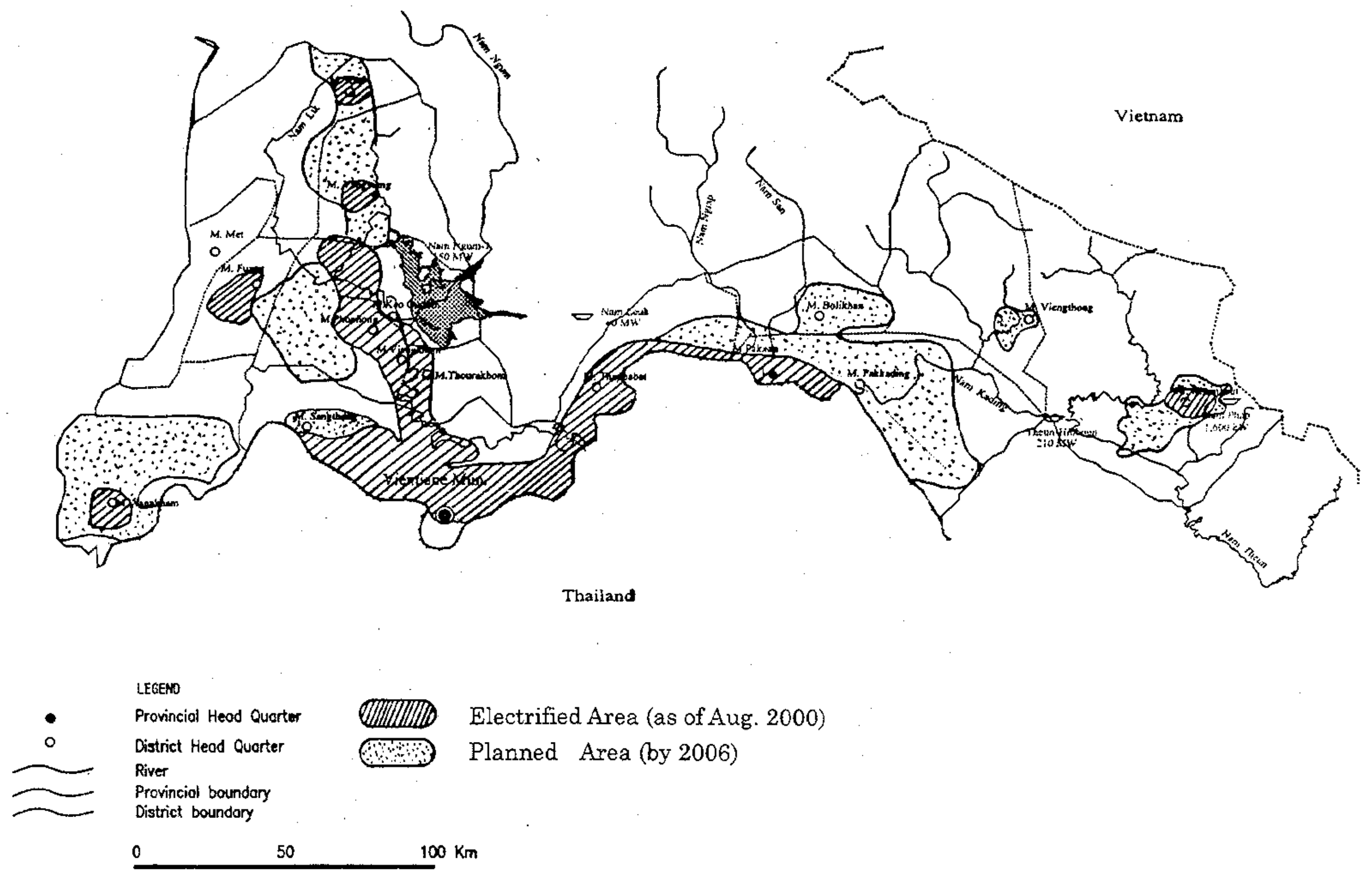
Cause	Corrective action
1. Dust or small article on PV module	Guide user to clean PV module surface
2. Shade	Remove origin of shade.
3. Damage to cable	Repair or change
4. A corroded or a loose connection	Clean the connecting parts. Re-connect and tighten securely with screwdriver.
5. Over-consumption, or bypassing of the controller	Guide user to reduce consumption. Explain that he must not bypass the controller. Bypassing damages the battery and causes frequent system stoppage due to low voltage
6. Controller fault	Connect a good controller. If the controller was faulty, report to technician.
7. Fitting of a battery which is too big (AH rating higher than recommended)	Change to a battery of recommended size
8. Damage to PV module	Report to technician

5) Frequent addition of battery water

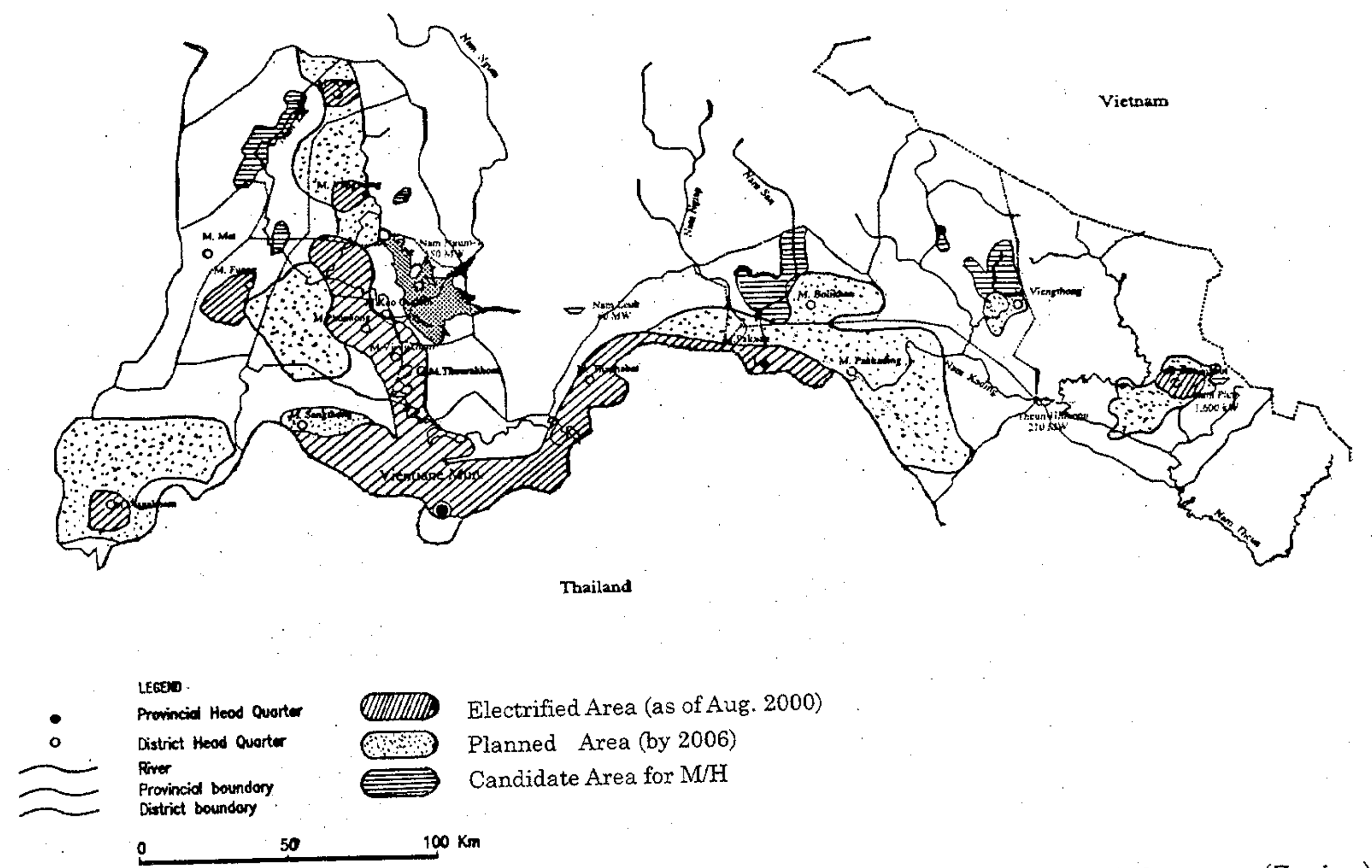
Cause	Corrective action
1. Over-consumption, or bypassing of the controller	Guide user to reduce consumption. Explain that he must not bypass the controller. Bypassing damages the battery and causes frequent system stoppage due to low voltage
2. Battery is too hot due to exposure to sun light or poor ventilation	Move battery into shade and ensure good ventilation. Explain to user that poor ventilation is dangerous due to trapping explosive gas
3. No power consumption for long time	When the system is not in use, the battery should be disconnected from the controller by switching the breaker off.
4. Battery may be at the end of its life.	After charging, check if battery voltage drops quickly. If so, replace battery.

7. Don't do it!

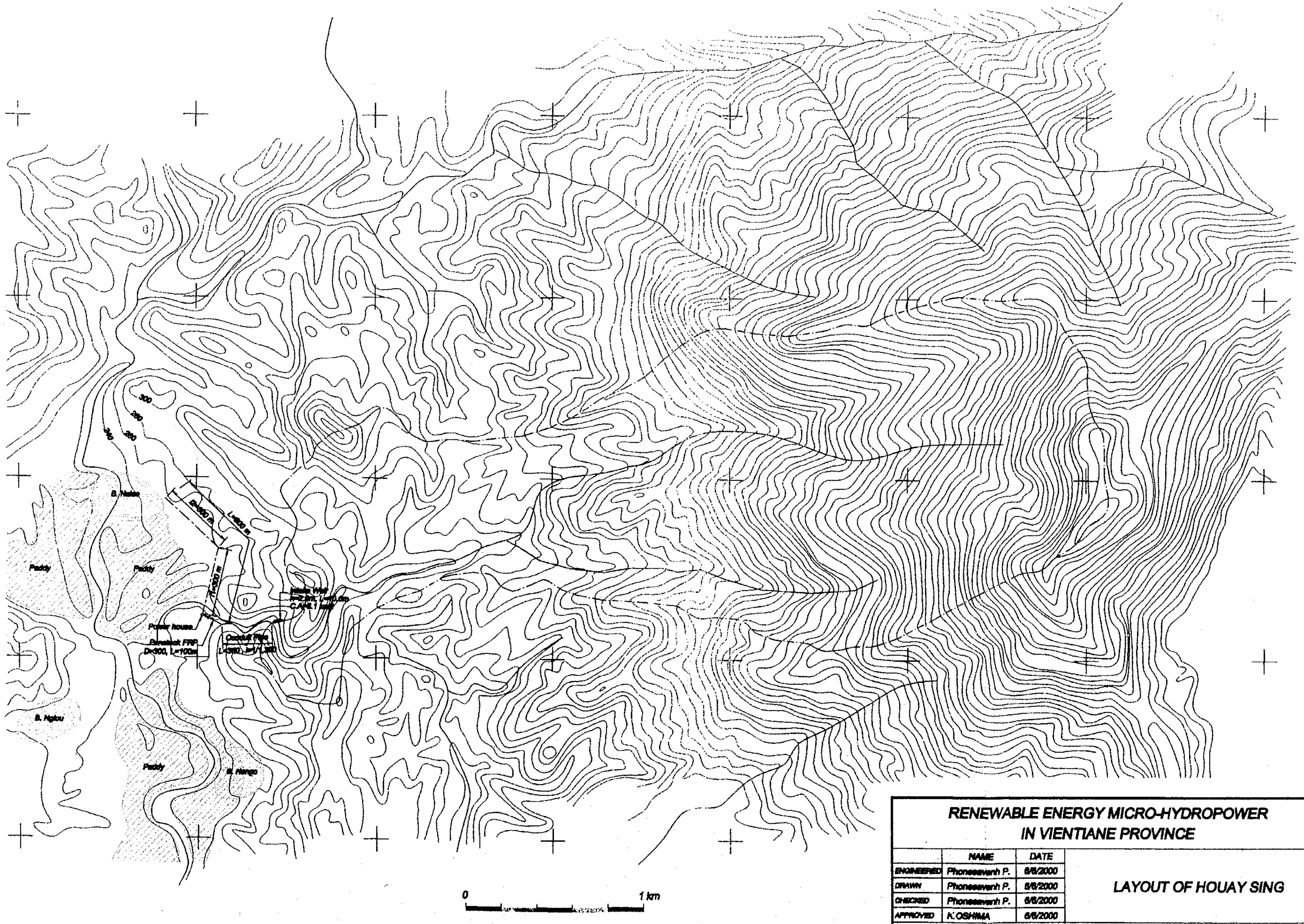
DO NOT tie rope to PV pole to hold animal or to dry clothing.	There is a danger that the PV pole may be tilted or twisted. The PV module will not work properly if angle and direction is not correct.
DO NOT connect load directly to battery bypassing controller.	The controller must never be bypassed. It protects battery from rapid deterioration.
DO NOT operate system when the battery liquid is below the minimum level.	Battery will deteriorate fast if operated like this. There is an increased danger of explosion.
DO NOT add impure water (pond water or tap water) to the battery.	This causes fast deterioration of battery. Battery life will be shortened.
DO NOT add acid to the battery when battery liquid level is low.	The system will not function properly. The battery will need replacement.
DO NOT connect a battery, which is not rated 12V nor has an incorrect AH rating.	The system cannot function properly.
DO NOT connect a second battery to the main battery.	There can cause damage to the batteries.



Electrified and Planned Area



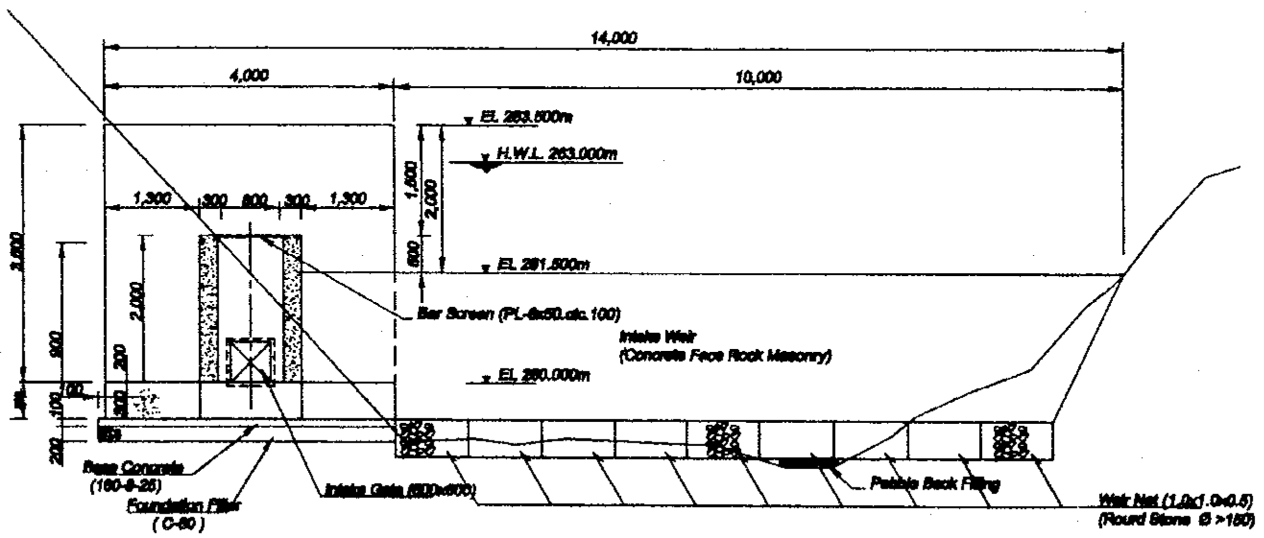
Candidate Area for Micro-Hydropower (Zoning)



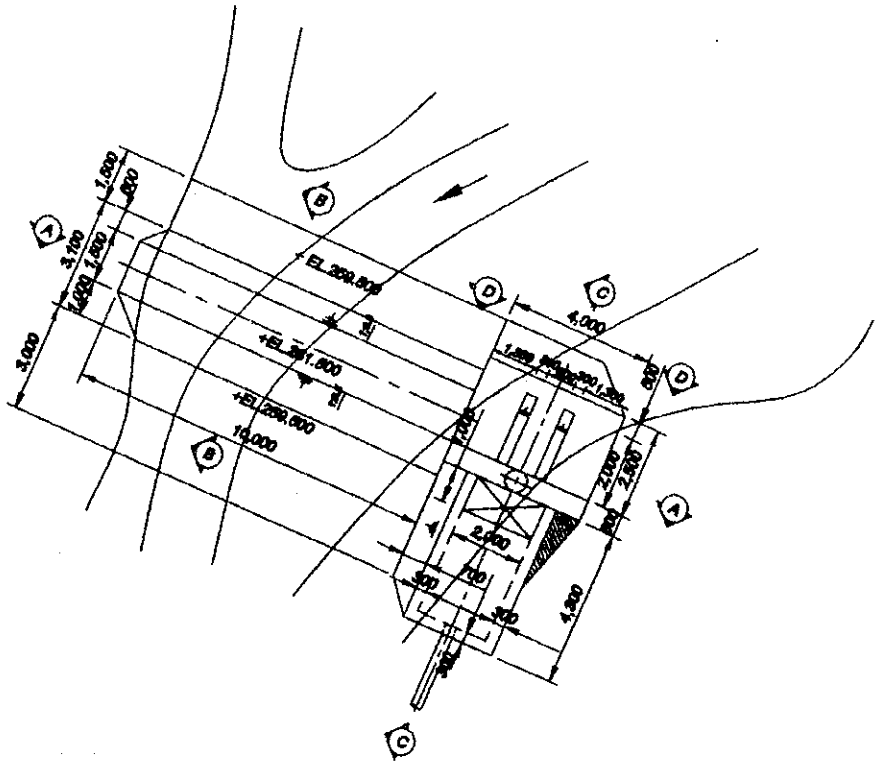
RENEWABLE ENERGY MICRO-HYDROPOWER IN VIENTIANE PROVINCE			
	NAME	DATE	LAYOUT OF HOUAY SING
ENGINEERED	Phonesavanh P.	6/6/2000	
DRAWN	Phonesavanh P.	6/6/2000	
CHECKED	Phonesavanh P.	6/6/2000	
APPROVED	K.OSHIMA	6/6/2000	
JAPAN INTERNATIONAL COOPORATION AGENCY			
SCALE : 1:20,000			DRWG No.

HOUAY SING PROJECT

SECTION A-A Scale 1:100



PLAN Scale 1:200



RENEWABLE ENERGY MICRO-HYDROPOWER IN VIENTIANE PROVINCE		
	NAME	DATE
ENGINEERED	Phonesavanh P.	6/6/2000
DRAWN	Phonesavanh P.	6/6/2000
CHECKED	Phonesavanh P.	6/6/2000
APPROVED	K.OSHIMA	6/6/2000

LAYOUT OF HOUAY SING

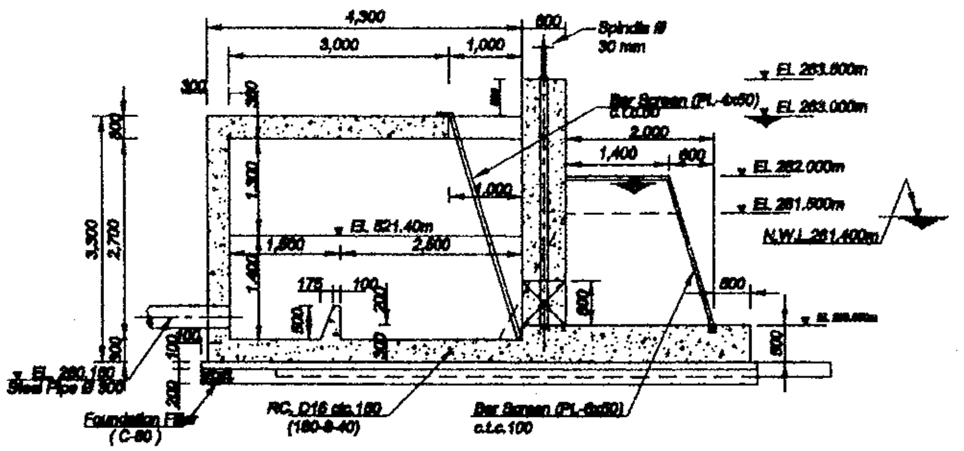
JAPAN INTERNATIONAL COOPORATION AGENCY

SCALE : 1:100 & 1:200

DRWG No. 2 of 3

HOUAY SING PROJECT

SECTION C-C



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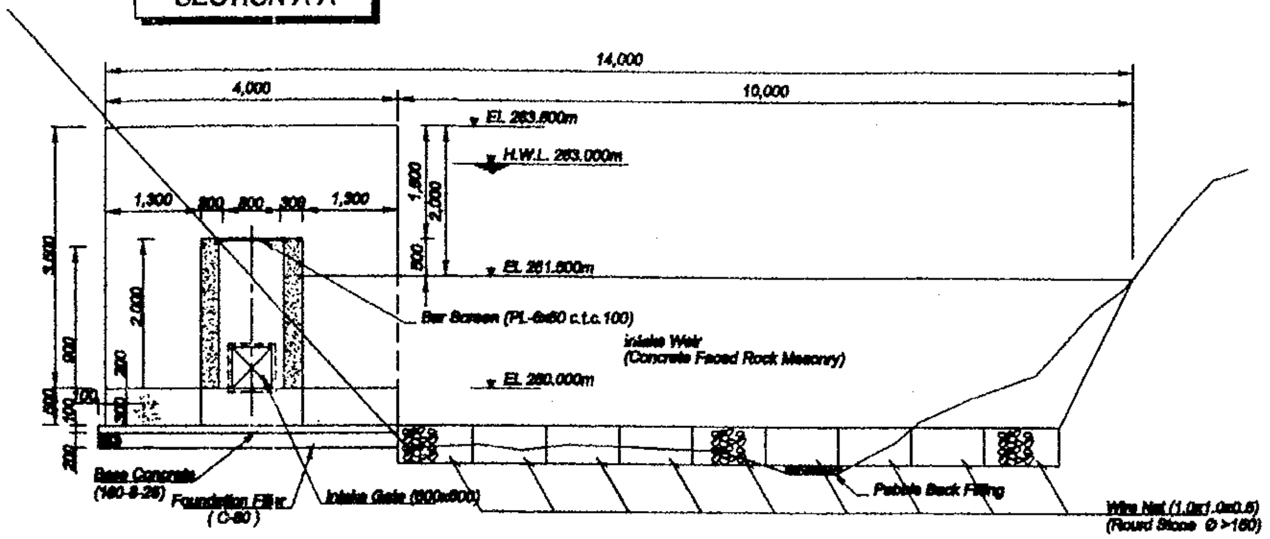
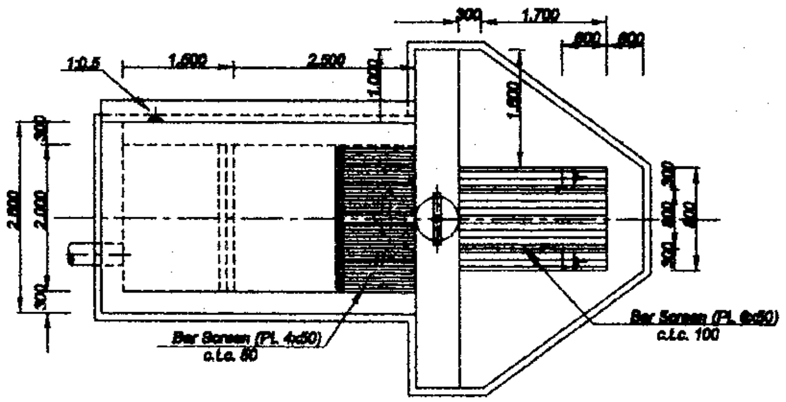


SECTION D-D



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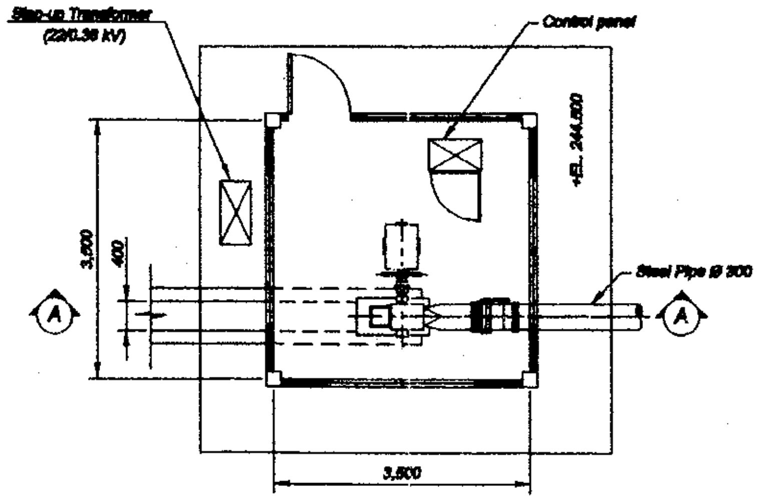
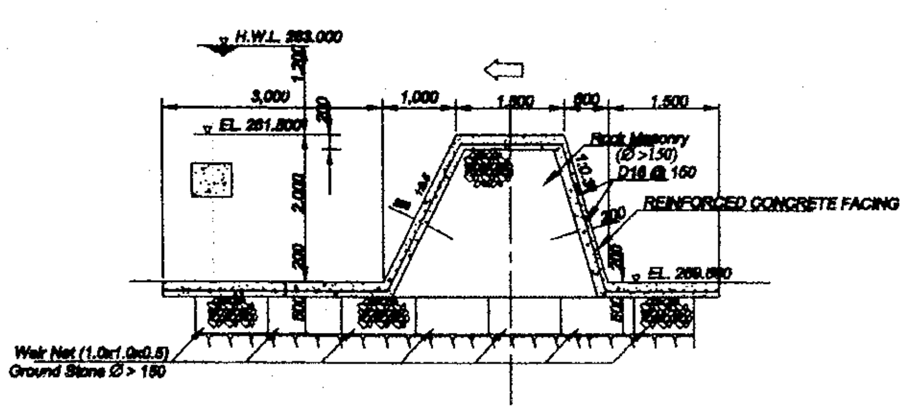


SECTION B-B

CROSS SECTION OF IN-TAKE WEIR



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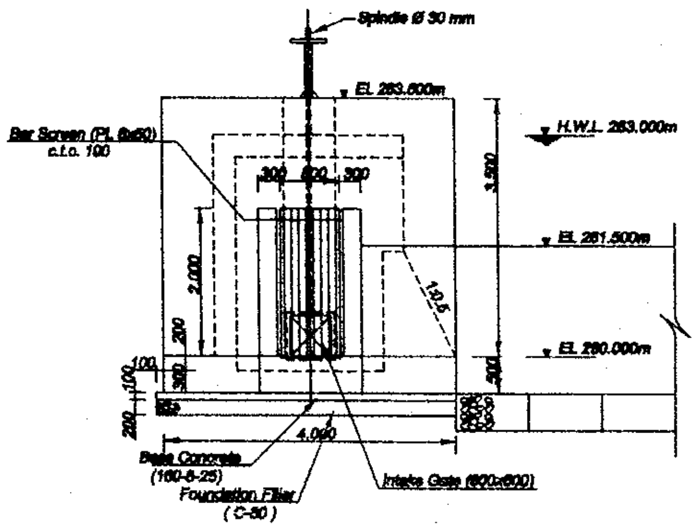

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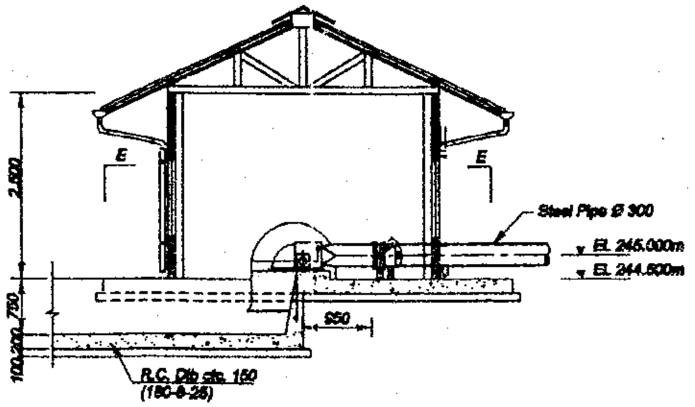


RENEWABLE ENERGY MICRO-HYDROPOWER IN VIENTIANE PROVINCE

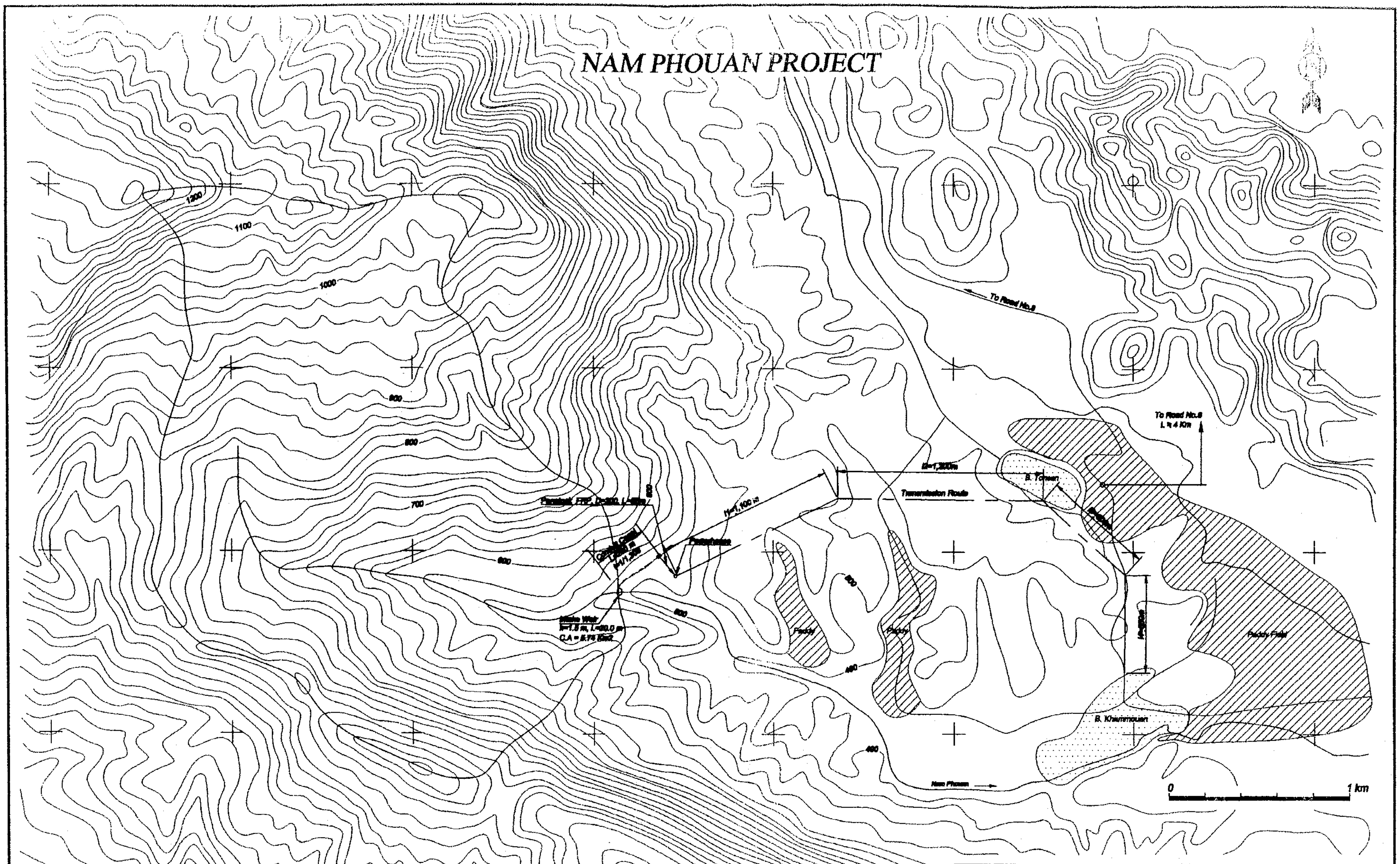
	NAME	DATE
ENGINEERED	Phonesavanh P.	6/6/2000
DRAWN	Phonesavanh P.	6/6/2000
CHECKED	Phonesavanh P.	6/6/2000
APPROVED	K.OSHIMA	6/6/2000

LAYOUT OF HOUAY SING

JAPAN INTERNATIONAL COOPERATION AGENCY

SCALE : 1:100

DRWG No. 6 of 9



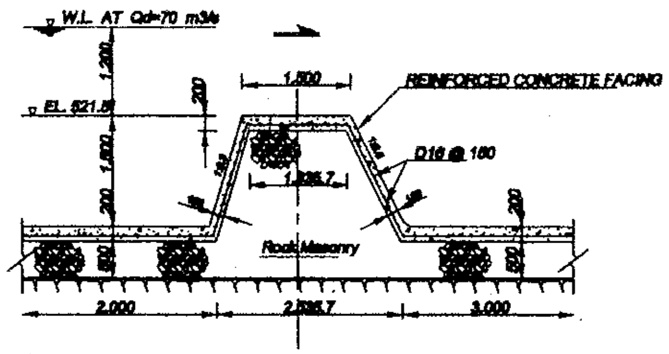
RENEWABLE ENERGY MICRO-HYDROPOWER IN BORIKHAMXAY PROVINCE

	NAME	DATE	
ENGINEERED	Phonesavanh P.	6/6/2000	LAYOUT OF NAM POUAN
DRAWN	Phonesavanh P.	6/6/2000	
CHECKED	Phonesavanh P.	6/6/2000	
APPROVED	K.OSHIMA	6/6/2000	
JAPAN INTERNATIONAL COOPORATION AGENCY			
SCALE : 1:20,000			DRWG No. 1 of 3

NAM PHOUAN PROJECT

SECTION B-B

CROSS SECTION OF IN-TAKE WEIR



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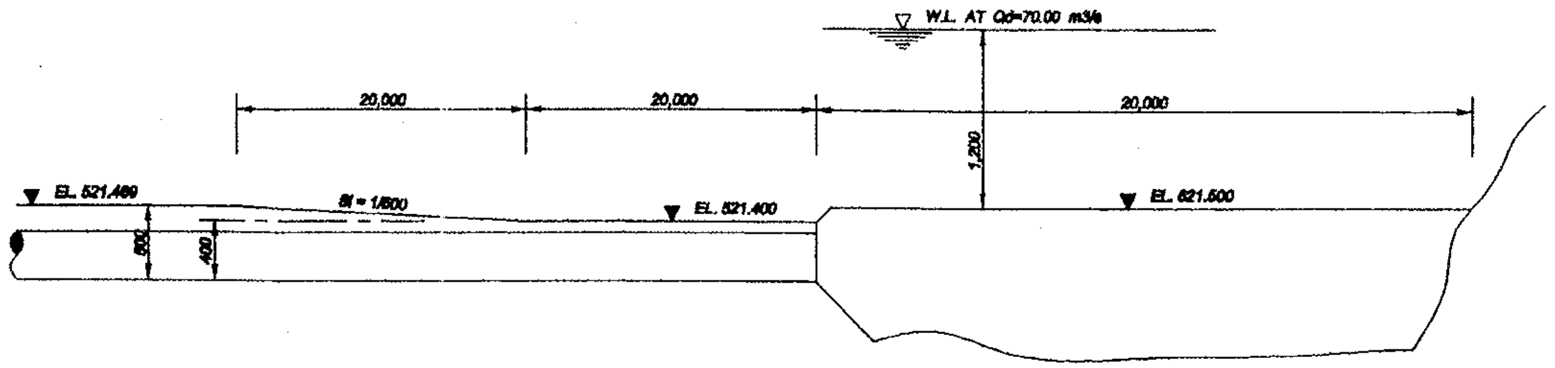

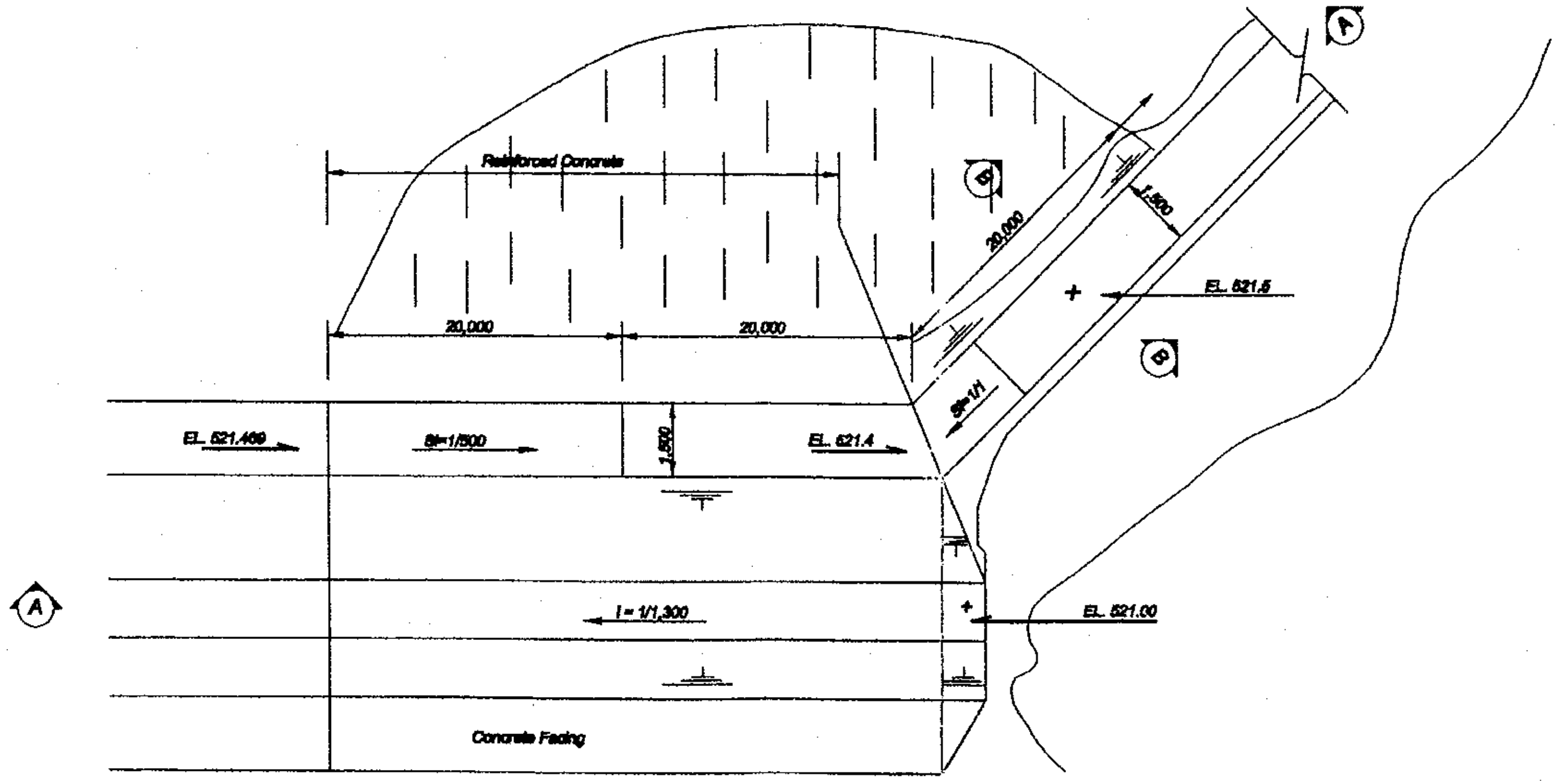

RENEWABLE ENERGY MICRO-HYDROPOWER IN BORIKHAMXAY PROVINCE		
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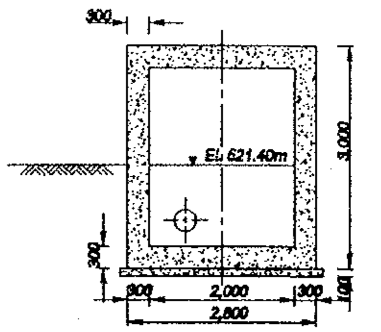
ENGINEERED	Phonesavanh P.	6/6/2000
DRAWN	Phonesavanh P.	6/6/2000
CHECKED	Phonesavanh P.	6/6/2000
APPROVED	K.OSHIMA	6/6/2000
JAPAN INTERNATIONAL COOPORATION AGENCY		
SCALE : 1/100		

LAYOUT OF NAM POUAN

NAM PHOUAN PROJECT

SECTION C-C



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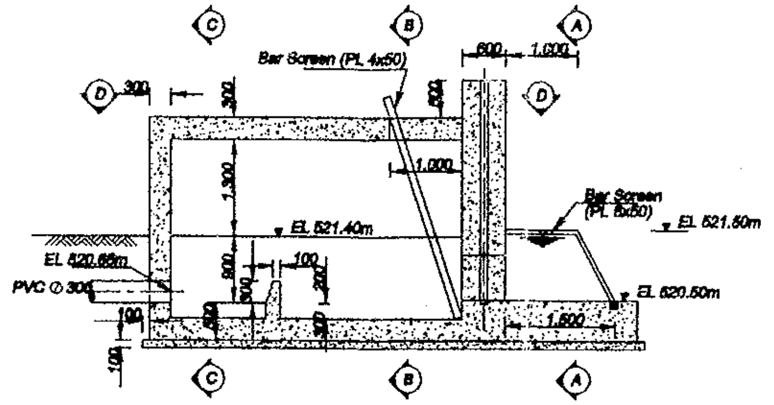

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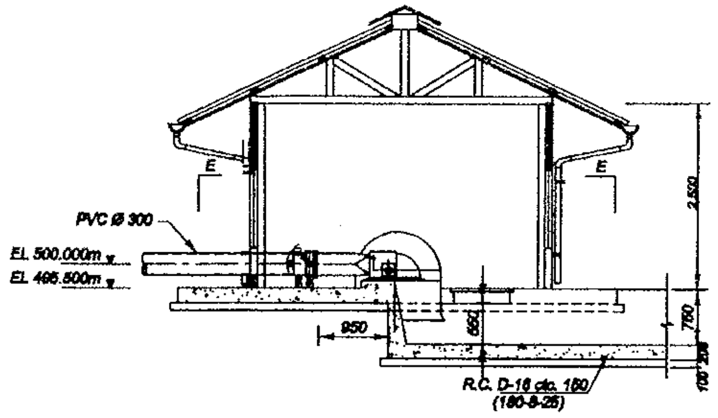

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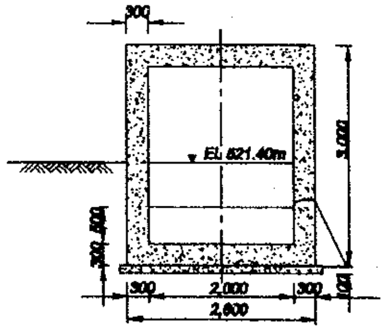

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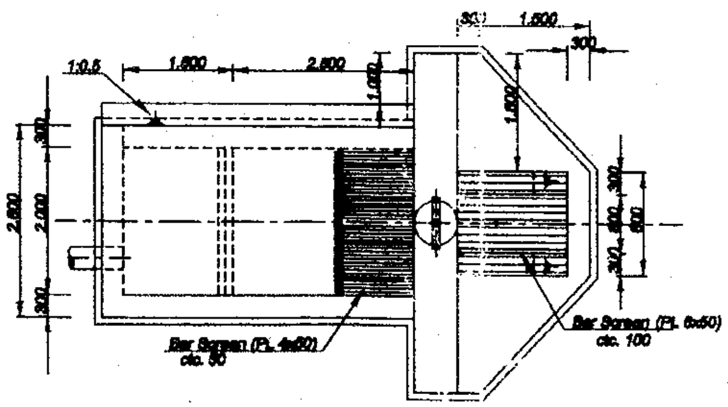

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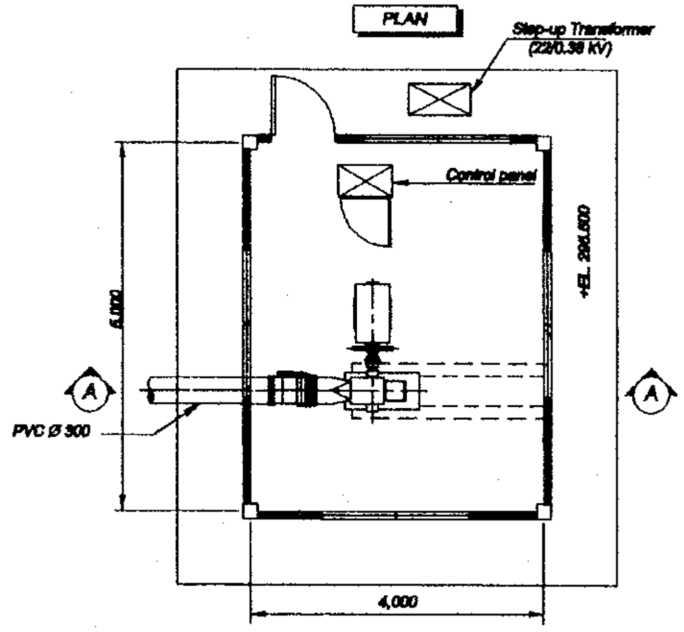
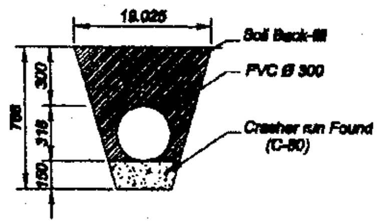
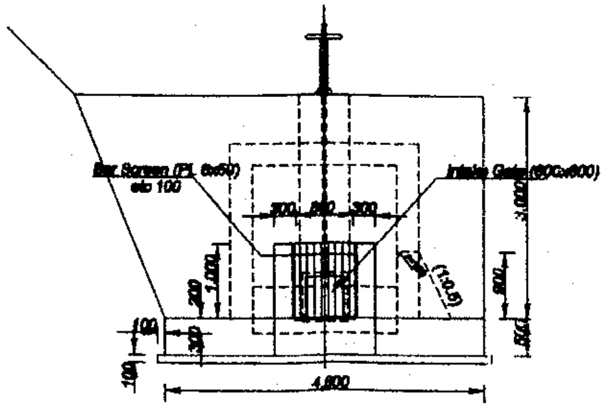


PIPE CONDUIT CROSS SECTION Scale 1:20



SECTION A-A



RENEWABLE ENERGY MICRO-HYDROPOWER IN BORIKHAMXAY PROVINCE

	NAME	DATE	
ENGINEERED	Phonesavanh P.	6/6/2000	LAYOUT OF NAM POUAN
DRAWN	Phonesavanh P.	6/6/2000	
CHECKED	Phonesavanh P.	6/6/2000	
APPROVED	K.OSHIMA	6/6/2000	
JAPAN INTERNATIONAL COOPORATION AGENCY			
SCALE : 1:100			DRWG No. 3 of 3

Tab.—A.10.1(1) Unit Prices for Civil Works in Laos

(in US$)

Work Items	Specifications	Quantity	Unit	Unit Price
Preparatory Works				
Logging		1.000	ha	650.000
Road Improvement	Regarded Unbushing	1.000	m2	1.400
Road Improvement	Unpaved	1.000	m2	4.640
Road Construction	Unbushing & Unpaved	1.000	m2	6.000
Soil & Rock Works				
Excavation & Removal	Manpower, H<=5.0m, l <= 50.0m, in-site	1.000	m3	11.000
Excavation & Removal	Machine, H<=5.0m, l <= 50.0m, in-site, Surface Clearnace	1.000	m3	1.600
Excavation & Removal	H>5.0m, l <= 50.0m, in-site	1.000	m3	
Soil Backfilling		1.000	m3	2.000
Backfill & Compaction		1.000	m3	4.400
Rock Excavation	Gravel or Soft Rock	1.000	m3	4.500
Rock Drilling & Removal	Medium or Hard Rock, In-site Removal	1.000	m3	7.800
Stone Crashing & Removal	In-site Removal	1.000	m3	5.350
Removal	l <= 50.0m, in-site	1.000	m3	3.000
Loose Masonry		1.000	m3	60.000
Masonry		1.000	m3	72.000
Machine Soil Works				
Excav. & Removal	Grade I	1.000	m3	0.160
Excav. & Removal	Grade II	1.000	m3	0.511
Excav. & Removal	Grade III	1.000	m3	0.711
Foundation&Others				
Wire Nets	1.0x1.0x0.5m, 0.6x150mm	1	Set	
Rock Filler	D<=150mm	1.000	m3	5.000
Filling & Placing		1.000	m3	
Sand or Soil Spraying		1.000	m3	4.640
Reinforced Concrete				
Frame Works	Compounded Panel, t=6mm	1.000	m2	
Iron Bar Works	D13, material&works	1.000	t	
Iron Bar Works	D16, material&works	1.000	t	
Iron Bar Works	D19, material&works	1.000	t	
Iron Bar Works	D22, material&works	1.000	t	
Iron Bar Works	D25, material&works	1.000	t	
Concrete Filling	Class A(210-8-40), with Frame & Iron Bar Works	1.000	m3	275.000
Concrete Filling	Class B(160-4-25), with Frame & Iron Bar Works	1.000	m3	185.000
Smoothing Concrete		1.000	m3	72.000
Gravel & Others				
Sand		1.000	m3	17.000
Pebble		1.000	m3	25.000
Sand	at L. N.Tha	1.000	m3	11.100
Pebble	at L. N.Tha	1.000	m3	9.720
Large Gravel	D200-D400mm, L. N. Tha	1.000	m3	6.900
Cement		1.000	t	150.000
Cement	From China, Transport to L. N. Tha	1.000	t	138.900
Cement	From Thailand, Transport to L. N. Tha	1.000	t	166.700
Others				
Steel Channel	150x50	1.000	kg	0.830
I Shape Steel	150x50	1.000	kg	0.830
Steel Channel	100x50x5x500mm	1.000	Nos	10.000
Steel Channel	50x50x5x500mm	1.000	Nos	
Angle Steel	50x100x400mm	1.000	Nos	46.000
Bricks		1.000	m2	20.000
Wall Cleaning		1.000	m2	15.000
Wall Painting		1.000	m2	2.000
Pipe Painting		1.000	m2	10.000
Tax			%	10.000

Source : EdL.

Tab.—A10.1(2) Unit Prices for Transmission System Construction(Tax Exempted)

(in US$)

Work Items	Specifications	Quantity	Unit	Unit Price
I. 22kV Transmision				
ACSR 150mm2	Aluminum Conductor Steel Reinforced	1	km	13,422.30
ACSR 95mm2	-ditto-	1	km	11,822.30
ACSR 70mm2	-ditto-	1	km	10,862.30
ACSR 50mm2	-ditto-	1	km	10,222.30
ACSR 35mm2	-ditto-	1	km	9,582.30
II. 0.4kV Transmission				
ACSR 70mm2	Aluminum Conductor Steel Reinforced	1	km	7,126.16
ACSR 50mm2	-ditto-	1	km	6,181.16
ACSR 35mm2	-ditto-	1	km	5,551.16
III. Sub Station				
30kVA		1	unit	5,593.00 *
50kVA		1	unit	5,885.64
100kVA		1	unit	6,825.94
160kVA		1	unit	7,965.84
250kVA		1	unit	9,943.77
315kVA		1	unit	11,191.31
400kVA		1	unit	12,551.07
500kVA		1	unit	14,036.22
630kVA		1	unit	16,117.44
800kVA		1	unit	18,870.53
1,000kVA		1	unit	23,216.44
Transformers				
5kVA		1	unit	1,090.00
10kVA		1	unit	1,910.00
15kVA		1	unit	2,100.00
20kVA		1	unit	2,273.00
30kVA		1	unit	2,335.00 *
50kVA		1	unit	2,457.00
100kVA		1	unit	3,297.00
160kVA		1	unit	4,096.05
250kVA		1	unit	5,398.05
315kVA		1	unit	5,949.30
400kVA		1	unit	7,099.06
500kVA		1	unit	8,033.55
630kVA		1	unit	9,358.65
800kVA		1	unit	11,636.10
1,000kVA		1	unit	13,910.40

Source : EdL

Tab.-A.10.2(1) Houay Sing Project Work Item Calculation Sheet

Work Items	Descriptions	Quantities	Unit
1. Intake Weir(Rock Masonry)			
(1) Rock Excavation(t=0.5m)	V=0.500x(3.100+3.000+1.500)x9.000=7.600x9.000=68.400	68.4	m3
(2) Weir Body	V=((1.3357+2.4023)/2)x2.000x9.500=3.738x9.500=35.511	35.5	m3
(3) Protection Concrete(t=200)	RC, D13@150mm		
	V=(0.2x4.500+(2.236+1.500+2.088)x0.2)x9.500=		
	2.0648x9.500=19.6156	19.6	m3
(4) Wire Nets(Material)	(1.0x1.0x0.5) ; n=(3.000+3.100+1.500)x9=68.400	69	sets
(5) Wire Nets(Filling&Placing)	V=(1.000x1.000x0.500)x69=34.500	34.5	m3
2. Intake Gate	(600x600mm)		
(1) Soil Excavation(normal)	V=(3.200x4.300/2)x5.0=34.400	34.4	m3
(2) Back Filling	V=(3.0x1.0/2)x3.300/3=1.650	1.7	m3
(3) Foundation Gravel(C-80)	V=(2.800x4.400+2.600x3.100+2x0.100x1.000)x0.200=4.116	4.1	m3
(4) Reinforced Concrete		27.7	m3
i) Base Slab	V=4.000x2.500x0.500=5.000	5.000	m3
ii) Behind Wall	V=(4.000x3.500-0.600x0.600)x0.600=8.184	8.184	m3
iii) Ceiling Slab(Body)	V=(4.300x2.600-1.000x2.000)x0.300=2.754	2.754	m3
iv) Base Slab(Body)	V=4.300x2.600x0.300=2.580	2.580	m3
v) Retain Wall(Body)	V=4.300x2.700x0.300=3.402	3.402	m3
vi) Front Wall(Body)	V=(4.300x2.700-1.300x4.000)x0.300=1.923	1.923	m3
vii) Sill	V=((0.100+0.275)/2)x0.500x2.000=0.1875	0.188	m3
viii) Overflow Section	V=(0.700x1.400/2)x4.300=2.107	2.107	m3
ix) Behind Wall(Body)	V=(2.000x2.700-πx(0.314x0.314)/4)x0.300=1.5968	1.597	m3
(5) Gate Body	Steel Gate-600x600, Water Sealed, with Frame&Slides	1	set
(6) External Bar Screen	(pl-6x50@100mm)		
	l=(1.400+2.100)x10=35.000	35.0	m
(7) Internal Bar Screen	(pl-4x50@50mm)		
	l=(3.462+0.100)x19=67.683	67.7	m
3. Penstock(300A)	l=450m, with Finishing & Anchor Blocks		
(1) Franged Steel Pipe(300A)	(Effective Length 5.5m)		
	n=450.000/5.500=81.800	82	nos
4. Additional Works			
(1) Surface Ripping	t=0.2m		
		0.3	ha
(2) Road Construction	W=5.0m, t=0.5m, L=0.5km		
	A=5.000x500.000=2,500.000	2,500.0	m2

Tab.-A.10.2(2) Nam Pouan Project Work Item Calculation Sheet

Work Items	Descriptions	Quantities	Unit
1. Intake Weir(Rock Masonry)			
(1) Rock Excavation(t=0.5m)	V=0.500x(2.700+3.000+1.500)x20.000=7.200x20.000=72.000	72.0	m3
(2) Weir Body	V=(1.3357+2.5357)/2x1.500x20.000=2.904x20.000=58.080	58.1	m3
(3) Protection Concrete(t=200)	RC, D13@150mm		
	V=(0.2x4.500+(1.677+1.500+1.566)x0.2)x20.000 =		
	1.8486x20.000=36.972	37.0	m3
(4) Wire Nets(Material)	n=(3.000+2.700+1.500)x18=129.600	130	sets
(5) Wire Nets(Filling&Placing)	V=1.000x1.000x0.500x130=65.000	65.0	m3
2. Intake Gate	(600x600mm)		
(1) Soil Excavation(normal)	V=(7.0x3.5/2)x8.0=98.000	98.0	m3
(2) Back Filling	V=(4.0x1.0/2)x3.1/3=3.100	3.1	m3
(3) Foundation Gravel(C-80)	V=(1.100x4.800+(1.600+4.800)/2x1.600)x0.200=2.080	2.1	m3
(4) Reinforced Concrete		25.1	m3
i) Base Slab	V=((1.400+4.600)/2x1.500+0.900x4.600)x0.500=4.320	4.320	m3
ii) Behind Wall	V=(3.000x4.600-0.600x0.600)x0.600=8.064	8.064	m3
iii) Ceiling Slab(Body)	V=(4.300x2.600-1.000x2.000)x0.300=2.754	2.754	m3
iv) Base Slab(Body)	V=4.300x2.600x0.300=2.580	2.580	m3
v) Retain Wall(Body)	V=2.400x4.000x0.300=2.880	2.880	m3
vi) Front Wall(Body)	V=(2.400x4.000-1.300x4.000)x0.300=1.320	1.320	m3
vii) Sill	V=((0.100+0.275)/2)x0.500x2.000=0.1875	0.188	m3
viii) Overflow Section	V=(0.600x1.200/2)x4.300=1.548	1.548	m3
ix) Behind Wall(Body)	V=(2.000x2.400-πx(0.318x0.318))x0.300=1.4162	1.416	m3
(5) Gate Body	Steel Gate-600x600, Water Sealed, with Frame&Slides	1	set
(6) External Bar Screen	(pl-6x50@100mm)		
	l=(1.000+1.120)x10=21.200	21.2	m
(7) Internal Bar Screen	(pl-4x50@50mm)		
	l=(3.162+0.100)x19=61.978	62.0	m
3. Penstock(300A)	PVC, l=200m, Effective Length=4.0m/Unit		
(1) Soil Excavation(normal)	V=((0.761+0.300)/2x0.768)x200.000=81.485	81.5	m3
(2) Back Filling	V=((0.761+0.390)/2x0.618-πx0.318x0.318/4)x200.000=55.247	55	m3
(3) Foundation Gravel(C-80)	V=((0.390+0.300)/2x0.150)x200.000=10.350	10.4	m3
(4) PVC Pipes(300A)	n=200.000/4.000=50.000	50	nos
4. Additional Works			
(1) Surface Ripping	t=0.2m		
		0.5	ha
(2) Road Construction	W=5.0m, t=0.5m, L=2km		
	A=2x1.000x2,000.000=4,000.000	4,000.0	m2

Tab.-A.10.3(1) Houay Sing Project Cost Estimation(Tax Exempted)

(in US$)

Work Items	Specifications	Unit	Quant.	U. Price	Price
1. Intake Weir					**9,024.52**
(1) Rock Excavation	Medium Hardness	m3	68.4	7.8	533.52
(2) Weir Body	Rock Maisonry	m3	35.5	72.0	2,556.00
(3) Protect. Conc.	Equiv.;210-8-40, D-13 ctc200, with Smoothing Concrete	m3	19.6	250.0	4,900.00
(4) Wire Nets	D6x150mm, 1.0x1.0x0.5-69sets, Filling&Placing	m3	34.5	30.0	1,035.00
2. Intake Gate					**8,599.46**
(1) Excavation		m3	34.4	1.6	55.04
(2) Refilling		m3	1.7	2.0	3.40
(3) Found. Gravels	C-80	m3	4.1	4.64	19.02
(4) Reinforced Conc.	D-16 ctc150, with Smoothing Concrete	m3	27.7	250.0	6,925.00
(5) Gate Body	600x600, Handle&Spindle, cum Frame Finishing	set	1	500.0	500.00
(6) Bar Screen (1)	pl-6x50@100mm, with Finishing	m	35.0	12.0	420.00
(7) Bar Screen (2)	pl-4x50@50mm, with Finishing	m	67.7	10.0	677.00
3. Penstock	l=450.0m, with Accessories				**20,250.00**
(1) Franged Steel Pipe	D300mm(Effec. Leng-.5.5m/Unit), with Finish.& Anc. Blocks	m	450.0	45.0	20,250.00
4. Generation Facilities					**23,000.00**
(1) Gen. Equip.	15kW Gen., Cross-flow Turb., Dummy Load Gov., Acc.	Unit	1	20,000.0	20,000.00
(2) Valves	cum Accessories	Unit	1	500.0	500.00
(3) Powerhouse		Unit	1	2,500.0	2,500.00
5. Additional Works					**5,945.00**
(1) Surface Ripping		ha	0.3	650.0	195.00
(2) Road Improvement	New Road for Civil Works, w=5m, t=0.5m, 0.5km	m2	2,500.0	2.3	5,750.00
6. Sub Total(Civil + Equipment)					**66,818.98**
7. Transmis. Facilities					**4,821.18**
(1) Trans. Line Install.	0.4kV, 50mm2	km	0.78	6,181.0	4,821.18
8. Sub Total	**Direct Works**				**71,640.16**
9. Overhead, etc.	with Site Management, Within 10% of Subtotal	Unit	1	8,048.57	**7,059.84**
Grand Total					**78,700.00**

Tab.-A.10.3(2) Nam Pouan Project Cost Estimation(Tax Exempted)

(in US$)

Work Items	Specifications	Unit	Quant.	U. Price	Price
1. Intake Weir					**15,994.80**
(1) Rock Excavation	Medium Hardness	m3	72.0	7.8	561.60
(2) Weir Body	Rock Maisonry	m3	58.1	72.0	4,183.20
(3) Protection Concrete	Equiv.;210-8-40, D-13 ctc200, wuth Smoothing Concrete	m3	37.2	250.0	9,300.00
(4) Wire Nets	D6x150mm, 1.0x1.0x0.5-69sets, Filling&Placing	m3	65.0	30.0	1,950.00
2. Intake Gate					**7,822.14**
(1) Excavation		m3	98.0	1.6	156.80
(2) Refilling		m3	3.1	2.0	6.20
(3) Found. Gravels	C-80	m3	2.1	4.64	9.74
(4) Reinforced Conc.	D-16 ctc150, with Smoothing Concrete	m3	25.1	250.0	6,275.00
(5) Gate Body	600x600, Handle&Spindle, with Frame Finishing	set	1	500.0	500.00
(6) Bar Screen (1)	pl-6x50@100mm, with Finishing	m	21.2	12.0	254.40
(7) Bar Screen (2)	pl-4x50@50mm, with Finishing	m	62.0	10.0	620.00
3. Penstock	l=200.0m, cum Additional Works				**10,889.06**
(1) Excavation		m3	81.5	1.6	130.40
(2) Refilling		m3	55.2	2.0	110.40
(3) Found. Gravels	C-80	m3	10.4	4.6	48.26
(4) PVC Pipes	D300mm(Effec. Leng-.4.0m/Unit), with Finishing Works	m	200	53.0	10,600.00
4. Generation Facilities					**23,000.00**
(1) Gen. Equip.	20kWGen., Cross-flow Turb., Dummy Load Gov., Acc.	Unit	1	20,000.0	20,000.00
(2) Valves	with Accessories	Unit	1	500.0	500.00
(3) Powerhouse		Unit	1	2,500.0	2,500.00
5. Additional Works					**9,525.00**
(1) Surface Ripping		ha	0.5	650.0	325.00
(2) Road Improvement	w=5m, t=0.5m, 2km	m2	4,000.0	2.3	9,200.00
6. Sub Total(Civil + Equipment)					**67,231.00**
7. Transmis. Facilities					**26,139.70**
(1) Trans. Line Install.	0.4kV, 50mm2	km	3.7	6,181.0	22,869.70
(2) Transformers	5kVA	Sets	3	1,090.0	3,270.00
8. Sub Total	**Direct Works**				**93,370.70**
9. Overhead, etc.	with Site Management, Within 10% of Subtotal	Unit	1.0	9,337.07	**9,129.30**
Grand Total					**102,500.00**

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