No.

BASIC DESIGN STUDY REPORT
ON THE PROJECT
FOR
RURAL ELECTRIFICATION ON
MICRO-HYDRO POWER IN REMOTE
PROVINCE OF MONDUL KIRI
IN
THE KINGDOM OF CAMBODIA

MAY 2005

JAPAN INTERNATIONAL COOPERATION AGENCY
GRANT AID MANAGEMENT DEPARTMENT

GM
JR
05-076

PREFACE

In response to a request from the Government of the Kingdom of Cambodia, the Government of Japan decided to conduct a basic design study on the Project for Rural Electrification on Micro-Hydropower in Remote Province of Mondul Kiri in the Kingdom of Cambodia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cambodia a study team from 1st.December through 29th December, 2004.

The team held discussions with the officials concerned of the Government of the Kingdom of Cambodia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Cambodia in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the teams.

May, 2005

Seiji Kojima
Vice-President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

May, 2005

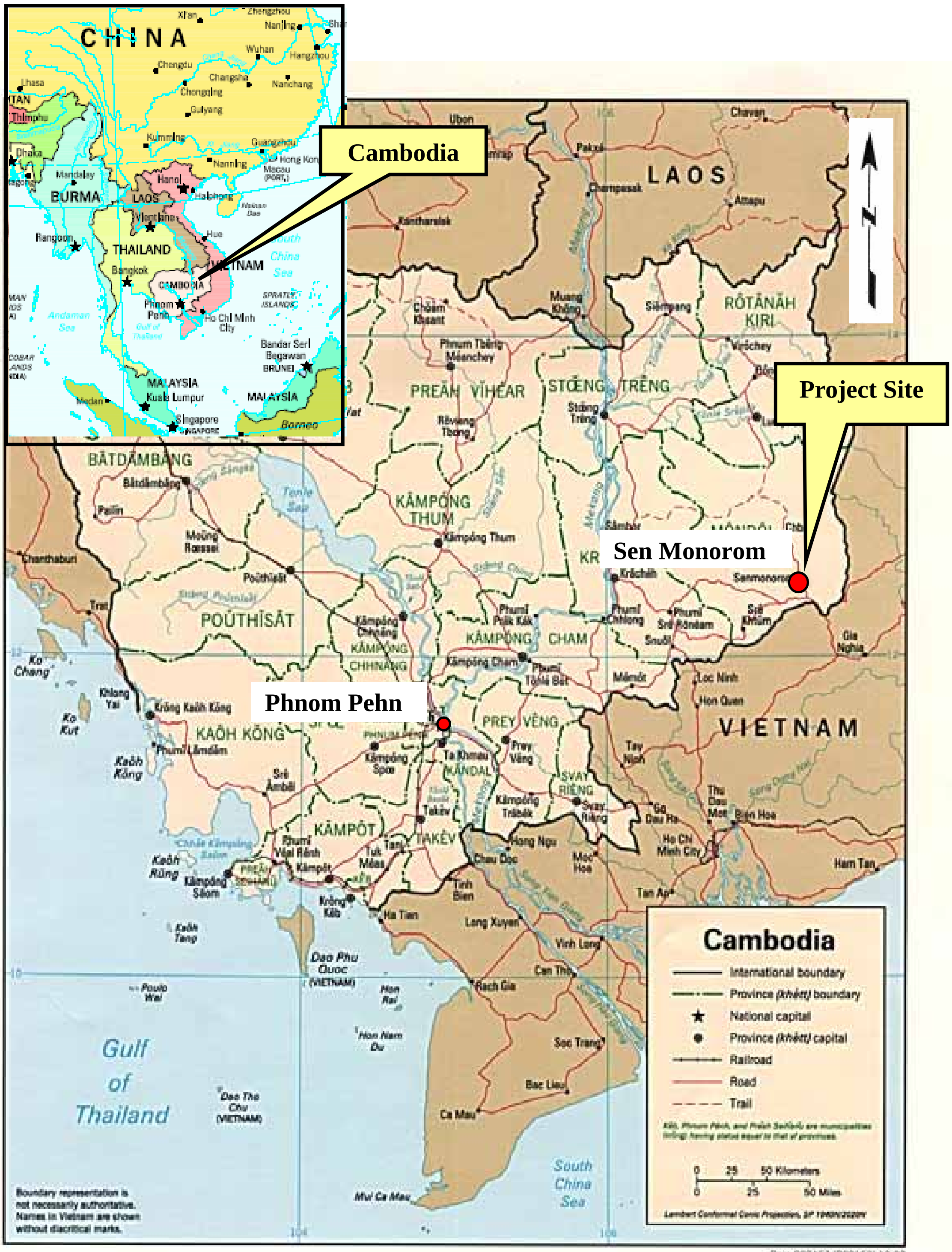
We are pleased to submit to you the basic design study report on the Project for Rural Electrification on Micro-Hydropower in Remote Province of Mondul Kiri in the Kingdom of Cambodia.

This study was conducted by the joint venture between Electric Power Development Co., Ltd and Nippon Koei Co., Ltd., under a contract to JICA, during the period from November, 2004 through May, 2005. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Cambodia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Tadao Sekizawa
Chief Consultant,
Basic design study team on the Project for Rural Electrification on Micro-Hydro power Remote Province of Mondul Kiri in the Kingdom of Cambodia
The joint venture between
Electric Power Development Co., Ltd
and Nippon Koei Co., Ltd.,



出典：http://www.lib.utexas.edu/maps/asia.html

Location Map

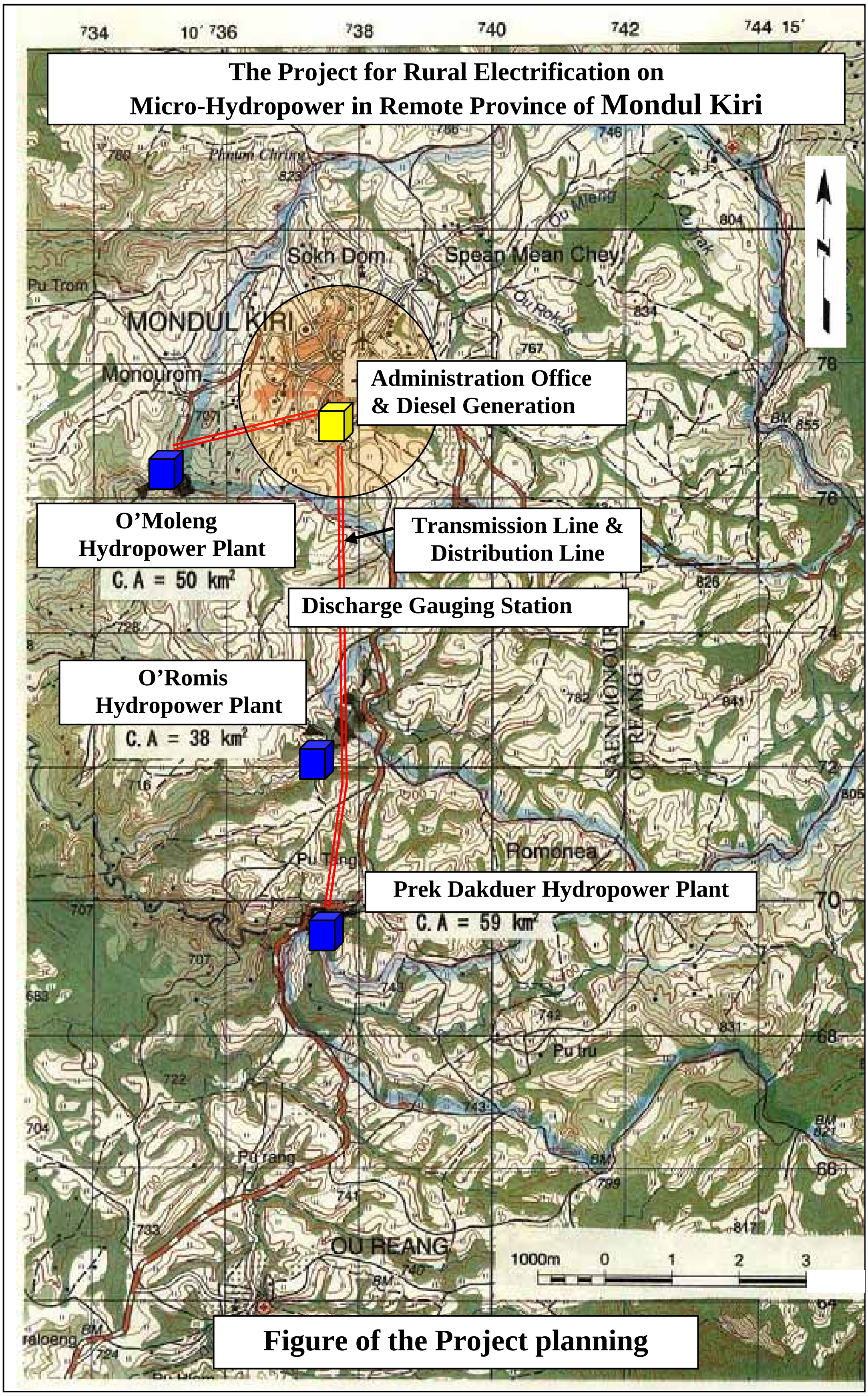


Figure of the Project planning

THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDRO POWER
IN REMOTE PROVINCE OF MONDUL KIRI

Perspective
(Prek Dakduer Hydropower Station)

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ABBREVIATIONS

CESS	Cambodia Energy Sector Strategy
CPSS	Cambodia Power Sector Strategy
DIME	Provincial Department of Industry, Mines and Energy
E/N	Exchange of Notes
EAC	Electricity Authority of Cambodia
EDC	Electricite du Cambodia
EIA	Environmental impact Assessment
GDP	Gross Domestic Product
GNP	Gross National Product
IEC	International Electrotechnical Commission
IEIA	Initial Environmental Impact Assessment
IMF	International Monetary Fund
IPP	Independent Power Producer
ISO	International Organization for Standardization
JBIC	Japan Bank for International Cooperation
JEAC	Japan Electric Association Code
JEC	Japanese Electrotechnical Committee
JEM	Standards of Japan Electrical Manufacture's Association
JICA	Japan International Cooperation Agency
JIS	Japanese industrial Standards
MD	Minutes of Discussion
MEF	Ministry of Economy and Finance
MIME	Ministry of Industry, Mines and Energy
MOE	Ministry of Environment
MRC	Mekong River Commission
NGO	Non-Government Organization
O&M	Operation and Maintenance
ODA	Official Development Assistance
OJT	On the Job Training
PEC	Private Electricity Company
PEU	Provincial (or joint with Private) Electricity Utility
PEOC	Private Electricity Operators/Company
PRSP	Poverty Reduction Strategy Paper
REE	Rural Electricity Enterprises
UNDP	United Nations Development Program
UNTAC	United Nations Transmission Authority in Cambodia
WB	World Bank

SUMMARY

Summary

The Kingdom of Cambodia (hereinafter "Cambodia") is located at the southern part of the Indochina, roughly at a latitude of 13 degrees north and a longitude of 105 degrees east, and borders with Viet Nam in the east, Thailand in the west, Laos in the north and the Gulf of Thailand in the south. The national land area of Cambodia is approximately 181,000 km^2, in which some 13.5 million people (as of 2002) live. The GDP per capita is US$291 (2002).

The power sector of Cambodia is characterized by delayed development, due to the 25-year long civil war that devastated most of the existing power facilities. Although many households in the Cambodian capital of Phnom Penh and local capitals are supplied electric energy by an isolated power system based on diesel power generation, it is only about 13% of the total households in this country that receives electricity, and the annual energy consumption per capita is 35 kWh, the lowest level in Southeast Asia. To put this situation in a different way, the local and rural areas of this country are inhabited by about 85% of the entire population, and only 9% of this rural population is endowed with the benefit of electricity.

The project site, Sen Monorom city, with some 1,400 households and a population of about 8,000, the capital of Mondul Kiri province, is situated in the mountains near the border of Viet Nam. No public power service is available in the city, except for small-scale independent power producers, who supply electricity by diesel generators during meal times, including the morning and evening hours. Chronic power shortage is a steady scene in this area. The electric tariff rate is about US 45 cents/kWh to 58 cents/kWh, about 4 times that in Phnom Penh, which is far beyond the reach of low income group. Such poor power availability hinders the local growth and development. The current national transmission system expansion plan, however, excludes this part of the country as a coverage area planned for electrification, even up to 2016. This means Sen Monorom city and its vicinity will not be able to obtain any power from the outside in more than a decade to come.

These circumstances are a major impediment to poverty reduction, local vitalization and promotion of the living infrastructure of the inhabitant in Mondul Kiri. If this continues, it will certainly aggravate the widening gap of the living standard between areas in Cambodia. Early and stable availability of a power energy source is very much desired to promote local development in this province.

To find ways to solve this problem, Mekong River Commission carried out an investigation on small hydropower project in Sen Monorom city and its vicinity in 1999. Based on the results of this investigation, the government of Cambodia made a request to the Government of Japan

for the provision of grant aid for constructing three micro-hydropower plants with a total output of 200 kW, including the transmission and distribution facilities to Sen Monorom city, as part of Cambodia's electrification plan to better the living standards of the people and reduce poverty in the Project site.

In response to this request, the Japan International Cooperation Agency (JICA) dispatched the Preparatory Study Team to Cambodia from 18th February through 12th March, 2004 and assured the Project adequate. Based on the result, the Government of Japan decided to conduct a basic design study and JICA dispatched the Basic Design Study Team to Cambodia from 1st through 29th December, 2004, to reconfirm the contents of the request and also to discuss the implementation contents of the Project with the people concerned on Cambodia. The Study Team also conducted a survey on the project sites and gathered relevant information.

On its return to Japan, the Study Team examined the necessity, expected socioeconomic effects and relevance of the Project based on the field survey findings and compiled the basic design implementation plan for the optimal project in the Outline of the Basic Design. Following the completion of this Outline document, JICA dispatched the Study Team to Cambodia again from 20th through 27th March, 2005 to explain the contents of the Outline of the Basic Design.

The scope of the requested Japanese assistance, determined based on the Basic Design Study, covers the entire contents of the Project, consisting of constructing three runoff river type small hydropower plants, each at O'Moleng, O'Romis and Prek Dakduer, to generate a total output of 370 kW, together with an auxiliary power source for the dry season, which will use diesel power generator with an output of 250 kW, 22 kV medium-voltage transmission lines and 400/230V low-voltage distribution lines. The project will benefit some 1,650 households with some 9,000 residents and public facilities by electrification in the target year (the end of 2012).

Since Prek Dakduer and O'Moleng sites are tourist areas, structures and locations of facilities under the Project will be taken special consideration so as to harmonize with the landscape of the both sites. Moreover, water intake will be restricted from 9 am to 4 pm so that tourist would enjoy waterfalls by the request of the local people in Sen Monorom City and Tourism Division of Mondul Kiri Province. In addition, the Electric Power Technical Standards being established in Cambodia through Japanese technical assistance will be adopted to the Project.

Major facilities are shown as follows:

Facilities	Description
1. O'Moleng Hydropower Plant	Intake Weir (Height 5.5m, Length 36m) Sedimentation Basin (Length 26m) Penstock (Diameter 0.6-1.0m, Length 457m) Turbine Generator (Output 130kW) Outlet
2. O'Romis Hydropower Plant	Intake Weir (Height 5m, Length 32m) Sedimentation Basin (Length 23m) Open Channel (Width 1m, Length 1,037m) Head Tank Penstock (Diameter 0.6-1.0m, Length 80m) Turbine Generator (Output 130kW) Outlet
3. Prek Dakduer Hydropower Plant	Intake Weir (Height 4.5m, Length 48m) Sedimentation Basin (Length 26m) Penstock (Diameter 0.6-1.0m, Length 536m) Turbine Generator (Output 110kW) Outlet
4. Diesel Power Plant	Power House(Floor Area 144m^2) Diesel Power Generator (Output 250kW) Fuel Tank (Volume 8,000liter)
5. Transmission	22kV Medium Voltage Transmission Line (Length 33.73km) 400-230V Low Voltage Transmission Line (Length 33.71km) Switchyard, Substation and Communication Facilities etc
6. Office Building	House (Floor Area 189m^2)

If the Project is implemented under the grant aid scheme of the Government of Japan, the project cost is estimated to be approximately ¥ 1,124 million (Japanese portion of about ¥ 1,103 million and Cambodia portion of about ¥ 21 million).

The project implementation period are estimated to be 26 months, 4 months for the detailed design and 22 months for the construction works and trial operation in the following year.

The Ministry of Industry, Mines and Energy (MIME), i.e. the implementation organization of the Project intends to establish Sen Monorom Community Power Utilization as an operator of the power business in the post-project period, with the Provincial Department of Industry, Mines and Energy (DIME, or MIME's regional bureau in Mondul Kiri) as its main organizers, so that the power business will be operated with the participation of both the provincial government and residents. Although MIME and DIME is supervising the power supply as the electricity administrative organs, they do not have enough experience to manage micro-hydropower plant. Therefore, soft component is needed to provide training on the operation, management, and maintenance to the operation staff for technical guidance.

The Project will benefit some 9,000 residents in 1,650 households in Sen Monorom city (at the end of 2012, target year of the Project). With the implementation of the Project, they will be able to obtain stable power supply (400 kW: including reserve capacity of 30 kW) all through the year and at an affordable power rate (about US 15 cents/kWh on the average), roughly one-third the current rate in 2004. The Project is also expected to improve the current electrification ratio of 32% in 2004 to about 80% in 5 years in the post-project period. At the same time, electrification by the public facilities will improve the public services by helping develop electric street lights, introduce PCs to schools and make medical equipment at hospitals available round the clock.

Improvement of power supply in Sen Monorom city, the capital of Mondul Kiri province, will lead the local economy in the entire province to the growth and promote the development of local tourist industry by ensuring a continued rapid rise in the number of tourists.

As the Project is expected to make great contributions to the Cambodian people in multiple ways, it is considered appropriate to implement the Project as a subject for Japan's Grant Aid. The recipient nation has sufficient personnel and funds necessary for acquirement of technology by soft component, operation and maintenance of the Project. Therefore, it is reasonable to consider that the Project will be smoothly and effectively implemented.

Efficient implementation of the Project requires Cambodia to acquire available land for the construction works of power generation, transmission, and distribution facilities and their temporary facilities by the start of the Project. To ensure the emergence and continuation of the positive effects of the Project, it is necessary that Cambodia should establish Sen Monorom Community Power Utilization and the Joint Coordination Committee, which should supervise the power business, obtain a license of the electric power business and electricity tariff rate and acquire and train the necessary personnel for Project operation alongside construction of the facilities.

CONTENTS

CHAPTER 1

BACKGROUND OF THE PROJECT

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The current condition of the Kingdom of Cambodia's (hereinafter "Cambodia") power sector is characterized by delayed development, due to the long civil war that devastated most of the existing power facilities. It is only about 13% of the total households in the country receives electricity, and the annual energy consumption per capita is 35 kWh, the lowest level in Southeast Asia.

The project site, Sen Monorom city, with some 1,400 households and a population of about 8,000, the capital of Mondul Kiri province, is situated in the mountains near the border of Viet Nam. No public power service is available in the city, except for small-scale independent power producers, who supply electricity generated by diesel generators during meal times, including the morning and evening hours. Chronic power shortage is a steady scene in this area. The electricity tariff rate is about 4 times that in Phnom Penh, which is far beyond the reach of low-income group. Such poor power availability hinders the local growth and development. The current national transmission system expansion plan, however, excludes this part of the country as a coverage area planned for electrification, even up to 2016. This means Sen Monorom city and its vicinity will not be able to obtain any power from the outside in more than a decade to come.

These circumstances are a major impediment to poverty reduction, local vitalization and promotion of the living infrastructure of the inhabitant in Mondul Kiri. If this continues, it will certainly aggravate the widening gap of the living standard between areas in Cambodia. Early and stable availability of a power energy source is very much desired to promote local development in this province.

To find ways to solve this problem, Mekong River Commission carried out an investigation on small hydropower generation in Sen Monorom city and its vicinity in 1999. Based on the results of this investigation, the Cambodian government requested application of Japan's Grant Aid to a plan of constructing three micro-hydropower plants with a total output of 200 kW, including the transmission and distribution facilities to Sen Monorom city, as part of Cambodia's electrification plan to better the living standards of the people and reduce poverty in the Project site.

CHAPTER 2

CONTENTS OF THE PROJECT

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2-1 Basic Concept of the Project

The electrification rate of Cambodia is about 13 percent, the lowest level of the Indochina Peninsular countries. Many local villages do not benefit from the power supply system. The Government of the Kingdom of Cambodia aims at achieving an electrification rate of 25 percent in 2010 in the medium term to redress the disparities between rural and urban areas and improve living conditions in the rural.

The objective of the project is to supply a stable electric energy to Sen Monorom City, the capital of Mondul Kiri Province, mainly by hydropower, renewable energy. The overall objective is to improve the living conditions of people in Sen Monorom City and its surrounding area.

This project is to construct a micro-hydropower plants at 3 sites, with a total power output of 370 kW, and an auxiliary power source for the dry season (diesel power generation, 250 kW), and 22 kV transmission line with low-voltage distribution lines in Sen Monorom City, to electrify about 1,650 households whose population is about 9,000 by the end of 2012.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

(1) Basic Policy

1) Policy for the Scope of the Project

The Project will construct micro-hydropower plants at 3 sites and a diesel power generation facility as an auxiliary power source for the dry season and establish facilities for supplying power with transmission and distribution facilities to households residing in the Sen Monorom urban area.

2) Policy for Site Selection

The hydropower plants will be constructed at the O'Moleng, O'Romis and Prek Dakduer sites, considering the hydropower potential based on the topographical and hydrological information and the diesel power generation facility will be located in Sen Monorom City, where is the center of demand.

3) Policy for Facility Scale

The facility scale satisfies the demand of Sen Monorom City after 5 years from the commencement of operation, or at the end of 2012.

4) Policy for Operation

Hydropower plants are to be main power sources in the Project and diesel power generation is an auxiliary power source during the dry season or other case of necessity. Considering that O'Moleng and Prek Dakduer are tourists areas, power generation of these two sites should be restricted from 9 am to 4 pm season from November to April, dry season.

(2) Policy for Natural Environmental Conditions

Since Prek Dakduer and O'Moleng sites are tourist areas, structures and locations of facilities under the Project will be taken special consideration so as to harmonize with the landscape of the both sites. Moreover, water intake will be restricted from 9 am to 4 pm so that tourist would enjoy waterfalls by the request of the local people in Sen Monorom City and Tourism Division of Mondul Kiri Province.

(3) Policy for Social and Economic Conditions

Increase in the number of guest houses and construction work of a new hotel are considered as the indication of economic growth in the area. Stable supply of electricity is expected to accelerate the improvement of the economic situation and the Project aims at involving lower income group in the development trends by setting up the electricity tariff system which enables needy people to have access to electricity and enjoy benefits.

(4) Policy for Construction and Procurement Conditions

The construction materials for the civil work are available in Cambodia, and general construction equipment can be procured at the capital, Phnom Penh.

Origins of the generator, power transmission and distribution materials will be further examined taking into consideration the quality, convenience of maintenance and so forth. They might be made in Japan, third countries and Cambodia.

(5) Policy for Effective Use of Local Contractors

Because the site is situated in a remote area and has wet and a dry seasons, management of works by Japanese contractors is essential to forward the works smoothly, who can complete the work without delay and with the required quality. It is planned that some capable contractors in Phnom Penh participate in the works at the site, in order to make the Project cost lower and to transfer technology.

(6) Policy for Operation and Maintenance Capacity of Project Implementation Body

Management Board will be newly established to operate and maintain the facilities of the Project consisting of Ministry of Industry, Mines and Energy (hereinafter "MIME") and Provincial Department of Industry, Mines and Energy (hereinafter "DIME"), residents and the local government. Since MIME/DIME do not have enough experience to manage micro-hydropower plant, it is necessary to acquire practical knowledge and skills by Soft Component in the Project and OJT. MIME/DIME also requires to making effort to learn skills from Electricity Authority of Cambodia (hereinafter "EDC") or other experienced organizations.

(7) Policy for Scope of Facilities, Equipment and Grades

The Electric Power Technical Standards of Cambodia was established in April 2004. This project will basically conform to the Standard however, Chapter 29 of the Standards allows for a relaxation of application of the Standards to "Renewable Energy, Micro Power Generation and Micro-Hydropower Generation". The Project is Micro-Hydropower, there is a low possibility of being connected to a nation-wide power transmission system and it will remain an independent system in the future, so the most suitable grade for scale of supply and demand will be established.

(8) Policy for Procurement and Construction Schedule

This project will be executed based on the Japan's Grand Aid. Considering the scale and terms of works of the Project, following schedule is proposed.

First year:

1) E/N exchanged between the Governments of Japan and the Kingdom of Cambodia for Detailed Design
2) Detailed Design and preparation of Draft Tender Documents

Second year:

1) E/N exchanged between the Governments of Japan and the Kingdom of Cambodia for Construction
2) Bid and Contract,
3) Commencement of Work, Construction Term 1

Third year:

1) Construction Term 2,
2) Completion of Work,
3) Soft Component (Technical Guidance)

2-2-2 Basic Plan

2-2-2-1 Scale of Facilities

(1) Demand Forecast

This power demand forecast is made based on the current conditions of power demand, December 2004.

1) Conditions Time

(a) Time

-The commencement of power supply service by the project is to be at the end of 2007 for this demand forecast analysis.

-The demand year employed in the project is 5 years after the commencement of power supply service, or the end of 2012.

-The demand forecast covers 15 years after the commencement of power supply service, or until the end of 2022.

(b) Intended Users

According to social condition survey, the number of users as of the end of 2004 is 1,264 houses, including offices.

For the growth rate of the number of households, population forecasts (for each year from 2001 to 2021) in Mondul Kiri Province are given in the 2003 Almanac (edited by the Ministry of Planning) and these figures were applied to find the growth rate. The national mean population growth rate of Cambodia is around 2 percent, while the forecast in Mondul Kiri Province is as large as about 3.5 percent.

(c) Electrification Rate

According to social condition survey, about 90 percent want to use electricity. However, it is necessary to determine the attainable condition. The electrification rate in the future was forecasted considering cases of other places and the actual conditions of Sen Monorom City.

The forecast is as follows: the electrification rate was taken at 70 percent in the year of commencement of power supply service. It would increase at a rate of 2 percent per year for the 5 years after that, to reach 80 percent in 2012. After that, it would increase at a rate of 1 percent per year, to reach 90 percent in 2022.

(d) Demand of General Households at the Beginning of Electrification

The persons receiving electrification there are thought to be the low-income class, so the load will be mainly light, such as illumination and radio. In this survey, the load per household for the peak hour between 6 and 7 pm was set at 80 W.

(e) Demand Growth Rate due to Improvement of Living Conditions

MIME drew up the Rural Electricity Action Plan in 2003 with the aid of the World Bank, and this plan gives an expected economic growth rate of 6 percent. This figure is applied as the growth rate due to improvement of living conditions.

(f) Growth Rate of Tourism Industry

According to the results of the social condition survey described above, the number of tourists visiting Sen Monorom is reported to have increased 7 times from 2001 to July 2004. This rapid growth is expected to continue for a time. Assuming, however, that it will stabilize sometime in the future, an annual rate of 10 percent was set.

2) Analysis Results

The calculation was done for each year to 2022, based on the daily load curve as of the end of 2004. The principal results are shown in Table2.1 and Fig.2-1.

The maximum demand at the end of 2012, which is the target year of the supply plan, is estimated at 331kW, or about twice the current figure.

The required scale of power output, which will be described later, is the sum of the maximum demand obtained here, a total of about 400 kW, including the loss due to power transmission and distribution, and the reserve capacity, such as for securing system stability and surplus for failure.

Table 2-1 Long Term Demand Forecast

Year	Electrification Rate (%)	Maximum Demand (kW)	Annual Energy Consumption (MWh)
the end of 2004 (Present)	32	152	696
the end of 2007 (Commencement of Energy Supply)	70	230	911
the end of 2010	76	285	1,215
the end of 2012 (After 5 years)	80	331	1,407
the end of 2017 (After 10 years)	85	461	1,944
the end of 2022 (After 15 years)	90	648	2,724

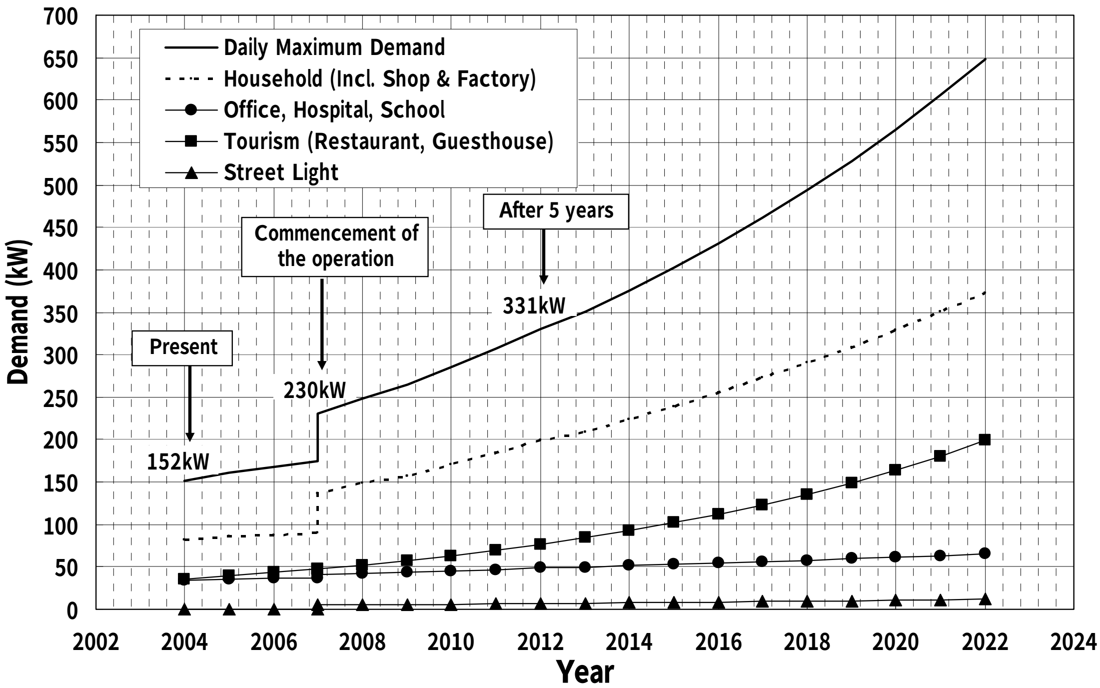


Fig. 2-1 Long Term Demand Forecast

The estimated daily load curve at the end of 2012, is shown in Fig.2-2 by the consumer categories and in total. From the figure, one will see that the maximum load occurs around 7 pm.

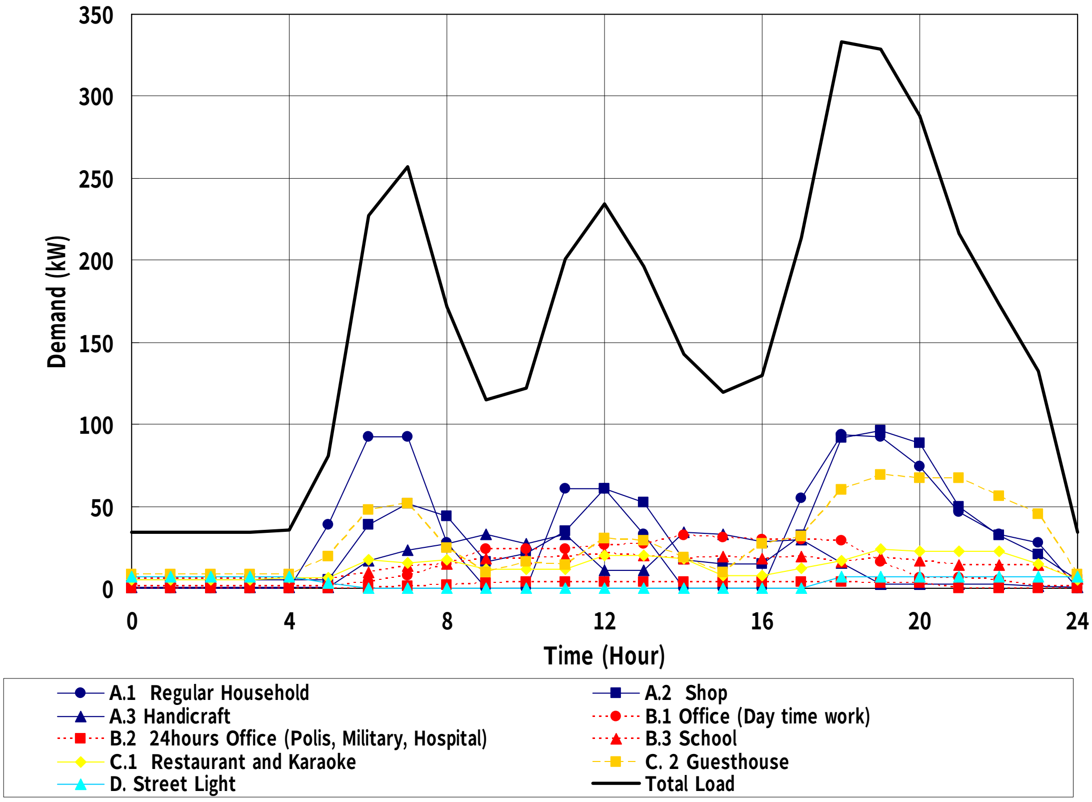


Fig. 2-2 Daily Load Curve at the end of 2012

Table2.2 and Table2.3 show the maximum power demand and monthly energy consumption until the end of 2022 by categories.

Table 2.2 Long Term Demand Forecast (Maximum demand)

Long term Demand Forecast

1. Maximum Demand

Condition

Number of consumers	1,264		
Number of Household	1,189	kW per Household in initial year	0.08 kW
(incl. Small shop and manufactory)	356	Increasing Rate of Energy Consumption due to level up of living	6 %/year
(incl. regular household)	833	Increasing Rate of Energy Consumption for tourism industry such as guesthouses and restaurant	10 %/year

Unit:kW

Item	Present 2004	2005	2006	Commencement 2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Electrification Rate	**32**	33	34	**70**	72	74	76	78	**80**	81	82	83	84	**85**	**86**	**87**	**88**	**89**	**90**
Increasing Rate of Number of Household %		4.7	2.2	4.3	4.2	2	3.9	3.8	3.6	1.8	3.4	3.3	3.2	3.1	3	2.9	2.9	2.9	2.8
Total Number of Consumer	1,189	1245	1272	1326.98	1383	1410	1465	1521	1576	1604	1659	1713	1768	1823.1	1877.8	1932.3	1988.3	2045.9	2103
Number of Electrified Household	21	55	77	573	640	688	758	830	905	943	1,004	1,066	1,129	1,194	1,259	1,325	1,394	1,465	1,537
Daily Maximum Demand (PM 6 to PM 7)																			
A. Household																			
A1 Regular Household	**2**	**4**	**6**	**47**	**55**	**62**	**71**	**81**	**92**	**101**	**112**	**123**	**136**	**149**	**163**	**178**	**194**	**212**	**230**
A2 Small Shop with housing	69	72	74	77	80	82	85	88	91	93	96	99	103	106	109	112	115	119	122
A3 Small Manufactory with housing	12	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20
Sub total	82	86	88	136	148	157	170	184	199	209	224	239	255	272	290	309	329	350	373
B. Office and School																			
B1 Office	22	23	23	24	25	26	27	28	29	29	30	31	32	33	34	35	36	38	39
B2 Hospital and Police	12	13	13	14	14	14	15	16	16	16	17	18	18	19	19	20	20	21	22
B3 School	0	0	0	3	3	3	3	3	4	4	4	4	4	4	4	4	4	5	5
Sub total	34	36	36	41	43	44	45	47	49	49	51	53	55	56	58	60	61	63	65
C. Tourism																			
C1 Restaurant and Karaoke	8	9	9	10	11	13	14	15	17	19	20	22	25	27	30	33	36	40	44
C2 Guesthouse	28	31	34	37	41	45	49	54	60	66	72	80	88	96	106	117	128	141	155
Sub total	36	39	43	48	52	58	63	70	77	84	93	102	112	123	136	149	164	181	199
D Public	0	0	0	5	5	6	6	6	7	7	8	8	8	9	9	10	11	11	12
Total	**152**	**161**	**168**	**230**	**249**	**264**	**285**	**307**	**331**	**350**	**375**	**402**	**431**	**461**	**493**	**528**	**565**	**605**	**648**
Increasing Rate (%)		**5.9**	**4.1**	**37.2**	**8.1**	**6.2**	**7.9**	**7.8**	**7.7**	**5.9**	**7.2**	**7.1**	**7.1**	**7.1**	**7.0**	**7.0**	**7.1**	**7.1**	**7.1**

Table2.3 Long Term Demand Forecast (monthly energy consumption)

Long term Demand Forecast

2： Monthly Energy Consumption (Mwh/month)

Number of consumers	1,264		
Number of Household	1,189	kW per Household in initial year	0.08 kW
(incl. Small shop and manufactory)	356	Increasing Rate of Energy Consumption due to level up of living	6 %/year
(incl. regular household)	833	Increasing Rate of Energy Consumption for	10 %/year

Unit:MWh

Item	Present			Commencement															
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Electrification Rate	**32**	33	34	**70**	72	74	76	78	**80**	81	82	83	84	**85**	**86**	**87**	**88**	**89**	**90**
Increasing Rate of Number of Household		4.7	2.2	4.3	4.2	2	3.9	3.8	3.6	1.8	3.4	3.3	3.2	3.1	3	2.9	2.9	2.9	2.8
Total Number of Consumer	1,189	1245	1272	1326.978	1383	1410	1465	1521	1575.81	1604.2	1659	1713	1768	1823.1	1878	1932	1988	2046	2103.23
Number of Electrified Household	21	55	77	573	640	688	758	830	905	943	1,004	1,066	1,129	1,194	1,259	1,325	1,394	1,465	1,537
A. Household																			
A1 Regular Household	**0**	**1**	**2**	**13**	**15**	**17**	**19**	**22**	**25**	**28**	**30**	**34**	**37**	**41**	**45**	**49**	**53**	**58**	**63**
A2 Small Shop with housing	**19**	**19**	**20**	**21**	**22**	**22**	**23**	**24**	**25**	**25**	**26**	**27**	**28**	**28**	**29**	**30**	**31**	**32**	**33**
A3 Small Manufactory with housing	**8**	**8**	**8**	**9**	**9**	**9**	**10**	**10**	**10**	**10**	**11**	**11**	**12**	**12**	**12**	**13**	**13**	**13**	**14**
Sub total	27	29	30	42	46	48	52	56	60	63	67	72	76	81	86	91	97	103	109
B. Office and School																			
B1 Office	8	8	8	9	9	9	10	10	10	11	11	11	12	12	12	13	13	14	14
B2 Hospital and Police	8	8	8	9	9	9	10	10	10	11	11	11	12	12	12	13	13	13	14
B3 School	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
Sub total	16	16	17	19	19	20	21	21	22	23	23	24	25	26	26	27	28	29	30
C. Tourism																			
C1 Restaurant and Karaoke	5	5	6	6	7	8	8	9	10	11	12	13	15	16	18	19	21	24	26
C2 Guesthouse	10	12	13	14	15	17	19	20	22	25	27	30	33	36	40	44	48	53	58
Sub total	15	17	18	20	22	24	27	29	32	36	39	43	47	52	57	63	70	76	84
D Public	0	0	0	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4
Total	**58**	**62**	**65**	**83**	**89**	**94**	**101**	**109**	**117**	**124**	**132**	**142**	**152**	**162**	**173**	**185**	**198**	**212**	**227**
Increasing Rate (%)		7.4	5.1	27.1	7.7	5.9	7.5	7.5	7.4	5.8	7.0	7.0	7.0	7.0	6.9	6.9	7.0	7.1	7.1

Unit:kW

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Monthly Energy Consumption per Consumer																			
A. Household																			
A1 Regular Household	**22**	**22**	**23**	**22**	**23**	**25**	**26**	**27**	**28**	**29**	**30**	**32**	**33**	**34**	**35**	**37**	**38**	**40**	**41**
A2 Small Shop with housing	58	61	62	65	67	69	71	74	77	78	81	84	86	89	92	94	97	100	103
A3 Small Manufactory with housing	216	226	231	241	251	256	266	276	286	291	301	311	321	331	341	351	361	371	382
B. Office and School																			
B1 Office	240	251	257	268	279	284	296	307	318	324	335	346	357	368	379	390	401	413	424
B2 Hospital and Police	1,297	1,358	1,388	1,448	1,509	1,539	1,599	1,660	1,719	1,750	1,810	1,870	1,929	1,989	2,049	2,108	2,169	2,232	2,295
B3 School	0	0	0	281	293	299	311	322	334	340	351	363	375	386	398	409	421	434	446
C. Tourism																			
C1 Restaurant and Karaoke	292	321	353	388	427	470	517	568	625	688	756	832	915	1,007	1,107	1,218	1,340	1,474	1,621
C2 Guesthouse	615	677	745	819	901	991	1,090	1,199	1,319	1,451	1,596	1,756	1,931	2,124	2,337	2,570	2,827	3,110	3,421

(2) Power Generation Plan

1) Basic Concept for Planning

Hydropower resources, which are renewable energy, should be utilized as much as possible, and diesel power generation, which is an auxiliary power source, should take place only when a shortage occurs. Note that diesel power generation servers as a complement for a supply deficit at peak hours in the morning and/or night in the dry season and an auxiliary generating source when hydropower is restricted by a tourism discharge of the waterfalls at the Prek Dakduer and O'Moleng sites (from 9 am to 4 pm).

2) Required Power Output

The power demand in 2012 was forecasted in the previous section. The power output enough to satisfy this demand must be larger by the sum of 1) the loss due to power transmission and distribution facilities and 2) the reserve capacity for system stability, failure and the like.

Here, the following conditions were established:

(a) Maximum Load at the Demand End

- Maximum load		= 331kW

(b) Loss due to Power Transmission and Distribution Facilities

In Japan, it is said to be about 6 to 7 percent. On the other hand, the actual power transmission loss in developing countries is in general 15 percent or over. In this project, because it is planned to renew the distribution lines, 10 percent is employed, considering the technical level of maintenance.

- Power transmission and distribution loss	= 331kW × 10%	= 33kW
- Maximum load at the generation plant terminal	= 331kW + 33kW	= 364kW

(c) Reserve Capacity for System Stability and Failure

To stabilize the voltage and frequency, prevent system downtime as far as possible, and secure a reserve capacity during no-operation of hydropower, 10 percent of the maximum load is considered.

- Reserve capacity	= 331kW × 10%	= 33kW

(d) Required Power Output

- Installed capacity = 364kW + 33kW = 397kW

≈ 400kW

From the above, the required power output is 400 kW.

3) Energy Source Breakdown

(a) Three Micro-Hydropower Plants

The total output of three hydropower generation is 370 kW, which is equivalent to the maximum load at the generation plant terminal. The reserve capacity of about 10 % is secured by diesel power generation. According to the results of analysis, the guaranteed output of the 3 plants totals 150 kW during the drought period (firm discharge with 95% probability).

(b) Diesel power generation facility

As the value after subtraction of the guaranteed output during the drought period of hydropower from the required power output of 400 kW, a power source of 250 kW must be established.

(c) Daily Operation Pattern (Demand at the end of 2012)

a) Ordinary period (period other than the drought period: about 8 months a year)
During the period from April to December with the rainy season intervening, the river discharge is ordinarily abundant and full operation of hydropower generation is possible. Diesel power generation is put on standby as a reserve capacity.

b) Dry season (period from around November to around April during which the river discharge is small)
Fig.2-4 shows the share of hydropower and diesel power generation during the 95-percent drought period (347th-day firm discharge). Note that a generation restriction will be established from 9 am to 4 pm because of a tourism discharge of the waterfalls at the O'Moleng and Prek Dakduer sites.

4) Specification of Generating Plan

Outline of the generation plan is as Table2.4.

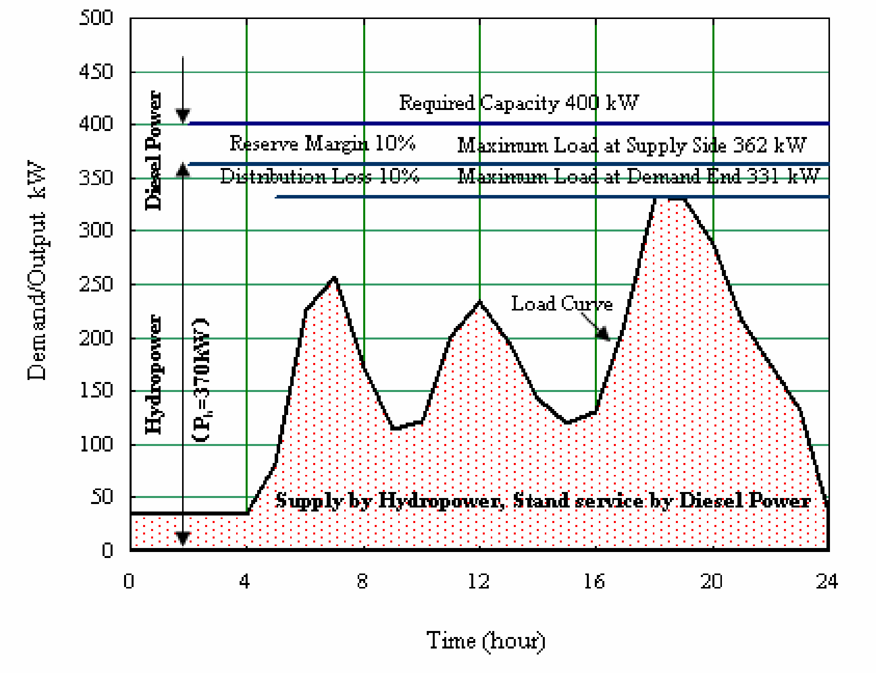


Fig. 2-3 Relation between Demand and Supply
(Ordinary season except dry season)

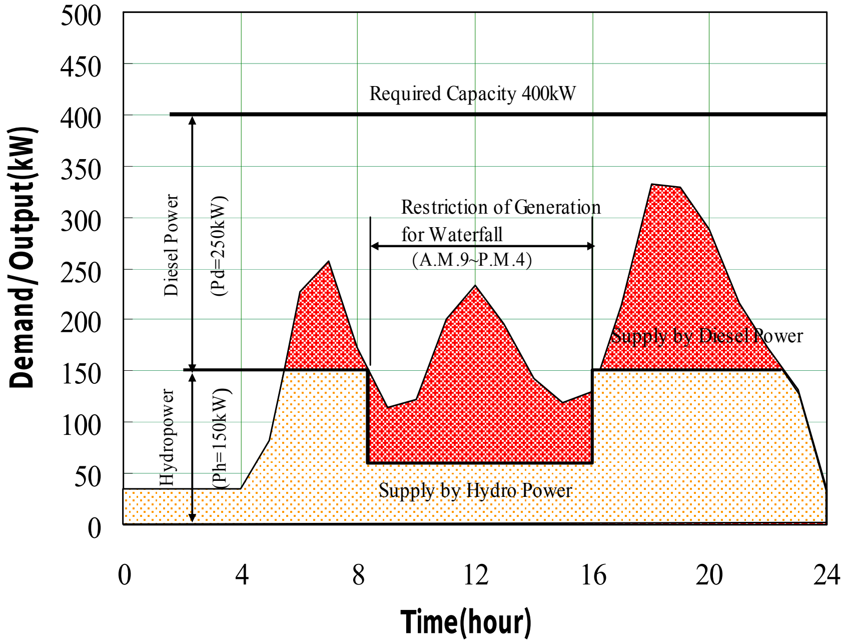


Fig. 2-4 Relation between Demand and Supply

(Dry Season)

Table 2-4 Outline of the Generation Plan

Item	Unit	O'Moleng	O'Romis	Prek Dakduer	Total
Catchments Area	km^2	50	38	59	147
Annual Average River Flow	m^3/s	2.86	2.17	3.38	
Average Flow during Rainy Season	m^3/s	5.60	4.26	6.61	
Firm Discharge (95%, 347th Flow)	m^3/s	0.60	0.46	0.71	
Intake Water Level	E.L.m	613.0	647.0	622.0	
Tailrace Water Level	E.L.m	591.0	616.0	605.0	
Gross Head	m	22.0	31.0	17.0	
Effective Head	m	20.5	28.0	15.5	
Maximum Power Discharge	m^3/s	0.94	0.70	1.10	
Installed Capacity	kW	130	130	110	370
Number of Turbine	Unit	1	1	1	
Type of Turbine		Cross flow	Cross flow	Cross flow	
Headrace		Not exist	Open Channel	Not exist	
Section	m	Not exist	1.00 × 1.00	Not exist	
Length	m	Not exist	1,050	Not exist	
Penstock		Under Ground Steel Pipe	Steel Pipe	Under Ground Steel Pipe	
Section	m	1.0	1.0	1.0	
Length	m	480	100	530	
Annual Available Energy	MWh	934	980	826	2,740
Plants factor of above	%	82	86	86	
Operation period by Maximum output	day	247	247	247	247
Firm Power Output	kW	50	50	50	150
Diesel Generation Installed Capacity	kW	250	-	-	250

Annual Energy Consumption at Demand End	Peak Demand	Annual Energy (MWh)		
		Total	Suuply resource	
	kW		Hydropower	Diesel
Year the end of 2007	231	991	750	241
Year the end of 2012 (After 5 years of Completion)	333	1,407	1,124	283

Note

1. A value to be considered outflow for the waterfall from intake weir at the both powerhouse sites, Prek Dakduer and O'Moleng power stations, during dry season for site-seeing
   Period: At least, 0.2m3/s of river flow will be discharged from AM 9 to PM 4 during dry season, April to November
2. Data of River flow to be calculated based on the data of O'Romis gauging Site from May 2003 to April 2004

2-2-2-2 Civil Work Structures and Building and Construction Facility Plan

Outline of the main structures of three hydropower site are shown in Table2.5, Table2.6 and table2.7.

Table 2-5 Main Structure of O'Moleng Hydropower Site

No.	Facility	Unit	Number	Note
1	Intake Weir	LS	1	Height H=5.5m, Length L=36m with Intake Gate and Screen
2	Sand Flash	LS	1	Width B=2m with Flash Gate
3	Sedimentation Basin	LS	1	Width B=2~4m, Height H=2~3m、Length L=26.25m with Spillway(Crest Length L=10m）, Screen and Sand flash
4	Penstock	m	457	Steel Pipe(Under Ground Type) Diameter D=1000-600mm
5	Powerhouse	Ls	1	Foundation: Reinforced Concrete , Building: One-story wooden house, Floor area A=56m^2
6	Outlet	LS	1	Reinforced Concrete Width B=3m, Height H=2m

Table 2-6 Main Structure of O'Romis Hydropower Site

No.	Facility	Unit	Number	Note
1	Intake Weir	LS	1	Height H=5m, Length L=32m with Intake Gate and Screen
2	Sand Flash	LS	1	Width B=2m with Flash Gate
3	Sedimentation Basin	LS	1	Width B=2~4m、Height H=2~3m、Length L=23.2m with Spillway (Crest Length L=10m), Screen and Sand flash
4	Open Channel	m	1,037	Reinforced Concrete, Width B=1.0m, Height H=1.2m,
5	Head Tank	LS	1	Width B=4m, Length L=15m, Height H=5m
6	Spillway	m	80	Steel Pipe Diameter D=800mm
7	Penstock	m	80	Steel Pipe Diameter D=600mm
8	Powerhouse	Ls	1	Foundation: Reinforced Concrete , Building: One-story wooden house, Floor area A=56m2
9	Outlet	LS	1	Reinforced Concrete Width B=3m, Height H=2m

Table 2-7 Main Structure of Prek Dakduer Hydropower Site

No.	Facility	Unit	Number	Note
1	Intake Weir	LS	1	Height H=4.5m, Length L=48m with Intake Gate and Screen
2	Sand Flash	LS	1	Width B=2m with Flash Gate
3	Sedimentation Basin	LS	1	Width B=2~4m, Height H=2~3m、Length L=26.25m with Spillway(Crest Length L=10m）, Screen and Sand flash
4	Penstock	m	457	Steel Pipe(Under Ground Type) Diameter D=1000-600mm
5	Powerhouse	Ls	1	Foundation: Reinforced Concrete , Building: One-story wooden house, Floor area A=56m^2
6	Outlet	LS	1	Reinforced Concrete Width B=3m, Height H=2m

(1) Intake Weir

The intake weir of the power plant should be located so as to be invisible from the area of the general activities of tourists at the waterfall, and the concrete gravity type should be employed for it, because the construction is relatively easy and a reduction of construction cost can be expected. Considering the effect of the backwater to the upstream on the neighboring environment after completion of the intake weir, the water level should be around 5 meters or less from the present riverbed (weir height 6 meters or less).

The intake weir should be equipped with an intake opening, sand flash and sedimentation basin, and they should each be equipped with a gate for their operation and maintenance.

The intake opening and sedimentation basin should be equipped with a screen to prevent driftwood, fallen leaves or other foreign matter from entering the water way.

(2) Water Way

1) Prek Dakduer and O'Moleng Power Plants

The water ways of the Prek Dakduer and O'Moleng power plants will pass through a natural forest, so we have to fell down neighboring trees as little as possible to build water way. The site is a sightseeing area, there is not enough space, the proper geographical conditions are not available for installing a head tank and effluent outlet, and the conduit extension is relatively short. Therefore, the water way structures should all be planned as a buried steel pipe.

2) O'Romis Power Plant

The length of the water way of the O'Romis power plant is relatively long and the raceway route runs in a grass field after felling trees over the entire extension. Topographically, space is available for installing a head tank and effluent outlet. Therefore, the waterway is planned as an ordinary open channel. However, concrete lids should be installed over the entire extension of the open channel to prevent fallen leaves, grass or artifacts from entering the open channel, and to facilitate the maintenance of the facilities after the commencement of operation.

A head tank and effluent outlet should be installed at the end of the open channel (the starting point of the steel pipeline). The head tank is to be open type. Water overflowing the head tank should be discharged to a spillway through the effluent outlet, and the spillway should be steel pipeline to prevent erosion or sliding of the slope surface or scouring of the neighboring ground surface.

The hydraulic pipeline should be a general aboveground iron pipeline.

(3) Powerhouse and Outlet

The powerhouse building should be open type reinforced concrete building. Considering the harmony with the neighboring environment, landscape architecture should be practiced so as not to give a feeling of strangeness in the neighboring environment, such as by employing the traditional house design of Mondul Kiri Province.

(4) Access Path for Operation and Maintenance

The temporary passageway made for plant construction should be used as access path for operation and maintenance. This access path should be installed along the water ways from an existing road to the intake weir and from the weir to the powerhouse. Because the access path will be constructed in the form of a branch from an existing road for tourists to the waterfall, a gate should be installed at the entrance of the access path to shut off outsiders.

(5) Building for PowerStation

1) Hydropower Station

The generator power house was planned taking the following into account:

i) Protection from falling rock and pastured livestock

ii) Considerations for operation and maintenance in an area of severe weather conditions

iii) Safekeeping of spare parts, consumables and the like

iv) Protection of equipment from bees, ants and the like

Considering the matters described above, the building foundation should be reinforced concrete and the shed should be wooden construction and have concrete block walls. Due considerations should be given to prevent insect intrusion by installing an insect screen around the air vent. A small room should be installed in the power plant as a station for maintenance personnel.

2) Diesel Power Station

Diesel Power Station will be located in the urban area of the Sen Monorom city so that influence of noise and vibration against surrounding area should be minimized. The building foundation should be reinforced concrete and the shed should be wooden construction and have concrete block walls.

(6) Substation (Indoor type)

Two indoor substations are planed in the city. The building foundation should be reinforced concrete and the shed should be wooden construction and have concrete block walls. The building works are also including concrete foundations for the transformers and cubicles, floor concrete, and cable ducts. The numbers of stations for the above works are two indoor type substations.

(7) Administration Office

Administration office will be located in the urban area of the Sen Monorom city near by the diesel power station.

2-2-2-3 Hydroelectric Power Facilities

(1) Basic Design Concepts of Hydroelectric Power Facilities

The electric facilities should be designed considering economic efficiency and technical capability for easy operation and maintenance. The currently applied standards for electrical and transmission/ distribution lines facilities in Cambodia is as follows:

Transmission line voltage	:	22 kV, 3-phase, 3-wire
Distribution line voltage	:	400/230 V, 3-phase, 4-wire
Frequency	:	50 Hz

As for the basic design of hydroelectric power facilities, it is applied the above standards of Cambodia in considering of operation and maintenance after commissioning. The hydro turbine, the power generation facilities and the transmission/distribution lines in this project were planned in accordance with the following concept:

1) Selection of turbine type

Turbine type selection is basically determined by effective head and water discharge. As can be seen from the natural conditions at sites, the Francis turbine and Cross-flow turbine are suitable for medium head.

However, the Francis turbine is more complex in structure and expensive than the Cross-flow turbine and it can be still more expensive if the discharge is low, because it becomes small size and its fabrication becomes more difficult. Moreover repair is difficult when it is out of order due to cavitations or the like after the commencement of operation.

Compared with Francis turbine, the Cross-flow turbine is simple in structure and economical for medium head and low water discharge, so it was decided to apply Cross-flow turbine for the project.

Turbine control generally takes place by installing a guide vane servomotor (automatic control) which regulates water consumption and speed in accordance with the demand (actual load).

However, for a unit output capacity of 100 kW or so, like this case, employing a servo motor makes the mechanism complex, difficult to maintain and uneconomical. For these and other reasons, the following type was applied:

(a) Water discharge regulation

Manual guide vane adjustment should take place whenever necessary to satisfy the requirements as far as possible within the allowable range of inlet flow. Ordinarily, adjustment should take place mainly for seasonal water volume variations at transitions between the dry and rainy seasons. However, a manual adjustment may have to be done once a day or so for diurnal variations if in need.

(b) Speed regulation

Control should take place to keep a constant rotation speed, irrespective of demand increase or decrease, by installing a dummy load in the Outlet.

(c) Inlet valve

A manually operated gate valve should be installed.
No intake gate should be installed in the upper tank.
In the case where this dummy load governor is applied, the design should be such that no mechanical damage or other problems will occur even if the governor should fail and a runaway speed is reached.

2) Selection of generator

Generator voltage is applied of 3-phases, 400 volts, ac considering standards voltage in Cambodia. The high revolving speed of generator is basically economic efficiency because of small body with low weight than low speed machine. Therefore, it is installed a speed increasing gear or belt at the connecting portion of the turbine-generator to increase the revolving speed of the generator, thus making the generator weight as small as possible and achieving an economy. The generator revolving speed is applied to be approximately 1,000 rpm.

3) Operation and control method of power plant

The monitoring and control of the power plant should take place by resident operators, and basically these should be by the constant continuous monitoring and control method.

Control method: It should be equivalent to an unmanned power plant by the continuous monitoring and control method, and the generator voltage should be controlled by an automatic voltage regulator (AVR).

4) System parallel operation

The turbine-generator is run continuously, and the generated power is boosted to 22kV through a step-up transformer and is connected to the transmission and distribution system. On the other hand, during the dry season or when a hydropower plant is scheduled and/or emergency shut down, the generator must be in system parallel operation with a separately installed diesel power generation facility (about 250 kW).

Therefore, these three hydropower plants should be equipped with a facility to make it possible for them to run in parallel with the diesel power generation.

(2) Basic Design of Hydropower Plant

The capacity of the three planned sites should be 110 to 130 kW considering the power generation equipment and following matters:

1) According to the results of a survey of river discharge, effective head and the like at the planned sites, an installed capacity of 110 to 130 kW can be secured for each power plant.
2) By equalizing the scale of the three sites, generators and hydraulic intake pipes of the same specifications can be used, thus achieving an economy.
3) Seeing the generation output in the rainy and dry seasons, the output decreases to about a third during the dry season. Therefore, a turbine should be selected that can generate power at low load.
The design summary is given below:

(a) Equipment design summary

i) Turbine

- Type:	Cross-flow turbine
- Governor:	A static governor should be applied as an electric dummy load governor that controls the current of the dummy load to keep the revolving speed constant by an electric circuit.
- Inlet valve:	Manually operated gate valve
- Rating:	As shown in Table2.8

ii) Generator

- Type:	3-phases AC brushless synchronous generator
- Frequency:	50 Hz
- Connection:	3-phases
- Rating:	As shown in Table2.8

iii) Control board

- Type: Indoor, self stand type with front doors
- Control and protection devices: A set of instruments, protective relays, AVR and governor control devices, magnetic switches and others.

The combined efficiency of the turbine-generator was taken at approximately 70 %, assuming that it would be possible to secure a turbine efficiency of approximately 78 %, a speed increasing gear efficiency of approximately 97 % and a generator efficiency of approximately 93 % or so.

(b) Operation and control method of power plant

The monitoring and control of the power plant should take place by resident operators, and basically these should be by the constant continuous monitoring and control method. It should be equivalent to an unmanned power plant by the continuous monitoring and control method. Turbine-generator can be started and stopped by the open or close of the inlet valve in manual operation and also can be run in parallel from control panel by synchronizer into the 22kV power system.

Table 2-8 Turbine and Generator Data

	Description	O'Moleng	O'Romis	Prek Dakduer
Turbine	No. of Unit	1	1	1
	Effective Head（m）	20.5	28	15.5
	Water Discharge (max. m^3/s)	0.94	0.7	1.1
	Output（kW）	144	144	120
	Revolving Speed（rpm）	400	600	318
Generator	No. of Unit	1	1	1
	Capacity（kVA）	180	180	150
	Voltage（V）	400	400	400
	Power Factor	0.8	0.8	0.8
	Revolving Speed（rpm）	1,000	1,000	1,000
Installed Capacity（kW）		130	130	110

(c) Protection method

The protection method of the power generation facility should consist of two types of protection: emergency shutdown and alarm.

a) Emergency shutdown

In case of heavy fault such as electrical and mechanical failures, a protective relay forces the circuit breaker of the generator main circuit to trip in order to disconnect the circuit from the system, as well as to shut off the turbine generator and lock the starter circuit. On the operation control board, there should be an integrated failure and operation indicator which should display the status and alert the operator of the failure by a bell. When the failure has been completely eliminated, it should be possible to restore the starter circuit manually to the normal state.

b) Alarm

When an alarming failure occurs, the integrated failure and operation indicator on the operation control board should display the status and alert the operator of the failure by a buzzer.

The bell and buzzer alarm should automatically stop after a certain length of time, or it should be possible to stop it manually.

2-2-2-4 Diesel Power Generation Facility

This diesel power generation facility is connected to the 22kV transmission and distribution power system in parallel and supplies power to that system. This facility should sufficiently satisfy the following conditions:

(1) Design Procedure

1) Diesel power generation facility rating items

- Type	:	Indoor, diesel power generation facility
- Rated Output	:	250 kW (continuous)
- Rated frequency	:	50 Hz
- Rated voltage	:	400 V or manufacturer's standard product
- Starting time within	:	60 seconds

2) Service condition

- Altitude	:	600 m
- Air temperature	:	Maximum 40°C
	:	Minimum 10°C

3) Operation Conditions with Power System

(a) During a drought period in the dry season or when some of the micro-hydroelectric power generation facilities are shut down, it should be possible to supply diesel-generated power to that power system.

(b) Parallel operation should be possible with other operable micro-hydropower generation facilities.

(c) The facility should be able to operate continuously in the state of being connected to the power system.

(d) The facility should be capable of a black start when the power system is totally shut down.

4) Operation Control and Protection Methods

(a) Operation control method

The constant continuous monitoring and control method should be employed, and startups and shutdowns should be possible by resident operators using a function equivalent to unmanned power generation control. When operating, a fully automatic method should be employed which can control startups and shutdowns by remote control from the operation control board. However, this method should be equipped with a changeover switch to make manual (test) operation possible. Equipment should be attached that can usually record necessary operation data. (Details will be given in the stage of approval drawing)

(b) Protection method

The protection method of the power generation facility should consist of two types of protection, emergency shutdown and alarm.

a) Emergency shutdown

In case of heavy fault such as electrical and mechanical failures, a protective relay forces the circuit breaker of the generator main circuit to trip in order to disconnect the circuit from the system, as well as to shut off the diesel power generator and lock the starter circuit. On the operation control board, there should be an integrated failure and operation indicator which should display the status and alert the operator of the failure by a bell.

When the failure has been completely eliminated, it should be possible to restore the starter circuit manually to the normal state.

b) Alarm

When an alarming failure occurs, the integrated failure and operation indicator on the operation control board should display the status and alert the operator of the failure by a buzzer.

The bell and buzzer alarm should automatically stop after a certain length of time, or it should be possible to stop it manually.

5) Diesel Engine

(a) Type and quantity

Vertical series water-cooled 4-cycle engine : one unit

(b) Ratings

- Rated Output	:	312 kVA (continuous)
- Rated rotation speed	:	less than 1,000 rpm
- Rated voltage	:	400 V or manufacturer's standard product
- Fuel	:	Diesel oil for diesel engine
- Starting method	:	Compressed air starting or cell motor starting
- Cooling method	:	Radiator cooling

(c) Performance, structure and other requirements

a) The diesel engine should be directly coupled with the generator and fixed on a common base.

b) Noise level

The noise level at 1 meter from the side of the machine and at 1 meter from the exhaust muffler outlet should be 90 dB (A-characteristics) or less, respectively.

c) Rotation speed regulation

When the rated load is connected or disconnected, the fluctuation of rotation speed should be within (±) 4 percent in the transient state and within (±) 0.3 percent in the steady state.

d) Speed governor

The engine should be equipped with an electric speed governor which should be stable and sure in operation and be sensitive and responsive.

e) Fuel shutoff valve

The fuel supply system should be fitted with an emergency fuel shutoff valve operated by a blocking relay.

f) Fuel tank

The fuel oil storage tank should be installed separately (on the ground) and it should have a capacity of approx. 8,000 liters and should be fitted with an inspection hole, oil level gauge, oil level alarm relay and the like.

g) Fuel oil transfer pump, valve, pipe and the like

To replenish the service fuel tank installed indoors, a complete set of a transfer, motors, pipe and valves should be supplied.

6) Diesel Generator

(a) Type and quantity

Protected 3-phase AC synchronous generator : one unit

(b) Ratings

- Rated Output : 312 kVA (continuous)
- Rated rotation speed : 1,000 rpm
- Rated voltage : 400 V or the standard product of the manufacturer
- Rated frequency : 50 Hz
- Rated power factor : 80 percent (lag)
- Number of poles : 4 poles
- Excitation method : Brushless

(c) Performance, structure and other requirement

a) Rotor

The rotor should be of the cylindrical rotating magnetic field type, and the cooling method should be self ventilation which cools by the fans attached to the rotor.

b) Overall voltage fluctuation

The overall voltage fluctuation of the generator combined with the diesel engine should be within (±) 2.5 percent.

c) Maximum voltage drop

The maximum voltage drop of the generator combined with the diesel engine should be within 30 percent and should return to within 3 percent of the final steady voltage within 2 seconds.

d) Insulation type

Both the stator and field windings should employ Class F insulation.

7) Operation Control Board

The operation control board should be able to display all the operation functions and protection and operation conditions. It should be installed in parallel with the control and protection board of the auxiliaries and should consist of the following:

- Operation control board (including auxiliaries control board)	:	1 panel
- System parallel-in synchronization board	:	1 panel
- DC power source board	:	1 panel

2-2-2-5 Transmission and Distribution Line Facilities

(1) Design Concept

The design policy for the system is to ensure high reliability and safety, to be compatible with the EDC's facilities for easy operation and maintenance, and to be flexible for future expansion considering the current technical level of MIME. The design will be formulated under the following criteria

1) Applied Standard

The design policy for the system is to ensure high reliability and safety, to be compatible with the existing facilities for easy operation and maintenance, and to be fixable for future expansion considering the current technical level of MIME. The design will be formulated under the following criteria:

Power Technical Standards and Guidelines	(Cambodia)
Japanese Industrial Standards	(JIS)
Japanese Electro Technical Committee Standard	(JEC)
Japanese Cable Standard	(JEC)
International Electrotechnical Commission	(IEC)
Other International Standard	(ISO)

The site election works for the project facilities shall be carried out in accordance with the regulation and/ or practices of EDC. And also the project shall be executed taking into account all necessary safety measures to the public and workers at the erection sites.

2) Voltage Levels

The voltage in the medium distribution line system of Cambodia is adopted 22kV. Moreover, the technological standard and guideline are made by aid of JICA, and medium voltage distribution line system is enacted as 22kV.

Therefore, three phase voltage levels in Mondol Kiri power system are shown in Table 2-9.

Table 2-9 System Voltage

System	Voltage level & Phases
Medium voltage distribution system	22kV, 3-phase, 3 –wire
Low voltage distribution system	400/230V, 3-phase, 4-wire

3) Basic Conditions

With reference to the climatic data for the past ten years in Mondol Kiri and the present design standards of EDC, the design conditions for the facilities to be provided under the Project will be adopted as follows:

The design wind pressures are worked out from the above mentioned wind velocity, and the sag and tension of overhead conductors are computed on the basis of the assumptions shown in Table 2-10.

4) Electrical Design Parameters

The electrical design parameters shown in Table 2-11 and Table 2-12 will be adopted for the MV and LV distribution systems:

Table 2-10 Design Conditions

Design Parameter	Design Value
Design wind pressures	
Conductors	36 kg/m^2
Poles	45 kg/m^2
Other equipment	36 kg/m^2
Ground temperaturemaximum	+ 25ºC
Sag and tension	75 ºC, still air
maximum sag occurs at	
maximum stress occurs at	13 ºC, maximum wind
every day stress (EDS) occurs at	27 ºC, still air
factor of safety at maximum stress	2.5 against UTS
actor of safety at EDS	4.0 against UTS
Solar constants maximum solar radiation	1,000 W/ m^2
solar emissivity	0.8
solar absorption	0.7

Table 2-11 MV Electrical Design Parameter

Design Parameter	Design Value
Distribution system	3 phase, 3 wire system
Nominal system voltage	22 kV
Maximum system voltage	24 kV
Rated impulse voltage withstand (peak)	125 kV
Rated power-frequency withstand voltage (1 min, rms.)	50 kV
Rated short-time current (1 sec rms.)	20 kA
Rated peak short-circuit current (peak value)	50 kA
Rated frequency	50 Hz

Table 2-12 LV Electrical Design Parameter

Design Parameter	Design Value
Distribution system	3 phase, 4 wire system
Nominal system voltage :	400/230 V
Maximum system voltage :	424/244 V
Rated power-frequency withstand voltage (1 mint, rms.) :	2,000 V
Rated impulse voltage withstand (peak) :	6,000 V
Rated frequency :	50 Hz

5) Earthing System

The earthing for the MV and LV distribution system are shown in Table 2-13.

Table 2-13 Grounding System

Particular	System
a) MV distribution system	Non-grounding system, (resistor grounding system at generator side)
b) LV distribution system	Solid grounding system

The low voltage neutral terminal of the all distribution transformer which to be installed under the project shall be adopted solidly grounding system.

6) Clearance

(a) Overhead distribution lines

The minimum clearance for conductors shown in Table 2-14 will be adopted.

Table 2-14 Minimum Clearance

Particular	Minimum Clearance (meters)
Clearance above ground - 22 kV	
along or across road	8.0
off road	5.5
Clearance above ground – LV	
along or across road	6.5
off road	5.5
Clearance above ground - Service	
along or across road	5.5
in place liable to be used by vehicles	3.5
elsewhere	2.7
Separation - 22 kV	
between phases horizontal	0.7
between phases vertical	0.6
to LV lines	2.0
to telephone lines	2.0
Separation - LV Bundled to telephone	0.3

(b) Safe working clearance

In the interests of personnel safety, the safe working clearance shown in Table 2-15 will be adopted.

Table 2-15 Safe Working Clearance

Particular	Minimum Clearance (meters)
22 kV	0.46
LV bare	0.15

7) Voltage Variation

The voltage variation shown in Table 2-16 will be kept to ensure a quality supply at end of the distribution line and/or the customer's switchboard:

Table 2-16 Voltage Variation

Voltage Level		Voltage Variation
MV network	22 kV	± 5%
LV network	400/230 V	+ 10% ~ - 6 %

(2) Project Area and Project Facilities

1) Project area

The object district of the Project is Mondol Kiri state Sen Monorom city located in the northeastern part of the Cambodia.

2) Project facilities

The facilities to be provided under the Project are as shown in Table2.17

(3) Distribution Line Facilities

The overhead and underground distribution line facilities to be provided for the project are as follows.

1) Overhead line support

Supports for overhead lines are to be of steel reinforced concrete pole, with 12 m long for MV distribution lines and 9 m for LV lines. The poles will be set in the concrete foundations. The pole assembly of the distribution lines is shown in Dwg. No.TD-04 and TD-05. The height of poles was decided as Table2.18.

2) Insulators

Pin and disk insulators are to be used for supporting the 22 kV line conductors. The conductors will be fixed to the insulators by insulated annealed aluminum bind wires.

3) Conductors

In the cause of the overhead distribution line faults, the majority is arising from the short circuit faults due to contact the line to line or earth faults due to contact the line to tree of the bare distribution line conductors. As these faults measures, the covered conductor is adopted in the Sen Monorom city because there are a lot of trees. The bare conductor is adopted between power stations and city area except where a lot of tree exists.

Table 2-17 Facility to be provided under the Project

No,	Item	Unit	Amount
1	New medium voltage line		
	Overhead line	km	30.52
	Underground line	km	3.21
	Total	km	33.73
2	New low voltage line		
	- Composite	km	16.47
	- Exclusive	km	14.17
	- House flank	km	1.42
	Underground line	km	1.63
	Total	km	33.71
3	Indoor type substation	Nos.	2
	100kVA x 2	kVA	200
	Total	kVA	200
4	Pole mount type transformer	Nos.	33
	10kVA x 8	Nos.	80
	25kVA x 16	kVA	400
	50kVA x 9	kVA	450
	Total	kVA	930
5	Watt-hour meter		
	1φ5/20A	Nos.	1,210
	1φ10/30A	Nos.	140
	3φ20/60A	Nos.	50
	Total	Nos.	1,400
6	Maintenance var	L.S.	1
7	Spare items	L.S.	1

Table 2-18 Basic Design Drawings

	MV Line (m)	LV Line (m)
Span	45	30
Minimum height of conductor above ground	8.00	5.50
Maximum sag of conductor	1.01	0.63
Minimum height of conductor above ground	0.25	0.25
Allowance of ground clearance	0.74	1.12
Depth of pole	2.00	1.50
Total (necessary pole height)	12.00	9.00

Taking account of the above, hard aluminum covered conductors will be used instead of the bare conductors as follows:

i) MV overhead line
- Covered conductor : Less 55sq.mm × 1-core all aluminum alloy conductors, cross linked polyethylene covered conductor (AAAC)

ii) LV overhead line cable
- Overhead cable : 3-core × less 70sq.mm + 1-core × less 70sq.mm aluminum conductors, vinyl insulated cable.

iii) LV underground cable :
- Underground cable : 3-core × less 95sq.mm + 1-core × less 50sq.mm aluminum conductors, vinyl insulated cable.

4) Arms

The conductors of the MV overhead distribution lines will be arranged in horizontal-formation for a circuit on the straight pole. The arms are to be fixed to the pole with two through bolts. The conductors on the angle and end poles will be arranged in horizontal formation with a cross arm which is to be fixed to the pole with a through bolt and two arm ties as shown in Dwg. No.TD-04.

5) Fuse cutout switches

Fuse cutout switch with cartridge fuses for the transformer protection will be adopted 24 kV, 100 A, drop-out type, and the fuse rating will be used 6.3A and 10A.

6) Lightning arresters

Lightning arresters will be of 24 kV, 5 kA non-linear resistor type and mounted on the end of lines, at the joint of underground cables and overhead lines, at the line switches, and distribution transformer stations.

7) Grounding

The transformer, lightning arrester, switch case and other metal parts required for safe operation will be grounded by means of a grounding rod. Copper coated steel rods will be used for grounding.

8) Watt-Hour Meters

Watt-hour meters will be of AC single and three-phase, outdoor use and cyclometer register type. The single phase watt-hour meters will be used for domestic consumers, and three phase watt-hour meters for metering of the large consumers.

The major electrical features of the watt-hour meter are shown in Table 2-19.

Table 2-19 Watt-hour Meter

		Single-phase	Three-phase	Three-phase with CT
Rated voltage	(V)	230	230/400	230/400
Frequency	(Hz)	50	50	50
Rated current	(A)	5 – 20	10 - 30	5
Power factor		0.7 - 0.98	0.7 - 0.98	0.7 - 0.98
Class		2	2	2
Number of digit		6	6	7

The single phase watt-hour meter for general consumer will be housed tree (3) or five(5) in the aggregate mater box and will be mounted on distribution line pole or building wall near the grouped consumers.

9) Underground Cable Line

The medium voltage underground cables will be of 24 kV, less 90sq.mm × 3-cores aluminum conductors, vinyl sheathed, cross linked polyethylene insulated steel armored cable. The low voltage underground cable will be of 1kV, less 50sq.mm × 4-core aluminum conductor, vinyl sheathed, cross linked polyethylene insulated steel armored cable. The cable ends will be of pre-mould stress cone type and the straight through joint of the cables will be installed in concrete pits for their protection. The cables at the routes along roads will be laid in the direct-burried system. The cables at the crossing portion of main roads will be laid in super vinyl pipes and/or in concrete ducts.

(4) Distribution Substation

The distribution substation to be provided under the project will be designed for the following two types:

- Indoor type substation
- Pole mount type substation

The project is also including new construction of the distribution substation buildings with installed transformer capacity of 100kVA. The arrangement of substation equipment and building drawings are as shown in Dwg. No.TD-08 and TD-09. The capacity of pole mount type substation is three kinds of 10kVA, 25kVA and 50kVA. The transformer, disconnecting switch with fuses, lighting arresters and LV distribution board will be installed on the S, A and T type concrete poles.

The major features of the above substations are as follows:

1) Transformer

- Type	:	Three-phase, oil immersed indoor type with no-load tap changer Tap changer (±5%, 5-steps)
- Capacity	:	25, 50 and 100kVA
- Voltage ratio		
Primary side	:	22kV, 3 phase, 3 wire system
Secondary side	:	400-230V, 3 phase, 4 wire system
- Voltage group	:	Dyn11
- Cooling system	:	ONAN

2) 22kV Incoming and Outgoing Feeder Cubicle

The 22 kV feeder cubicles and transformer primary circuit cubicles will be of self-supporting, metal-enclosed indoor type. The switches for the feeder circuit cubicles will be of load break switch type. The transformer primary circuit cubicle will provide a load break switch and power fuses. All cubicles will be designed taking account of future expansion of the switchgear in the both sides of cubicles.

- Rated voltage and frequency	:	24kV, 50Hz
- Switch	:	Load break switch
- Rated current		
For feeder circuit	:	630A
For transformer circuit	:	200A
- Short circuit current	:	16kA (0.1second)

- Control mode : Manual operation mode
- Protection mode : Auto off by power fuse for transformer circuit

3) 22kV Fuse Switch
   - Type : Pole mounted, hand operation
   - Rated voltage : 24kV
   - Rated current : 100A frame
   - Rated breaking current 10k

4) 22kV Lightning Arrester
   - Type : Non-linear zinc oxide resistor (ZnO), pole mounted type
   - Rated voltage : 24kV, 50Hz
   - Nominal discharge current : 5kA
   - Max. residual voltage at normal current : 79.9kV

5) Low Voltage Distribution Board

   LV distribution board will be of wall mounted, metal-clad indoor type. The board will provide a molded case circuit breaker (MCCB) for the main switch of LV circuit and cartridge type fuses for the feeder circuits.

   - Service voltage : 400-230V, 3 phase, 4 wire system
   - Switch
     Main circuit : 400A
     Feeder circuit : 400A
   - Short circuit current : 32kA (1.0second)
   - Feeder circuit : 8 circuit

6) LV Load Break Switch
   - Type : MCCB
   - Rated voltage : 600V
   - Rated current : 100AT

7) Meter Box

   Aggregate meter boxes will be made from plastics for out door use. The size of boxes will be for mounting three or five single phase watt-hour meters or one three phase watt-hour meter with necessary accessories and fittings such as terminal blocks, miniature circuit breakers and fuses etc. The boxes will be mounted on distribution line pole or building wall near the grouped consumers.

(5) Grounding Works

All distribution substation equipment and other metal parts required for safe operation will be grounded by means of a 35 mm2 copper cable and ground rods. Cooper coated steel rods will be used for grounding. The grounding resistance for neutral terminal of distribution transformers shall be of less than 10 ohm.

(6) VHF FM Radio Set

The telecommunication among hydropower plants to other hydropower plant and/or diesel power generation facility is provided with VHF FM radio set consist of the following parts.

1) VHF Base Station : 1 set
2) VHF Fixed Station : 3 sets
3) VHF Mobile Station : 1 set
4) VHF Portable Station : 2 sets
5) VHF Antenna : 4 poles

The VHF radio receivers are banded 136MHz-174MHz, useable in Cambodia.

2-2-2-6 Equipment for Operation and Maintenance

Table 2-20 are required equipments for operation and maintenance to supply stable electric energy to Sem Monoromu City.

Table 2-20 List of Equipment for Operation and Maintenance

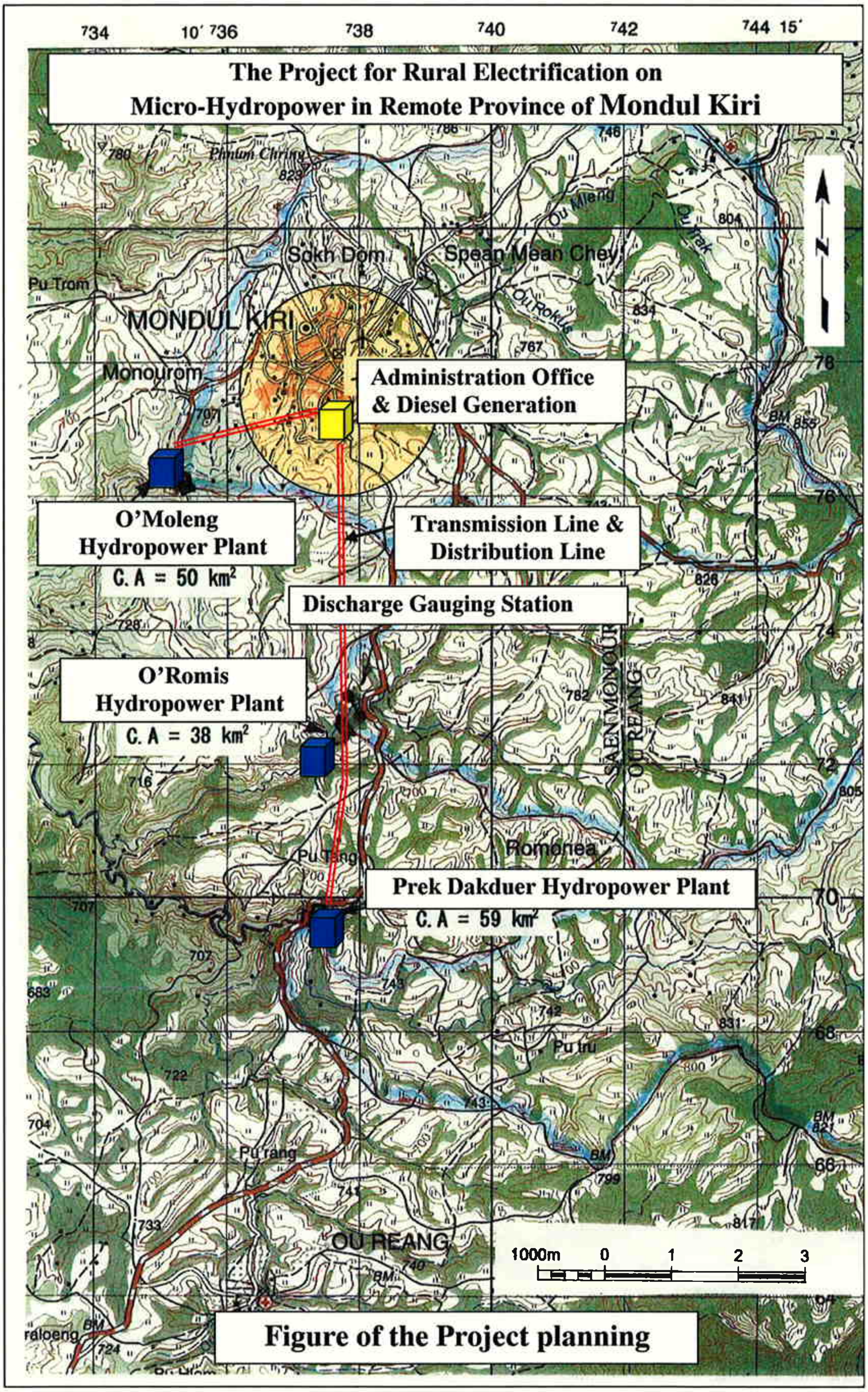
Name	Unit	Note
Pickup type Vehicle	1	Patrol and maintenance for the Power facilities
Work vehicle with mobile elevating work platform	1	Maintenance for Pole and Line

2-2-3 Basic Design Drawings

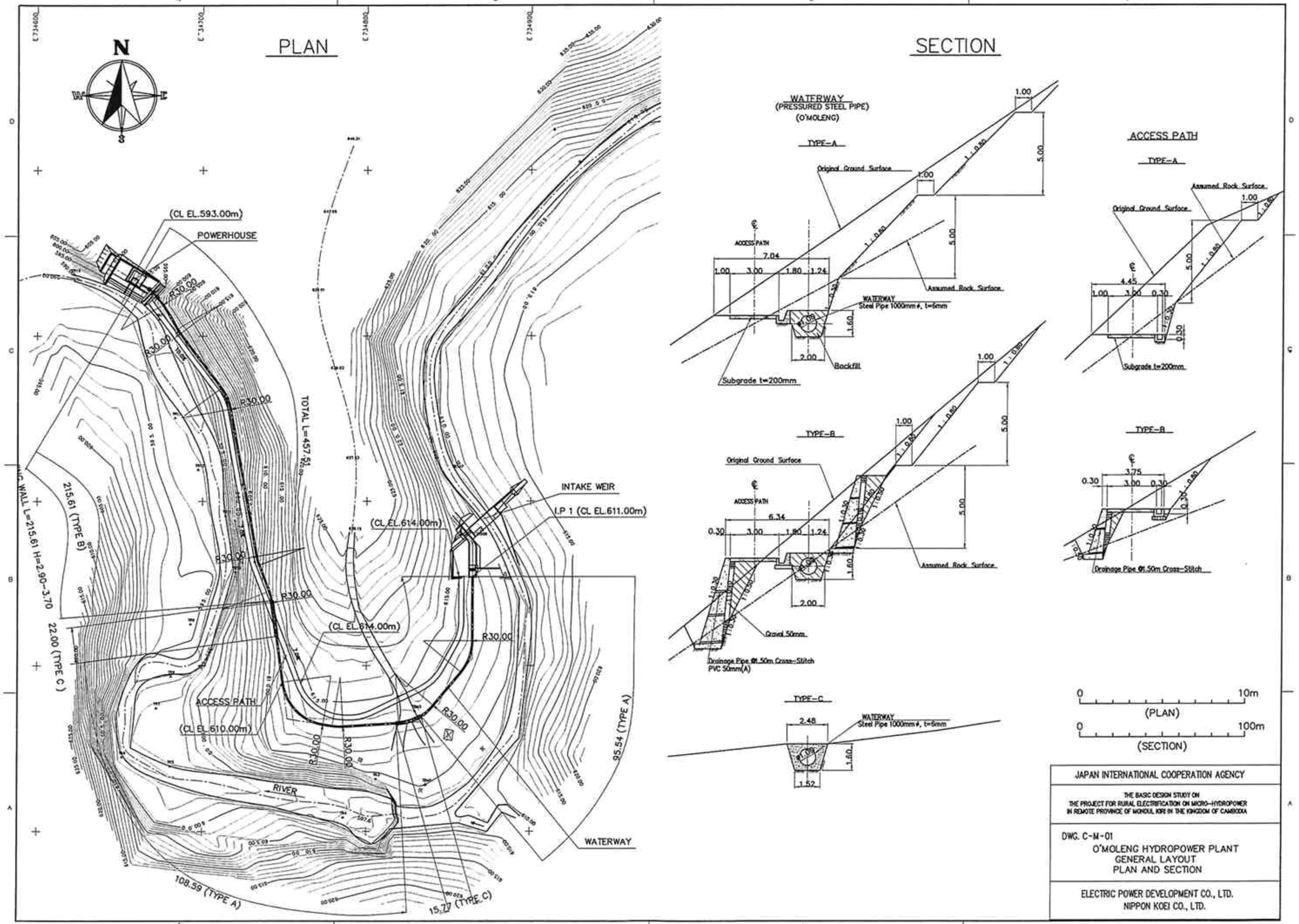
The basic design drawing of the project is attached at the end of this document as shown in Table2.21.

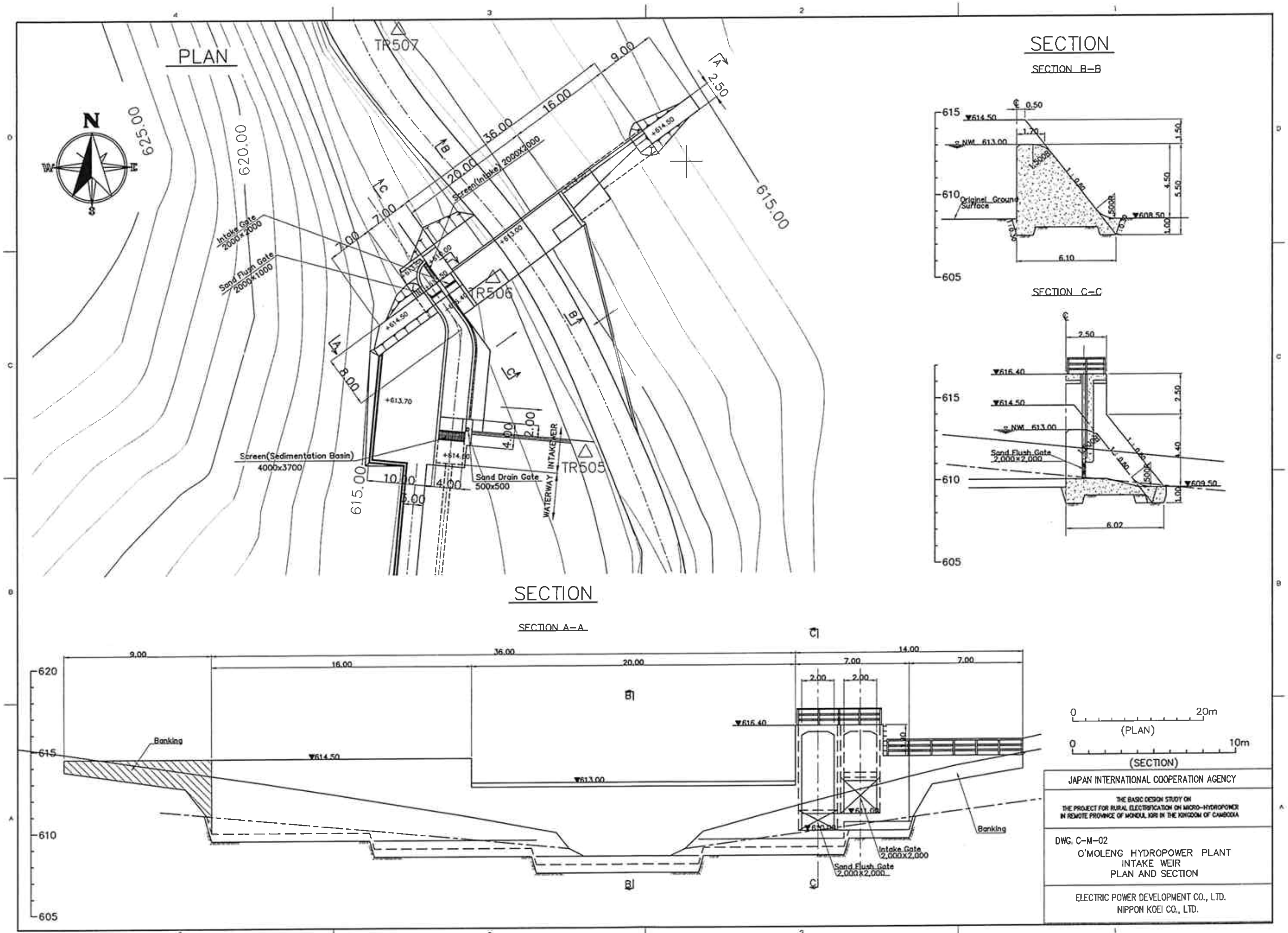
Table 2-21 List of Drawings

1.	G-01	Location Map
2.	C-M-01	O'Moleng Hydropower Plant General Layout Plan and Section
3.	C-M-02	O'Moleng Hydropower Plant Intake Weir Plan and Section
4.	C-M-03	O'Moleng Hydropower Plant Powerhouse Plan and Section
5.	C-R-01	O'Romis Hydropower Plant General Layout Plan and Section (1/2)
6.	C-R-02	O'Romis Hydropower Plant General Layout Plan and Section (2/2)
7.	C-R-03	O'Romis Hydropower Plant Intake Weir Plan and Section
8.	C-R-04	O'Romis Hydropower Plant Head Tank, Penstock and Powerhouse Plan and Section
9.	C-P-01	Prek Dakduer Hydropower Plant General Layout Plan and Section
10.	C-P-02	Prek Dakduer Hydropower Plant Intake Weir Plan and Section
11.	C-P-03	Prek Dakduer Hydropower Plant Powerhouse Plan and Section
12.	A-01	Location Map of Buildings
13.	A-02	Building of Diesel Power Plant, Substation and Administration Office Plan
14.	E-M-01	Arrangement of Hydropower Generating Equipment (O'Moleng, O'Romis& Prek Dakduer)
15.	E-M-02	Single Line Diagram of Hydropower Generating Equipment (O'Moleng, O'Romis & Prek Dakduer)
16.	D-01	Arrangement of Diesel Generating Equipment
17.	D-02	Single Line Diagram of Diesel Equipment
18.	TD-01	Route map of Transmission and Distribution Lines
19.	TD-02	22kV Network of Transmission and Distribution Line
20.	TD-03	Support for 22kV Overhead Line
21.	TD-04	Pole Mounted Transformer Station
22.	TD-05	Connection Diagram of Indoor Substation



G-01 Location Map


PLAN
SECTION
POWERHOUSE
(CL EL.593.00m)
INTAKE WEIR
I.P 1 (CL EL.611.00m)
(CL EL.614.00m)
(CL EL.614.00m)
(CL EL.610.00m)
ACCESS PATH
RIVER
WATERWAY
TOTAL L=457.51
215.61 (TYPE B)
22.00 (TYPE C)
108.59 (TYPE A)
95.54 (TYPE A)
15.77 (TYPE C)
R30.00
WATERWAY
(PRESSURED STEEL PIPE)
(O'MOLENG)
TYPE-A
TYPE-B
TYPE-C
Original Ground Surface
Assumed Rock Surface
WATERWAY
Steel Pipe 1000mm φ, t=6mm
Backfill
Subgrade t=200mm
Gravel 50mm
Drainage Pipe Ø1.50m Cross-Stitch
PVC 50mm(A)
ACCESS PATH
Drainage Pipe Ø1.50m Cross-Stitch
(PLAN)
(SECTION)
0
10m
100m
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. C-M-01
O'MOLENG HYDROPOWER PLANT
GENERAL LAYOUT
PLAN AND SECTION
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.


PLAN
SECTION
SECTION B-B
SECTION C-C
SECTION
SECTION A-A
TR507
TR506
TR505
625.00
620.00
615.00
36.00
16.00
20.00
9.00
2.50
7.00
8.00
Screen(Intake) 2000X2000
Intake Gate 2000×2000
Sand Flush Gate 2000×1000
Screen(Sedimentation Basin) 4000x3700
Sand Drain Gate 500x500
WATERWAY
INTAKE WEIR
+614.50
+613.70
+613.00
Original Ground Surface
NW 613.00
▼614.50
▼608.50
6.10
▼616.40
Sand Flush Gate 2,000×2,000
▼609.50
6.02
14.00
▼615.40
▼613.00
Banking
Intake Gate 2,000x2,000
Sand Flush Gate 2,000x2,000
(PLAN)
(SECTION)
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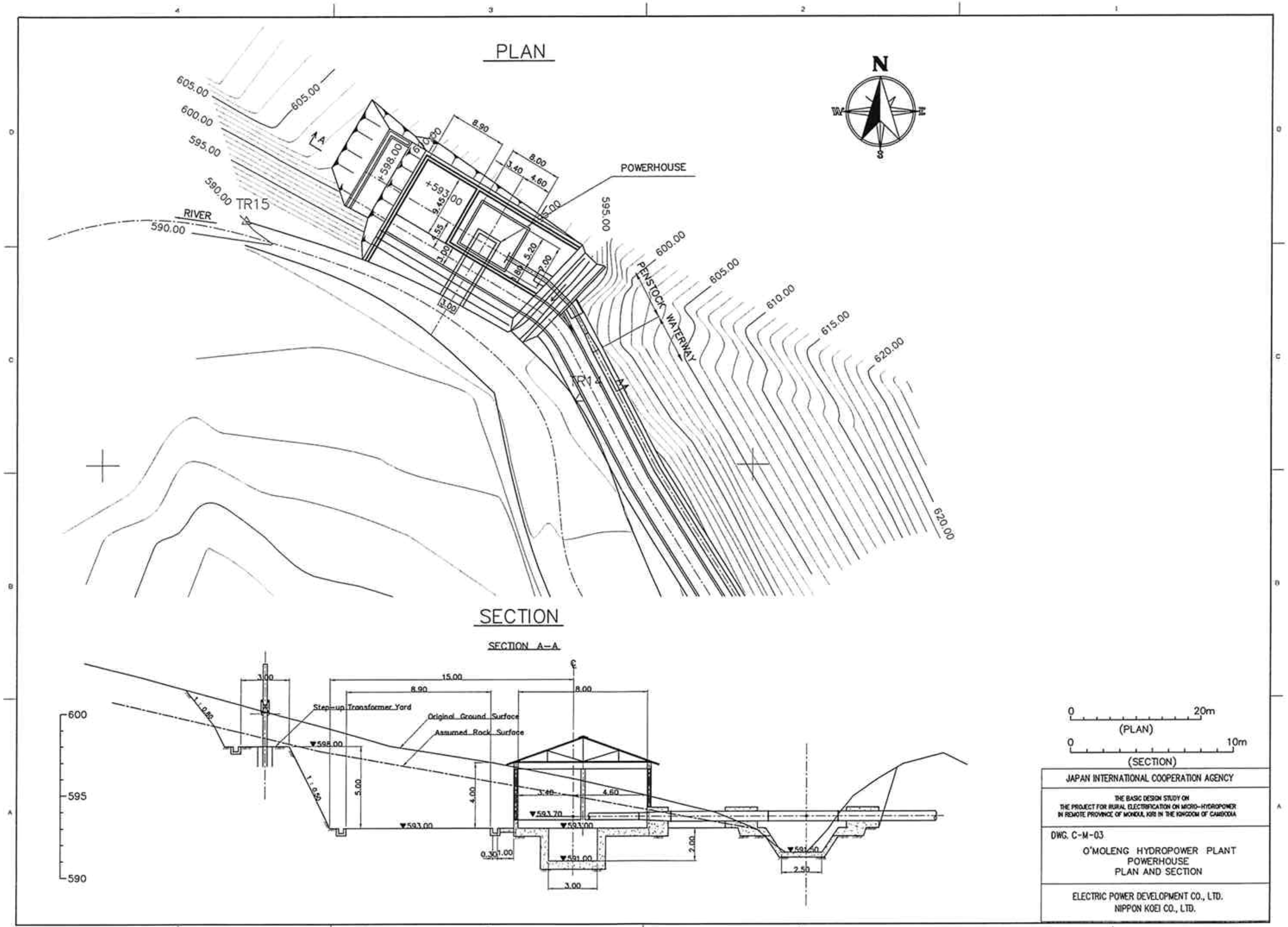
THE BASIC DESIGN STUDY ON THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. C-M-02
O'MOLENG HYDROPOWER PLANT
INTAKE WEIR
PLAN AND SECTION
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.


PLAN
POWERHOUSE
RIVER
TR15
TR14
PENSTOCK WATERWAY
605.00
600.00
595.00
590.00
610.00
615.00
620.00
+598.00
+593.00
8.90
8.00
3.40
4.60
9.45
5.20
3.00
SECTION
SECTION A–A
15.00
8.90
8.00
3.00
Step-up Transformer Yard
Original Ground Surface
Assumed Rock Surface
▼598.00
▼593.00
▼593.70
▼593.00
▼591.00
▼591.50
1 : 0.80
1 : 0.50
5.00
4.00
3.40
4.60
2.00
0.30
1.00
3.00
2.50
600
595
590
0
20m
(PLAN)
0
10m
(SECTION)
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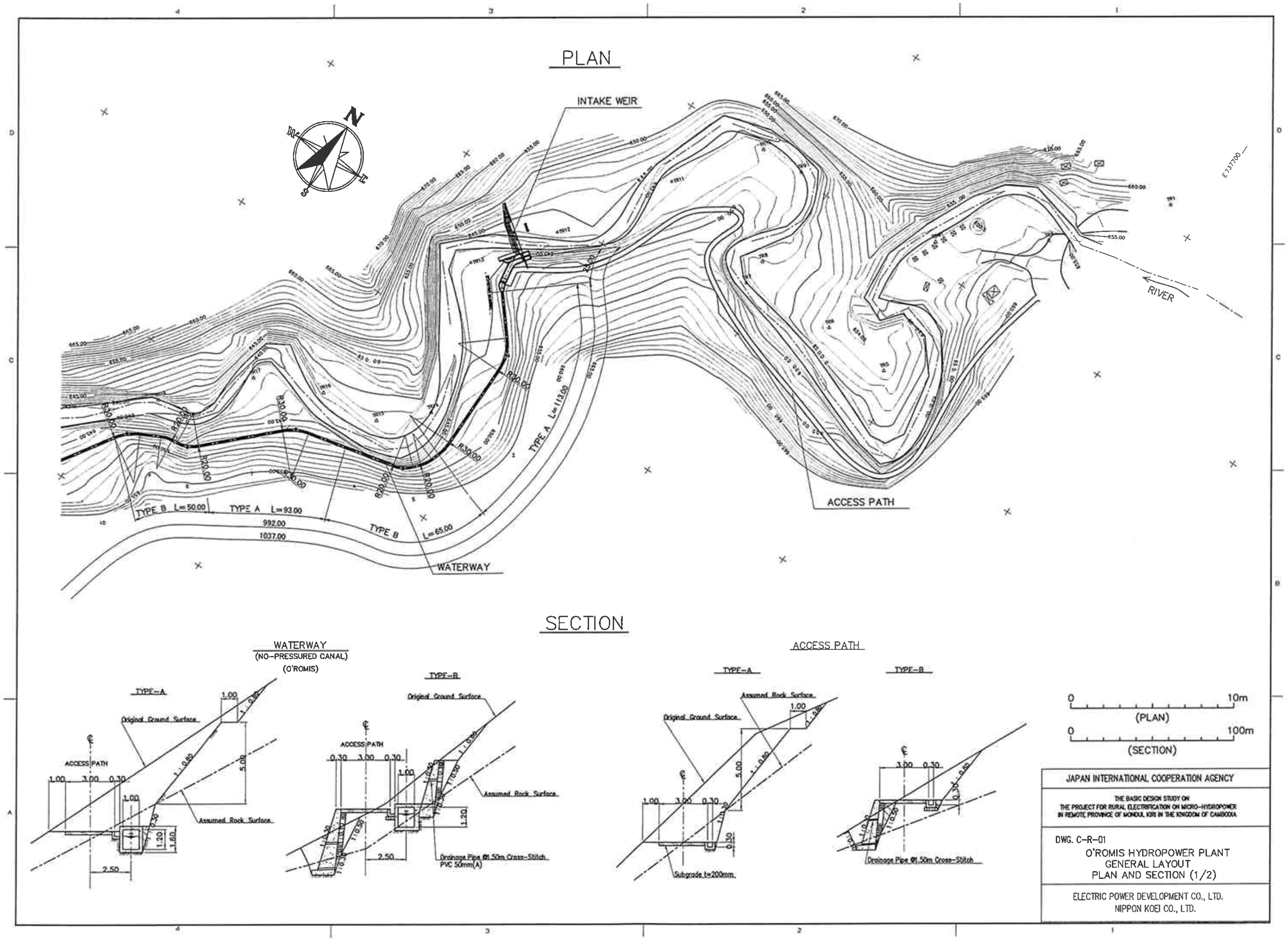
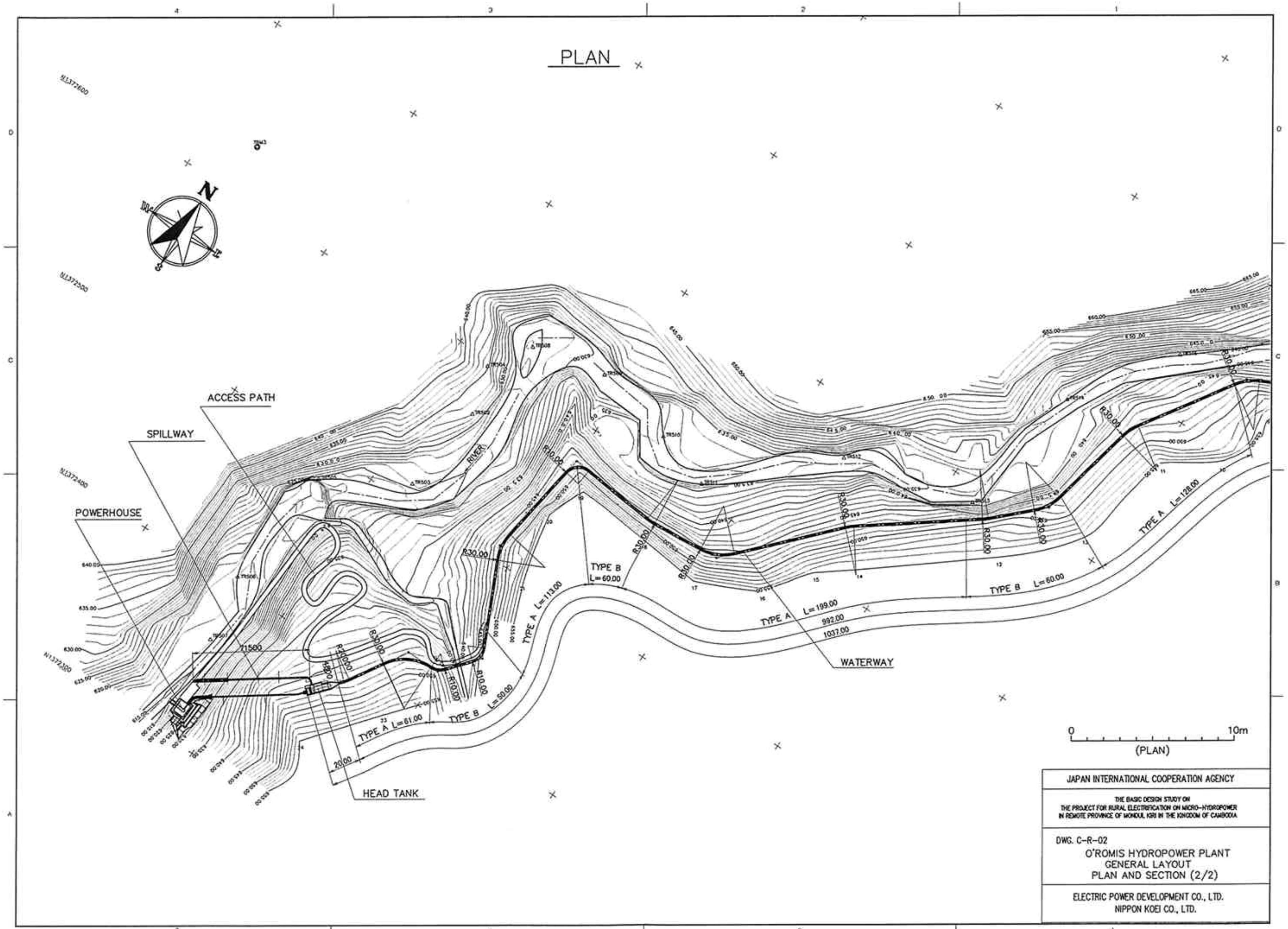
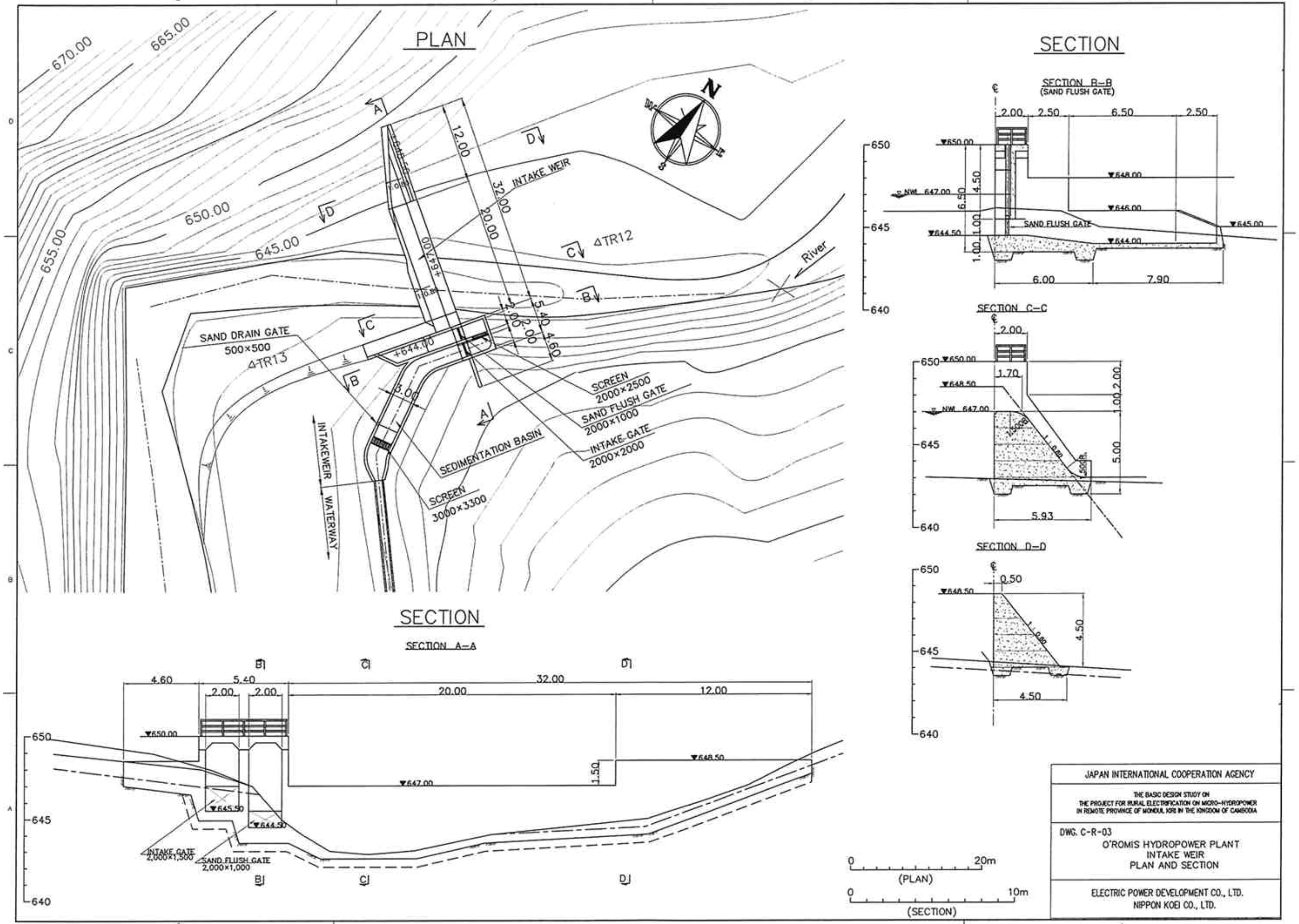
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. C-M-03
O'MOLENG HYDROPOWER PLANT
POWERHOUSE
PLAN AND SECTION
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.


PLAN
INTAKE WEIR
N
RIVER
ACCESS PATH
WATERWAY
TYPE B L=50.00
TYPE A L=93.00
TYPE B L=65.00
TYPE A L=113.00
992.00
1037.00
SECTION
WATERWAY
(NO-PRESSURED CANAL)
(O'ROMIS)
TYPE-A
TYPE-B
ACCESS PATH
Original Ground Surface
Assumed Rock Surface
Drainage Pipe Ø1.50m Cross-Stitch PVC 50mm(A)
Subgrade t=200mm
Drainage Pipe Ø1.50m Cross-Stitch
0 10m
(PLAN)
0 100m
(SECTION)
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. C-R-01
O'ROMIS HYDROPOWER PLANT
GENERAL LAYOUT
PLAN AND SECTION (1/2)
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.


PLAN
ACCESS PATH
SPILLWAY
POWERHOUSE
RIVER
WATERWAY
HEAD TANK
TYPE A L=61.00
TYPE B L=50.00
TYPE A L=113.00
TYPE B L=60.00
TYPE A L=199.00
TYPE B L=60.00
TYPE A L=128.00
992.00
1037.00
0
10m
(PLAN)
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. C-R-02
O'ROMIS HYDROPOWER PLANT
GENERAL LAYOUT
PLAN AND SECTION (2/2)
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.



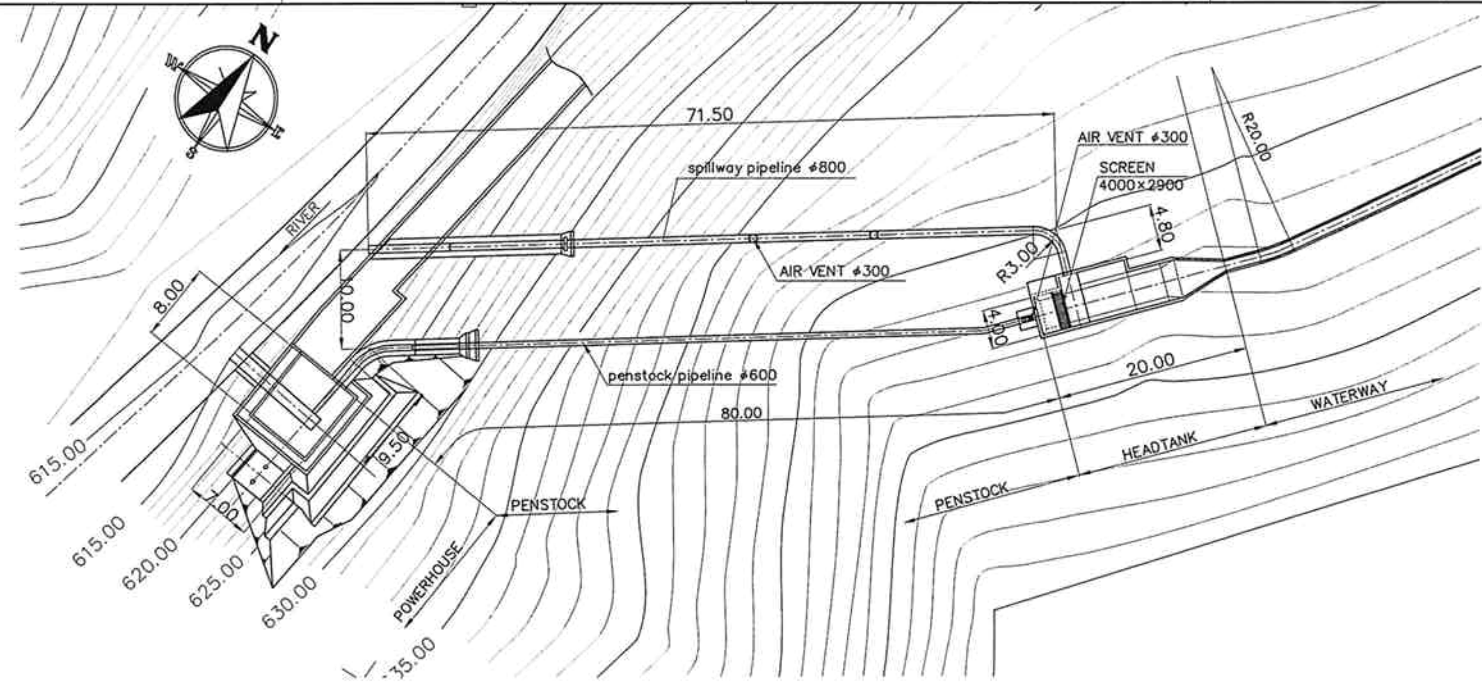
JAPAN INTERNATIONAL COOPERATION AGENCY

THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA

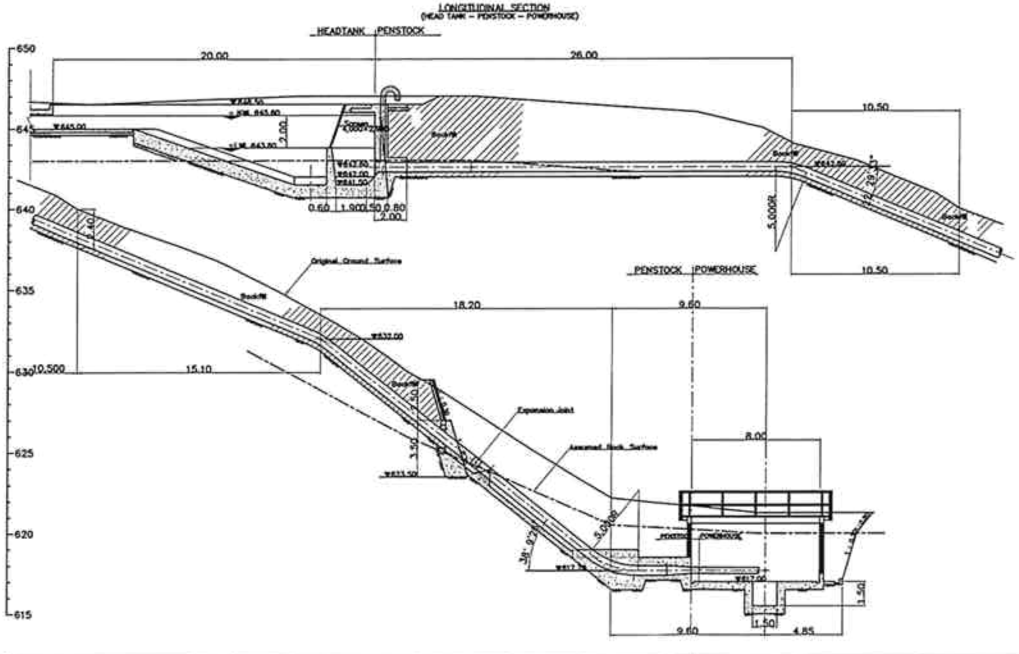
DWG. C-R-03
O'ROMIS HYDROPOWER PLANT
INTAKE WEIR
PLAN AND SECTION

ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.

PLAN



SECTION



0 20m (PLAN)

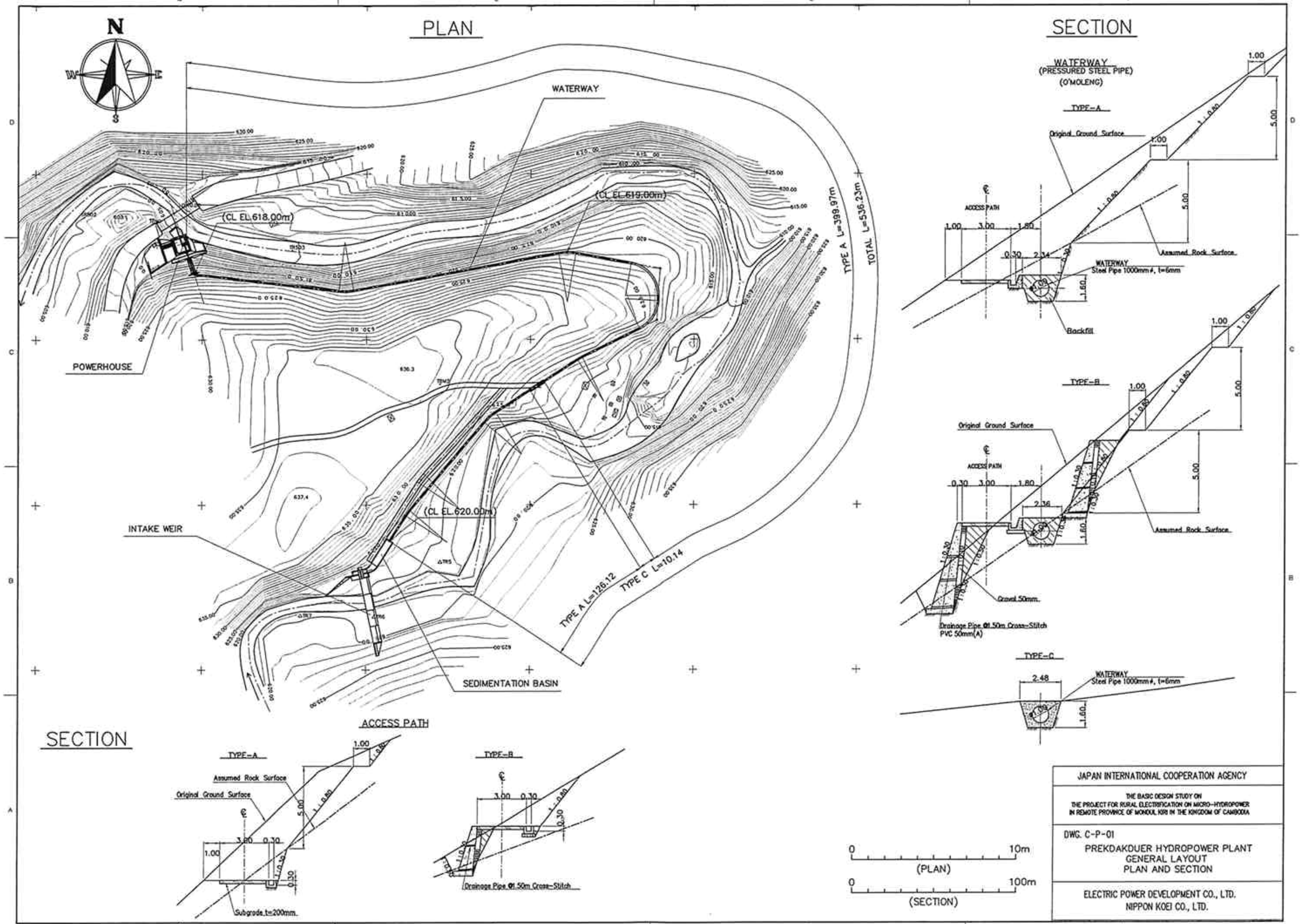
0 10m (SECTION)

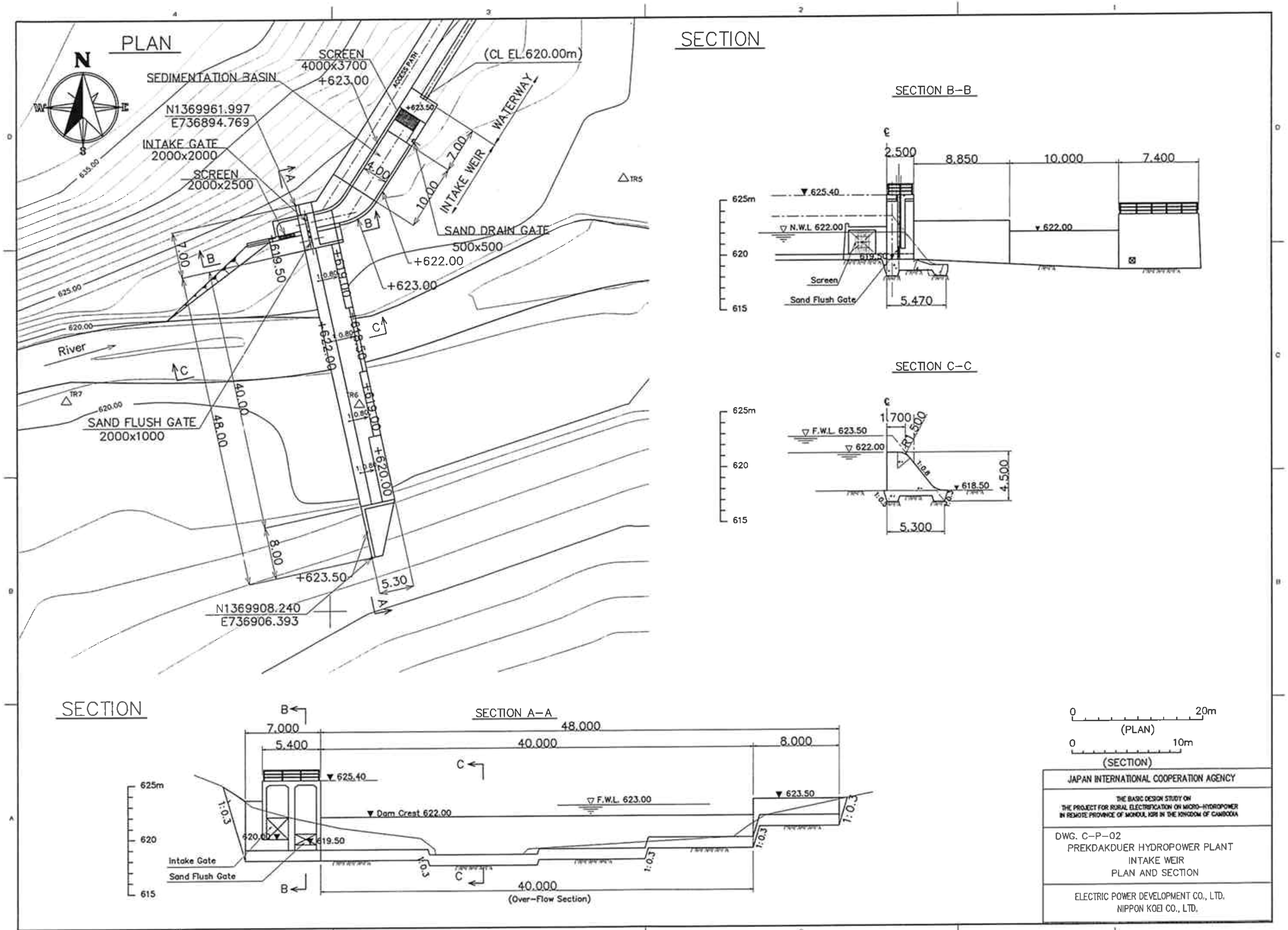
JAPAN INTERNATIONAL COOPERATION AGENCY

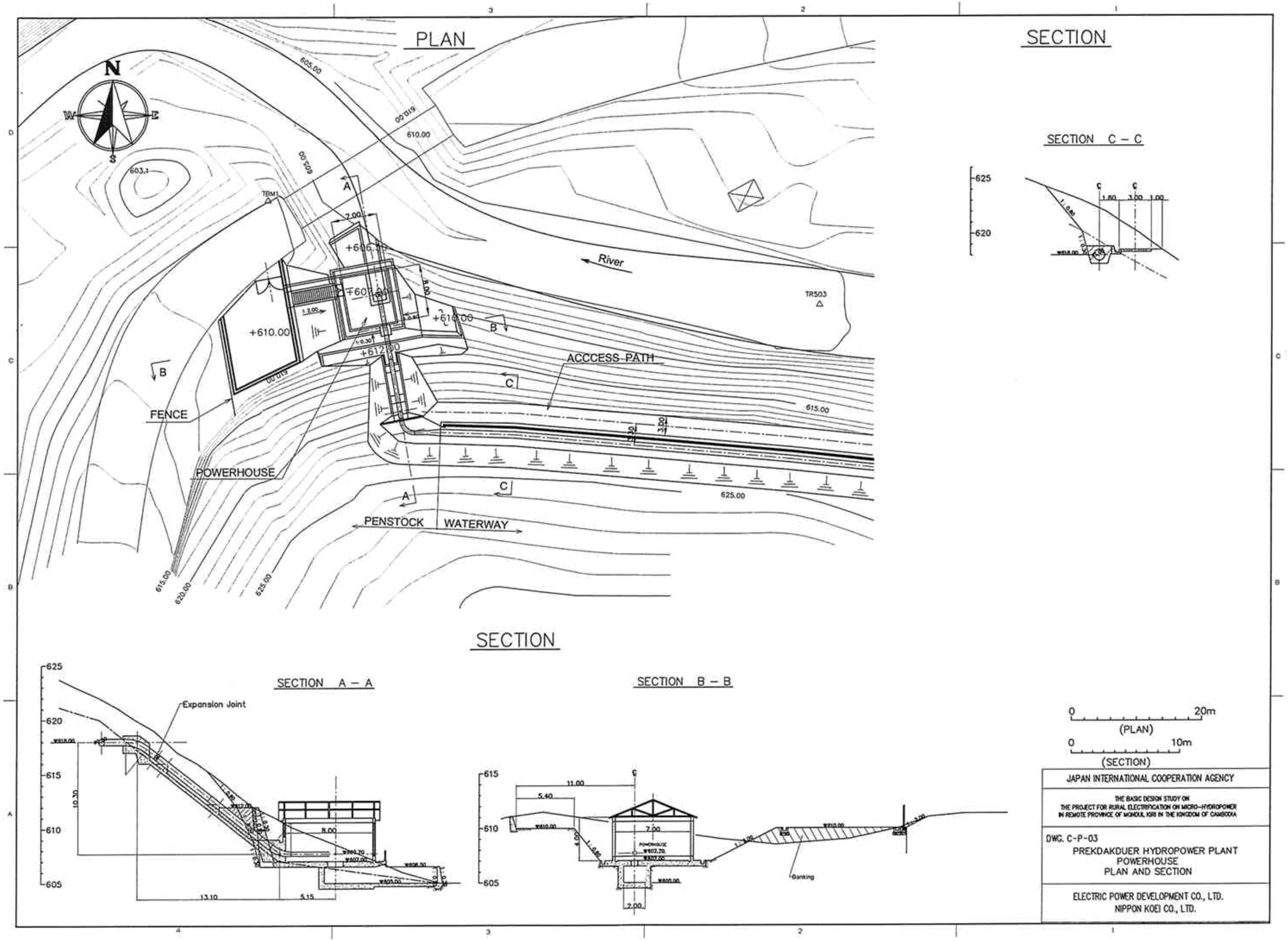
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA

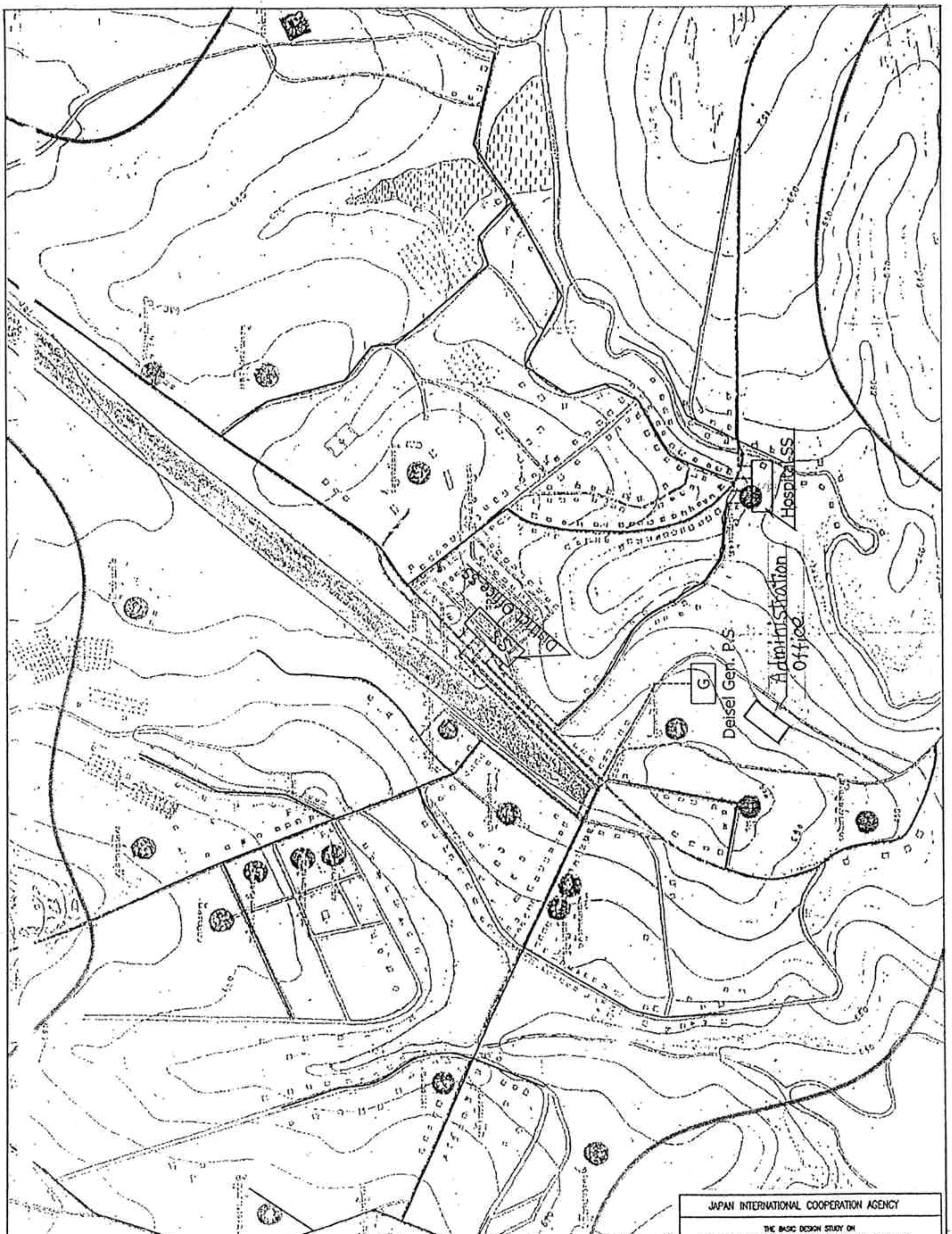
DWG. C-R-04
O'ROMIS HYDROPOWER PLANT
HEAD TANK,PENSTOCK AND POWERHOUSE
PLAN AND SECTION

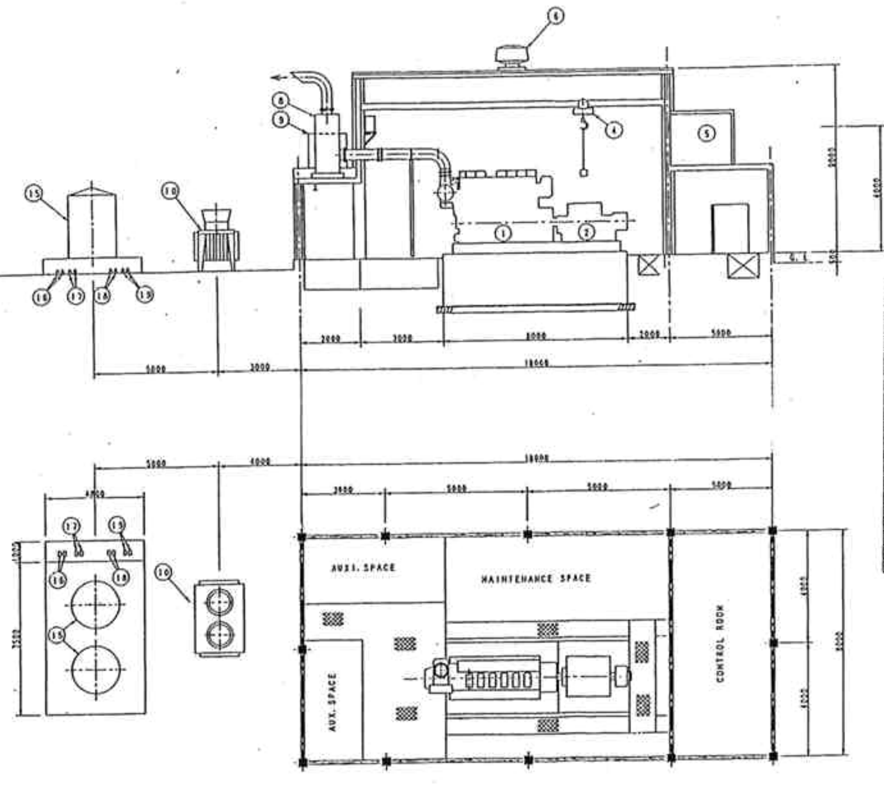
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.


PLAN
SECTION
WATERWAY
(CL EL.618.00m)
(CL EL.619.00m)
(CL EL.620.00m)
POWERHOUSE
INTAKE WEIR
SEDIMENTATION BASIN
TYPE A L=399.97m
TOTAL L=536.23m
TYPE A L=126.12
TYPE C L=10.14
WATERWAY
(PRESSURED STEEL PIPE)
(O'MOLENG)
TYPE-A
TYPE-B
TYPE-C
Original Ground Surface
Assumed Rock Surface
ACCESS PATH
Backfill
Gravel 50mm
Drainage Pipe Ø1.50m Cross-Stitch
PVC 50mm(A)
ACCESS PATH
Subgrade t=200mm
0 10m (PLAN)
0 100m (SECTION)
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. C-P-01
PREKDAKDUER HYDROPOWER PLANT
GENERAL LAYOUT
PLAN AND SECTION
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.

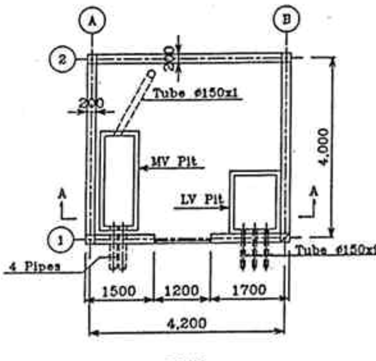

PLAN
SCREEN
4000x3700
+623.00
(CL EL.620.00m)
SEDIMENTATION BASIN
N1369961.997
E736894.769
ACCESS PATH
+623.50
WATERWAY
INTAKE GATE
2000x2000
SCREEN
2000x2500
INTAKE WEIR
7.00
4.00
10.00
SAND DRAIN GATE
500x500
+622.00
+623.00
619.50
+619.00
+622.00
18.50
+619.00
+620.00
River
SAND FLUSH GATE
2000x1000
40.00
48.00
8.00
+623.50
5.30
N1369908.240
E736906.393
SECTION
SECTION B–B
2.500
8.850
10.000
7.400
625m
620
615
625.40
N.W.L 622.00
622.00
619.50
Screen
Sand Flush Gate
5.470
SECTION C–C
1.700
R1.500
F.W.L 623.50
622.00
1:0.8
618.50
4.500
5.300
SECTION
SECTION A–A
7.000
5.400
48.000
40.000
8.000
625.40
Dam Crest 622.00
F.W.L. 623.00
623.50
620.00
619.50
Intake Gate
Sand Flush Gate
1:0.3
40.000
(Over-Flow Section)
0
20m
(PLAN)
10m
(SECTION)
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. C–P–02
PREKDAKDUER HYDROPOWER PLANT
INTAKE WEIR
PLAN AND SECTION
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.


PLAN
SECTION
SECTION C – C
N
River
TBM1
TR503
+606.70
+607.20
+610.00
+610.00
+612.00
ACCCESS PATH
FENCE
POWERHOUSE
PENSTOCK
WATERWAY
605.00
610.00
615.00
620.00
625.00
603.1
7.00
8.00
SECTION
SECTION A – A
Expansion Joint
13.10
5.15
10.30
SECTION B – B
11.00
5.40
7.00
2.00
Banking
0
20m
(PLAN)
0
10m
(SECTION)
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. C-P-03
PREKDAKDUER HYDROPOWER PLANT
POWERHOUSE
PLAN AND SECTION
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.

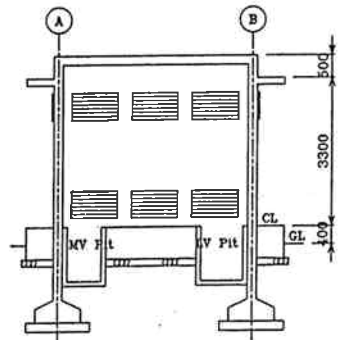

Hospital SS
Administration Office
District Office SS
SS
G
Deisel Gen. P.S
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
A-01
Location Map of Buildings
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.



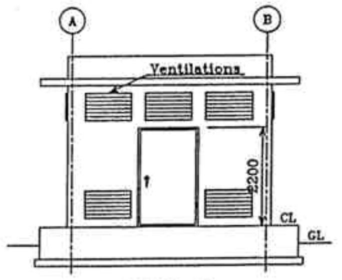
NO.	NAME	Q'TY	REMARKS
1	DIESEL ENGINE	1	900RPM X 1450PS
2	AC GENERATOR	1	1250KVA (1000KW)
3			
4	OVER HEAD CRANE	1	1TONS (CUSTOMER'S SUPPLY)
5	INTAKE AIR CHAMBER	1	
6	EXHAUST AIR FAN	1	
7			
8	EXH. GAS SILENCER	1	
9	D.O SERVICE TANK	1	2000L
10	RADIATOR	1	
11			
12			
13			
14			
15	D.O STORAGE TANK	2	50KL
16	D.O UNLOADING PUMP	2	
17	H.O UNLOADING PUMP	2	
18	D.O TRANSFER PUMP	2	
19	H.O TRANSFER PUMP	2	
20			



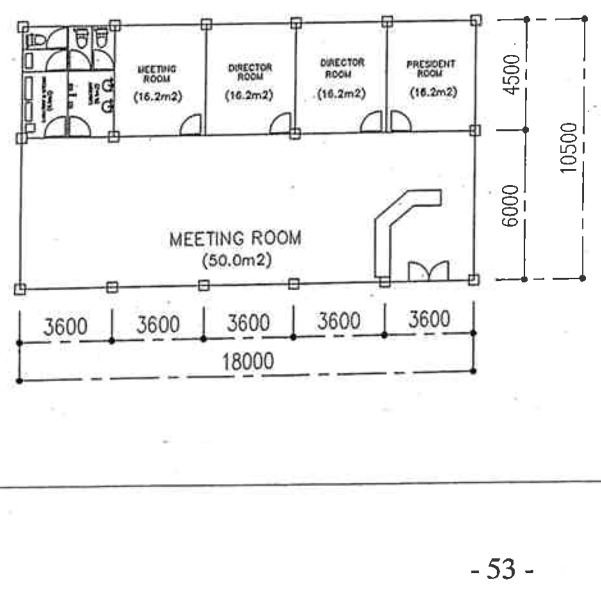
PLAN



SECTION A – A



FRONT VIEW

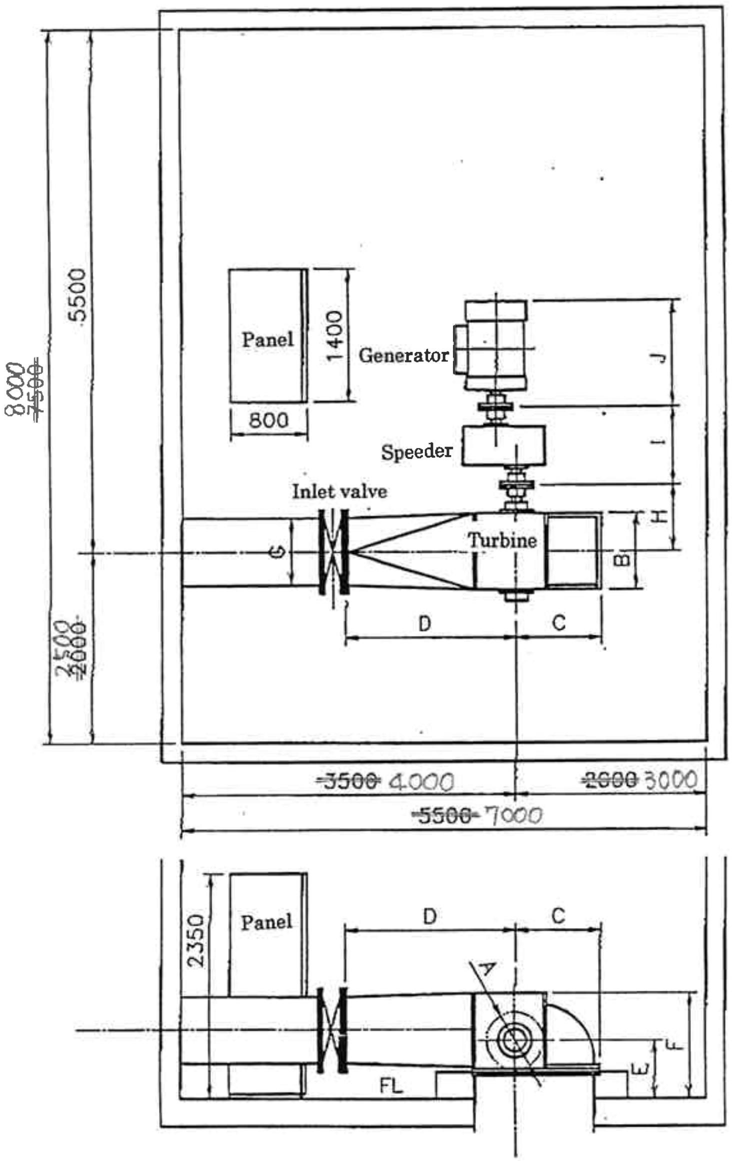


JAPAN INTERNATIONAL COOPERATION AGENCY

THE BASIC DESIGN STUDY ON THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA

A-02
Building of Diesel Power Plant, Substation and Administration Office Plan

ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.



P.S	O' Meleng	O' Romis	Prek Dakuduer	
有効落差（m）	20.5	28.0	15.5	Head
流量（m^3/s）	0.94	0.70	1.10	Discharge
水車出力（kW）	144	146	127	Output
A	550	450	600	
B	700	600	800	
C	850	700	900	
D	1650	1350	1800	
E	600	600	600	
F	1050	950	1100	
G	650A	550A	700A	
H	650	550	700	
I	850	850	850	
J	1500	1500	1200	

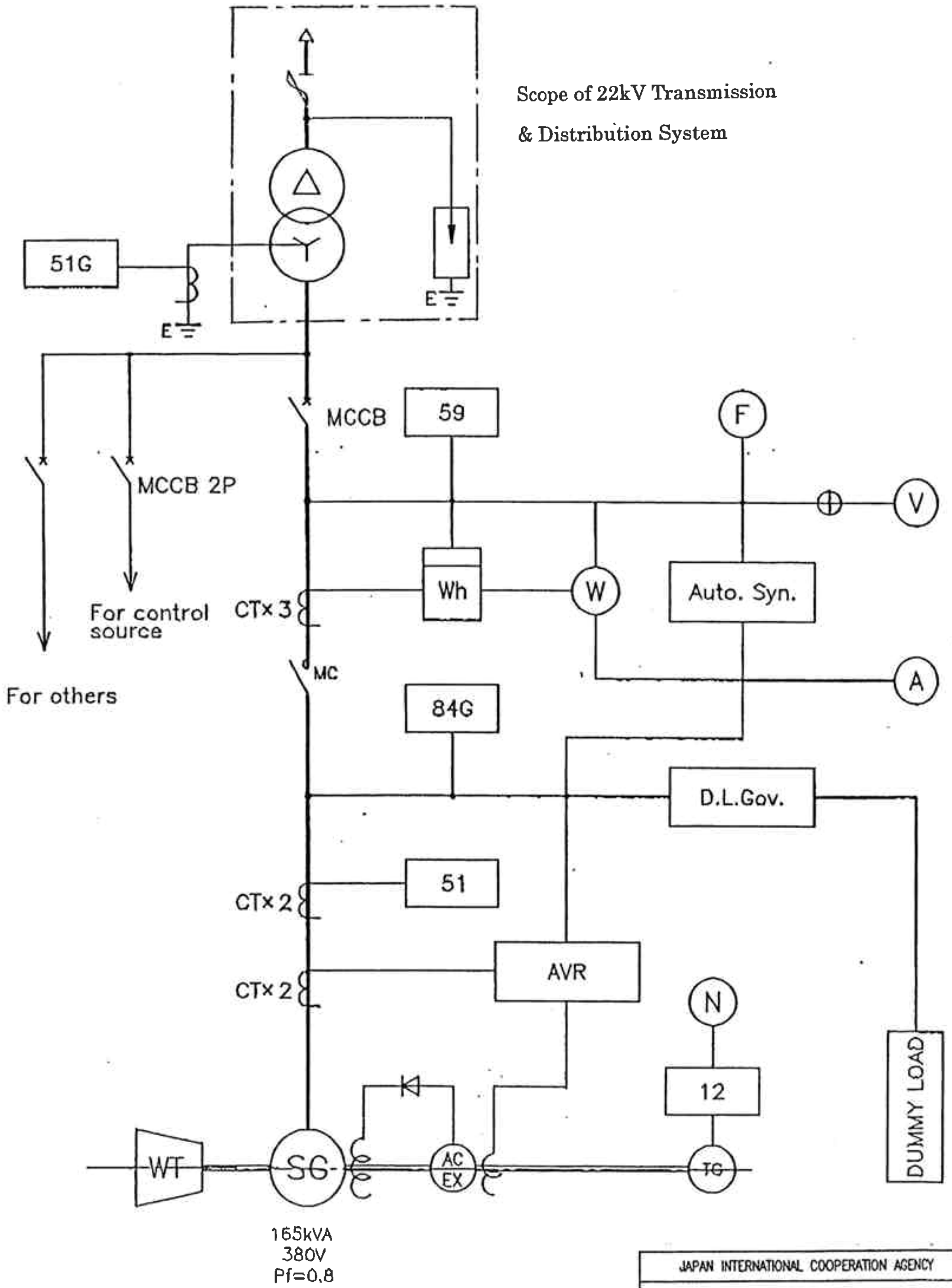
番号	年月日	訂正記事

JAPAN INTERNATIONAL COOPERATION AGENCY

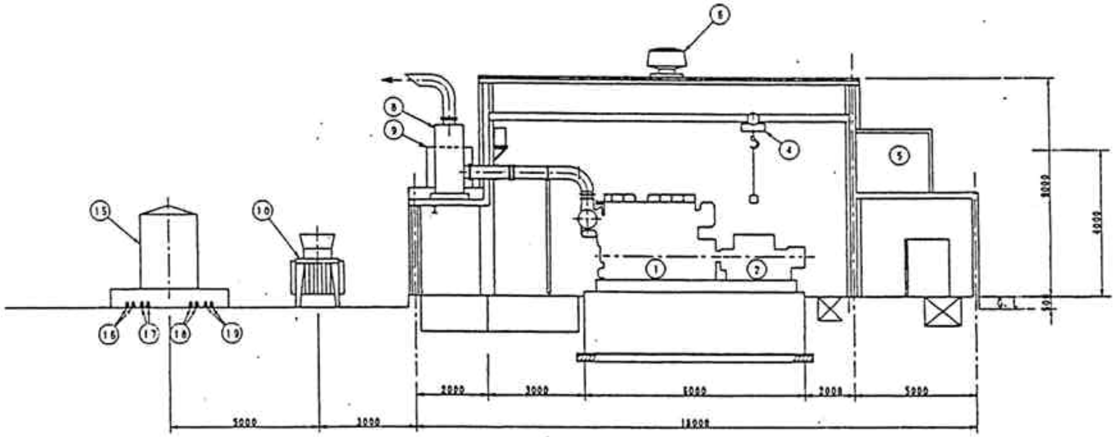
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA

DWG. E-M-01
Arrangement of Hydropower Generating Equipment
(O'Moleng, O'Romi & Prek Dakuduer

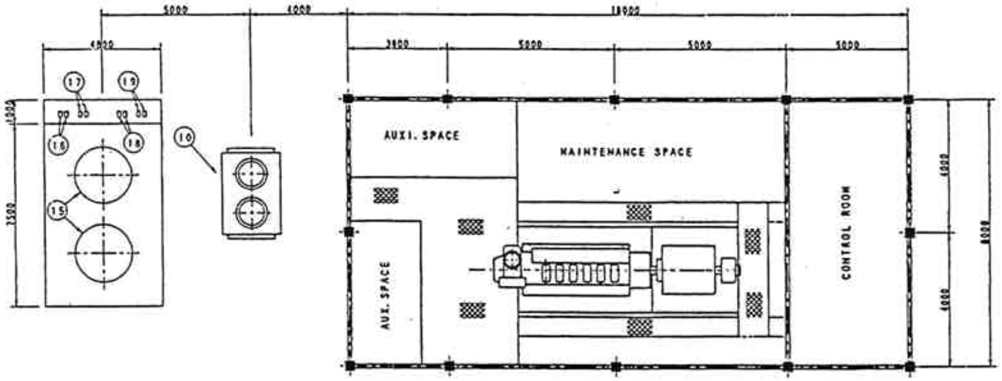
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.



JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. E-M-02 Single Line Diagram of Hydropower Generating Equipment (O'Moleng, O'Romi & Prek Dakuduer
ELECTRIC POWER DEVELOPMENT CO., LTD. NIPPON KOEI CO., LTD.



NO.	NAME	Q'TY	REMARKS
1	DIESEL ENGINE	1	900RPM X 1450PS
2	AC GENERATOR	1	1250kVA (1000kW)
3			
4	OVER HEAD CRANE	1	1TONS (CUSTOMER'S SUPPLY)
5	INTAKE AIR CHAMBER	1	
6	EXHAUST AIR FAN	1	
7			
8	EXH. GAS SILENCER	1	
9	D.O SERVICE TANK	1	2000L
10	RADIATOR	1	
11			
12			
13			
14			
15	D.O STORAGE TANK	2	50KL
16	D.O UNLOADING PUMP	2	
17	H.O UNLOADING PUMP	2	
18	D.O TRANSFER PUMP	2	
19	H.O TRANSFER PUMP	2	
20			

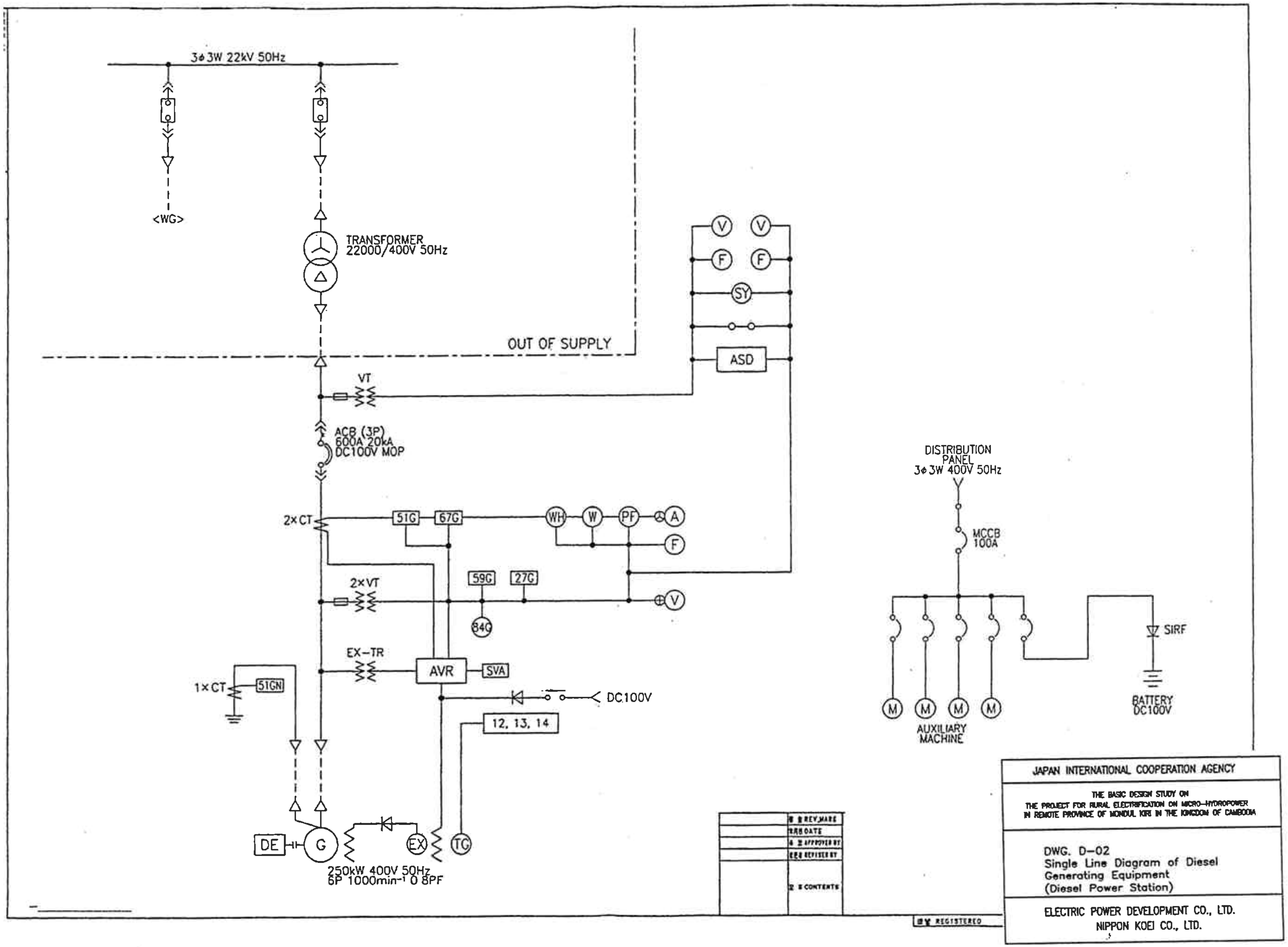


JAPAN INTERNATIONAL COOPERATION AGENCY

THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA

DWG. D-01
Arrangement of Diesel Generating Equipment
(Diesel Power Station)

ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.


3φ3W 22kV 50Hz
<WG>
TRANSFORMER 22000/400V 50Hz
OUT OF SUPPLY
VT
V
F
SY
ASD
ACB (3P) 600A 20kA DC100V MOP
2×CT
51G
67G
WH
W
PF
A
2×VT
59G
27G
84G
EX-TR
AVR
SVA
1×CT
51GN
DC100V
12, 13, 14
DE
G
EX
TG
250kW 400V 50Hz 6P 1000min⁻¹ 0.8PF
DISTRIBUTION PANEL 3φ3W 400V 50Hz
MCCB 100A
SIRF
M
AUXILIARY MACHINE
BATTERY DC100V
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. D-02
Single Line Diagram of Diesel Generating Equipment (Diesel Power Station)
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.

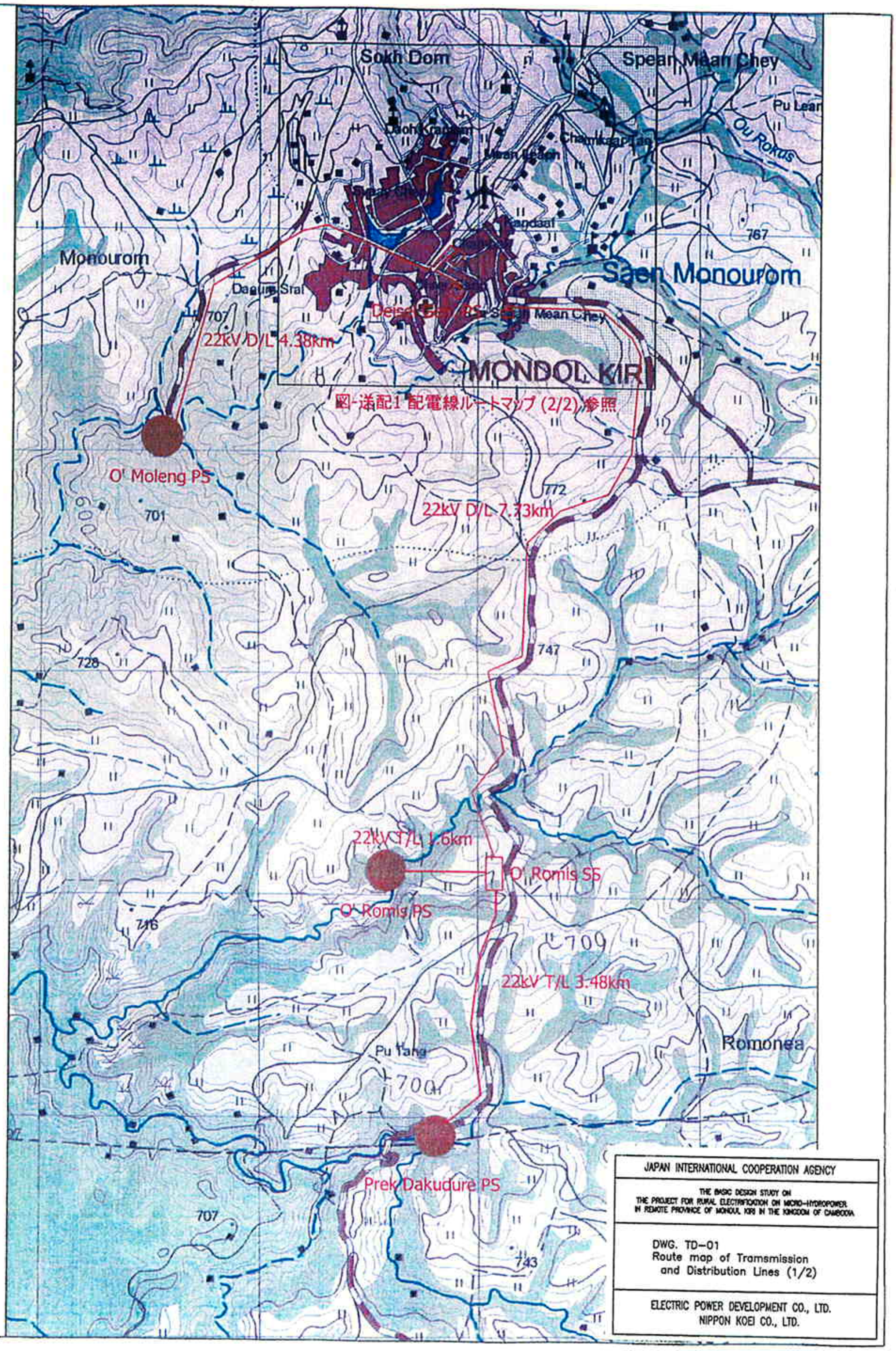
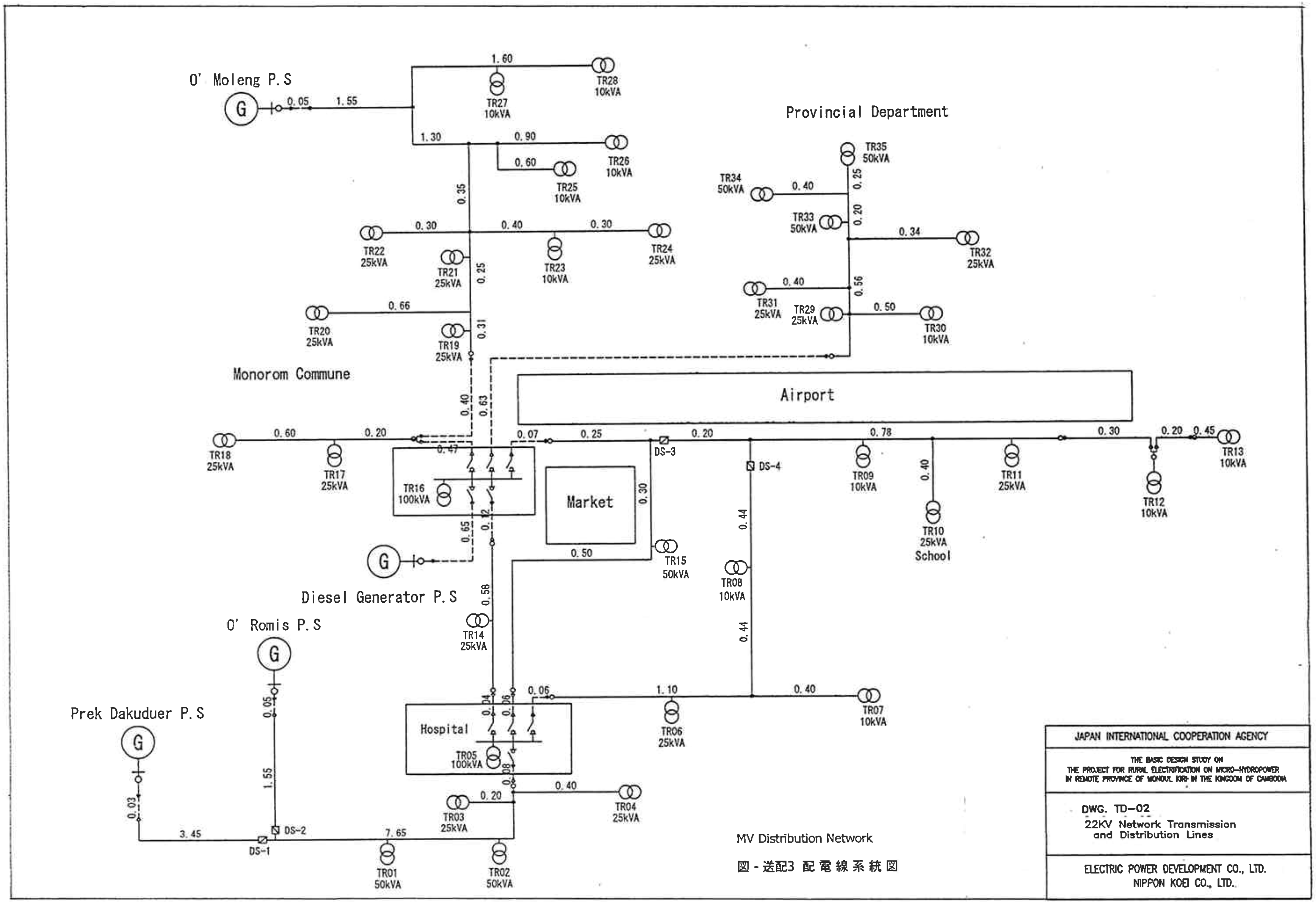
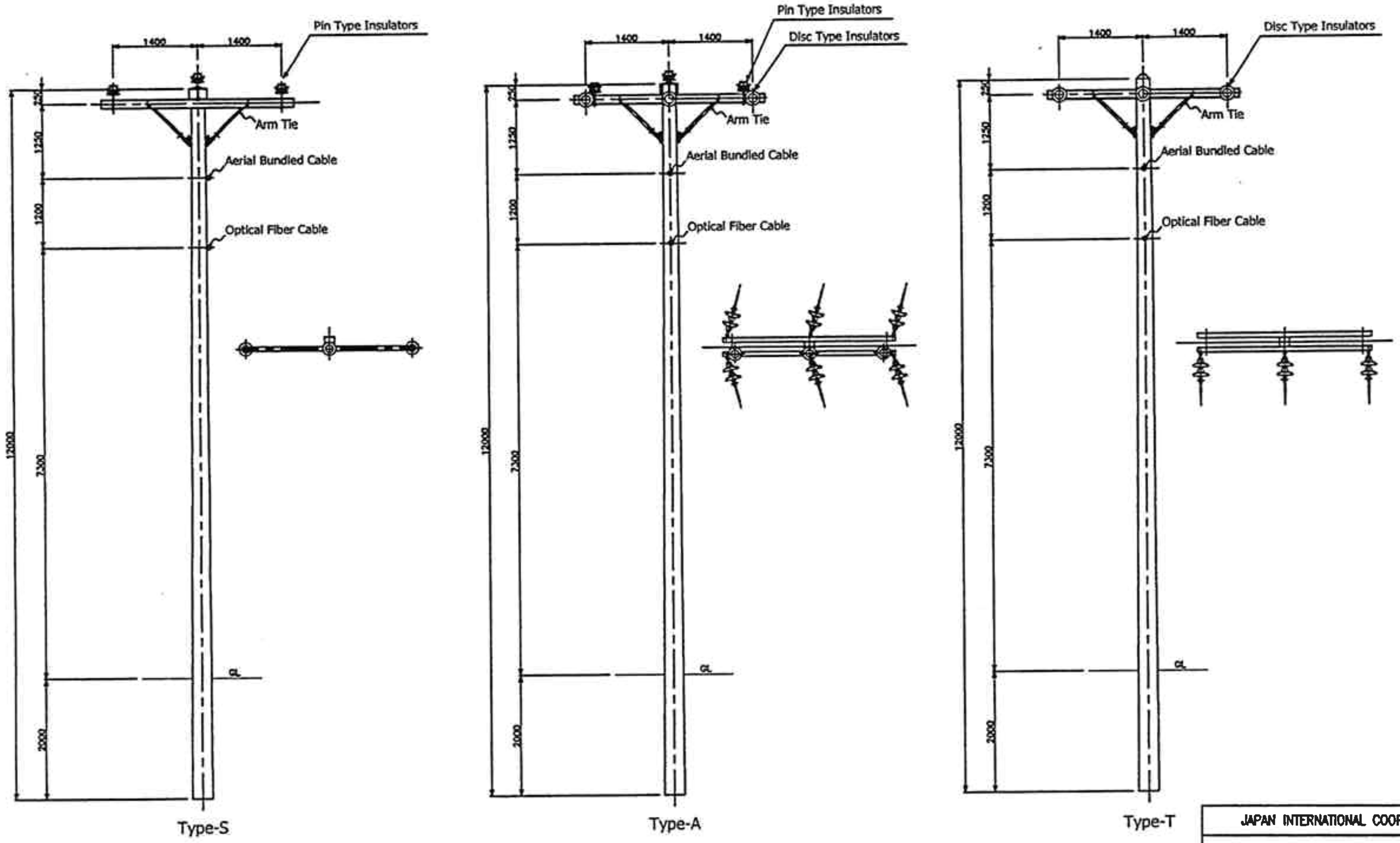


図-送配1 配電線ルートマップ (1/2)


O' Moleng P.S
Provincial Department
Monorom Commune
Airport
Market
Diesel Generator P.S
O' Romis P.S
Prek Dakuduer P.S
Hospital
School
TR01 50kVA
TR02 50kVA
TR03 25kVA
TR04 25kVA
TR05 100kVA
TR06 25kVA
TR07 10kVA
TR08 10kVA
TR09 10kVA
TR10 25kVA
TR11 25kVA
TR12 10kVA
TR13 10kVA
TR14 25kVA
TR15 50kVA
TR16 100kVA
TR17 25kVA
TR18 25kVA
TR19 25kVA
TR20 25kVA
TR21 25kVA
TR22 25kVA
TR23 10kVA
TR24 25kVA
TR25 10kVA
TR26 10kVA
TR27 10kVA
TR28 10kVA
TR29 25kVA
TR30 10kVA
TR31 25kVA
TR32 25kVA
TR33 50kVA
TR34 50kVA
TR35 50kVA
DS-1
DS-2
DS-3
DS-4
MV Distribution Network
図-送配3 配電線系統図
JAPAN INTERNATIONAL COOPERATION AGENCY
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA
DWG. TD-02
22KV Network Transmission
and Distribution Lines
ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.

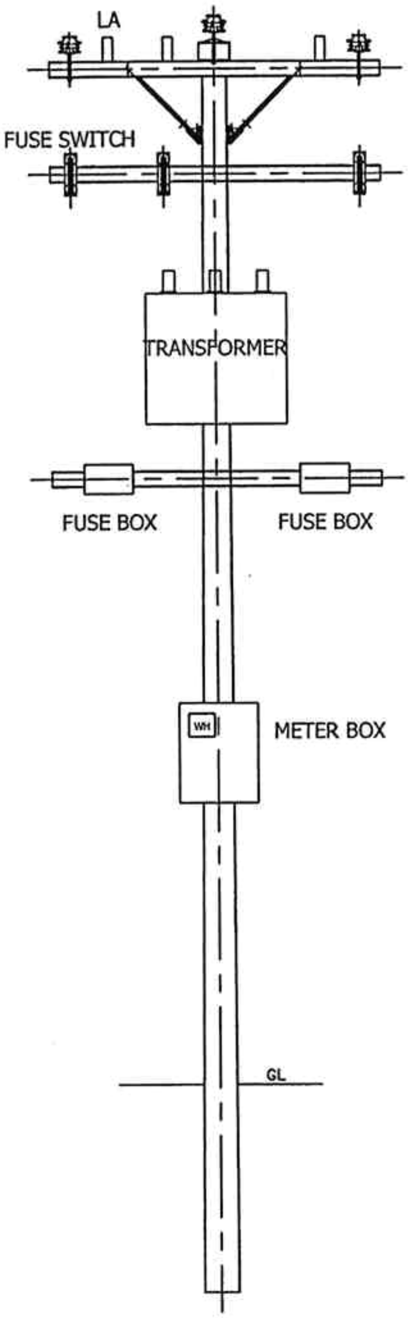


JAPAN INTERNATIONAL COOPERATION AGENCY

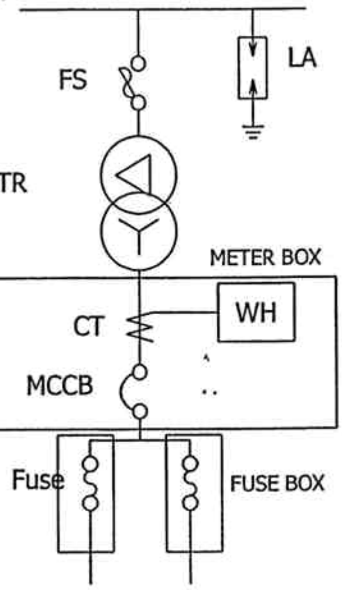
THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA

DWG. TD-03
Support for 22 kV Overhead Line

ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.



Type-TR



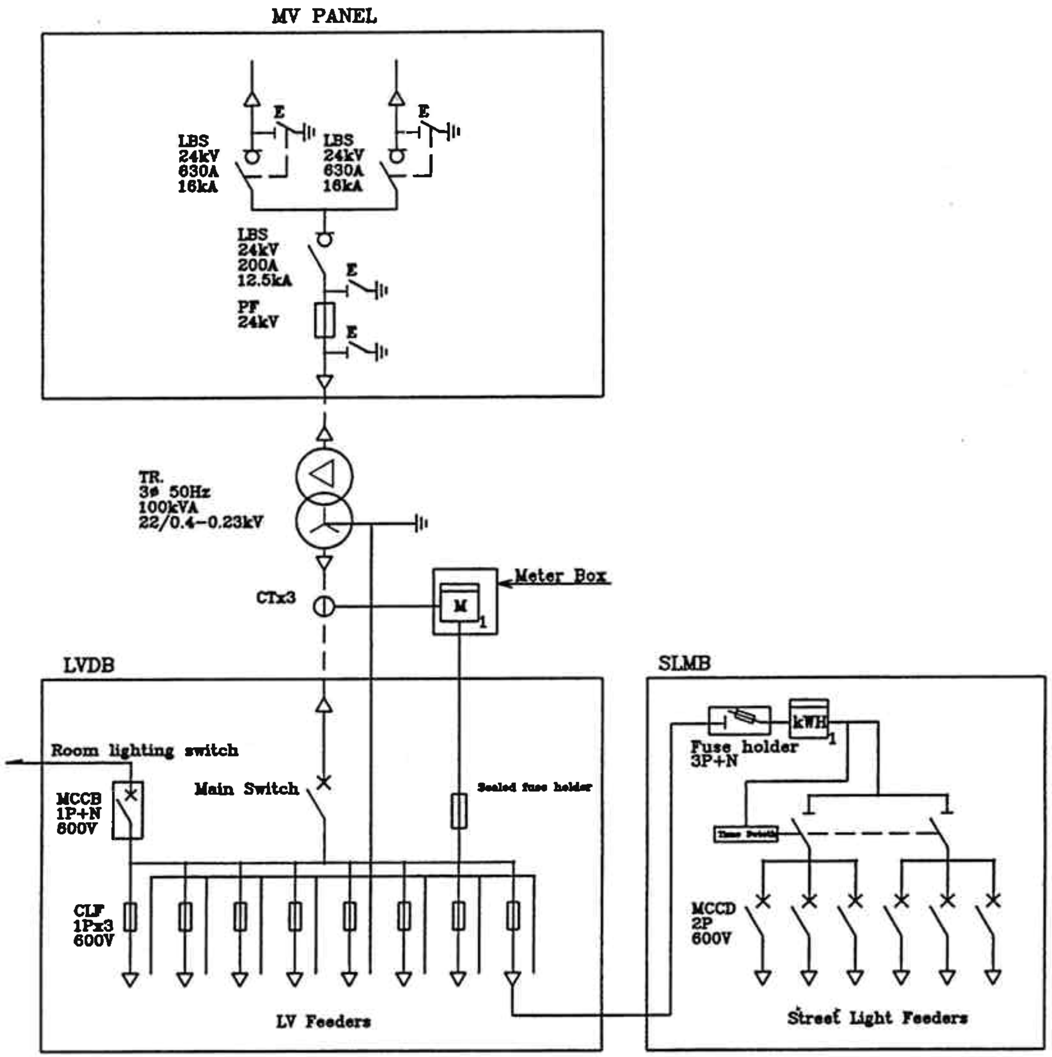
Connection Diagram

JAPAN INTERNATIONAL COOPERATION AGENCY

THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA

DWG. TD-04
Pole Mounted Transformer Substation

ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.



Symbol	Discripsion
	Cable Termination
	Disconnecting Switch with Earth
	Load Circuit Breaker
	Current Limited Fuse
	Distribution Transformer
	Current Transformer
	Circuit Breaker
	Contactor
	Electronic meter
	Watthour meter

JAPAN INTERNATIONAL COOPERATION AGENCY

THE BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL ELECTRIFICATION ON MICRO-HYDROPOWER
IN REMOTE PROVINCE OF MONDUL KIRI IN THE KINGDOM OF CAMBODIA

DWG. TD-05
Connection Diagram of Indoor Substation

ELECTRIC POWER DEVELOPMENT CO., LTD.
NIPPON KOEI CO., LTD.

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

This project will be implemented in the framework of the Japan's grant aid scheme. Therefore, the project will be instituted after project implementation is approved by the Japanese Government, and an Exchange of Notes (E/N) is exchanged between the Governments of the two countries.

The basics and considerations in instituting the project are given below:

(1) Project Implementation Body

The responsible agency for implementation of this project on the Cambodian side is the Ministry of Industry, Mines and Energy (MIME). At the site in Sen Monorom, its subordinate agency, DIME, will take charge of implementation. On the Cambodian side, it is necessary to appoint a person in charge of the project in MIME for close communication and negotiation with the consultant and contractor from Japan and for smooth progress of project implementation.

The appointed person in charge must explain the details of the project for the Government officials on the Cambodian side and also for the residents of Sen Monorom City to help them understand the content of the project. In addition, the person in charge must call attention to security during implementation of construction and give guidance for cooperation with the progress and maintenance of the project.

(2) Consultant

To execute facility construction, equipment and material procurement and installation work, a Japanese consultant will conclude a detailed deign and supervision contract with the Cambodian Government to carry out the execution detailed design and construction supervision service involved in the project. The consultant should prepare tender documents and assist in an examination of bidding qualifications and bid execution work held by MIME, which is the project Implementation Body.

(3) Contractor

In accordance with the Japan's grant aid scheme, Japanese corporate body selected by an open bid on the Cambodian side. The contractor will be required to execute the facility construction, equipment and material procurement and installation work of the project.

After completion of the project, the contractor must provide after-services, such as a supply of spare parts and countermeasures to take if there is a failure, and therefore must construct a liaison and coordination structure after delivery of the relevant facilities.

(4) Necessity of Dispatch of Engineers

This project is a complex work, consisting of construction and installation work of a hydropower generation facility at 3 sites and a diesel power generation facility at one site and a power transmission and distribution facility. Therefore, it is necessary to delegate a field chief who can manage and guide the entire work consistently including the schedule, quality and security.

The work of the relevant power generation facility and transmission and distribution facility requires comprehensive knowledge and skilled engineering for the performance, functions and configuration of the facilities. Therefore, experts must be delegated by the contractor during the construction and installation period of major facilities and at trial runs and adjustments.

2-2-4-2 Implementation Condition

(1) Construction Situation of Cambodia

1) In Cambodia, workers (laborers) engaged in construction work are available; however, there are few skilled workers and engineers who have expertise in schedule management, quality control, safety management and the like. Therefore, the Japanese contractor must delegate engineers or skilled workers from Japan to Cambodia as necessary.
2) There are very few hydropower generation facilities in Cambodia, and procurement of such facilities is difficult in Cambodia. Dispatch of engineers from Japan should be planned.
3) For inland transport equipment necessary for facility construction work and equipment and materials and construction equipment necessary for installation work of the project, it is thought that the necessary minimum can basically be procured in Cambodia. However, the amount of supply is small, and procurement from neighboring countries must be considered.

(2) Notes on Construction Planning

1) Because there are waterfalls at the hydroelectric sites in O'Moleng and Prek Dakduer where tourists visit, the work must take place considering the environment as far as possible.

2) At the relevant site, May to October fall during the rainy season. Therefore, the intake facility and other river work should be planned to ensure the ability to flee or otherwise secure sufficient safety if a flood occurs.

3) If the work involves felling or the like of existing trees, the time and scale of felling should be confirmed with DIME beforehand, and measures should be taken to gain confirmation of the persons concerned and understanding of the residents beforehand to avoid environmental destruction or a residential issue.

2-2-4-3 Scope of Work

(1) The work demarcation between Japan side and Cambodia side is shown in Table2.22.

Table 2-22 Work Demarcations between the Japanese and Cambodian Sides

No	Item	Japan Side	Cambodia Side
1	To secure land for the permanent facilities and temporally use for the Project		O
2	To clear, level and reclaim the site when needed		O
3	To remove existing power generation and distribution facilities		O
4	To maintain existing roads which are used for the construction work of the project		O
5	To construct Intake structures of three hydropower plants	O	
6	To construct Water way structures of three hydropower plants	O	
7	To construct Powerhouse facilities of three hydropower plants	O	
8	To construct Diesel power generation plant	O	
9	To construct Transmission and Distribution facilities	O	
10	To construct Administration Office	O	
11	To set Watt-hour meters	O	
12	To put service wiring to the consumers		O

2-2-4-4 Consultant Supervision

Based on the Japan’s Grand aid scheme, the consultant should think of the gist of basic design and organize a consistent project team covering execution design to construction management for smooth work execution. The consultant should station at least one engineer at the site during the work execution period who must exercise schedule supervision, quality control and safety management. The consultant should delegate the relevant expert engineers according to the progress of facility construction, equipment installation, trial operation and adjustment, delivery test and other kind of work to exercise supervision on those kinds of work carried out by the constructors.

In addition, it should witness on-the-spot factory inspections and delivery inspections of equipment and materials fabricated in Japan and a third country, if necessary, thus supervising to prevent equipment or material troubles from occurring after their transport to the site.

(1) Basic Policy of Construction Supervision

As the basic policy, the consultant should supervise the progress of work to complete the project within the prescribed construction schedule and supervise and guide the contractors to observe the quality and delivery deadline of equipment and materials stated in the contract document.

Major considerations in construction supervision are given below.

1) Schedule supervision

Comparison of the implementation schedule planned by the contractor at the contract with the actual progress should take place weekly and/or monthly for each of the items below. If a delay is expected, the consultant should issue a warning to the contractor as well as ask for submission of countermeasures to take and guide the contractor to complete the work and delivery of equipment and materials within the deadline.

- Confirmation of work performance (including factory work performance of equipment and materials)
- Confirmation of the time of shipment
- Confirmation of the state of preparation for temporary work and construction equipment
- Confirmation of carrying-in performance of equipment and materials (power generation equipment and materials and construction work)

- Confirmation of production rate and the actual count and actual productivity of engineers, skilled workers and laborers

2) Safety management

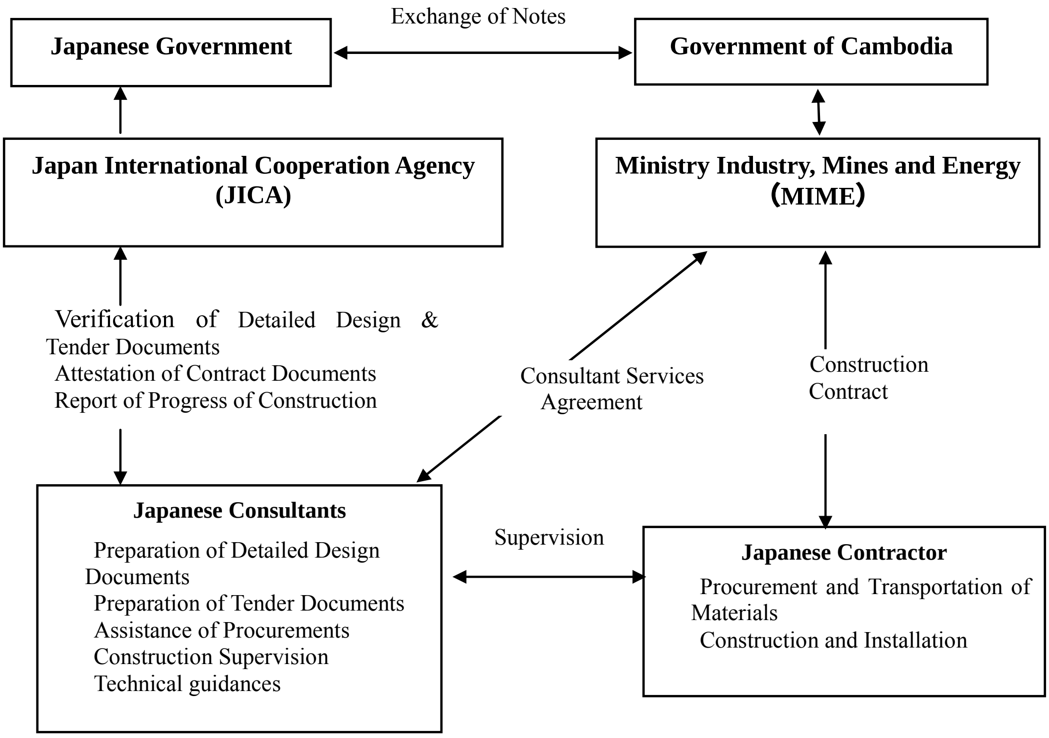
The consultant should negotiate and cooperate with the person in charge of the contractor to do safety management to prevent accidents at work at the site or on third persons from occurring during the construction period.

The considerations about safety management at the site are as follows:

- Establish safety management provisions and appoint a manager.
- Enforce the safety management provisions and confirm the enforcement at regular intervals.
- Carry out a regular inspection of construction equipment to prevent accidents.
- Lay down a running route for construction vehicles and equipment and enforce strict observation of driving at reduced speed.
- Take welfare measures for the laborers and encourage their taking holidays.

(2) Overall Relationship concerning Project Implementation

The mutual relationship between the persons in charge involved in the project is as shown in Fig.2-5, including construction supervision.



＊: The consulting services agreement and the construction contract must be verified by the Government of Japan

Fig.2-5 Project Implementation System

2-2-4-5 Procurement Plan

The countries where equipment and materials should be procured are shown in Table2-23.

Table 2-23 Procurement Plan of Principal Equipment

	Equipment/Materials	Japan	Third Countries	Cambodia
1.	Construction Material for Civil and Building works			
	Sand, Gravel, Stone			O
	Cements			O
	Steel		O	
	Building materials		O	O
2.	Hydropower Facilities			
	Turbine	O	O	
	Generator	O	O	
	Controller	O	O	
3.	Diesel Generation Facilities			
	Diesel Engine	O	O	
	Generator	O	O	
	Controller	O	O	
4.	Transmission and Distribution Facilities			
	Concrete pole		O	O
	Conductors, cable	O	O	
.	Transformers and Circuit breaker etc.	O	O	
	Telecommunication system	O	O	

2-2-4-6 Quality Control Plan

Supervision should be exercised based on the following items to see whether or not the quality of the facilities and equipment and materials stated in the consultant contract documents (technical specifications, execution design drawings and the like) are secured by the contractor. If the contractor is in danger of not being able to secure the quality, it should be asked for corrections, alterations and modifications.

(1) Check the facility construction drawing and the site performance.

(2) Check the fabrication drawing and specification document of equipment and materials.

(3) Check the on-the-spot factory inspection result report or factory inspection result report of equipment and materials.

(4) Check the packing and transport method and the on-site temporary storage method.

(5) Check the installation procedure document and working drawing of equipment and materials.

(6) Check the factory and on-site inspection procedure documents of equipment and materials.

(7) Supervise the on-site installation work of equipment and materials and witness their trial run, adjustment and inspection.

(8) Check the completion drawing.

2-2-4-7 Implementation Schedule

Based on the grant aid scheme of Japan, the project implementation schedule will be as Table2-24.

Table 2-24 Implementation Schedule

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Detailed Design																						
Field Investigation																						
Design and Analyses																						
Preparation of Draft Tender Documents																						
Tendering and Contract																						
Arrangement and Approval of Tender Documents																						
Public notification of Prequalification																						
Deadline of Prequalification																						
Evaluation of Prequalification																						
Public notification of Tendering																						
Tendering																						
Evaluation of Tendering																						
Construction Contract																						
Construction																						
Construction Work (Term - 1)																						
Construction Work (Term - 2)																						
1. Preparation Work																						
(1) Preparation and Clearance																						
(2) Procurement and Transportation of Materials																						
2. Civil Works																						
(1) O'Moleng Hydropower Site																						
(2) Prek Dakduer Hydropower Site																						
(3) O'Romis Hydropower Site																						
(4) Diesel Powerhouse and others																						
3. Electromechanical Works																						
(1) Hydro-electromechanical Work																						
(2) Diesel Generating Work																						
(3) Transmission and Distribution Work																						
4. Adjustment and Trial Operation																						
Technical Guidance																						

2-3 Obligations of Recipient Country

During the implementation of the Project, apart from the work responsibilities of the Cambodian side as outlined in 2-2-4-3 Scope of Work, the Cambodian side will be responsible for the following items.

(1) To provide necessary data and information for the Project

(2) To secure land for the permanent facilities and temporally use for the Project

(3) To clear, level and reclaim the site when needed

(4) To remove existing power generation and distribution facilities.

(5) To maintain existing roads which are used for the construction work of the project

(6) To bear the commissions, advising commission of Authorization to pay and Payment commission, to the Japanese foreign exchange bank for the banking services based upon the Banking Arrangement

(7) To ensure unloading and customs clearance and to exempt tax of the products at the port of disembarkation in Cambodia

(8) To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contact such facilities as may be necessary for their into the Cambodia and stay therein for the performance of their work

(9) To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in Cambodia with respect to the supply of the products and services under the verified contracts

(10) To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant

(11) To bear all the expenses, other than those to be borne by the Grant, necessary for construction of the facilities as well as for the transportation and installation of the equipment

2-4 Project Operation Plan

2-4-1 Basic Policy

According to the Electricity Law promulgated in 2001, the operator of a power utility is subject to obtaining a business license and approval of the electricity tariff rate from the EAC. MIME, intends to operate the power utility after completion of the planned facilities by establishing Management Board with a core of MIME and DIME, and with the provincial government and residents of Mondul Kiri. The ownership rights of the facilities of this project lie with MIME.

Although MIME and DIME exercise administration and supervision of power utilities as power administration agencies, they do not possess the function to directly operate and manage a power utility. After completion of the facilities of the project, it is most important to operate and manage them by appropriate techniques and engineering in a sustainable manner. Therefore, it is necessary to the facilities through Soft Component for the personnel engaged in operation and management of the utility.

2-4-2 Management Organization

Fig.2-6 proposes a Management Organization after the completion of project implementation. This organization will consist of a company organization to operate (manage and administer) the utility and a committee to advise the utility. The management rights of the utility are held by MIME, and MIME will appoint operators (4 persons, including a representative, accounting officer, technical officer and auditing officer) who will carry out its operation. The accounting and technical officers take charge of his/her subordinate organizations; that is, the accounting section and operation and maintenance section.

The utility company will be 31 strong, the breakdown of which will be as follows:

- Officers: 3 persons
- Paperwork and accounting section: 5 persons
- Operation and maintenance section: 23 persons

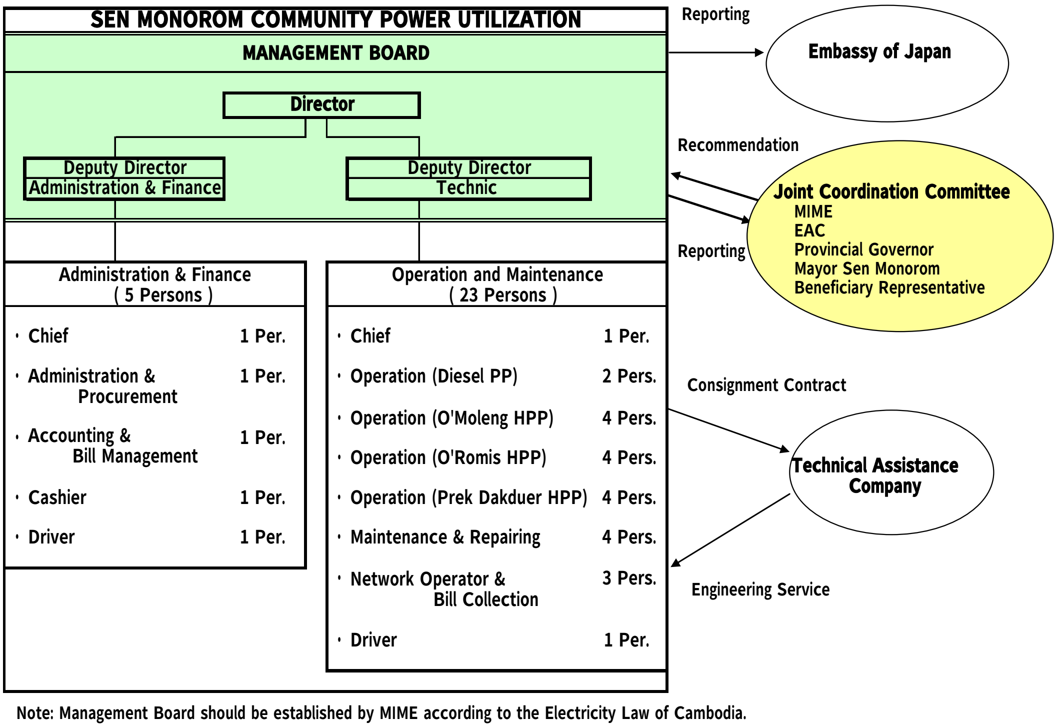


Fig. 2-6 Organization Chart of Sen Monorom Community Power Utilization

2-4-3 Operation and Maintenance Plan

This project assumes a power supply structure of a power system with multiple power sources at 3 sites of hydropower generation and one site of diesel power generation. A central command center will be established in Sen Monorom City, which will keep track of a startup, shutdown and other operation conditions at each power plant and issues a command for startup, shutdown and the like.

Duties of each section are given below.

(1) Administration

9 persons, including the section chief. This section takes charge of the following duties.

- Reading of watt-hour meters, and collection and management of electricity charge
- Payment of business operation costs (tax, personnel cost, facility maintenance and repair costs, and others)

- Business balance management and electricity tariff rate planning
- Operation of the Advisory Committee and general external affairs

(2) Operation and Maintenance

20 persons, including the section chief. This section takes charge of the following duties.

- Operation, maintenance and facility management of the 3 power plants
- Operation, maintenance and facility management of the diesel power generation facility
- Maintenance, inspection, spare parts management and repair of the entire facility including the transmission and distribution lines
- Tracking of operation conditions at each power plant and issuance of startup and shutdown commands

(3) Management Board

It is comprised of the president and the two directors who control the Administration section and Operation and Maintenance section. The Board makes a decision on all matters related to business operation.

(4) Advisory Committee

It is comprised of MIME, DIME, Governor of Mondul Kiri Province, Mayor of Sen Monorom City, representatives of consumers (several representatives of the various sectors of industry), and, EAC. The Committee gives advice in response to a consultation from the utility and voluntary advice of its own. The advice of the Committee has no binding force on business operation. DIME takes charge of the secretariat office of the Committee and the office negotiates and coordinates with the utility.

(5) Technical Assistance Company

It is suggested that an annual blanket contract should be closed with an expert company (consultant or expert firm) which gives technical advice about operation and maintenance and cooperates in inspection, repair and spare parts supply for several years after commencement of operation.

2-4-4 Electricity Tariff Rate Plan

The overall objective of the Project is to improve the living conditions of the residents in the intended area. Therefore, a low electricity tariff rate should be established so that residents of low income can use electricity. Establishing an electricity tariff rate is subject to approval of EAC (Electricity Authority of Cambodia). An ordinance concerning establishing an electricity tariff rate (EAC Sub-decree, Regulations and procedures for regulating Electricity Tariff in the Kingdom of Cambodia) came into effect in April 2005, and the electricity tariff rate of the project will be established in accordance with this ordinance.

(1) Current Electricity Tariff Rate

The electricity tariff rates in Cambodia are basically determined on a cost valuation basis and vary by the independent power systems, that is, they differ from region to region and from private utility to private utility. Seeing the electricity tariff rates of the various districts of EDC, there is a large difference between the lowest Phnom Penh area and the highest Takeo area.

Comparison of electricity tariff rate for general residences (households)

- Lowest: 350 Riels/kWh (US$ 9 ct/kWh); Phnom Penh area (for consumption of 500kWh/month)
- Highest: 900 Riels/kWh (US$ 23 ct/kWh); Takeo area

In rural regions, a still higher electricity tariff rate is established because rural private electricity utilities (REE) can freely establish their electricity tariff rate according to the fuel cost, facility operation cost and the like. High rates have remained nationwide. According to the rural centralized solar power generation and supply system installation survey carried out by JBIC in 2004, the electricity tariff rate is as high as 35 to 75 ct/kWh in the case of diesel power generation of 1 MW or less in provincial capitals, and the monthly electricity charge is reported to be US$ 4 to 10 per month per household for a household consuming an electric energy of 10 to 20 kWh for a month on an average. The current electricity tariff rate of Sen Monorom City is about 1,800 to 2,300 Riel/kWh (60 ct/kWh), which is 4 times as high as the mean rate of Phnom Penh.

(2) Paying Capacity of Residents

According to the above-stated social condition survey, the willingness to pay of the residents of Sen Monorom City ranged widely from 200 to 3,000Riels/kWh and the mean was 590.8Riels/kWh. About 50 percent of respondents say they can pay 700 Riels/kWh, which is the mean of Phnom Penh. The payable electricity tariff rate can be thought to be about 700Riels/kWh. On the other hand, about 17 percent of respondents say they can pay 200 to 400Riels/kWh, and the payable electricity tariff rate of the low-income class is estimated at about 300Riels/kWh. The payable amount of the low-income class currently not supplied with electricity was estimated from their amount of money paid for the consumption of lighting energy. According to the estimate, 5,000 Riels or less showed the highest proportion. From this, the payable electricity charge of the low-income class can be thought to be about 5,000Riels per month. (Refer to Fig.2-7 and Fig.2-8)

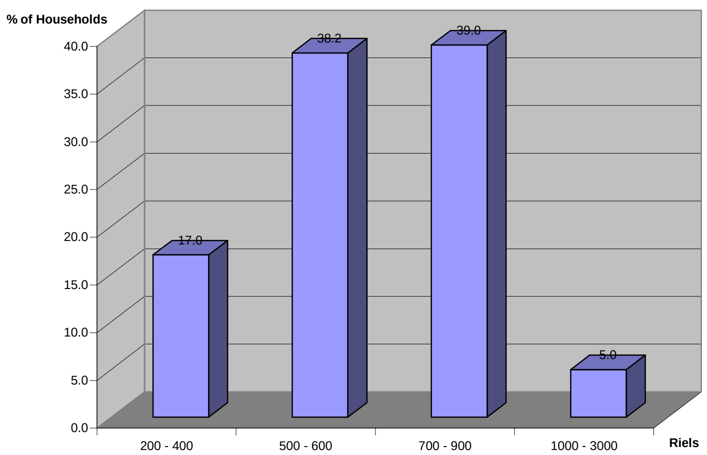


Fig.2-7 Willingness to Pay Monthly Tariff

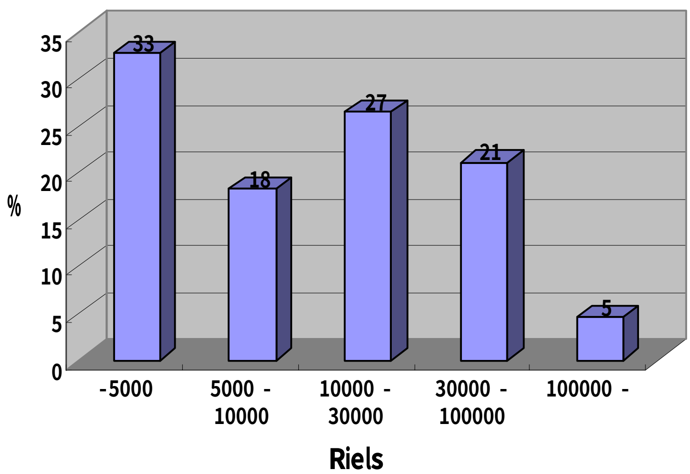


Fig.2-8 Payable Electricity Charge

(Money paid for the consumption of lighting energy)

(3) Power Generation Cost

The maintenance and operation of electric power facilities of the project must be covered by electricity charge. The calculation method of generation cost follows the above-stated EAC Sub-decree. This ordinance describes that the depreciation cost need not be included in the electricity tariff rate calculation in the case of a grant aid project. That is, considerations are given in order that the benefits of grant aid will reveal themselves in electricity tariff rate. Because this project is a case of grant aid from the Japanese Government, the depreciation cost basically should not be considered. However, a reserve fund for overhaul once several years should be accumulated for the purpose of sustainable facility operation to the extent that the electricity charge will fall within the range of willingness to pay.

Table2-25 shows the estimated value of generation cost of the commencement year.

From the calculation results, the cost per electric energy consumption is estimated at about 570 Riels/kWh.

Table 2-25 Energy Generation Cost Calculation Sheet (Commencement Year)

Item	Unit	Hydropower	Diesel Generation	Total
Generation Capacity	kW	370	250	620
Energy				
Energy Generation	MWh	1,257	327	1,584
Own consumption	%	1	4	
Own consumption	MWh	8	13	21
Energy sent out	MWh	1,249	314	1,563
Energy Purchased	MWh	0	0	0
Total Energy available	MWh	1,249	314	1,563
Distribution Loss	%	10	10	10
Ditto	MWh	125	31	156
Energy sold	MWh	1,124	283	1,407
Unit Fuel Cost				
Fuel consumption	l/kWh		0.25	
DO price, excl. VAT and Transportation	$/ton		530	
Fuel cost	$/kWh		0.1113	
Ditto	Riels/kWh		456	
Lubricants oil Consumption	l/kWh		0.001	
Lubricants oil price	$/barrel		415	
Lubricants oil cost	$/kWh		0.0026	
Ditto	Riels/kWh		11	
Miscellaneous	Riels/kWh	10	10	
Generation Cost				
Cost of Fuel	1000Riels		149,220	149,220
Cost of Lubricants	1000Riels		3,486	3,486
Miscellaneous	1000Riels	12570	3,270	15,840
Sub Total		12,570	155,976	168,546
License Generation	Riels/kWh	1.6	1.60	
Ditto	1000Riels	1,799	452	2,251
Employees Cost	1000Riels	112,102	37,367	149,470
O & M Spares	1000Riels	10,000	40,000	50,000
Ad. & General Affairs Expenses (30% of Employees Cost)	1000Riels	33,631	11,210	44,841
Reserve fund for Overhall	1000Riels	20,000	50,000	70,000
Interest	1000Riels	0	0	0
Total	1000Riels	188,303	294,553	485,107
Cost/ sold kWh	Riels/kWh	168	1,042	306
Transmission and Distribution Cost				
Employees Cost	1000Riels	64,058		64,058
O & M Spares	1000Riels	5,000		5,000
Ad. & General Affairs Expenses (30% of Employees Cost)	1000Riels	19,218		19,218
Interest	1000Riels	0		0
License Distribution and Sell	Riels/kWh	1.1		
Ditto	1000Riels	1,547		1,547
Total	Riels	89,823		89,823
Cost/kWh	Riels/kWh	80		80
Financial cost				
Minimum Tax	1000Riels	20,473		20,473
Banking Charges	1000Riels	2000		2,000
Total	1000Riels	22,473		22,473
Cost/kWh	Riels/kWh	16		16
Total	1000Riels			597,403
Cost per Sold Energy	Riels/kWh	263	1,138	425

Note: Demand value of the end of 2007 is adopted for the calculation.

(4) Proposed Electricity Tariff Rate

Referring to the willingness to pay and affordability to pay of the residents classified by income according to the social condition survey, an electricity tariff rate is proposed in the following Table2.26.

Table 2-26 Proposed Tariff Rate

Class (amount of electric energy consumption per month)	Electricity Tariff Rate	
	Riels/kWh	US¢/kWh
I 0~20 kWh/month	400	9.8
II 20~100kWh/month	600	14.6
III 100~200 kWh/month	800	19.5
IV 200~kWh/month	1,000	24.4

1US$ = 4,100 Riels

Class I: 0~20 kWh/month, 400 Riels/kWh

Lowest tariff is set as 400 Riels. This tariff will cover generation cost of hydropower portion. Therefore cross subsidy will not be occurred among the consumers. Most part of the new consumers belongs to this class. This part of energy is used for basic human life and everybody can get its benefit of the project.

Class II: 20~100 kWh/month, 600 Riels/kWh

Consumption Range of Second class is from 20 to 100 kWh per month. More than 90% of households belong to Class I and II. This tariff will cover average generation cost.

Class III: 100~200 kWh/month, 800 Riels/kWh

This range will be business and manufacture consumer such as shop, factory and office.

Class IV: More than 200 kWh/month, 1,000 Riels/kWh

Highest tariff is set as 1,000 Riels/kWh. But 1,000 Riels is still lower than the generation cost of Diesel power. This part of energy will be for Tourist business consumers such as Guesthouse.

2-5 Estimated Project Cost

2-5-1 Estimated Project Cost

This cost estimate is provisional and would be further examined by the Government of Japan for the approval of the Grant. In the case of the Project's implementation under Japan's grant aid scheme, the total project cost is estimated to be approximately ¥1,124 million (Japanese side ¥1,103 million, Cambodia side ¥21 million). The breakdown of the cost based on the division of work between the Japanese and Cambodia side is outlined here based on the estimation condition listed in (3) below. However, this cost estimate is provisional and would be further examined by the Government of Japan for the approval of the Grant.

(1) Japanese Portion ¥1,103 million

Table 2-27 Estimated Cost of Japanese Portion

Item		Estimated Cost (¥million)
Facility	Three Hydropower Plants	604
	Diesel Power Plant	76
	Transmission and Distribution Facilities	271
Equipment for Operation and Maintenance		9
Detailed Design, Work Supervision and Soft Component		143
Total		1,103

(2) Cambodia Side Portion

Table 2-28 Estimated Cost of Cambodia Side Portion

Item	Estimated Cost (US$)	Description
1) Land Acquisition Cost and Rental Expense	62,000	Total area is about 15 ha.
2) Maintenance of Existing Road	24,000	Length is 20 km.
3) Removal of Existing Power Facilities	15,000	
4) Service Wiring from Watt-Hour Meter to Consumer	24,000	1,200 households
5) House Wiring	24,000	1,200 households
6) Reserved Fund for the Local Staff	5,000	28 local staffs
7) Fund for the Commencement of Operation	36,000	
Total	190,000	Approximately ¥21 million

(3) Estimation Conditions

1) Date of Estimation December, 2004

2) Foreign Exchange Rate: 1 US$ = ¥109.91 (TTS average from June to November, 2004)
1 US$ = 3,885 Riels (as above)

2-5-2 Operation and Maintenance Cost

(1) Annual Balance

The following Table shows the annual financial balance, including the operation and maintenance costs, in the case where the commencement of operation is taken at January 2008.

It is expected from the Table that the annual balance will be in the black in the year of the commencement of operation. However, the amount of power supply from hydropower generation will vary according to the amount of precipitation of that year, and the amount of diesel power generation will also vary accordingly. Therefore, balance variations due to the change of fuel costs are expected.

Table 2-29 Annual Balance Sheet of Commencement Year

Item	Unit	Hydropower	Diesel Generation	Total
Energy sold	MWh	750	241	991
Average tariff Rate	Riel/kWh			631
Revenue	1,000Riels			625,788
Ditto	1,000US $			153
Generation Cost				
Running Cost				
Cost of Fuel	1,000Riels		128,229	128,229
Cost of Lubricants	1,000Riels		2,995	2,995
Miscellaneous	1,000Riels	8,410	2,810	11,220
License Fee		1,200	386	1,585
Sub Total		9,610	134,420	144,030
Constant Cost				
Employees Cost	1,000Riels	96,088	32,029	128,117
O & M Spares	1,000Riels	10,000	40,000	50,000
Ad. & General Affairs Expenses (30% of Employees Cost)	1,000Riels	28,826	9,609	38,435
Provision for Overhall	1,000Riels	20,000	50,000	70,000
Sub Total		154,914	131,638	286,552
Total	1,000Riels	164,523	266,058	430,581
Transmission and Distribution Cost				
Running Cost				
License Distribution and Sell		1,090		1,090
Sub Total		1,090		1,090
Constant Cost				
Employees Cost	1,000Riels	85,411		85,411
O & M Spares	1,000Riels	5,000		5,000
Ad. & General Affairs Expenses (30% of Employees Cost)	1,000Riels	25,623		25,623
Interest	1,000Riels	0		0
Sub Total		116,035		116,035
Total	1,000Riels	117,125		117,125
Financial cost				
Minimum Tax	1,000Riels	14,422		14,422
Banking Charges	1,000Riels	2,000		2,000
Total	1,000Riels	16,422		16,422
Total Annual Expenses	1,000Riels	564,128		
	1,000US $	138		
Annual Balance	1,000Riels	61,660		
	1,000US $	15		9.9%
Note: Exchange Rate 4,100 Riels/US$				

(2) Operation funds at the first period from the commencement of generating operation

Table 2-30 shows the monthly balance that does not consider the time difference of charge collection.

Table 2-30 Monthly Financial Balance of Initial Period

(Units: 1,000 US$)

Item	1	2	3	4	5	6	7	8	9	10	11	12
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Monthly Energy Consumption												
at Demand End	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6
at Supply Site (Power house)	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5
Generating Energy by Hydropower	45.0	40.0	40.0	45.0	80.0	90.0	90.0	90.0	90.0	85.0	85.0	80.0
Generating Energy by Diesel power	48.5	53.5	53.5	48.5	13.5	3.5	3.5	3.5	3.5	8.5	8.5	13.5
Tariff Revenue	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
Generation Cost												
Fuel & Oil Cost	5.9	6.5	6.5	5.9	1.6	0.4	0.4	0.4	0.4	1.0	1.0	1.6
Others	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Transmission & Distribution Cost	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Total Cost	14.7	15.3	15.3	14.7	10.4	9.2	9.2	9.2	9.2	9.8	9.8	10.4
Monthly Balance	-2.0	-2.6	-2.6	-2.0	2.3	3.5	3.5	3.5	3.5	2.9	2.9	2.3
Balance Carried	-2.0	-4.6	-7.2	-9.2	-7.0	-3.5	-0.0	3.5	7.0	9.8	12.7	15.0

Because the commencement of operation will be in the dry season, the amount of diesel power generation must be large for the first 4 months, and this will increase the fuel cost. Accordingly, the monthly balance will turn out a deficit of 2 to 3 thousand dollars. The loss forwarded is expected to reach its maximum in April and amount to 9 thousand dollars.

Because this business is covered by electricity charges, operation funds to cover at least the time after the collection of electricity charges are needed. Assuming that the collection task takes place in the following month and the collected charge is counted two months after, the cost for those two months is estimated at 32 thousand dollars. And there are still two month deficit, about 5 thousand dollars should be added. As a result, the amount of funds to be secured at the commencement of operation is estimated at about 36 thousand dollars.

2-6 Soft Component (Technical Guidance) Plan

(1) Background

The Cambodian side earnestly requests the provision of soft component (technical guidance). During the implementation period of the project, technical transfer will be provided to the counterpart at each of the detailed design and construction stages concerning the structure, and function of the planned facilities. This technical transfer will be carried out through on-the-job training and/or by the workshop. However, this will only provide general basic knowledge about the power facilities and equipment, and it is difficult to transfer not only techniques for maintenance and repair of power facilities but also the methods of the management of organization and operation of the power plants order to sustain the Sen Monorom Community Power Utilization.

(2) Objective

The objective of this soft component is to enable the Sen Monorom Community Power Utilization to be function continuously and to properly operate and manage the power plant constructed by the Project.

(3) Outcome

1) Establishment of the project implementing system and organization
2) Establishment of the office management system
3) Establishment of the maintenance and operation method of civil work structures
4) Establishment of the maintenance and operation method of power generation and distribution facilities

(4) Activities (Input Plan)

The following activities should be carried out to achieve the above four objectives.

1) Project operation

(a) Trainees: Member of Management Board (3 directors)

The director engaged in business operation, and the two deputy directors in charge of management for administration and finance and management of engineering matter.

(b) Item of activities

Table 2-31 Technical Guidance for Project Operation

Activities	Description
1) Establishment of the Management Board	To provide technical guidance on development of rules during the preparation period and guidance on how to operate the organization when the Board is established and help them establish the Joint Coordination Committee.
2) Establishment of the Joint Coordination Committee	
3) Arrangements to obtain license for electricity business and approval for electricity tariff rate	To provide technical guidance on how to prepare an application form for business license and a statement on electricity tariff rate during the preparation period, provide direct instructions on the application procedure and guidance so as to help them become capable of obtaining the license
4) Start-up of power supply business	To check management of the Sen Monorom Community Power Utilization during test operation, advise on points for improvement and help the local staff continuously carry out their own management

(c) Monitoring of the Outcome

Result of above activities will be evaluated and confirmed by following methods.

- Presenting a report to the Japanese Embassy by the implementing organization of the recipient country
- Commencement of the electricity business during the Project Period
- Acquisition of the approval of EAC

2) Office management

(a) Trainees : 8 new local members

A total of 8 members, including 5 members of the Administration Section in charge of collection of electricity charge s and balance management and 3 members of the Operation and Management Section in charge of collection of electricity charge and wiring maintenance. It is expected that the majority of them will have no experience in power-related services.

(b) Item of activities

Table 2-32 Technical Guidance for Office Management

Activities	Description
1) Outline and functions of power facilities	To help the trainees learn the basics of power plant facilities and understand the roles of the staff through lectures, including visits to the site
2) Lecture on electricity charge system	To hold a lecture on the concept of electricity charge and its system so that the trainees can learn the background of the work of 3) and 4)
3) Development of office management manuals	To help the trainees complete the office management manual based on the draft prepared in advance and establish the work flow through workshops
4) Guidance on recording energy consumption, issuance and sending of invoices and collection of electricity charge s	To help the trainees memorize the work procedures (described left) through lectures and field practice
5) Guidance on documentation (meter reading, invoicing, collection of charges)	To help the trainees memorize the work (described left) through lectures and field practice

(c) Monitoring of the Outcome

Result of above activities will be evaluated and confirmed by following methods.

- Development of the office management manual
- Field examination of electricity charge collection and balance management (to be implemented upon completion of training; the purpose is to have the trainees learn, for instance, how to read the energy consumption meter)
- Examination to check the degree of understanding or learning on recording and filing (metering and invoicing and collection of electricity charge) (to be implemented upon completion of training; the purpose is to have them document and organize records using the check form in accordance with the manual)

3) Maintenance of civil work structures

(a) Trainees: 19 new local members

A total of 19 members, excluding three of the maintenance section in charge of wire maintenance. The majority of them are expected to have no experience in electricity business services. Drivers are supposed to take lessons only for 1) and 2) below.

(b) Item of activities

Table 2-33 Technical Guidance for Maintenance of Civil Work Structures

Activities	Description
1) Outline and functions of power plant facilities	To help the trainees learn the basics of power plant facilities and understand the roles of the staff through lectures, including visits to the site
2) Guidance on functions and structure of civil work structures	To help the trainees understand the functions and structure of the facilities through lectures and field visit
3) Preparation of the civil engineering facility maintenance manual	To help the trainees complete the manual based on the draft prepared in advance and establish the work flow through workshops
4) Guidance on inspection, maintenance and repair of civil work structures	To help the trainees learn how to make daily inspection, mainly through field practice, and be capable of judging on repair necessity
5) Guidance on documentation of maintenance of civil work structures (operation, shut-down, inspection and repair)	To help the trainees be capable of filling out inspection sheets, mainly through field practice

(c) Monitoring of the Outcome

Result of above activities will be evaluated and confirmed by following methods.

- Development of the civil engineering facility maintenance manual
- Field examination of maintenance of civil work structures (to be implemented upon completion of training; the purpose is to have them learn how to operate, for instance, the intake gate and monitor its condition)

4) Maintenance of power generation and transmission facilities

(a) Trainees: 18 new local members

A total of 18 local members, excluding three of the Operation Maintenance Section in charge of wire maintenance, and one driver

(b) Item of activities

Table 2-34 Technical Guidance for Maintenance of Power Generation and Transmission Facilities

Activities	Description
1) Guidance on functions and structure of power generation and distribution facilities	To help the trainees understand the functions and structure of the facilities through lectures and field visit
2) Guidance on inspection, maintenance and repair of power generation and distribution facilities	To help the trainees learn how to make daily inspection, mainly through field practice, and to be capable of judging on repair necessity
3) To prepare the power plant operation and maintenance manual	To help the trainees complete the manual based on the draft prepared in advance and establish the work flow through workshops
4) Guidance on operation, shut-down, and condition monitoring of power generation equipment	To help the trainees learn the basic operation of power generation, mainly through field practice
5) Guidance on documentation (operation, shut-down, inspection and repair)	To help the trainees be capable of filling out inspection sheets mainly through field practice

(c) Monitoring of the Outcome

Result of above activities will be evaluated and confirmed by following methods.

- Development of the power plant operation and maintenance manual
- Field examination of operation and maintenance of electrical installations (to be implemented upon completion of training; the purpose is to have them learn how to operate or shut down electrical installations and monitor their conditions)

(5) Soft component Schedule

The Soft Component Schedule and period of each area are shown in Table 2-27.

Table 2-35 Soft Component Schedule

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
(1) Guidance for Project Operation				□	■			□	■					□■								■
(2) Guidance on Office Management																				□	■	
(3) Guidance on Maintenance of Civil Work Structures																				□	■	
(4) Guidance on Maintenance and Operation of Electrical Equipments																				□		■

(6) Obligation of the Recipient Country's Implementing Organization

In order to ensure continuous, appropriate and effective use and maintenance of the materials, facilities and equipment to be supplied or constructed by the Project, MIME, the implementing organization of the recipient country, should:

(a) make available the necessary staff, including a Project Manager from MIME, to establish the Management Board;

(b) make available the budget for MIME necessary to realize the Technical Guidance;

(c) make available the maintenance staff to operate and maintain the power plant and its facilities, including distribution and transmission wires;

(d) keep the local staff having the appropriate skills constantly employed;

(e) use appropriate manuals and guidelines and have all the staff and employees use them;

(f) hold periodic sessions of the Joint Coordination Committee; and

(g) provide a periodic report (once a year) on the progress of the project to the Embassy.

CHAPTER 3

PROJECT EVALUATION AND RECOMENDATIONS

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

3.1 Project Effects

(1) Direct Effects

With the implementation of the Project, Sen Monorom city will have a stable power supply and some 9,000 residents in 1,650 households will get benefit of electrification at the end of 2012: the following effects will be expected:

Table 3-1 Direct Effects of the Project

Item	Outcome index	
	Current Situation (the end of 2004)	Planning (in 5 years after completion, the end of 2012)
1) Power Supply (generation end)	170 kW (provided by private power providers, who are expected to close their businesses)	400 kW (stable year-round output, including reserve capacity)
2) Hours of Power Supply	3 hours in the morning; 3 hours in the noon time; and 6 hours in the evening; irregular power supply often occurs.	24 hour supply
3) Electrification Rate	About 32%	About 80%
4) Electricity Tariff Rate	US 45 ¢/kWh to 58 ¢/kWh	About US 15 ¢/kWh on the average
5) Improvement in Public Service	No street lights installed	Installation of street lights, introduction of PCs to schools, round-the-clock availability of medical equipment at hospital, etc.

(2) Indirect effects

1) Development of regional economy

Sen Monorom city is the capital of Mondul Kiri province and is the center of administration as well as regional economy in the province. Improvement of electricity availability in this city will boost up the entire growth of regional economy in the province.

2) Development of tourist industry

Cambodian national road No. 7 was recently repaired with the help of Japan's grant aid. The road improved traffic accessibility to Mondul Kiri with the start of a long-haul regular bus service and then the number of tourists to the province has been rapidly rising in these years. If electricity availability in the area is improved, the tourist industry, especially construction of hotels in the province is expected to be further promoted.

3.2 Recommendations

Cambodia should meet the following necessities to ensure the emergence and continuation of the positive effects of the Project.

(1) With the implementation of the Project, the capacity for power supply up to 2013 will be ensured. But it is necessary to acquire another power sources without fail to meet the demand after 2013.

(2) Electricity tariff structure of the Project holds the independent accounting arrangement and enables low income group of the target area to enjoy electricity with lower tariff rate. Administration section of the Sen Monorom Community Power Utilization manages the account and the revenue from energy sells shall be spent only for purposes of sustainable operation, maintenance and management of the Project.

(3) Sen Monorom Community Power Utilization should operate the facilities of the Project with high efficiency according to the regulation and the standard of Cambodia. Reduction of the generation cost by increasing efficiency should be used to lower the tariff rate for low income group as priority.

(4) An appropriate operation plan should be prepared in such a manner that hydropower should be given priority in operation to reduce generation cost.

(5) As for two hydropower plant sites, O'Moleng and Prek Dakduer, which have waterfalls as sightseeing spots for tourists, environmental preservation should be addressed in the operation and maintenance of the power plants.

(6) The skills acquired from the soft component should be sustained and improved by the staff on their own.

The outcome of soft component should be reliably and accurately conveyed to the operation and maintenance staff of the power plants. The efforts to improve the operation and maintenance skills of the staff should be made.

[Appendices]

1. Member List of the Study Team
2. Study Schedule
3. List of Parties Concerned in the Recipient Country
4. Minutes of Discussions