The Project for Operation and Maintenance of the Rural Electrification on Micro-hydropower in Mondul Kiri, Cambodia

Seminar for Small Hydropower

1. Small Hydropower (Plan)
2. Technical Issue of Hydropower Plant (Design)
3. Mondul kiri Electrification Project (Construction)

Date: 22 February 2011 at 9:30 – 11:30

Place: Conference room, JICA Cambodia office

By JICA Study Team
/Electric Power Development Co., Ltd. (J-POWER)
/The Chugoku Electric Power Co., Ltd. (ENERGIA)

Project for Operation and Maintenance of the Rural Electrification on Micro-hydropower in Mondul Kiri, Cambodia

1. Small Hydropower

By JICA Study Team
/Electric Power Development Co., Ltd. (J-POWER)
/The Chugoku Electric Power Co., Ltd. (ENERGIA)

1. Small Hydropower (Plan)

Source: Mondul Kiri Project, Cambodia (JICA 2008) /J-Power (Photo)

Source: J-WatER, 2009 and GIAC, 2007

1. Development of Small Hydropower Plant

1.1 Why Introduction and How effectiveness

Potential ability of renewable energy to electric power as a Small hydropower production; the merit of

(1) Economical effect

It can sell or consume by own generated energy (kW)

- Energy cost per project in 2005 = 9.4 J.yen/kWh (approx. 9 cent)
- Weighted average cost = 8.4 J.yen/kWh (approx. 8 cent)

(Source: ANRE report Feb. 2007)

(2) Environmental effect

Hydropower is as a clean energy instead of fossil fuel

Co^2 emissions intensity in actual,

- Electric power industry : 0.453kg-Co^2/kWh(FY2007)
- In Japan : 0.373kg-Co^2/kWh(FY2008)

(Source: JEPIC Annual Report, 2009)

1.1 Why Introduction and How effectiveness

(3) Save energy effect:

Applying subsidy support (10 to 50 %) by the Government, and then Public open by the law of RPS (Renewable Portfolio Standards)

1.2 How many capacity is a small scale hydropower plant ?

The power utility companies in Japan generally definite that the out put of less 10,000kW is a small hydropower.

Other hand, it is clearly classified a less 1,000kW vs. over 1,000kW under the law of Japan.

Defined Small Hydropower in Foreign Country

No.	Countries	Capacity (kW)	Remarks
1	The Philippines	Less 5,000	National Electrification Administration
2	Thailand	Less 6,000	National Energy Administration
3	Indonesia	1,000 to 2,000	Government development plan
4	Japan	Less 3,000	Promotion Act for introduction of Electric into Rural Areas
5	USA	Less 1,500	Law were amended to quicken the procedure for approving development plans with the small scale plants
6	Sweden	Less 1,500	Subsidies are offered for a small scale plants
7	France	Less 4,500	Approved by provincial level for the small scale plants

1.3 Where the power station can install

Ordinary river

Soil serving dam

Irrigation canal

Waterworks

1.3 Where the power station can install

Sewerage system

River maintenance water

Generation discharge

Cooling water at factory & Building

1) Installed location (Site by Site)

(1) Ordinary river
- Classified : Class A river (Kyoto pref.)
- Head 1.74m, Discharge 0.55m³/s,
- Output 5.5kW
- Operation : December, 2005

Source: Project for NEDO's subsidy Support

(2)River maintenance flow
- Classified: River maintenance (Gunma pref.)
- Discharge 0.329m³/s,
- Output 230kW
- Operation : October, 2005

Source: Project for NEDO's subsidy Support

Installed location (Site by Site)

(3)Soil saving dam
- Classified : Soil saving dam (Kumamoto pref.)
- Head 14.38m, Discharge 2m³/s,
- Output 190kW
- Operation : April, 2005

Source: Project for NEDO's subsidy Support

(4)Waterworks
- Appling natural head of water supply pit (Osaka pref.)
- Head 35m, Discharge 0.48m³/s,
- Output 129kW
- Operati0n : January, 2007

Source: Project for NEDO's subsidy Support

Installed location (Site by Site)

(5)Irrigation water
- Appling dead head of irrigation (Yamanashi pref.)
- Head 77.5m, Discharge 0.5m³/s,
- Output 320kW
- Operation : March, 2007

Source: Project for NEDO's subsidy Support

(6)Generation water
- Appling discharge water (Gifu pref.)
- Head 8m, Discharge 2.3m³/s,
- Output 150kW
- Operation : July, 2005

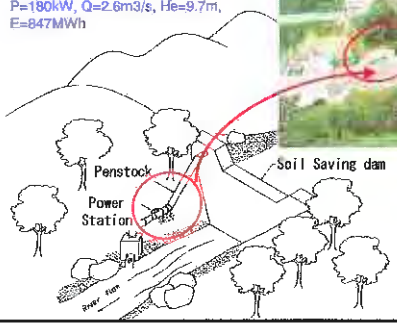
Source: Project for NEDO's subsidy Support

(1) Installed at Soil Saving Dam

- Soil block
- prevention of river erosion

Installed at Soil Saving Dam

「K. P.S」(Okayama Pref.)
P=180kW, Q=2.6m3/s, He=9.7m,
E=847MWh



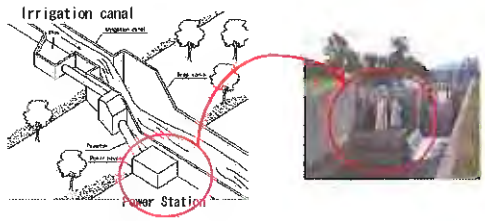
(2) Installed at irrigation canal

Flow of Gradual Sloop (Falling work)

Flow of Steep Slope

Installed at Irrigation Canal

「Y. Power Station」(Niigata Pref.)
P=18kW, He=2.24m, Q=2.46m3/s



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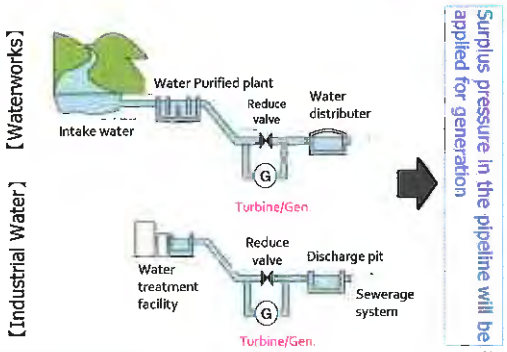
(3) Installed at Utilities Waterworks



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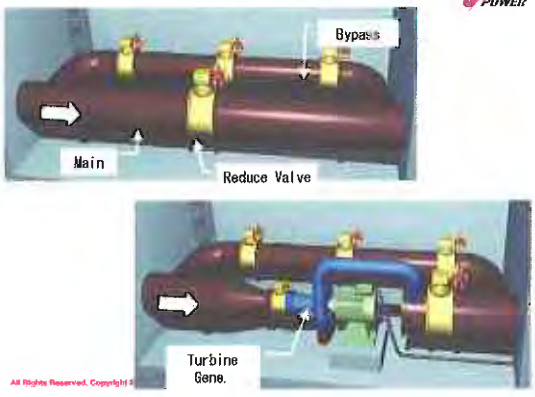
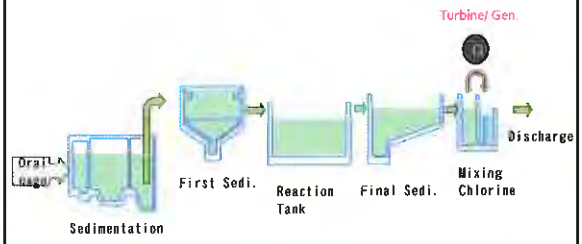
Installed at Utilities Waterworks (for example)



(4) Installed at Sewerage



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Installed at Sewerage
(Morigasaki Water Recycle Center)

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1.4 How to consume & interconnect

(1)Rule of technical matter must be in accordance with [Standards of Power Interconnection (JEAC9701-2006)],Public regulation.

(2)In case of alternative plan, the applicant may negotiate with power utility company, Japan.

(3)Type of interconnection

Case-1: Power only receive and no send from/to distribution line

Case-2: Power receive and send from/to distribution line

Case-3: Power only send to distribution line

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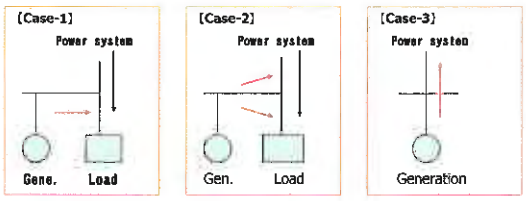
Power Interconnection

There are 3 cases of the interconnection between the Power station and public power system.



2. Characteristics of Small Hydropower

(1) There is a different to develop the potential ability of the project: between near towns/villages vs. remote mountain area.

(2) There is a different the construction cost: per kWh depending on the project locations site by site. (Hydro-valley plan, Japan : 0.5 ~10 US$/kWh)

(3) Law application of difficulty is different depending on the project sites: because of river control and protection.

(4) There is no problem or equal on technical matter for development of the project: such as land acquisition, move of houses, environmental preservation and equipment specifications, etc.

3. Merits of Development

(1) Economical point: It is necessary to be made a priority on the project site, because of easy and economical maintenance cost.

(2) Easy application of law: It is necessary to get the approval of the government, because of spending a time and cost, etc.

(3) Applying of Subsidy and/or Support system

(4) Making consensus for residents and parties

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2. Technical Issue of Hydropower Plant (Design)

By JICA Study Team
/Electric Power Development Co., Ltd. (J-POWER)
/The Chugoku Electric Power Co., Ltd. (ENERGIA)

Electricity of Mundul Kiri (EOM), EDC

Technical Issue of Hydropower Plant for Mondul Kiri Electrification Project

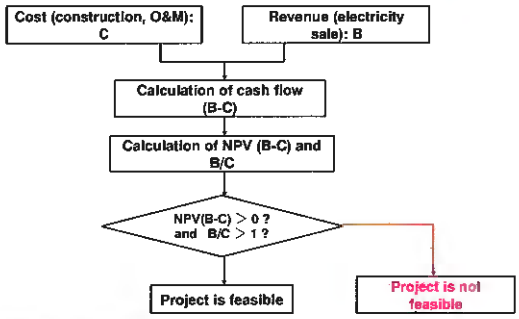
Source: Mondul Kiri Project, Cambodia (JICA 2008) /J-Power (Photo)

Prepared: Electric Power development Co., Ltd. (J-Power), February 2011

1. Process from Planning to Operation in Hydropower Development

- Investigation &Planning
  - Reconnaissance Study (Preliminary Study)
  - Feasibility Study
- Design
  - Detailed Design
- Construction
  - Civil Works
  - Hydro mechanical and Electrical Works
  - Transmission line/distribution line
- Operation & Maintenance
  - Operation of Hydropower Plants
  - Environmental Monitoring

1.1 Flow chart of project evaluation (Feasibility study)



1.2 Type of Hydropower Station

In a general, Hydropower generation systems are classified according to the location and type of structure based on the topographic conditions:

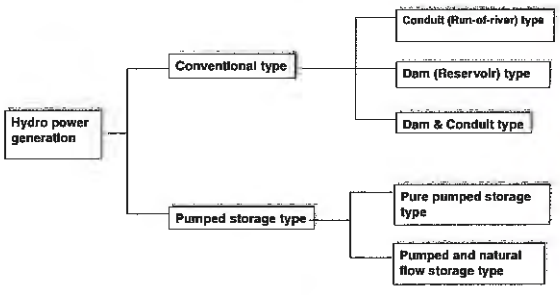
➢ **Location of structure**

1) Waterway type power station (Run-of-river type),
2) Dam type power station,
3) Dam with waterway type power station
4) Using agricultural water way facilities (micro hydro)

➢ **Type of structure**

1) Above ground type,
2) Semi-ground type,
3) Underground type

Types of Hydropower Plant



Conduit Type (Run-of-River Type)

Fig-1 Run-of-River Type

Dam Type

Fig-2 Dam (Reservoir/ Pondage) Type

Dam and Conduit Type

Fig-3 Dam & Conduit Type

Pumped Storage Power Station

Fig-4 Pumped Storage Type

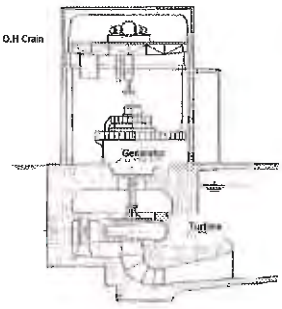


Fig-5 Example of ground type power house

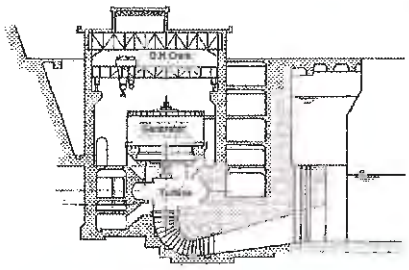


Fig-6 Example of semi ground type power house

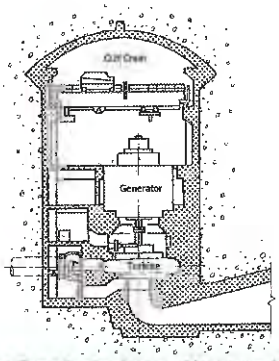


Fig-7 Example of underground type power house

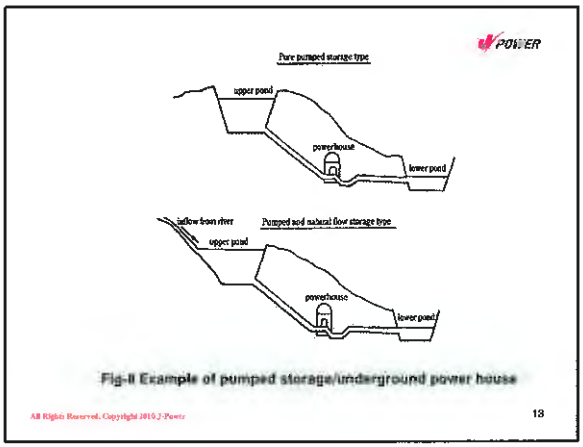


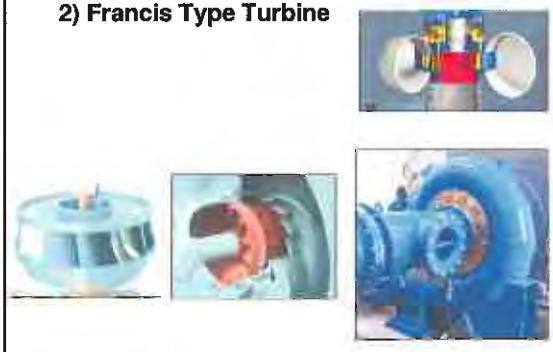
Fig-8 Example of pumped storage/underground power house

Table -1 Classification of Turbine Type

Type	Turbine	Characteristics
Impulse Type	Pelton Turbine Turgo Impulse turbine Cross-Flow turbine	• High head & efficiency at Partial • High speed & low cost • High efficiency at Partial
Reaction Type	Francis turbine	• High reliability & efficiency
	Diagonal Flow (Deriaz) Turbine	• Wide operation & low head range
	Propeller (Kaplan) Turbine Tubular (Bulb) Turbine	• Wide operation range & low head range
	Reverse Pump Turbine	• Low cost & head & simple construction

1) Pelton Type Turbine

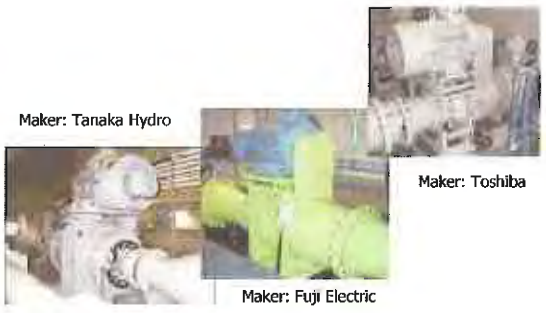
2) Francis Type Turbine



3) Cross-flow Type Turbine

Seiwa PS, Kumamoto pref.
Source: Tanaka Hydro

4) Inline Type Turbine



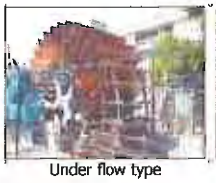
Maker: Tanaka Hydro

Maker: Toshiba

Maker: Fuji Electric

5) Open Type Turbine

Spiral flow type



Under flow type

Upper flow type

6) Other Type Turbine

Reverse Pump Turbine

Packaged Type Bulb Turbine

Turgo Impulse Turbine

2. Design of Hydropower Facility for Mondul Kiri Power Station, EDC

Hydropower station is consisted,

1) **Civil facility**: Dam (weir), Intake, head tank, waterway, spill way and tailrace (outlet)
2) **Electro-mechanical facility**: Turbine, generator, control equipment, auxiliary equipment and step-up transformer
3) **Transmission line facility**: transmission lines, distribution lines, step-down transformer and substation

2.1 Civil Facilities
1) Dam and intake facilities

2) Sedimentation

3) Waterway (headrace)

4)Head tank

5) Gate

6) penstock

7) Spillway and Tailrace (Out let)

2.2 Electro-mechanical Facility
2.2.1 Water Turbine

1) Selection of Water turbine type

The water turbines are categorized two type impulse and Reaction type turbines. (Table-1)
Turbine type will be mainly selected by two factor of Head (m) and discharge (m^3/s).
Turbine discharge will be determined by yearly duration curve as shown Fig-9, and head will be also determined by the topographical condition and located powerhouse. Then, the turbine type will be selected in considering Fig-10.

Fig-9 Typical Flow Duration Curve
(To determine the turbine discharge)

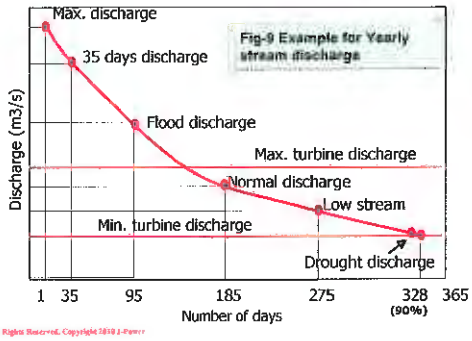
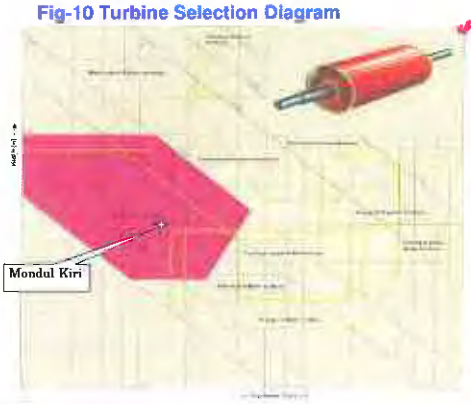


Fig-10 Turbine Selection Diagram



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2) Cross Flow Turbine(1/2)

(1) Small hydropower

The Cross flow turbines have a long history of growth, since their initial development, and several hundred units have already been put into operation as small hydraulic turbines.

(2) Simple construction

The cross flow turbine has a very simple construction and is suitable for use in small power plant, so it is advantageous in cost and easier maintenance.

(3) Partial operation

Since cross flow turbine has relatively high efficiency under operation at partial discharge, it is suitable for small capacity and medium and low heads (5 to 100m) refer to Fig-1.

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4) Main construction

As shown in Fig-2, the main construction consist of the runner, main shaft, guide vanes, runner case housing, etc.

5) Draft tube and Water flow

There is normally no daft tube in the cross-flow turbine outlet, so that getting rid of cavitation pitting than reaction type turbine. (But there is a type of cross-flow turbine with draft.)

Water flow from the penstock is brought to the runner through the guide vane. The water moves through the inner side of the runner, passage through the runner towards the outer side of runner and then discharged, while parts of the water to the runner is discharged from the outer side of runner to the tailrace.

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Fig-11 Construction of Cross Flow

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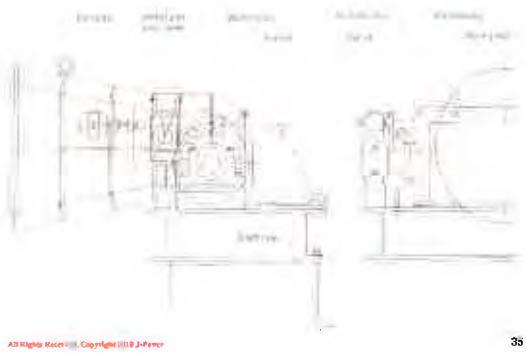
Fig-12 Section of Cross Flow Turbine



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Shop Test for Turbine of Mondul Kiri Project

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Construction of Cross Flow Runner, O'Molen

Standardized range for Cross-flow turbine

Net head : 7 ~ 100 m
Discharge : Approx. 0.15 ~ 5.0 m3/ sec
Output : Approx. 50 ~ 1,000 kW
Speed : 100 ~ 1,000 rpm (50Hz),
100 ~ 1,200 rpm (60Hz)
Specific speed: 40 ~ 200 m-kW

210kW Cross-flow Hydro Turbine, Japan

3) Head and Discharge (1/2)

(1) The application range of the cross flow turbine is such that the head is within 7 to 100 m, the discharge is within 0.1 to 6 m3/ sec, and the output is less than 1,000 kW.

(2) In the case of head more than 100 m, a special design would be required for turbine.

(3) The net head (He) of cross flow turbine is specified as a head between Intake water level (IWL) and center of runner level (CRL) as shown below;

for example: O'Moleng power station

He = IWL − CRL − H loss (penstock loss)
= 614m − 593.7m−1.6m=18.7m

(4) Since the runner will rotate in atmospheric air like Pelton turbine, the water discharge from the runner can not used as energy.

(5) In case of large discharge (Q max.) is specified, the turbine output (kW) decreases or sometimes the unit requires to stop the operation due to occurrence of cavitation and vibration at low efficiency zone in the dry season. In general, the allowable operation range of discharge *(m^3/s)* is as follows;

- ***Francis turbine : 100 ~ 40 %***
  (Partial load Francis runner : 100 ~ 25 %)
- ***Tubular turbine : 100 ~ 25 %***
- ***Pelton turbine : 100 ~ 20 %***
- ***Cross flow turbine : 100 ~ 15 %. (with 2 G.Vs)***

4) Specific Speed of Turbine

(1) Specific speed (Ns)

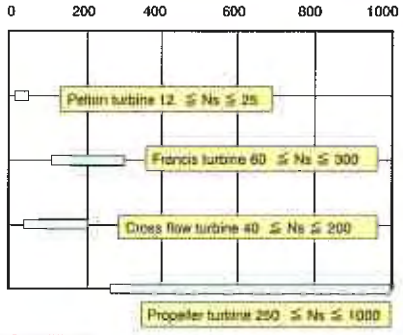
The specific speed of similar runner in a group is expressed by the rotational speed (N) obtained when one runner has the effective head H=1m and output P=1kW.

$$Ns = N \times P^{1/2} / H^{5/4} \text{ ---------- (1)}$$

As seen from equation (1), as long as the rotational speed (N) has been determined, the Ns can be calculated by using the H and P.

By comparing the obtain specific speed for range of various turbine, the type desired can be roughly determined in the Figure-13.

Fig-13 Range of Ns by Turbine Type



(2) Maximum specific speed

The Fig-4 was prepared on the basis of experiments and actually proven example and shown the applicable range for each turbine type corresponding to the limit of specific Speed (Ns). For water turbines, the speed increase is primarily limited by the balance which also occurs in other hydraulic machine. For simply determining the speed while taking into account the prevention of harmful cavitation, it is recommended the following formulas be used for calculating the applicable maximum specific speed.

$$Ns_{max} \leqq 650\ H^{-0.5} \quad \text{---------- (2)}$$

e.g. O'Romis Turbine: Ns max, = 650 x $18.7^{-0.5}$ = 128 m-kW

(Design Ns = 92 m-kW)

5) Efficiency of Cross Flow Turbine (1/2)

(1)In order to utilize the high efficiency during partial discharge, the guide vane (G.V) located over the full width of the runner is divided into two portions with one-third (1/3) or two-thirds (2/3) width. According to discharge in the width of the G.V is selected 1/3 + 2/3= 3/3, 2/3 or 1/3 to obtain the characteristics shown in Fig-5.

(2)The change of the guide vane for high efficiency operation zone will be made manually in turbine runner against river flow during dry season.

(3)However, where the effective head is greater than 70m or the output smaller than 50kW, the guide vane switching method stated above cannot be easily applied for structural reasons (monolithic G.V type).

Fig-14 Turbine Efficiency Model

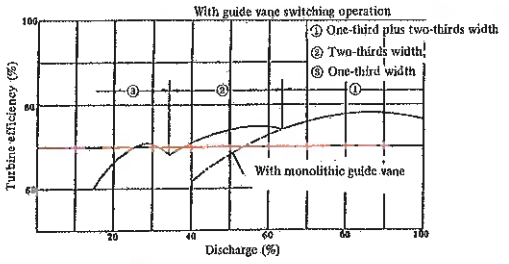
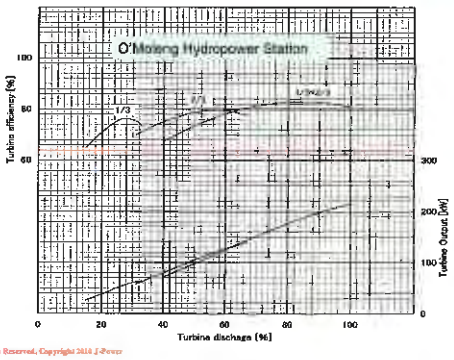


Fig-14-1 Turbine Efficiency Curve



5) Efficiency of Cross Flow Turbine (2/2)

(4)Variable discharge characteristics are about 15% of the rated discharge for G.V switching construction and about 40% for monolithic G.V construction.

(5)Also, the variable head range is considered approximately 70% of the maximum head.

(6)The cross flow turbine is normally installed above the tailrace water level in order to prevent the runner from being submerged during operation excepting other specified design.

(7)In the case of turbine speed is low, as with a cross flow turbine, generator speed can often be increased over that of the turbine by adopting a speed-increasing gear from the viewpoint of economy.

6) Construction of Speed Increaser

(1)Parallel shaft helical gears are normally used for the speed increaser, and anti-friction bearing are employed as bearings and also for supporting the thrust of gears.

(2)For coupling the machine with turbines or generators, flange type flexible couplings are normally employed but geared coupling are sometimes adopted in the range of large-capacity. As lubricating method in the increaser, the built-in oil type is normally applied but, the oil-circulating type is sometimes applied for the large-capacity.

(3)The speed increaser is placed between the turbine and generator to enhance the economic design of the generator when the speed of the turbine is within a range of less than 600 rpm (50Hz) or 720 rpm (60Hz).

Speed Increaser for O'Moleng Hydropower

7) Turbine Output

(1) As the effective head and discharge of the power station being planned have been roughly determined in the case study, the turbine out put can be easily obtained from the following formula, if turbine efficiency is assumed;

$$Pt\ (kW) = 9.8\ Q \cdot H \cdot \eta t \quad \text{---------- (1)}$$

Where,

Pt : turbine output (kW), 9.8: constant, Q: discharge (1.45 m3/s), H: effective head (18.7m), ηt: turbine efficiency (70~77%)

i.e. Efficiency : *Cross flow turbine: 70 ~ 77 %*
Pelton turbine: 82%
Francis turbine: 84%
S-type tubular turbine: 84%

(2) As seen from formula (1), the turbine output is calculated for O'Moleng power station;

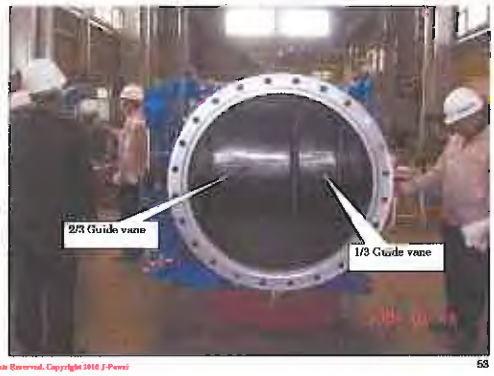
Pt = 9.8 x 1.45 x 18.7 x 0.7 = 186 kW ~ 204.6 kW

8) Turbine Guide Vane

(1)Turbine guide vanes (G.V) can control the water flow, it means that the output of turbine will be determined depending on the G.V opening.

The G.V is divided into 2 pieces as a 1/3 and 2/3, so that the output can obtain 1/3, 2/3 and 3/3 of the rated output.

Guide Vane, Mondul Kiri Turbine



Guide Vane Servo-motor Unit

9) Analysis of Transient Phenomena

in assuming safe and reliable operation of the power station, measures required for the items listed below are primarily taken at the generating equipment side.

(1)Pressure rise in penstock during sudden load rejection

➢ Water pressure rise in penstock will be occurred during sudden load rejection such as emergency trip of electrical and mechanical troubles. Then, an accident necessitating the interruption of power transmission occurs during the operation of power plants.

➢ The circuit must be disconnected by circuit breakers located between the main circuit and power transmission line for separating the turbine and generator facility.

➢ This is sudden load rejection. In this case, the operation of the unit must be immediately stopped by close of the guide vanes or inlet valve.
This operation of the guide vanes causes water Hammer in the penstock, thereby rising water pressure in the penstock.

➢ Therefore, the closing time of the guide vane must be set in such a manner that the pressure rise in the penstock will not exceed the allowable maximum design values in withstand of the penstock.

(2) Pressure rise during runaway speed

➢ This transient phenomena becomes problematic if the discharge characteristics of the runner type, such as Francis, Cross flow or Propeller type turbine, cause a pressure rise in the penstock after sudden load rejection in a power station having a relatively long time for the guide vanes.

➢ That is, if speed of runner begins to increase to runaway speed, then the discharge increases or decreases depending on the runner characteristics. If the change in this discharge per unit period of time is large, then a pressure rise occurs in the penstock.

(2) Pressure rise during runaway speed

➢ The unit reaches runaway speed (Nr) for a state where the Closing time of guide vanes is relatively long after a sudden load rejection and the moment of inertia of rotor is small, or where the guide vanes fail to close after sudden load rejection.

Runaway speed

1) Pelton turbine: 1.7 ~ 2
2) Francis turbine: 1.6 ~ 2.3
3) Cross-flow turbine: 1.6 ~ 2.5
4) Kaplan turbine: 2 ~ 3.2
5) Tubular turbine: 2.5 ~ 3

Name Plate of Hydraulic Turbines

2.2.2 Inlet Valve

Inlet valve is used for the following:
purposes and to be installed between the end of penstock and turbine.

1)Water-open or close during ordinary start and stop the turbine.
2)Flow interruption in the event of stalled guide vane movement
3)Water-close during maintenance such as inside inspection of turbine

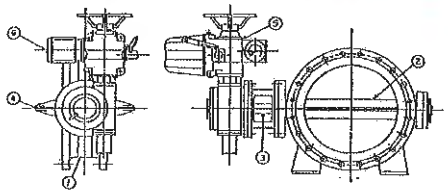
1) Type and Selection

Butterfly valve : with head of less than 150 m
Sluice valve : with head of less than 200 m

2) Operation Method

Manual type : where operation of power station is made at the machine side by hand.
Oil or Motor type : where operation of power station is made by one man control.
In addition to the operation method the above, closing operation will be applied by a counter weight under both ordinary and emergency cases without relaying upon motor or oil pressure.

Fig-15 Construction of Inlet Valve (butterfly type)

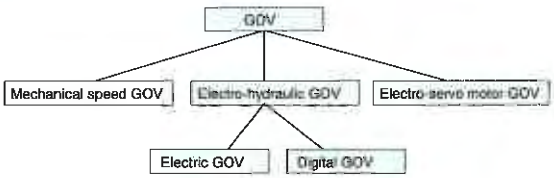


No.	Part name	Material
1	Valve body	Rolled steel plate for ordinary construction or carbon steel.
2	Valve element	Same as above.
3	Valve shaft	Stainless steel, carbon cast steel or carbon steel for mechanical construction.
4	Valve seat	Rubber.
5	Speed reducer	--
6	Motor	--

Butterfly Inlet valve, Mondul Kiri Project

2.2.3 Governor

The governor (GOV) is used for speed control and frequency control which means adjusting the output (load control).
The GOC is classified as follows.



1) Speed Governor Control

(1) Speed control
When the output of the unit is in balance with the load, the unit is operated at the rated rotational speed, so that power with rated frequency of 50Hz (or 60Hz) is supplied to the system. The GOV under those conditions operate in a neutral state without performing positive speed control.

(2) Load control
In this event, if the load increases or decreases and the balance with output is lost, then the rotating speed deviates from the rated values and falls or rises. This causes fluctuations in the frequency at the same time and, if this situation is not recovered, power supply may be sometimes poor quality, depending on the change in speed (frequency).

The GOV quickly responds to such changes in speed and perform control operation to always maintain the turbine rated speed.

2) Dummy Load Governor Control (DL GOV)

The difference of basic function against to speed GOV is that the dummy load GOV has no speed control function, but DL GOV can control the system load by dummy heaters (kW) as like consumers' loads.

(O'Romis and O'Moleng P.S have a dummy load of 210kW)

So-call peak operation is one of the output control operations, in which the relevant power station is subordinated to other power generating facilities in the system and the turbine output of the power station is increased or decreased or its operation started or stopped in response to rise or falls in the system loads.

Dummy Load Heater

2.2.4 Generator

1) Type

There are two types of generators such as Synchronous generator and Induction generator,
Generally, induction generator has a simple construction with no exciter system so that it is easy maintenance and economy than synchronous generator, but induction generator can not be used for independent operation and causes a large rush current at the moment when parallel into the system.
Therefore, induction generator will be applied the following conditions;
No required for independent operation and connecting to the large power system.
Considering rush current effect at the moment of paralleling in the system

2) Characteristics

Characteristics	Induction generator	Synchronous generator
1. Independent operation	No independent operation due to required excitation from system	Independent operation is possible
2. Excitation system and Power factor (p.f)	No exciter and no adjustable, then rush current is big	Exciter is required and p.f can be adjusted.
3. Synchronization	No required synchronization	Required synchronizer, and parallel-in by C.B
4. Stability	Stable and no step-out from the system	Step-out from the system Due to load fluctuation
5. Maintenance	Easy maintenance than synchronous generator	Necessary maintenance

Shop Test for Generator, Mondul Kiri Project

3) Rated Frequency (F)

- The frequency of generator will be applied with 50HZ or 60Hz in the each countries, Mondul Kiri power system applied 50Hz according to the Cambodian power system.

4) Rated Rotation Speed (N)

- The rotational speed is an important factor and is closely related to the external dimensions, weight and characteristics of the generator. The high speed generator is advantageous economy and efficiency performance than low speed generator. Refer to Table-2 .

Table-2 Speed Selection

No. of poles	50 Hz	60 Hz	No. of poles	50Hz	60 Hz
6	1,000	1,200	32	188	225
8	750	900	36	167	200
10	600	720	40	150	180
12	500	600	48	125	150
14	429	514	56	107	129
16	375	450	64	94	113
18	333	400	72	83	100
20	300	360	80	75	90
24	250	300	88	68	82
28	214	257			

Rated Rotation Speed

The rotational speed (N) of generator is determined by the rotational speed of the water turbine, then it can not be established by its self. However, in cross flow turbine or tubular turbine, the rotational speed may be low, and they are considered design of a speed increaser due to the economical point (cost) and efficiency performances of the generator.

Relations between the rated speed, number of poles and frequency of generator; Number of poles means the number of magnetic poles of generator has the following relationship

$$N = 120 \times f / P \text{ (rpm)}$$

Where, P: Number of poles
f: Frequency (Hz)
N: Synchronous rotating speed (rpm)

In the design stage for cross flow turbine, the rated speed may be determined on the basis of 6 poles with speed increaser. For Mondul Kiri project is

$$N = 120 \times 50 / 6 \text{ (rpm)} = 120 \times 8.333 = 1{,}000 \text{ (rpm)}$$

Standard rotational speed is actually adopted in the Table-1 .

5) Rated Voltage (V)

The generator voltage is determined on the basis of capacity, economy and characteristics of generator as follows.

1,000 MW (kVA) : less than 10,000V
More than 400 kW (kVA) :1,000 – 7,000V
200 – 300 kW (kVA) : 200 – 400 V

6) Rated Power Factor (P.F)

Power factor is the ratio of apparent power VI (kVA) to active power P (kW) and is expressed by the following formula;

$$P.F = P \text{ (kW)} / V \times I \text{ (kVA)} \text{——— (1)}$$

where, P.F : Power factor
P : Active power (kW)
V : Voltage (V)
I : Current (A)

In the case of synchronous generator, the power factor can be adjusted by the exciter and the rated power factor must be predetermined. The rated power factor will be selected in the range of 0.8 to 0.95 depending on the requirement of reactive power from power system.

In case of under the electrification isolated areas, it is recommended P.F of 0.8 in planning to supply the reactive power from the generator into the power system.

7) Rated Output (Pg)

(1)Output of generator is determined by the following formula;

$$Pg \text{ (kW)} = Pt \times \eta g \times \eta s \times \cos\Phi \text{ ---- (2)}$$

where, Pg : Generator output (kW)
Pt : Turbine output (kW)
η g : Generator efficiency (p.u)
η s : Speed increaser efficiency (p.u)
cosΦ : Power factor (p.u)

(2)The apparent power Pg (VI) at generator terminal is given by formula (1)

$$Pg(VI) = \sqrt{3} \times V \times I \times 10\text{-}3 \text{ (kVA) ----- (3)}$$

(3)Summary of Specifications for Mondul Kiri generator is,

- 3 Phases Synchronous generator
- Frequency: 50Hz
- Generator capacity: 200kVA (rated), 250kVA (maximum)
- Rated voltage: 400V
- Rated current: 333 A (rated), 361A (maximum)
- Power factor: 0.8

$$Pg = 1.732 \times 400 \times 361 \times 10\text{-}3 \text{ (kVA)} = 250 \text{ kVA (maximum)}$$

(4)Therefore, the installed (rated) capacity of Mondul Kiri Power plant at generator terminal is calculated by equation (2) and (3);

$$P = \sqrt{3} \times V \times I \times 10\text{-}3 \times \cos\Phi \text{ (kW)}$$
$$= 1.732 \times 400 \times 333 \times 0.8 = 185 \text{ kW}$$

Name Plate of Synchronous generator

8) Insulation Class

The stator coils are made of insulated wires wound the required number of turns. The insulation of stator coil is normally applied Class B and F. Recently, Class F insulation is employed for reducing the size of machine with economical reasons.

(1) **Class F Insulation**: Stator winding 100℃, Rotor winding 110℃ for temperature rise limit and limited max temperature be 155 ℃.

(2) **Class B Insulation**: Stator winding 80℃, Rotor winding 90℃ for temperature rise limit and limited max temperature be 130 ℃.

2.2.5 Exciter System

For synchronous generator, an exciter system is required for supplying field currents to generator by which the constant terminal voltage can be maintained in response to load fluctuation.

1) Type of Exciter Method

Recently, brushless exciter and direct thyristor excitation method are mainly employed.

The brushless type is a good maintainability and widely utilized in small-scale hydropower plant.

2) Brushless Exciter

- The brushless type consists of an AC exciter directly coupled to the main generator, a rotary rectifier and separately provided thyristor type automatic voltage regulator (AVR).
- An exciter is always employed in synchronous generator for preventing a change of generator terminal voltage due to fluctuations of the load or rotating speed.

3) Automatic Voltage Regulator (AVR)

AVR is devices for automatically regulating the field current in order to make the generator voltage constant, and the continuous operating by using semiconductors unit.

2.2.6 Bearing

Kind of bearing and their lubrication method can be classified as follows.

(1) Anti-friction bearing
- **Grease type**
- **Built-in type (Roller type)**
- **Forced lubrication type**

(2) Sleeve bearing
- **Built-in type (oil ring or oil disc type)**
- **Forced lubrication type**

Normally, anti-friction type bearing is used for small machine less than 500kVA, and built-in type sleeve bearing for machine with capacity of 500 to 1,000kVA and forced lubrication method for machine with the large capacity larger than those.

Turbine Shaft Bearing

2.2.7 Control System

The Control system is applied for each method,
(1) Supervisory control methods,
(2) Operation control method, and
(3) Output control method

1) Supervisory Control Methods

There are three (3) supervision and operation system in power station;

(a) Continuous supervisory control method

Operators are always resident at the power station to supervise and control the equipment such as starting and stopping operation, etc.

(b) Remote continuous supervisory control method

The power station is unmanned controlled, but operators are always stationed at control center to supervise the operation condition by remote control system.

(c) Occasional supervisory control method

The power station is unmanned controlled, and operators are not always stationed at control center, but they will supervise the operation condition as required by patrol/inspections.

In case of small-scale hydropower plant in isolated area, the Continuous supervisory control method (a) is normally employed and also dam and intake facilities are maintained by the operators.

2) Operation Control Method

(a) Manual operation method

Start-up, shut down and other controls are performed manually at site by the judgment of operators.

(b) One-man control method

Automatic start up or shut down is performed by master control switch at control board.

(c) Full automatic control method

The turbine/ generator is automatically started or stopped by predetermined conditions as required water level, operation hours and so forth without operators.

3) Protection and Instrumentation

The protection and instrumentation are important items for the safe operation of the plant.

They should be designed depending on the duty or capacity (kW) of the plant, or rather, small scale hydropower generation will provide simple and easy protection and instrumentation.

Shop Test for Control panels

4) Control panel

4) Synchronous Parallel-in Unit

(1) When the synchronous generator is connecting to the power system, the synchronization is required between the generator and power system in the following conditions.

- The voltage is the same as between them
- The frequency is the same
- The phase is the same

(2) When the parallel-in by the automatically, a synchronism check relay (25) with speed matcher and voltage balance unit are required.

2.2.8 Protection System

Protection system is required to prevent failures of important equipment or spread of accident in the power plant. The protection system varies slightly depending on the method of supervisory control, but four (4) types are normally used as follows.

(a) Emergency Stop (86-1)

This protection is employed when it is necessary to immediately stop the operation after the occurrence of electrical failures such as shot-circuit or ground fault at generator.

In this case, circuit breaker (CB) for the generator must be immediately opened and then turbine quickly stopped.

(b) Quick Stop (86-2)

This protection is employed when it is necessary to immediately stop the operation after the occurrence of mechanical failures such as over-heat or bearing melt and governor trouble at generator or turbine.

In this case, the turbine input must be reduced and generator CB opened and turbine stopped.

(c) No-load no-excitation operation

When an electrical fault such as generator over-voltage occurs, the generator CB be opened, but the turbine is continuous running and generator is no-excitation and no-load operation, thus the plant can be connected immediately in to the power system after the fault has been cleared.

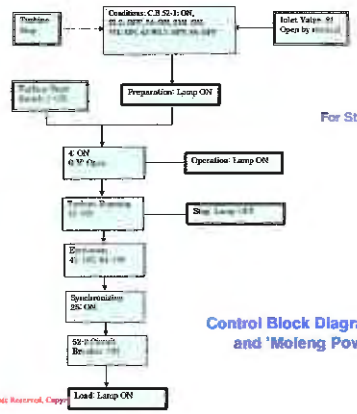
(d) Light fault

When a minor accident occurs but the machine is not required the stopping, an alarm is given in order to urge the operator to take necessary measures for preventing the fault expansion.

In the case of small-scale hydropower, fault 86-1, 86-2 and No-load no-excitation operation are, all handled together, categorized as [emergency stop] and [alarm].

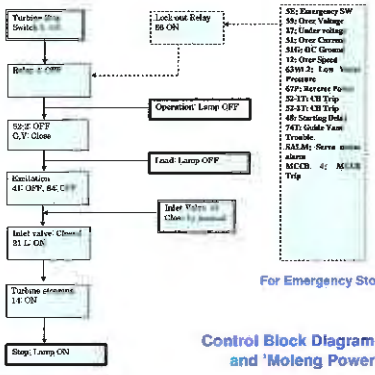
2.2.9 Instrumentation System

Instrumentation is provided for supervising and periodically recording the Voltage (V), Current (A), frequency (Hz), out put (kW), etc. and temperatures of generator winding in order to determine the operation conditions. Instruments are normally of meters, record indication lamps for visual and writing method.



For Starting sequence

Control Block Diagram for O'Romis and 'Moleng Power Stations



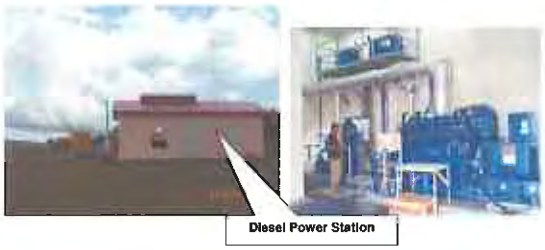
For Emergency Stopping

Control Block Diagram for O'Romis and 'Moleng Power Stations

For Normal Stopping

3. Diesel Generator Power Station (300kW) in Mondul Kiri Power System

DG station is having a function for black start of the power system



Diesel Power Station

4. Transmission Line Facility

1) 400V/22kV Step-up Transformer (250kVA)
2) 22kV/400V Substation

1) 400/220V Distribution line: 33 km
2) 22kV Transmission line :28 km

4.1 Disconnecting Switch

1) Disconnecting switch

The switch does not have ability of switching the load current. The switches are used for open or connect between the line and generator main circuit or using for maintenance of the circuit breaker, transformer and generator.

2) Cut-out Switch

Cut-out switch have a power fuse function, the fuses is apply for greater than 1,000 V and called for power fuse: 24kV, 16A, 12.5kA.

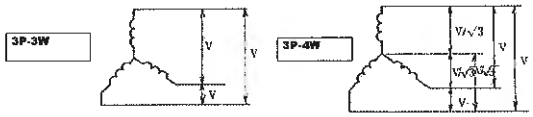
3) Air load breaking switch

The switch is used in the high voltage AC lines for switching the lines. The load current can be switched but can not be switched short-circuit current in the lines. 24kV, 600A, 12.5kA outdoor

4.2 Transmission Method

1) The three (3) phases - three (3) wires transmission system is a most advantageous followed by the single phase transmission line.

2) The three (3) phases - four (4) wires system is frequently utilized for distribution lines.



Transmission method

4.3 Reactive Power

- The transmission lines must be kept the system voltage within 22kV ±8% at sending and receiving terminal in target. The reactive power is controlled by the power stations as required for adjusting the voltage of receiving points at the substation.
- If large lagging current flows through the transmission line as a results of the operation of lagging loads like induction motors, etc, resulting in a voltage drop.
- Long distance transmission lines are greatly affected by the charging current of the line during light load, so as to make the voltage at receiving points higher than the voltage at the sending points.
- The reactive power can be controlled by generator operation with adjustment exciter current as a power factor from sending terminal.

4.4 Lightning Prevention

To cope with external abnormal voltages due to lightning or surging phenomena in the power system, it is necessary to provide countermeasure against the abnormal voltage within the predetermined value for preventing the occurrence of accident.

Actual measures to be taken are,

- To direct the lightning strike by means of an overhead ground wire (OGW),
- To pass the current due to lightning strike safely through steel towers and tower-footing resistance to the earth,
- To limit the abnormal voltage by means of lightning arrestors or surge absorbers.

4.5 Grounding at Power Station

Grounding at power stations are provided with earth electrodes and earthen wire mesh for reducing the ground resistances according to the design values.

For preventing a tower from back-flashover due to lightning stroke in the power station and for protecting personals, beast and low voltage equipment during accidents in the power system.

All equipment in the power station must be connected with grounding system.

4.6 Distribution Facility

Distribution means the allocation and supply of power, and the portion located downstream of the distribution substation as called distribution system.

1) Distribution Network

The distribution network is classified 1) Tree-, 2) Loop-, 3) Mesh- and 4) Junction connection in the distribution lines.

2) Distribution Voltage

Various countries are different operating voltage depending on the owned power system. Cambodia standards has provided with 400V/ 230V for distribution system for consumers.

3) Distribution Line Materials

1) Electric wire

Hard drawn copper wires, PVC insulated wires and All Aluminum Conductor (AAC) and All Aluminum Alloy Conductor (AAAC)

2) Supports

Wooden poles, concrete poles or panzer masts are used as electric poles. Wooded arms or metal fittings are attached to the poles for supporting wires or racks are installed for vertical arrangement.

3) Distribution transformers

Distribution transformers are normally installed on electric poles and providing 5 to 30kVA of single, but three phases transformers are installed large capacity such as 30 to 100kVA.

4) Insulators

There are kind of insulators such as a) Pin type, b) Tension type and c) Suspension type.

4.7 Neutral Grounding Method

The following methods can be applied as grounding system.

1) Un-grounding system (Floating system)
2) Solidly grounding system
3) Resistance grounding system
4) Reactor grounding system

This should be determined in relation to the each design of the power system.

Bun-e Waterfall, Mondul Kiri Province

Thank you for your attention

J-Power Group, Japan

Project for Operation and Maintenance of the Rural Electrification on Micro-hydropower in Mondul Kiri, Cambodia

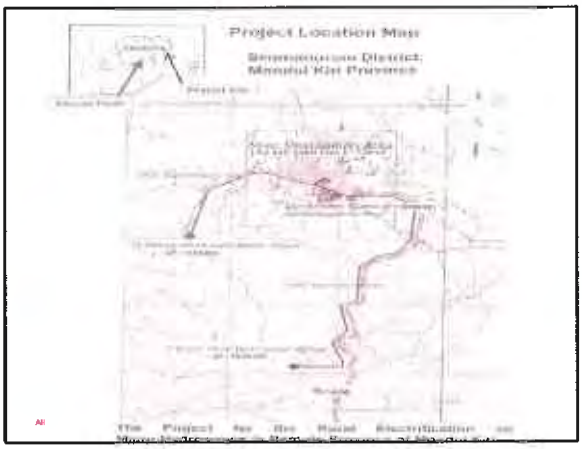
3. Mondul kiri Electrification Project (Construction)

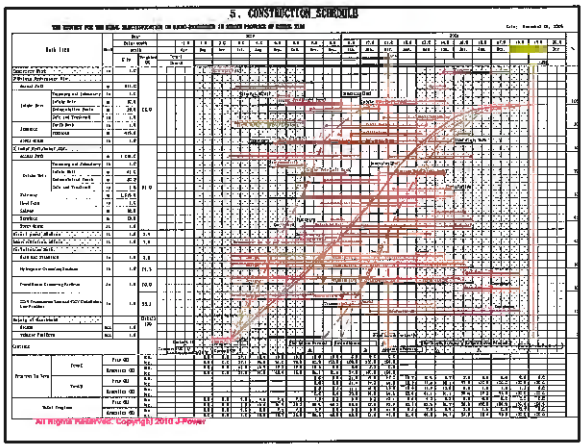
By JICA Study Team
/Electric Power Development Co., Ltd. (J-POWER)
/The Chugoku Electric Power Co., Ltd. (ENERGIA)

Mondul Kiri Electrification Project, MIME/DIME

under the Project Aid, JICA Japan in 2008

Consultant: J-Power, Japan





Main Working Item of The Project

1.Construction Works

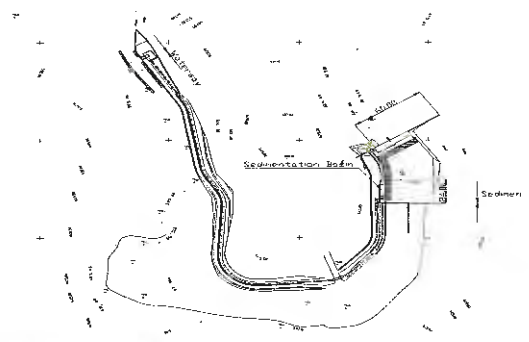
(1) O'Moleng Hydropower Station

a) Access PathRoad	:Width: 2.8m, :Length: 411m
b) Intake Weir	: Height: 5.2m, : Length: 60m
c) Sedimentation Basin	: Width: 2-4m, Height: 5-6m, Length: 23m
d) Penstock	:Length: 415m, Diameter: 1.2-0.7m

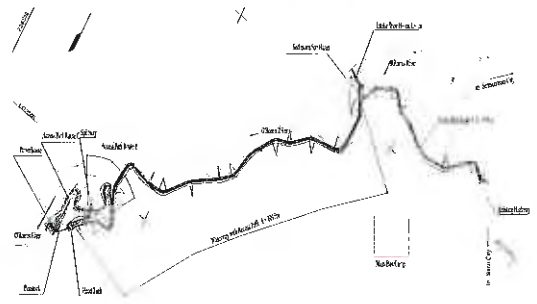
(2) O'Romis Hydropower Station

a) Access PathRoad	: Width: 2.8m, Length: 1,085m
b) Intake Weir	: Height: 4.3m, Length: 41m
c) Sedimentation Basin	: Width: 2-4m, Height: 5-6m, Length: 23m
d) Waterway	: Length: 1,015m, Canal: 1.0m width
e) Head Tank	: Width: 1-4m, Length: 20m, Height: 1.6-5.0m
f) Spillway	
g) Penstock	:Length: 63m, Diameter: 0.8-0.6m
h) Powerhouse	: One-Story, 56m2

General View of O'Moleng Hydropower Plant



General View of O'Romis Hydropower Plant



(3) Diesel Generating Powerhouse One-Story, 144m2

(4) Administration Office One-Story, 189m2

(5) Hydropower Generating Facilities

a) Hydraulic Turbine & Aux. Facilities :
185 kW x 2 units = 370 kW

b) Generator & Control Facilities
250 kVA x 2 units = 500 kVA

c) Power Station Earthing Work 1 lot

(6) Diesel Power Generating Facilities

a) Diesel Engine & Aux. Facilities 300 kW x 1 unit
b) Generator & Control Facilities 375 kVA x 1 unit
c) Power Station Earthing Work 1 lot

(7) 22kV Transmission and 400V Distribution Lines

a) 22kV Transmission Lines : 28 km
b) 400V Distribution Lines : 33 km
c) Fitting materials : 1 lot
d) General Electrical Work : 1 lot
e) VHF Radio System Facilities : 1 lot

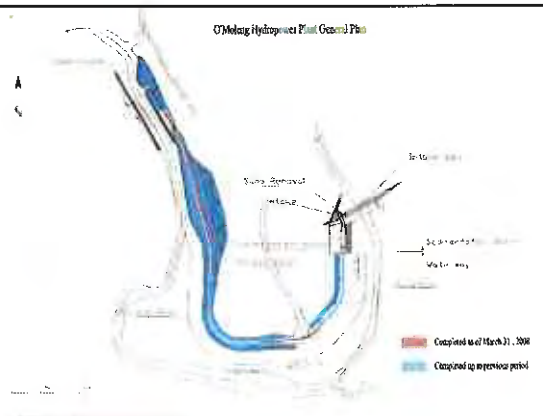
2. Procurement Works of the Facilities

(1) Pickup type Vehicle : 1 unit
(2) Work vehicle with Mobile Elevating work platform : 1 unit

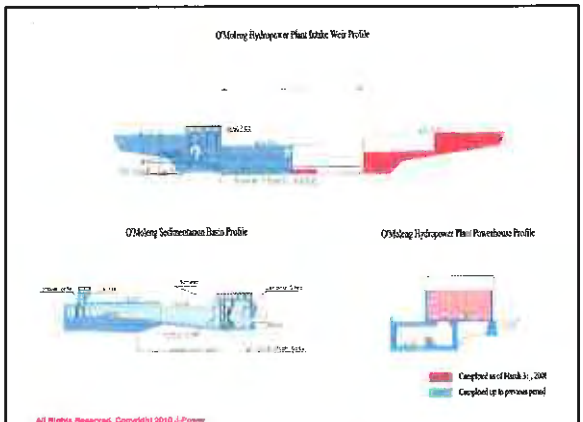
3. Project Cost (1us$= 115JY)

(1) Civil work : 345Million (JY)
(2) Supply and Installation facilities : 600.6Million (JY)
(3) Procurement Equipment : 13.8 Million (JY)
Total : 960 Million (JY)

O'Mokong Hydropower Plant General Plan



O'Mokong Hydropower Plant Intake Weir Profile



O'Mokong Sedimentation Basin Profile

O'Mokong Hydropower Plant Powerhouse Profile

General View of O'Moleng Hydropower Plant

O' Moleng Power Plant

General view ① of the work for intake weir

State of form work for the wing wall at O'Moleng intake weir

O' Moleng Power Plant

General view ② of the work for steal penstock & access path

State of backfilling with sand for steal penstock

O' Moleng Power Plant

State of concrete block work of powerhouse

General view ③ of the work for powerhouse

O' Moleng Power Plant

Inspection of the work bout completion of concrete block work at O'Moleng powerhouse

Monthly meeting on March by client with consultant at office

O' Moleng Power Plant

Intake Dam and Drainage gate


O' Moleng Power Plant
Penstock and Powerhouse
Intake and Penstock
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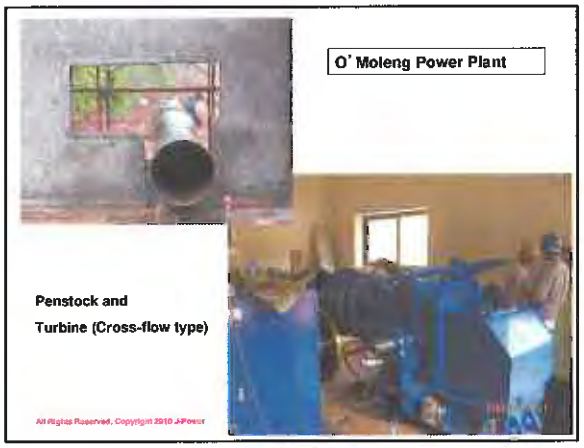
O' Moleng Power Plant
Penstock and
Turbine (Cross-flow type)
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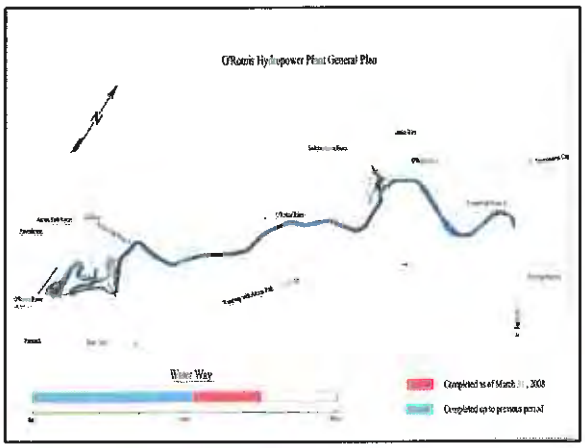
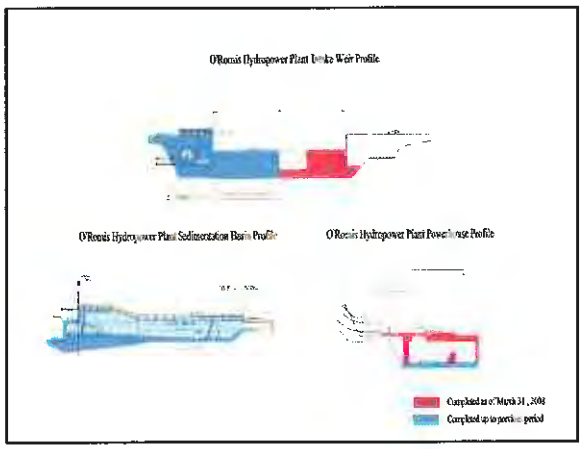
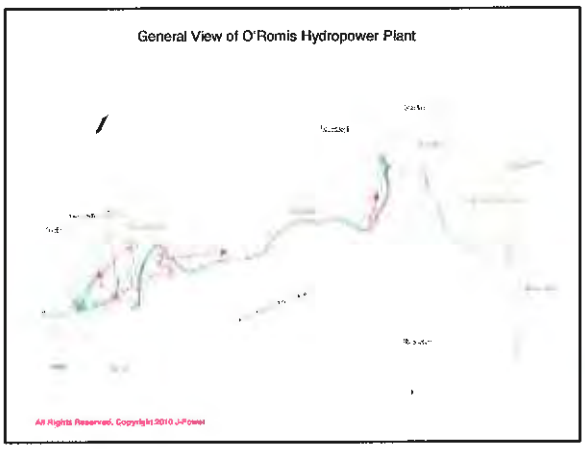
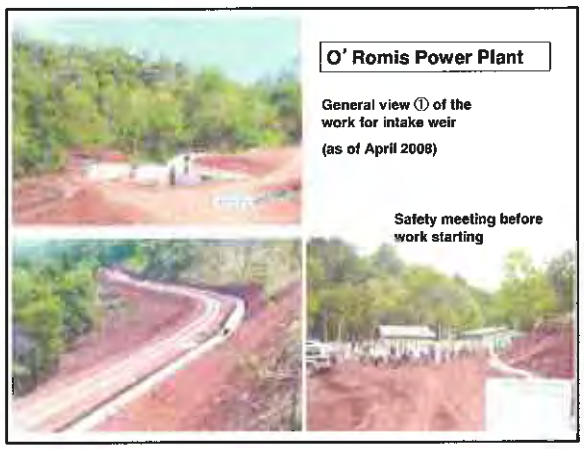

O'Romis Hydropower Plant General Plan
Water Way


O'Romis Hydropower Plant Intake Weir Profile
O'Romis Hydropower Plant Sedimentation Basin Profile
O'Romis Hydropower Plant Powerhouse Profile


General View of O'Romis Hydropower Plant
All Rights Reserved, Copyright 2010 J-Power


O' Romis Power Plant
General view ① of the
work for intake weir
(as of April 2008)
Safety meeting before
work starting

O' Romis Power Plant

General view ③ of the work for water way, head tank, penstock and spill way

General view ④ of the work for powerhouse and steal penstock

O' Romis Power Plant

State of re-bar and form work for water way

State of re-bar and form work for the base of powerhouse

O' Romis Power Plant

State of earth work for access path

Monthly safety meeting on March

at O'Romis site

O' Romis Power Plant

Intake Dam

O' Romis Power Plant

General view ① of the work for Intake weir

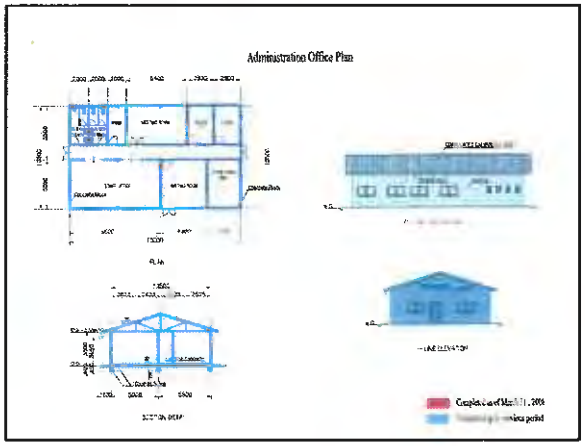
(As of 28 May 2008)

General view ② of the work for water way & access path

(as of 28 May 2008)

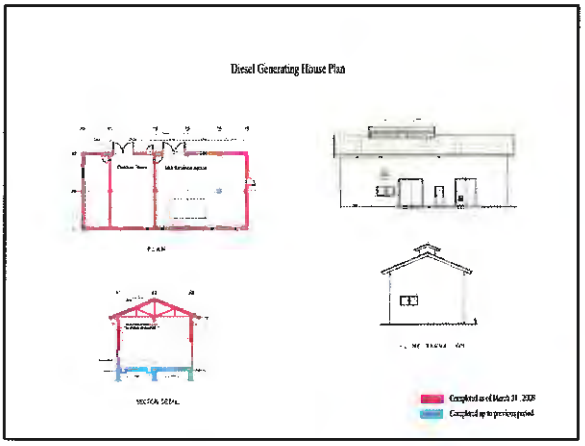
Waterway and Head Tank for O'Romis Power Plant (as of May 2008)


O' Romis Power Plant
Penstock and Powerhouse
O'Romis Water Turbine 185kW
(Cross-flow type)

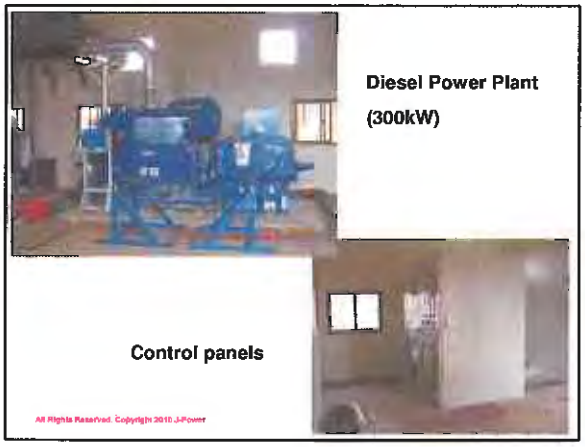

Administration Office Plan


General view of the work for administration office and diesel generating powerhouse
State of steel structure work for diesel generation powerhouse
State of plaster work for diesel generation powerhouse


Diesel Power Plant (left) and Administration Office (below)


Diesel Generating House Plan


Diesel Power Plant
Fuel Oil Storage Tank
(10,000 litters)


Diesel Power Plant
(300kW)
Control panels
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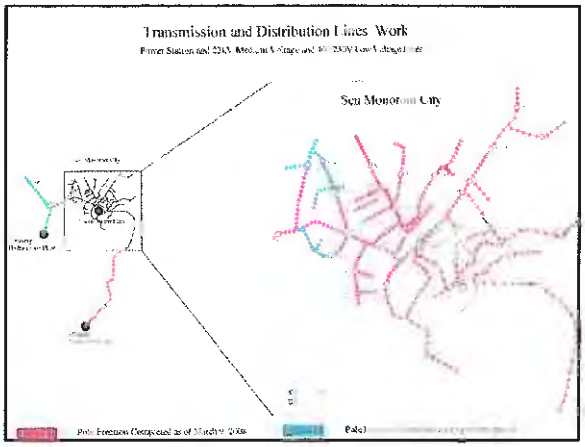
Transmission and Distribution Lines Work
Sen Monoronm City


General view of 22kV Transmission Lines
from O'Romis to Sen Moronom town
Erected Pole No. OR070
Erected Pole No.OR052


22kV Transmission Lines
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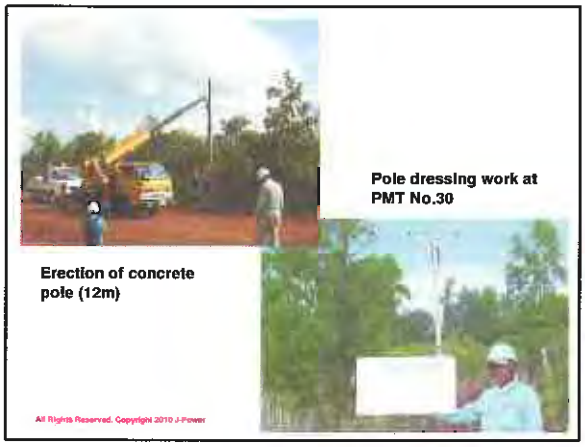
Pole dressing work at
PMT No.30
Erection of concrete
pole (12m)
All Rights Reserved. Copyright 2010 J-Power


Pole mounted 400V
distribution lines at Market
area (image photo)
Pole mounted transformer
and switchgear cubicle at
district office
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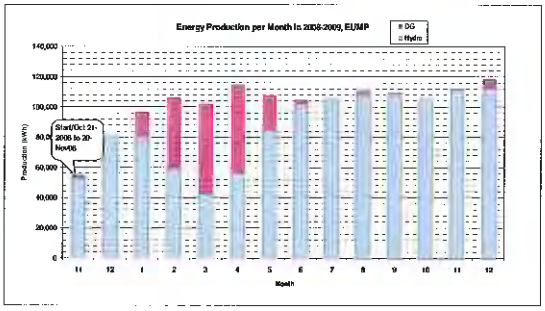
Completion of O'Moleng Power Station, October 2008

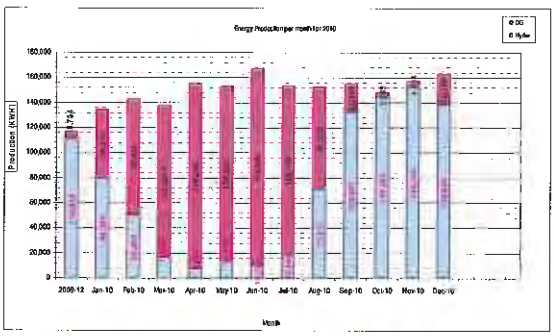
Completion of O' Romis Power Station, October 2008

Completion of DG Power Station & Transmission Line, October 2008

O&M Data : Energy Production during 2008-2009



O&M Data : Energy Production in 2010



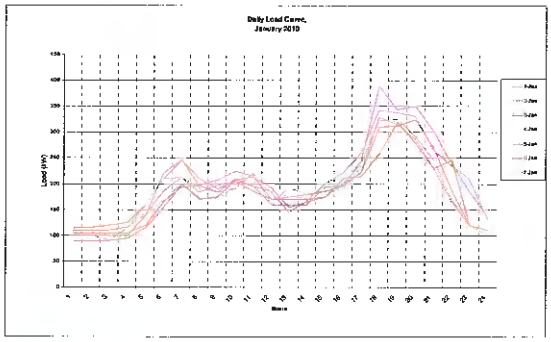
Energy production &Total Running Hours during 2008-2009

	kWh	kWh	kWh	Total Running Hours		
	Hydro	DG	Load	O'Moleng	O'Romis	D/G
2008/11	53,113	1,398	54,511	905	895.5	
12	80,221	0	80,221	706	706	67.19
2009/1	80,884	15,906	96,490	715	744	140.7
2	59,494	46,484	105,978	453	731	386
3	42,767	59,198	101,585	266	631.8	409.5
4	58,572	58,341	114,913	291	760.3	480.2
5	84,770	22,526	107,296	610	710.3	180.9
6	102,185	3,033	105,198	822	801.6	41.9
7	105,240	0	105,240	888	720	0
8	108,250	1,981	109,817	705	513.3	26.8
9	109,458	587	109,045	713	712.9	3.3
10	105,229	0	105,229	693.4	692.7	0.5
11	111,858	57	111,915	898	897.2	3.8
12	112,498	5,939	118,437	879.5	887.8	63.3
Total	1,211,535	214,630	1,426,165	8454.9	9666.3	1785.89

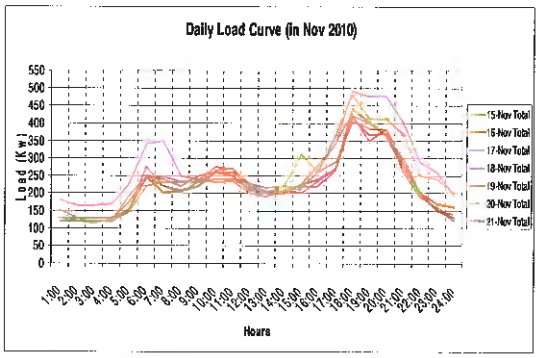
Energy Production & Total Running Hours in 2010

	kWh	kWh	kWh	Energy Sold	Total Running Hours		
	Hydro	DG	Load	in kWh	O'Moleng	O'Remis	D/G
2009-12	110,910	5,734	116,644	[illegible]	704	711.8	55
Jan-10	80,034	54,310	134,344	[illegible]	482	741	124.3
Feb-10	50,589	92,427	142,968	[illegible]	317.8	758.9	587.4
Mar-10	16,822	121,319	138,141	[illegible]	177.8	284.1	643
Apr-10	7,238	148,293	155,531	[illegible]	132.9	27.2	758.7
May-10	14,153	139,035	153,188	[illegible]	214.7	72.5	707
Jun-10	10,125	158,904	167,030	[illegible]	190.3	15.1	720
Jul-10	16,564	135,136	153,720	[illegible]	169	155.5	708.7
Aug-10	71,277	81,332	152,609	[illegible]	474.4	567.2	485.5
Sep-10	132,957	22,394	155,351	[illegible]	688.2	744.1	177.9
Oct-10	145,302	2,885	148,187	[illegible]	719.0	720.8	66.9
Nov-10	152,743	4,684	157,427	[illegible]	708	720.9	88.1
Dec-10	138,063	24,758	162,841	[illegible]	684.9	715.8	194.5
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

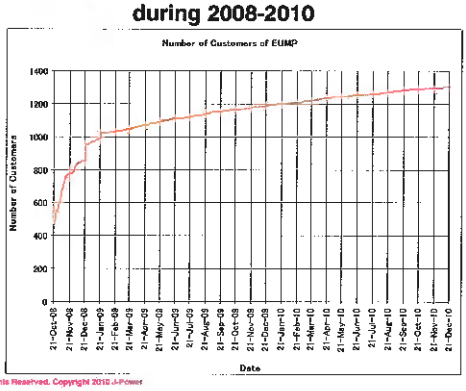
O&M Data : Daily Load Curve (Jan. 2010)



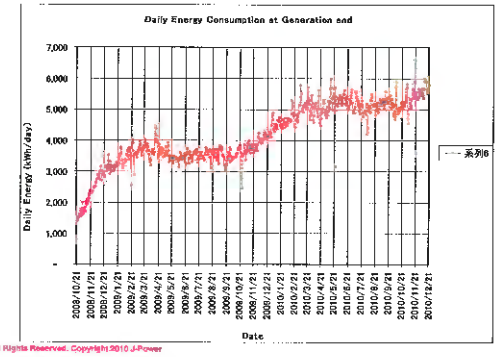
O&M Data : Daily Load Curve (Nov. 2010)



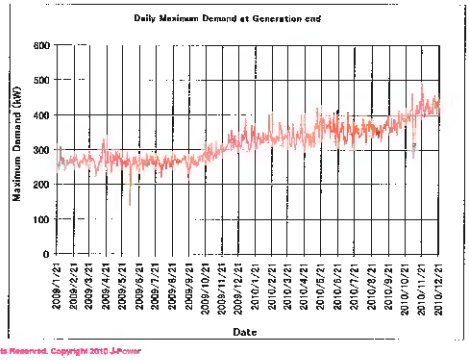
O&M Data : Number of Customers during 2008-2010



O&M Data : Daily Energy Consumption during 2008-2010



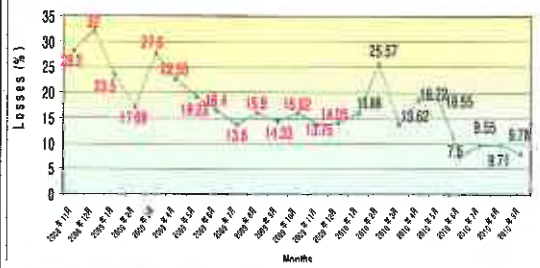
O&M Data : Maximum Daily Demand during 2008-2010



O&M Data : System Losses during 2008-2010

At the first month of commercial operation, the Energy losses is approximately 32 % high. But the losses is decreasing gradually in the following months, even if energy consumption is being increased.

Total Losses In Power System



Thank you for your attention,

J-Power Group, Japan

Disaster Prevention Plan for Electricity of Mondulkiri, EDC

(February 2011)

Contents

Chapter 1 Establishment of Disaster Management Support System (DMSS)

Clause 1 Disaster Management Support System (DMSS)
Clause 2 Operation of DMSS
Clause 3 Cooperation and Public Relation

Chapter 2 Disaster Prevention

Clause 1 Education of Disaster Prevention
Clause 2 Disaster Prevention for Electrical Generating Facility
Clause 3 Provision of Materials, Goods and Foods

Disaster Prevention Plan

Chapter 1 Establishment of Disaster Management Support System (DMSS)

Clause 1 Disaster Management Support System (DMSS)

1. Categorized DMSS

In case of accident, disaster and calamity may happen or has happened; such emergency case is categorized as follows. Natural disaster and calamities concerns primary mean floods, high winds, heavy rains, lightning and earthquakes.

Table-1 Categorized DMSS

Categorized DMSS	Situation of disaster
1. Primarily position	✓ There is a fear that disaster would happen, but not necessary to issue "Alert position". So, information and communication system must be provided.
2. Alert position	✓ There is a fear that disaster may happen. ✓ Alert position be issued due to heavy rainy and high winds become strong and continuous a few days.
3. Emergency position	✓ There have been happened disasters. ✓ Emergency position be issued due to heavy damage and broken houses/machines or so on.

2. Disaster management support system (DMSS)

In case of disaster has happened, DMSS must be organized for CENTER OF EMERGENCY PREPAREDNESS AND RESPONSE COMMUNICATIONS (**CEPRC**). Alert and Emergency positions at Branch office of Mondulkiri, EDC is in accordance with Table-1 Categorized DMSS. But, primarily position is not necessary to organize the center.

And also in case of disaster area or facilities, the stronghold must be located for its countermeasure and activity.

Clause 2 Operation of DMSS

1. Announce and cancel of disaster prevention position

(1) The announcement and cancel for the disaster prevention position must be judged by the chief of Mondul kiri, EDC.

(2) In case of alert and emergence positions are issued, the CEPRC must be set at headquarter, Mondulkiri as quickly as possible.

(3) The disaster prevention position must be cancelled when it is solved.

(4) Relief of the judgment for announce and cancel must be nominated in advance.

2. Exertion of authority

(1) In case of alert and emergence positions are issued, the activities and support must be instructed by CEPRC.

(2) In case of alert and emergence positions are issued, the leader of CEPRC must act and instruct to the staff.

3. Mobilization

When issued the disaster prevention position, the leader of CEPRC must instruct to act the obligated staff.

4. Root of correspondence and communication

When issued the disaster prevention position, the root of communication and instruction must be Fig-1 as follows.

The emergency announcement should be made by nominated group leader under the decision of leader of CEPRC as shown in Table-2 as attached.

Clause 3 Cooperation and Public Relation

1. Public congress of disaster prevention, etc.

In usually, Mondulkiri, EDC try to contact and join the meeting in Mondulkiri province or other public congress, also in abnormal, Mondulkiri, EDC aim the disaster prevention plan doing smoothly and adequately in relation with concerned party or public disaster center

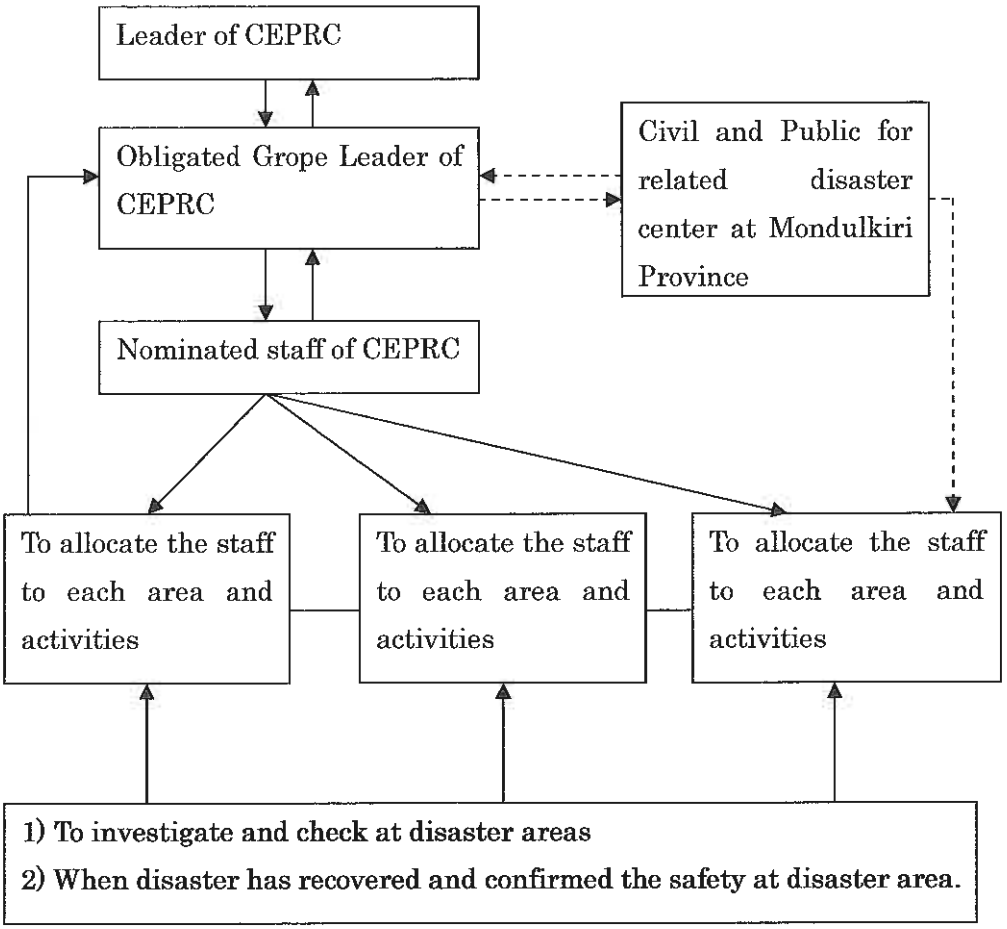
2. Cooperation of related disaster center

Mondulkiri, EDC should provide to exchange the prevention information and correlation system with public meteorological observatory and/or fire station. Refer to Fig-1 hereinbefore.

3. Correlation with headquarter of EDC

In periodically, Mondulkiri, EDC should provide the correlation system under headquarter of EDC and contractors in order to support staff, shortage parts and emergency budget, etc. in case of disaster.

Fig-1 CENTER OF EMERGENCY PREPAREDNESS AND RESPONSE COMMUNICATIONS (CEPRC) at Mondulkiri



Chapter 2 Disaster Prevention

Clause 1 Education of Disaster Prevention

Mondulkiri, EDC should make the education or seminar for the disaster prevention to all staff such as related law, quickly action, support and recovery, etc. by using pamphlet and professional center.

Clause 2 Drill of Disaster Prevention

Mondulkiri, EDC should confirm and carry out the disaster prevention training, at least, once a year in order to do the effectiveness function of the DMSS, and also to join the training of other public

center or so on.

Clause 2 Disaster Prevention for Electrical Generating Facility

1. Flood control measures

(1) Hydropower generating facility

Taking the past experiences and practices of the disasters into consideration, it is necessary to provide the countermeasure such as water barriers, extend of floor base, setting drainage pump, seal of cable ducts and emergency communication system, etc.

Especially, the prevention of flood control is important and the following must be check and maintained.

□ Dam, intake-gate, sedimentation and dam banks

□ Waterway and its surrounding area

□ Powerhouses

□ Water level measuring unit

(2) Transmission and distribution lines facility

□ Overhead lines

Reinforcement for transmission line roots due to landslide and erosion, etc.

□ Under ground cable

Water proof for cable heads

(3) Substation

The spot to be flood must be extended and reinforced by seal protection, making drainage and water barrier, etc.

2. Wind damage measures

Outdoor equipment such as transmission and distribution lines facilities and street lights must be reinforced and protected from strong wind.

3. Lightning damage measures

(1) Transmission and distribution lines facility

Ground wire and lightning arrestor as well as reducing earth-resistance must be considered.

In the case of announcement of heavy lightning or rain, operator and transmission line staff must be made a safety measure and good communication each other.

(2) Substation facility

The protection of lightning should be considered.

4. Land slide and ground sinking measure

The patrol and safety measure for land slide and ground sinking should be made, when unexpected happens. In case of such damage, the recovery and repairing work must be executed as soon as possible.

5. Fire, blast and oil leakage measure

The patrol and safety measure for the fire, blast and oil leakage should be made, when unexpected happens. The chemical and/or water extinguisher and oil fences, etc must be provided.

6. Earthquake measure

The patrol and safety measure for the fire, blast and oil leakage, land slide and collapsed houses, etc should be made, when unexpected happens.

(1) Hydropower station
(2) Diesel powr station
(3) Substation
(4) Transmission lines and distribution lines
(5) Telecommunication system
(6) Others

Clause 3 Provision of Materials, Goods and Foods

1. Providing necessary materials, goods and foods and water

As for the emergency measure necessary materials, goods and foods and water must be considered to provide each station or storage room, when unexpected happens.

Those good and material must be checked in periodically.

2. Providing transportation

Transportation for the above item 1 such as material, goods, foods and water should be lined up.

TABLE-2 DISASTER MANAGEMENT SUPPORT SYSTEM (DMSS)

ELECTRCITY OF MONDULKIRI BRANCH, EDC

Leader of CEPRC

/Chief of EOM
(Mr. Chin Sokhun)
/Deputy Chief of EOM
(Mr. Thai Khin)

CENTER OF EMERGENCY PREPAREDNESS AND RESPONSE COMMUNICATIONS AT HEADQUARTER (CEPRC)				
Group	Leader of Group	Description of Tasks		
Information G	Administration Devision (Mr. IM Vichet)	(1) Report to EDC Headquarter (2) Place of Crisis Measure Center (CMC) (3) Call of Supporter (4) Set of Communication (5) Collection of information (6) Contact of every group	(7) Report to Public office and Province (8) Public announce to the customers (9) Procurement of emergency goods (10) Emergency transportation (11) Providing food, clothes, medicine and accommodation (12) Taking care of disaster area	(13) Logging of all information and data (14) Others
Generation G	Electrical Devision (Mr. Theng Setha)	(1) As for all generating facilities that ①Countermeasure for trouble and fault ②Decision of measure plan ③Decision to contractor, maker, etc.	(2) Confirm telecommu. /VHF or telephone line (3) Disposition of supporter to disaster area (4) Logging for information and data	
Civil G	Technical and Operation Division (Mr. Thai Khin)	(1) As for all civil facilities that ①Countermeasure for trouble and fault ②Decision of measure plan ③Decision to contractor, maker, etc.	(2) Confirm telecommu. /VHF or telephone line (3) Disposition of supporter to disaster area (4) Logging for information and data	
Transmission line G	T & D line Division (Mr. Savuth Sothea)	(1) As for all transmission/distribution lines facilities that ①Countermeasure for trouble and fault ②Decision of measure plan ③Decision to contractor, maker, etc.	(2) Confirm telecommu. /VHF or telephone line (3) Disposition of supporter to disaster area (4) Logging for information and data	
Support G	Finance and Business Division (Ms Chres Malout) (Mr. Kong Botrachhany)	(1) Support for all divisions activities (2) Providing food, clothes, medicine and accommodation (3) Providing for emergency transportation (4) Procurement of emergency goods (5) Others		
Kev Siema G	Kev Siema Division (Mr. Pen Pidu)	(1) Support for Information Group (2) Support for Transmission line Group		

Table-3 Emergency Announcement № 1	
Purpose	Call for all staff in EOM at disaster occurred (within working hours①)
Situation	In case emergency
Announcer	Leader of administration group (but, after emergency system has build, the leading group must be Information group)
	① This is a crisis management support team ② Today ○:○day, ○:○ time, we have a disaster around ○○ area (or power station), in Mondul kiri city ③ As of now, EOM announces to operate the disaster management support system (DMSS) ④ The support staff must come at administration office and collection for any information ⑤ The related group must first report to information group about their safety at disaster area within 30 minutes An unnecessary matter must restraint to contact with disaster area and group.
Be clear and cool, you announce 2~3 times continuously	

Meeting Memo (No.1)
For Interconnection from Viet Nam Power System

Date: June 11, 2010 15:00-16:00
Place: EDC meeting room
Attendants: EDC, EUMP and JICA study team, as attached list
Summary of meeting:

1. We have the first meeting for plan of interconnection on the tranamission line from Viet Nam.

1) EDC has surveyed route of interconnection lines one month before (May 2010), and also confirmed the border of Viet Nam. This survey is a starting of our plan.
2) The plan of interconnection line is to be 22kV.
3) The transferring capacity is to be limited 3,000kW

2. EDC has also surveyed distribution route on June 3 to 7, 2010 at site.

1) EDC has a plan to use a conductor: a) ACSR 150 sq.mm, b) Insulated cable 150 sq.mm, and c) ABC cable 150sq.mm.

2) AVR compensator for voltage regulation will be installed at the end terminal of interconnection line

3) Both line of Dak Dam and Nam Lea (Busra) have been surveyed but Keov Seima line is not yet. There is possibility Dak Dam line after discussion of EDC and V.N, even if transmission line of V.N side will be longer than Cambodia side.

3. EDC is a lucky chance to import the power from V.N because of reducing the tariff in the future.

4. JICA study team has explained reasons why to have a meeting as attached paper and request the technical study on 21 June 2010 at 10:00 at EDC head office.
EDC confirmed to have a meeting on 21 June 2010.

5. EDC strongly requested JICA study team to join the technical meeting later on.
EDC will explain next meeting more detail information for the interconnection plan.

---- Ended------

Attached : 1) Attendants list
2) Information from JICA study team

KINGDOM OF CAMBODIA

NATION RELITION KING

LIST OF ATTENDANCE

Veue : EDC

Date : 11 June 2010 Time : 15:00

Subject : Survey Plan for Interconnection of EUMP 22 kV Transmission line

No.	Name of attendance	Position	Signature
	Mr. Ros Chanda	Director of Generation EDC	
	Mr. Houng Chantha	Head of Technical office	
	Mr. IV Visal	D.D. of Distribution	
	M. Peh Pha	Chief of technical office	
	M. Chim Sokhun	[illegible] director	
	Mr. THAI KHIN	deputi	
	Mr. YAMAKAWA HIROKATSU	SV of JICA	
	Mr. HIRAGA Y	JICA Study Team	
	Mr. Kry Mang Ang	"	

APPROVE BY :

Route of Interconnection between EUMP Power System and 22kV V.N System

2010/06/11

1.The comparison of 22kV T/L routes between EUMP and V.N

	Description	Route A (Keov-Seima)	Route B (Dak Dam)	Route C (Busra)
1	Route length from border	Approx. 70km	Approx. 30km	Approx. 70km
2	Road condition	Pavement	Dirt	Dirt and no road in some area
3	Environmental condition	Passing forest and required cutting trees some area	No forest and no required cutting trees	Passing forest and required cutting trees so many
4	Waiting consumers	Approx. 50-100 households	same	same
5	T/L condition in V.N side	There is existing 22 kV line from 18km of border, To s/s approx. ? km	To s/s approx. 80km and required to change conductor (55mm2 to ?)	To s/s approx. 45km

2. Technical point

1) Change of the conductor
Modul Kiri: AAAC55 sqmm
V.N: 150 sqmm

2) Different of Transmission line system
Mondul Kiri: 3 Phases 3 wires- floating system (Non grounding system)
V.N: 3 Phases 4 wires- Resistance grounding system

3) Voltage drop

Meeting Memo (No.2)

For Interconnection from Viet Nam Power System

Date: June 21, 2010 10:00-12:00

Place: EDC meeting room

Attendants: EDC, EUMP, JICA Volunteer Expert and JICA study team

Summary of meeting:

1. The 2nd meeting of Interconnection of V.N is a discussion of technical matter and showing EDC' plan.

2. EDC explained 2 items that,
   1) Connection point of the 22kV transmission line (T/L) in Mondul Kiri power system,

   EDC explained that 22kV T/L will be set with double lay on the existing concrete pole from No. PMT-01 (near O'Romis P.S) up to Hospital or District Cubicle stations. This connection cubicle (end terminal) will be fixed after site survey at site.
   EDC will design and provide the necessary equipment such as LBS, Metering, AVR (auto transformer) Capacity bank, and synchronizing equipment, etc.

   2) Plan of synchronizing between V.N and Mondul Kiri system.
   EDC asked JICA study team to suggest the Specifications and cost estimation of synchronizing equipment, JICA study team will advise it.

3. The Specifications and cost estimation will be provided within this year and make bidding, if possible.

4. Next meeting will be held in July with Mr. Shinohara (T/L advisor) and August with Mr. Hiraga.

---- Ended------

Attached : 1) Connection plan drawing

Meeting Memo (No.3)
For Interconnection from Viet Nam Power System

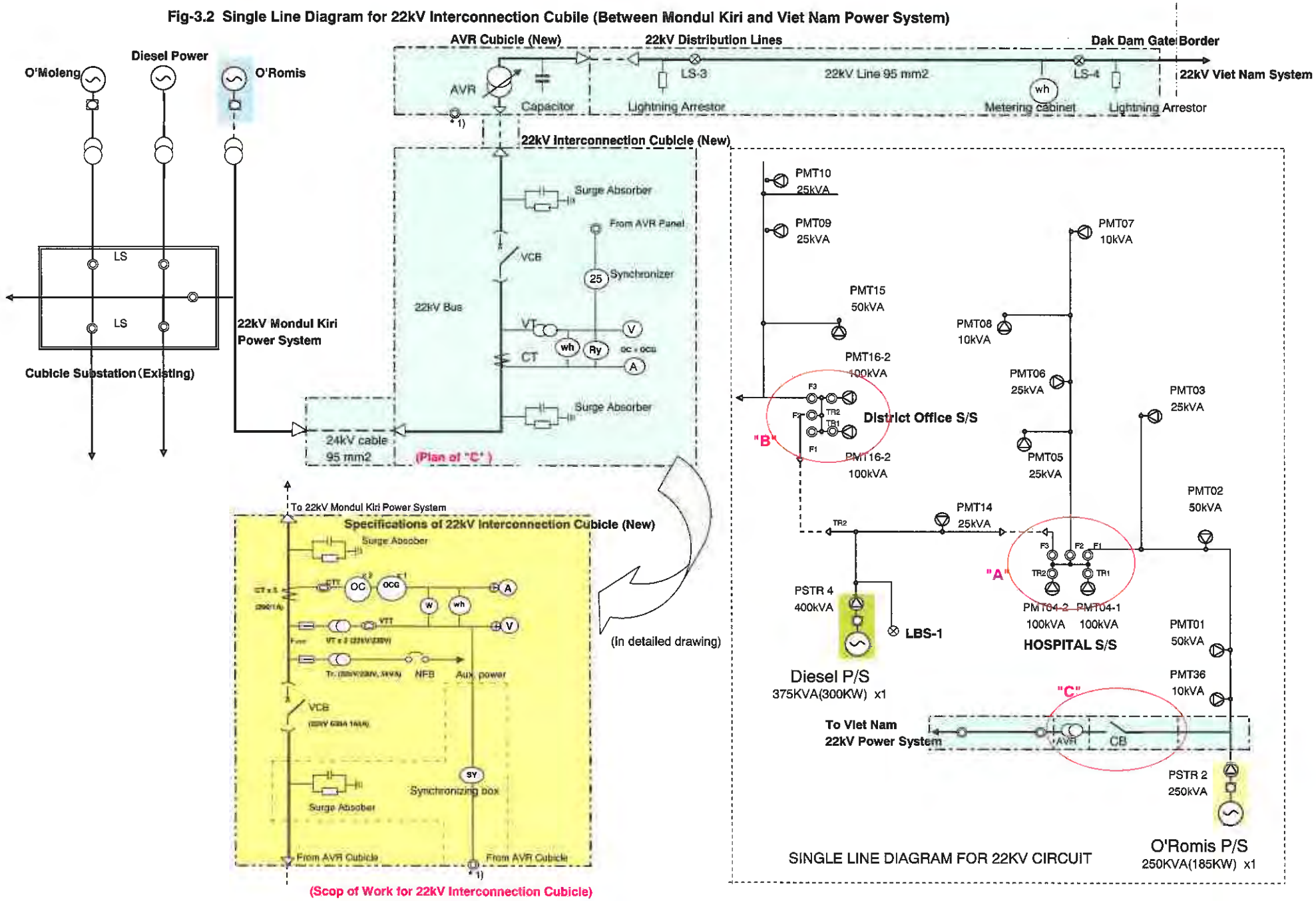
Date: August 12, 2010 9:00-11:00
Place: EDC meeting room
Attendants: EDC Mr. Houng Chantha (technical office), Generation Dept.
EM Mr. Khinand, JICA study team (Mr. Hiraga)

Summary of meeting:

1. EDC has surveyed the route of interconnection lines and decided the interconnection point at inside of O'Romis power station or near national road area.
   EDC will finalize the place after internal discussuin.
2. As for the save of budget, the conductor is to be changed 22kV AAAC 95mm2 from 150mm2.
3. The construction of 22kV line will be started around early next year, 2011 after bidding finished.
4. JICA study team has recommended taking consideration of safety measure and maintenance condition to be placed the interconnection point.
5. JICA study team has also recommended that CB (circuit breaker) panel is provided in the design due to the technical point of view.
6. EDC requested that JICA study team will advise the design of CB panel with budget breakdown by the next visiting.
7. After getting the advise from CB panel design, EDC will make a proposal of budget and design plan and finalization of the interconnection plan.

---- Ended-----

Fig-3.2 Single Line Diagram for 22kV Interconnection Cubile (Between Mondul Kiri and Viet Nam Power System)



Appendix 4-12

TECHNICAL SPECIFICATIONS
FOR
INTERCONNECTION OF 22KV POWER SYSTEM
IN MONDUL KIRI, EDC
(Between Mondul Kiri and Viet Nam)

September 2010

Recommended by JICA Study Team

TECHNICAL SPECIFICATIONS

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TECHNICAL SPECIFICATIONS

Section 1 General

1.1 Scope of Works

The Contractor shall be responsible for the designing, manufacturing, supplying, testing before shipment, finishing, painting, packing for transport, insuring, shipping, delivering to the Port, landing, customs clearing, transporting to the Site, erecting, training, Site testing and commissioning of the Scope of Works.

1.2 General Requirement for Works

(1) Contractor's Temporary Facilities

The Client will provide the Contractor, free of charge, with stock yard in temporary for construction materials at the Site. After completion of the Works, the Contractor shall, at his own cost and expenses, clean and repair restore the stock yard into the original condition.

(2) Minimum Requirement

(a) The Contractor shall submit the Implementation schedule.

(b) The Contractor shall be responsible for making every necessary arrangement to secure the safety during the Construction at site.

(c) In case of the repair in finishing works for concrete foundation put on the panels shall be undertaken only by the Contractor at his own expense and shall be subject to inspect by the Client.

(d) The Contractor shall, at his own expense, do all excavation, backfilling and restoration for the purposes of repairing into original conditions or other defect as discovered during the period of the test.

(e) The work under this section shall comprise the supply of fence to be protected from any miscellaneous objective in the setting area for electrical equipment.

(f) The installation work shall include storage, transport to the work spot, installation, erection, site tests shall be executed in accordance with the "For Work Drawings" and the approved installation procedures by the Client.

g) The shop test for Interconnection cubicle including circuit breaker (VCB) shall be conducted under the presence of Client.

h) The Contractor shall submit Client the technical drawing and documents for approval and also submit a required necessary data for reference

The drawing/document/Instruction manual shall be submitted each 5 sets for Approval, for Final and for As-built-drawing. 2 sets of completed PDF file in CD-R for As-built-drawing shall also be submitted to Client.

1.3 Tests on Completion

After completion of the entire project works, the site test shall be done prior to the charging test of the 22kV lines in close cooperation with the Client.

Section 2 Interconnection Equipment

2.1 Scope of 22kV Interconnection Equipment

The Contractor shall supply and commission the following equipment:

(1) 22kV Interconnection Panel (VCB Panel)
(2) 22kV Vacuum Circuit Breaker (VCB)
(3) 22kV Surge Absorber (SA)
(4) Control and Protection equipment
(5) General electrical works
(6) Spare parts

2.2 22kV Interconnection Panel (VCB Panel)

The cubicle shall be consisted the following equipment and parts.

One (1) set of 22kV outdoor Kiosk with metal-clad type switchgear assembly mounted inside the following equipment:

(1) One (1) set of three-pole 22kV Vacuum type circuit breaker (VCB) for main circuit
(2) Two (2) sets of 2-poles 230 V MCCB for auxiliary power supply circuit with shunt trip mechanism (one for spare)
(3) One (1) set of three phases busbar
(4) One (1) watt meter 0-3,000 kW for main circuit
(5) One (1) A.C. voltmeters 0-25 kV with change over switch
(6) One (1) A.C. ammeters 0-300 A with change over switch
(7) One (1) frequency meter 45-50-55 Hz
(8) One (1) watt-hour meters
(9) One (1) set of group fault indicators
(10) One (1) set of status indication lamps
(11) Two (2) over current relays (51)
(12) One (1) over current ground relays (51G)
(13) One (1) overvoltage relay (59)
(14) One (1) reverse-power relay (67)
(15) One (1) lot of VT, CT of auxiliary transformers for the control and protection
(16) One (1) lot of indication lamps as required
(17) One (1) synchronizing equipment with control relay (automatic – manual change)
(18) One (1) lot of alarming devices; buzzer, bell and their control bottoms
(19) Six (6) sets of surge absorber
(20) One (1) Voltage indicator (LED) for charging

(21) Six (6) sets of Cable terminal for Income and outgoing

(22) Terminal blocks and other necessary accessories to make a complete working excitation control system

2.2.1 Enclosure

(1) Type

22kV switchgear shall be of floor-standing, outdoor installation, metal-clad type conforming to IEC 298 (1981) and of robust construction.

The degree of protection for the enclosures and partitions, conforming to IEC 694 & 298, shall be as follows:

(a) Enclosures: IP 2X or equivalent

(b) Partitions: In Compartment

(2) Construction requirement

The enclosures for the switchgear shall be constructed by rigid framed, floor-standing structure completely enclosed by sheet steel.

The withdrawable type equipment compartment shall be provided with a shutter to prevent exposure of stationary live contacts when the equipment is in the disconnected, test or removed position.

The enclosure shall be provided with access doors to facilitate inspection of the equipment, provided with suitable handles with locks.

The enclosure shall be provided with suitable cable terminal compartments for the following 22 kV cross-linked polyethylene (XLPE) insulated power cables: Suitable means shall be provided for supporting the terminal and cables.

(a) One (1) circuit of 95 mm^2 or more, three-core type, for 22kV income circuit from 22kV Viet Nam power system under this Contract,

(b) One (1) circuit of 95 mm^2 or more, three-core type, for 22kV outgoing circuit to existing 22kV power system line.

A copper ground busbar of 3 x 20 mm^2 or a similar size shall be provided at the bottom of the enclosure. Clamp type grounding terminals shall be provided for connecting the grounding system.

(3) Accessories

The following items shall be provided for the enclosures:

(a) Name plates for the equipment to be housed

(b) Channel bases

(c) Foundation bolts and nuts

(d) Grounding pads

(e) Other necessary accessories

2.2.2 Busbars and Connections

(1) Type

The busbars and electrical connections shall be of electrolytic copper or aluminium alloy silver coated, sufficiently insulated from ground and from each other.

(2) Rating

The busbars shall be rated as follows:

(a) Rated voltage 24 kV

(b) Rated insulation level 125 kV

(c) Rated normal current 630 A

(d) Rated short-time withstand current 16 kA for one (1) second

The busbars shall be designed to carry continuously the rated normal current without exceeding a temperature rise of 50°C at an ambient temperature not exceeding 40°C.

2.3 22kV Vacuumed Circuit Breaker (VCB)

(1) Requirement: One (1) set

The circuit breaker shall be served for 22kV line control and protection according to Standards IEC60056 (or JEC2300).

(2) Type

The circuit breaker shall be of vacuum type, three-pole, single throw, withdraw-able, surge suppressive type, electrically and mechanically trip-free in any position with anti-pumping feature, complete with necessary controls and wiring, draw-out wheels, and any other accessories needed for operation.

(3) Rating

The circuit breakers shall be rated as follows:

(a) Rated voltage 24 kV

(b) Rated insulation level 125 kV

(c) Rated normal current 630 A

(d) Rated short-circuit breaking current (r.m.s.) 16 kA

(e) Rated interrupting time 5 cycles

(f) Rated operating sequence CO- 15 sec.-CO

(4) Operating mechanism

The circuit breakers shall be provided with local electrical controls driven by an AC operated closing and tripping system of capacitor trip power supply device and a local manual operation gear. A molded case circuit breaker shall be provided for the A.C supply circuit.

(5) Accessories

The following items shall be provided for the circuit breakers:

(a) Rating plate
(b) Position indicating lamps; red and green
(c) Auxiliary switches
(d) Operation counter
(e) Closing spring condition indicator
(f) Draw-out unit with handle and guide
(g) Necessary terminal connections
(h) Local control box with push buttons of "ON" and "OFF"
(i) Other necessary accessories
(j) One (1) set of maintenance tools
(k) One (1) manual charging handle
(l) One (1) moving cart

(6) Spare parts

The following spare parts shall be furnished and quoted:

(a) One (1) closing coil
(b) One (1) tripping coil
(c) One (1) spring charging motor (if applicable)
(d) One (1) bushing of each type
(e) 500% of actual use of indicating lamps and fuses
(f) One (1) set of indicating lamp lenses; red and green
(g) One (1) set of contacts, coils, relays, valves and other small components

(7) Tests

(a) The following test shall be carried out at the manufacturer's plant before shipment, in compliance with IEC 56-4 (1972).

i) Appearance check
ii) Power-frequency voltage dry test on the main circuit
iii) Voltage withstand tests on control and auxiliary circuits
iv) Measurement of the resistance of the main circuit
v) Mechanical operating test
vi) Measurement of making and breaking time

(b) The certificates of the following type test items shall be submitted with the test report:

i) Mechanical test
ii) Temperature rise test
iii) Impulse voltage test
iv) Short-circuit making and breaking test
v) Short-time current test

(c) The preliminary and performance tests as specified in Clause GS3.15.19 of Part A General Specifications shall be carried out by the Contractor at the Site.

2.4 Surge Absorbers

The surge absorber shall be consisted of capacitor and lightning arrester. The surge absorbers shall be installed in the 22kV Interconnection Cubicle. The rating of the surge absorber shall be as follows:

(a)	Rated voltage	:	24 kV
(b)	Rated discharge current	:	10 kA
(c)	Rated frequency	:	50 Hz

The grounding wire for the surge absorber on one pole can be connected together to one electrode, but the grounding circuit of the surge absorber shall not be connected to the grounding circuit of other equipment.

2.5 Current Transformers

(1) Type

The current transformer shall be of single-phase, epoxy molded type according to Standards IEC60044-1 (JEC1201).

(2) Rating

The current transformers shall be rated as follows:

(a)	Highest system voltage	24 kV
(b)	Rated insulation level	125 kV
(c)	Rated current ratio (Rated primary current/Rated secondary current)	15-100/5 A
(d)	Rated burden	as required
(e)	Rated short-time thermal current	16 kA for one (1) second
(f)	Accuracy class	
	i) for measuring	1.0
	ii) for protective relaying	5P20

The rated burden of each current transformer shall be proposed by the Contractor to suit the actual burden required for the protective relays, cables and wires. A calculation sheet for the rated output shall be submitted for approval.

The current transformer with other type and ratings for protective relaying may be proposed by the Contractor for approval.

(3) Accessories

The following items shall be provided for the current transformers:

(a) Rating plates

(b) Necessary terminal connections

(c) Other necessary accessories

(4) Tests

(a) The following tests shall be carried out at the manufacturer's plant:

i) Appearance check
ii) Measurement of current ratio
iii) Check of relative polarities
iv) Power frequency voltage test on primary winding

(b) The certificates of the following type test items shall be submitted with the test report:

i) Short-time current test
ii) Temperature rise test
iii) Impulse voltage test
iv) Test for accuracy

2.6 Voltage Transformers

(1) Type

The voltage transformers shall be of three-phase, epoxy mold type according to Standards IEC60044-2 (JEC1201).

(2) Rating

The voltage transformers shall be rated as follows:

(a)	Highest system voltage	24 kV
(b)	Rated primary voltage	22 kV
(c)	Rated secondary voltage	110 V
(d)	Rated burden	As required
(e)	Rated voltage factor	1.2 for continuous
(f)	Rated insulation level	125 kV
(g)	Accuracy class	1.0

(3) Accessories

The following items shall be provided for the voltage transformers:

(a) Rating plates
(b) Necessary terminal connections
(c) Fuse for secondary circuit
(d) Other necessary accessories

(4) Spare parts

The following spare parts shall be furnished and quoted:

(a) 500% of actual use of fuses

(5) Tests

(a) The following tests shall be carried out at the manufacturer's plant:

i) Appearance check
ii) Measurement of voltage ratio
iii) Check of relative polarity

iv) Power frequency voltage test on primary winding

(b) The certificates of the following type test items shall be submitted with the test report:

i) Temperature rise test

ii) Impulse voltage test

iii) Test for accuracy

2.7 Control and Protection for 22 kV Power System

The following measuring and control instruments shall be furnished and mounted on the front panel or inside of the cubicle. Parts are referred to Clause 2.2.

(1) Composition for control and protection

(a) One (1) auxiliary circuit breaker (NFB) with two positions of "ON" and "OFF"

(b) One (1) A.C. voltmeter 0-25 kV with a change-over switch

(c) One (1) A.C. ammeter 0-300 A with a change-over switch

(d) One (1) watt meter 0-3,000 kW for main circuit

(e) One (1) set of group fault indicators

(f) Two (2) over current relays (51) for protection, suitable for tripping low over current rate

(g) One (1) over current ground relay (51G) for protection

(h) Test Terminal Blocks (TTB)

(i) One (1) NFB for spare

(j) Other necessary accessories

(2) Spare parts

The following spare parts shall be furnished and quoted:

(a) One (1) set of protective relays of each type.

(b) One (1) set of meters of each type.

(c) One (1) set of auxiliary relays, contactors, switches, timers, rheostats, rectifiers, etc. of each type.

(d) One (1) lot of fuses for 500 per cent of supply

(e) One (1) lot of indicating lamp and lenses

2.8 Miscellaneous Materials

2.8.1 Scope of Miscellaneous Materials

The miscellaneous materials to be supplied and installed are as follows:

(1) Power cables and fittings

(2) Control cables and fittings

(3) Insulated wires and fittings

(4) Bare copper conductors

(5) Other materials

(6) New cubicle earthing system

(7) Outdoor lighting for new cubicle

2.8.2 Power Cables

All power cables shall be of single- or multi- core copper, PVC sheathed type with suitable cable ends. The power cables for 22 kV circuit shall have metal shield or have semiconducting tape and tinned copper wire shield.

The following power cables shall be supplied and installed by the Contractor:

(1) 22 kV cross-linked polyethylene (XLPE) insulated cable of 100 mm^2 single-core or 150 mm^2 multi core type for 22 kV circuit.

(2) Other power cables required for the equipment to be covered under this Contract shall also be supplied and installed by the Contractor. The minimum size of power cables shall be proposed by the Contractor.

2.8.3 Control Cables

The control cables shall be of jacket type 600 V polyvinyl chloride (PVC) insulated, PVC sheathed cables of single-core or multi-cores (CVV) for general use, with the sectional area of core not less than 1.5 mm^2.

2.8.4 Insulated Wires

600 V grade, PVC insulated wires (IV) may be used for power and space heater circuits for auxiliary equipment. The minimum size shall be 1.5 mm^2.

2.8.5 Bare Copper Conductor

Bare copper stranded wire shall be used for the earthing system. The size of earthing conductor shall be 50 mm^2.

2.8.6 Earthing Rod

Earthing rod shall be used for the earthing connected with earthing mesh. The size of earthing rod shall be of about 25 mm in diameter and 2 m long copper plated steel rod.

2.8.7 Other Materials

All cable trays and supporting brackets required for the installation of power cables and control cables shall be supplied and installed by the Contractor.

All other miscellaneous materials; such as conduit pipes, wooden cable cleats, angle steel, channel steel, steel plate, bolts, nuts and other items required for putting into service the Plant shall be supplied and installed as required according to the Consultant's instruction.

Section 3 Drawings

The following drawings are referred to design and supply of equipment.
The Contractor shall submit a necessary drawings, documents, calculation sheets, instruction & maintenance manuals, etc for approval.

3.1 Single Line Diagram for 22kV Power System of Mondul Kiri, EDC

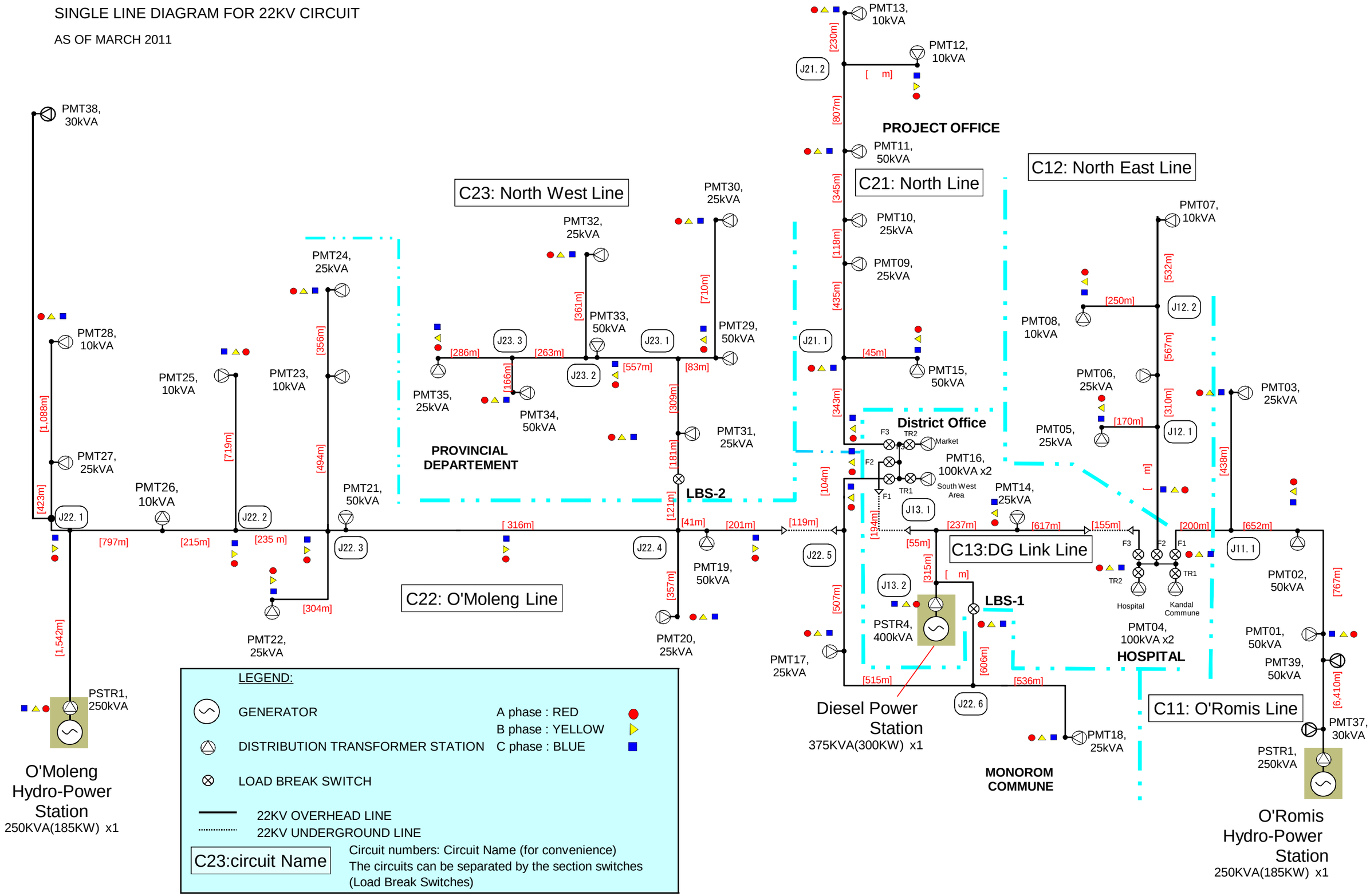
3.2 Single Line Diagram for Interconnection Cubicle

Appendix 5 Transmission and Distribution Line Facilities

Appendix 5-1 : Single line diagram for 22kV Transmission Line System (as of March 211)
Appendix 5-2 : Distribution line map (as of March 211)
Appendix 5-3 : Self-evaluation sheets for T/L section (June 2010)
Appendix 5-4 : Self-evaluation sheets for T/L section (September 2010)
Appendix 5-5 : Self-evaluation sheets for T/L section (February 2011)
Appendix 5-6 : Action plan sheets for T/L section
Appendix 5-7 : Energy Loss Calculation

SINGLE LINE DIAGRAM FOR 22KV CIRCUIT

AS OF MARCH 2011



As of 1st Mart. 2011

Total length of 22kV MVL :	27.8km
Total length of 400/230V LVL :	32.4km
Total number of Transformers	44 pcs
Distributiob Transformer	41 pcs
Step-up Transformer	3 pcs
Total capacity of Transformers	1,865 KVA

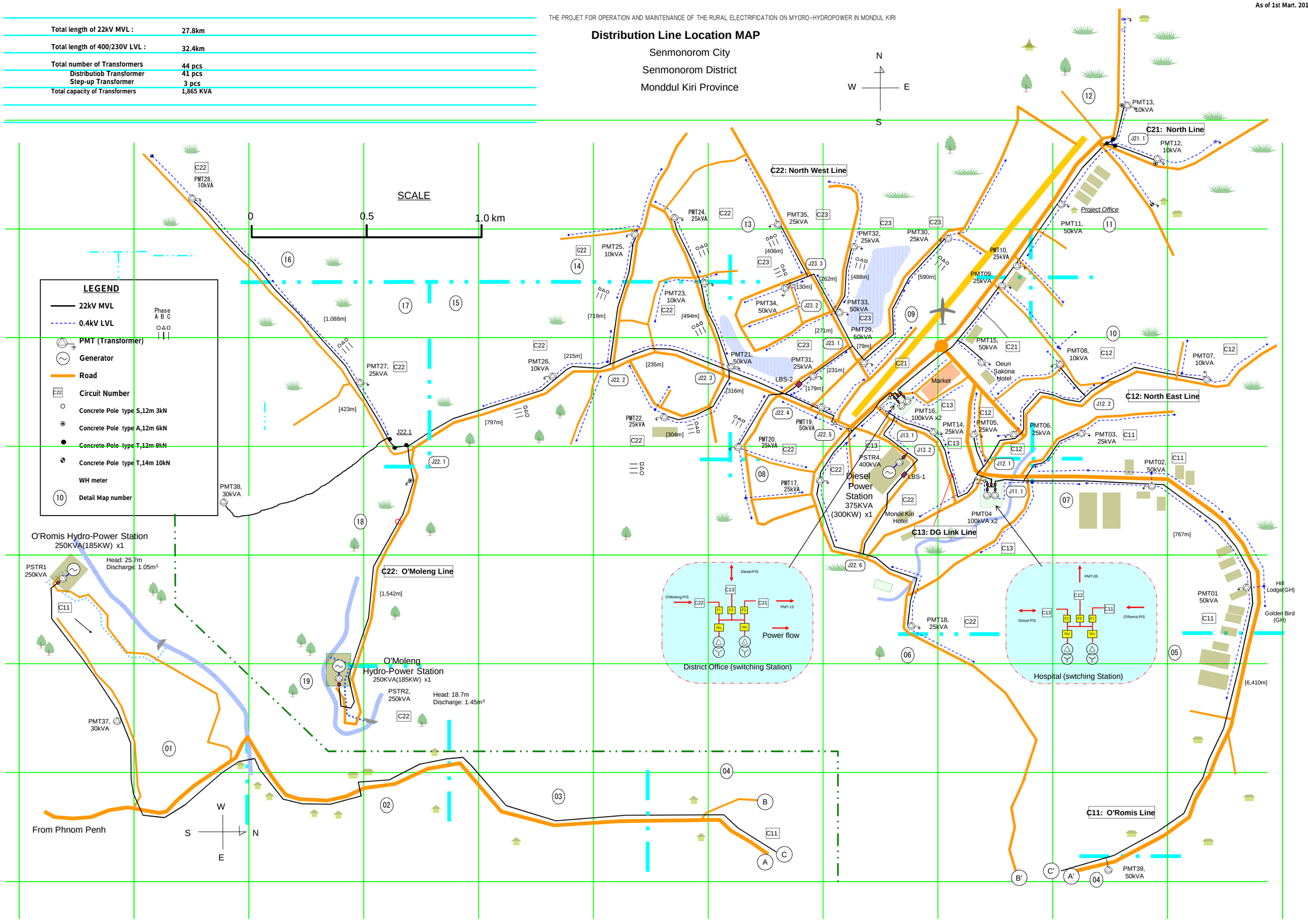
THE PROJET FOR OPERATION AND MAINTENANCE OF THE RURAL ELECTRIFICATION ON MYCRO-HYDROPOWER IN MONDUL KIRI

Distribution Line Location MAP

Senmonorom City

Senmonorom District

Monddul Kiri Province



Appendix 5-3

Evaluation Plan for Abilities of EUMP

Transmission and Distribution

May, 2010

JICA Advisor Team
Project for Operation and Maintenance
of the Rural Electrification on Micro-hydropower
in Mondul Kiri

1. Summary of Evaluation Plan for Transmission and Distribution Ability

(1) Term of Evaluation: From May, 2010 until March, 2011

(2) Evaluation Point of Time: 1St Point - May, 2010

2nd Point - September, 2010

3rd Point - February, 2011 (Final)

(3) Target: Technical Personnel of EUMP

1）Technical Division: 2 members

2）T/L , D/L & Metering Section: 5 members

2. Evaluation Methodology

First Evaluation: May 2010

1) First Self-Evaluation by using Evaluation Sheet

Target person in charge conducts the first self-evaluation of items in Task Code by using "Evaluation Sheet". JICA advisor will give some suggestions.

2) Making out Action Plan

Based on the result of the first self-evaluation, target person in charge makes out each action plan to improve the ability of O&M and submits it to JICA Advisory team.

JICA advisor will give some suggestions.

⇩

Second Evaluation: September 2010

3) Interim Self-Evaluation

Target person in charge conducts the second self-evaluation by using "Evaluation Sheet" and modifies the action plan if needed.

⇩

Third Evaluation: December 2010

4) Final Self-Evaluation

Target person in charge conducts the third self-evaluation by using "Evaluation Sheet". And Target person in charge submits it and the result of action plan to JICA advisory team.

5) Advise by JICA team

JICA advisor will give some suggestions to improve their ability though interview.

⇩

Comprehensive Evaluation: February 2011

6) Comprehensive Evaluation

JICA advisor conducts comprehensive evaluation by using the report and attitude during OJT.

How to Check the Ability

To check the ability is the five-level rating system.

Rating: (High) A－B－C－D－E (Low)

Legend:

A: 100~80% ⇒ I can completely do tasks and necessary O&M techniques of T/D.

B: 79~60% ⇒ I can fairly do tasks and necessary O&M techniques with no instruction.

C: 59~40% ⇒ I can completely do tasks for O&M with the instruction of T&D section Manager.

D: 39~20% ⇒ I can completely do tasks for O&M with the instruction of Technical division Manager.

E: 19% and below ⇒ I need more training for self-operation.

Result of Achievement Evaluation

Task Item & Code	Task Number	First Evaluation	Second Evaluation	Third Evaluation	Comprehensive Evaluation
1）Planning	① ②				
2）Measurement	① ②				
3）Scheduled Outage Operation	① ② ③ ④ ⑤				
4) Fault Outage Operation	① ② ③ ④				
5) Maintenance	① ② ③				

	④ ⑤				
6) Customer’s Request or Claim	① ② ③ ④				
7) Construction	① ② ③ ④ ⑤				
8) Customer Contract	① ② ③ ④ ⑤ ⑥				

Annex-1. Evaluation Sheet

Rating: (High) A－B－C－D－E (Low)

Check 1: Planning (Task Code: TT2)

① Do you have the capacity to make long and mid-term plan and budget?
② Do you have the capacity to make daily activity plan of operation, maintenance and construction?

Check 2: Measurement (Task Code: TT3)

① Do you have the capacity to analyze operation condition such as load, loss and voltage drop?
② Do you have the capacity to measure voltage and current?

Check 3: Scheduled Outage (Task Code: TT4)

① Do you have the capacity to make the switching procedure?
② Do you have the capacity to notify the scheduled outage to customers?
③ Do you have the capacity to order switching operation?
④ Do you have the capacity to operate the switch?
⑤ Do you have the capacity to record scheduled outage operation?

Check 4: Fault Outage (Task Code: TT5)

① Do you have the capacity to decide the method to restore?
② Do you have the capacity to order each action to restore?
③ Do you have the capacity to find and restore the fault?
④ Do you have the capacity to record fault outage operation?

Check 5: Maintenance (Task Code: TT6)

① Do you have the capacity to patrol and inspect T&D facility?
② Do you have the capacity to record patrol and inspection result?
③ Do you have the capacity to negotiate with owner of obstruct close to T&D line?
④ Do you have the capacity to control spare parts?
⑤ Do you have the capacity to maintain working tools?

Check 6: Customer's Request or Claim (Task Code: TT7)

① Do you have the capacity to deal with interruption of power supply?
② Do you have the capacity to deal with abnormal voltage?
③ Do you have the capacity to deal with Wh meter broken?
④ Do you have the capacity to deal with Wh meter checking?

Check 7: Construction (Task Code: TT8)

① Do you have the capacity to make a specification of constructions?
② Do you have the capacity to construct T&D facility?
③ Do you have the capacity to supervise construction work?
④ Do you have the capacity to inspect construction?
⑤ Do you have the capacity to update facility book?

Check 8: Customer Contract (Task Code: TT9)

① Do you have the capacity to do technical review of supply application?
② Do you have the capacity to do connection work?
③ Do you have the capacity to install Wh meter?
④ Do you have the capacity to deliver invoices to customers?
⑤ Do you have the capacity to do temporary disconnection & re-connection?
⑥ Do you have the capacity to remove Wh meter from ex-customer?

Annex -2 Format of Self-evaluation sheet

Division, Position _____

Name _____

Date, Place _____

Name of JICA Advisor _____

Task Item and Code Number	Number of Detailed Task	Grade of Evaluation	Reason or Comment	Check by JICA
1)	①	A B C D E		
	②	A B C D E		
2)	①	A B C D E		
	②	A B C D E		
3)	①	A B C D E		
	②	A B C D E		
	③	A B C D E		
	④	A B C D E		
	⑤	A B C D E		
4)	①	A B C D E		
	②	A B C D E		
	③	A B C D E		
	④	A B C D E		
5)	①	A B C D E		
	②	A B C D E		
	③	A B C D E		
	④	A B C D E		
	⑤	A B C D E		
6)	①	A B C D E		
	②	A B C D E		

	③ ④	A B C D E A B C D E		
7)	① ② ③ ④ ⑤	A B C D E A B C D E A B C D E A B C D E A B C D E		
8)	① ② ③ ④ ⑤ ⑥	A B C D E A B C D E A B C D E A B C D E A B C D E A B C D E		

Note: Number of detailed task shall be referred to Evaluation sheet

Result of the First Self-Evaluation for Transmission and Distribution Work on May 25, 2010

Item	Name	Mr. Chin Sokhun	Mr. Thai Khin	Mr. Theng Setha	Mr. Savuth Sothea	Mr. Ret Soksamdy	Mr. Reoum Navy	Mr. Tim Seanghi	Mr. Ros Panha	Mr. Ruos Samnang	Mr. So Sovannarith	Average
	Current Position	Deputy Director	Division Manager	Group Leader of DG Section	Section Manager	Group Leader	Operator	Operator at O'Romis Section	Operator (from January 201(	Operator	Operator	
	Future Position after transferring EUMP to EDC	Director	Deputy Director	Division Manager	Section Manager	Group Leader	Operator	Operator	Opeator	Leave	Leave	
TT2 Planning	① Do you have the capacity to make long and mid-term plan and budget?	A	D	B	D	-	-	-	-	-	-	65%
	② Do you have the capacity to make daily activity plan of operation, maintenance and construction?	B	B	A	C	-	-	-	-	-	-	80%
TT3 Measurement	① Do you have the capacity to analyze operation condition such as load, loss and voltage drop?	A	A	A	C	C	B	B	C	B		80%
	② Do you have the capacity to measure voltage and current?	A	A	A	B	B	B	B	C	B		84%
TT4 Scheduled Outage	① Do you have the capacity to make the switching procedure?	A	A	A	B	C	C	B	D	B		78%
	② Do you have the capacity to notify the scheduled outage to customers?	A	A	A	B	C	A	B	C	B		84%
	③ Do you have the capacity to order switching operation?	A	A	A	B	C	D	C	C	B		76%
	④ Do you have the capacity to operate the switch?	A	A	A	B	B	B	B	C	B		84%
	⑤ Do you have the capacity to record scheduled outage operation?	A	A	A	B	B	B	B	C	B		84%
TT5 Fault Outage	① Do you have the capacity to decide the method to restore?	A	A	B	C	C	D	B	C	C		71%
	② Do you have the capacity to order each action to restore?	A	A	B	B	C	B	A	C	C		80%
	③ Do you have the capacity to find and restore the fault?	A	A	A	B	C	C	B	C	B		80%
	④ Do you have the capacity to record fault outage operation?	A	A	A	B	B	B	B	C	B		84%
TT6 Maintenance	① Do you have the capacity to patrol and inspect T&D facility?	A	A	A	B	B	A	A	C	B		89%
	② Do you have the capacity to record patrol and inspection result?	A	A	A	B	B	B	A	C	B		87%
	③ Do you have the capacity to negotiate with owner of obstruct close to T&D line?	A	A	B	B	B	A	B	B	C		84%
	④ Do you have the capacity to control spare parts?	A	A	A	C	C	D	D	C	C		69%
	⑤ Do you have the capacity to maintain working tools?	A	A	A	B	B	B	B	C	B		84%
TT7 Customer's Request or Claim	① Do you have the capacity to deal with interruption of power supply?	A	A	B	B	C	A	B	D	C		78%
	② Do you have the capacity to deal with abnormal voltage?	A	A	C	B	C	B	B	C	B		78%
	③ Do you have the capacity to deal with Wh meter broken?	A	A	A	B	B	A	B	C	B		87%
	④ Do you have the capacity to deal with Wh meter checking?	A	A	A	B	B	B	A	C	B		87%
TT8 Construction	① Do you have the capacity to make a specification of constructions?	B	D	B	C	D	D	B	D	B		60%
	② Do you have the capacity to construct T&D facility?	A	A	B	B	D	D	C	D	C		67%
	③ Do you have the capacity to supervise construction work?	A	A	A	C	D	D	B	D	B		71%
	④ Do you have the capacity to inspect construction?	A	A	B	B	D	D	B	D	B		71%
	⑤ Do you have the capacity to update facility book?	A	A	B	C	D	D	D	C	C		64%
TT9 Customer Contract	① Do you have the capacity to do technical review of supply application?	A	A	A	B	C	A	B	C	B		84%
	② Do you have the capacity to do connection work?	A	A	A	B	B	A	B	C	B		87%
	③ Do you have the capacity to install Wh meter?	A	A	A	B	B	A	A	C	B		89%
	④ Do you have the capacity to deliver invoices to customers?	A	A	A	B	B	A	A	C	B		89%
	⑤ Do you have the capacity to do temporary disconnection & re-connection?	A	A	A	B	B	A	A	C	B		89%
	⑥ Do you have the capacity to remove Wh meter from ex-customer?	A	A	A	B	B	A	A	C	B		89%

Legend: A 100%, B 80%, C 60%, D 40%, E 20% : Selected item for Action Plan * Mr. So Sovannarith was not in Mondul Kiri during the evaluation.

Result of the Interim Self-Evaluation for Transmission and Distribution Work on September 25, 2010

Item	Name	Mr. Savuth Sothea	Mr. Ret Soksamdy	Mr. Reoum Navy	Mr. Tim Seanghi	Mr. Ros Panha	Mr. Sum Dara	Mr. Hang Rotha	Average
	Position	Section Manager	Group Leader	Operator	Operator	Opeator	Operator(New)	Operator(New)	
TT2 Planning	① Do you have the capacity to make long and mid-term plan and budget?	B	-	-	-	-	-	-	80%
	② Do you have the capacity to make daily activity plan of operation, maintenance and construction?	A	-	-	-	-	-	-	100%
TT3 Measurement	① Do you have the capacity to analyze operation condition such as load, loss and voltage drop?	A	A	A	B	A	C	B	89%
	② Do you have the capacity to measure voltage and current?	A	A	A	A	A	A	A	100%
TT4 Scheduled Outage	① Do you have the capacity to make the switching procedure?	A	A	B	B	A	B	B	89%
	② Do you have the capacity to notify the scheduled outage to customers?	A	A	A	A	A	A	A	100%
	③ Do you have the capacity to order switching operation?	A	A	B	A	A	B	A	94%
	④ Do you have the capacity to operate the switch?	A	A	B	A	A	A	A	97%
	⑤ Do you have the capacity to record scheduled outage operation?	A	A	A	A	A	A	A	100%
TT5 Fault Outage	① Do you have the capacity to decide the method to restore?	A	A	B	B	A	A	A	94%
	② Do you have the capacity to order each action to restore?	A	A	A	B	A	B	B	91%
	③ Do you have the capacity to find and restore the fault?	A	A	B	A	B	C	A	89%
	④ Do you have the capacity to record fault outage operation?	A	A	A	A	A	A	A	100%
TT6 Maintenance	① Do you have the capacity to patrol and inspect T&D facility?	A	A	A	A	A	A	A	100%
	② Do you have the capacity to record patrol and inspection result?	A	A	A	B	A	A	A	97%
	③ Do you have the capacity to negotiate with owner of obstruct close to T&D line?	A	A	A	A	A	A	A	100%
	④ Do you have the capacity to control spare parts?	A	A	A	B	A	A	B	94%
	⑤ Do you have the capacity to maintain working tools?	A	A	A	A	A	A	A	100%
TT7 Customer's Request or Claim	① Do you have the capacity to deal with interruption of power supply?	A	A	A	B	A	A	A	97%
	② Do you have the capacity to deal with abnormal voltage?	A	B	A	B	A	C	A	89%
	③ Do you have the capacity to deal with Wh meter broken?	A	A	A	A	A	A	A	100%
	④ Do you have the capacity to deal with Wh meter checking?	A	A	A	A	A	A	A	100%
TT8 Construction	① Do you have the capacity to make a specification of constructions?	B	B	B	B	B	C	B	77%
	② Do you have the capacity to construct T&D facility?	B	B	B	B	A	B	A	86%
	③ Do you have the capacity to supervise construction work?	C	A	B	B	A	B	B	83%
	④ Do you have the capacity to inspect construction?	C	A	C	B	A	C	B	77%
	⑤ Do you have the capacity to update facility book?	B	A	C	B	A	A	B	86%
TT9 Customer Contract	① Do you have the capacity to do technical review of supply application?	A	A	A	A	A	A	B	97%
	② Do you have the capacity to do connection work?	A	A	A	A	A	A	A	100%
	③ Do you have the capacity to install Wh meter?	A	A	A	A	A	A	B	97%
	④ Do you have the capacity to deliver invoices to customers?	A	A	A	A	A	A	A	100%
	⑤ Do you have the capacity to do temporary disconnection & re-connection?	A	A	A	A	A	A	A	100%
	⑥ Do you have the capacity to remove Wh meter from ex-customer?	A	A	A	A	A	A	A	100%

: Selected item for Action Plan

Result of the Final Self-Evaluation for Transmission and Distribution Work on December 15, 2010

Item	Name	Mr. Savuth Sothea	Mr. Ret Soksamdy	Mr. Roem Navy	Mr. Thim Seanghai	Mr. Ros Panha	Mr. Som Dara	Mr. Hang Rotha	Average
	Position	Section Manager	Group Leader	Operator	Operator	Opeator→Warehouse in October	Operator(New)	Operator(New) absent	
TT2 Planning	① Do you have the capacity to make long and mid-term plan and budget?	A	-	-	-	-	-	-	100%
	② Do you have the capacity to make daily activity plan of operation, maintenance and construction?	A	-	-	-	-	-	-	100%
TT3 Measurement	① Do you have the capacity to analyze operation condition such as load, loss and voltage drop?	A	A	A	B	-	A	-	96%
	② Do you have the capacity to measure voltage and current?	A	A	A	A	-	A	-	100%
TT4 Scheduled Outage	① Do you have the capacity to make the switching procedure?	A	A	A	A	-	A	-	100%
	② Do you have the capacity to notify the scheduled outage to customers?	A	A	A	A	-	A	-	100%
	③ Do you have the capacity to order switching operation?	A	A	A	A	-	A	-	100%
	④ Do you have the capacity to operate the switch?	A	A	A	A	-	A	-	100%
	⑤ Do you have the capacity to record scheduled outage operation?	A	A	A	A	-	A	-	100%
TT5 Fault Outage	① Do you have the capacity to decide the method to restore?	A	A	A	A	-	A	-	100%
	② Do you have the capacity to order each action to restore?	A	A	A	A	-	B	-	96%
	③ Do you have the capacity to find and restore the fault?	A	A	A	A	-	B	-	96%
	④ Do you have the capacity to record fault outage operation?	A	A	A	A	-	A	-	100%
TT6 Maintenance	① Do you have the capacity to patrol and inspect T&D facility?	A	A	A	A	-	A	-	100%
	② Do you have the capacity to record patrol and inspection result?	A	A	A	A	-	A	-	100%
	③ Do you have the capacity to negotiate with owner of obstruct close to T&D line?	A	A	A	A	-	A	-	100%
	④ Do you have the capacity to control spare parts?	A	A	A	A	-	A	-	100%
	⑤ Do you have the capacity to maintain working tools?	A	A	A	A	-	A	-	100%
TT7 Customer's Request or Claim	① Do you have the capacity to deal with interruption of power supply?	A	A	A	A	-	A	-	100%
	② Do you have the capacity to deal with abnormal voltage?	A	A	A	A	-	B	-	96%
	③ Do you have the capacity to deal with Wh meter broken?	A	A	A	A	-	A	-	100%
	④ Do you have the capacity to deal with Wh meter checking?	A	A	A	A	-	A	-	100%
TT8 Construction	① Do you have the capacity to make a specification of constructions?	B	A	B	A	-	B	-	88%
	② Do you have the capacity to construct T&D facility?	A	B	A	A	-	B	-	92%
	③ Do you have the capacity to supervise construction work?	B	A	A	B	-	B	-	88%
	④ Do you have the capacity to inspect construction?	A	A	A	A	-	A	-	100%
	⑤ Do you have the capacity to update facility book?	A	A	A	A	-	A	-	100%
TT9 Customer Contract	① Do you have the capacity to do technical review of supply application?	A	A	A	A	-	A	-	100%
	② Do you have the capacity to do connection work?	A	A	A	A	-	A	-	100%
	③ Do you have the capacity to install Wh meter?	A	A	A	A	-	A	-	100%
	④ Do you have the capacity to deliver invoices to customers?	A	A	A	A	-	A	-	100%
	⑤ Do you have the capacity to do temporary disconnection & re-connection?	A	A	A	A	-	A	-	100%
	⑥ Do you have the capacity to remove Wh meter from ex-customer?	A	A	A	A	-	A	-	100%

: Selected item for Action Plan

Division and Position	Name
Chief of T&D Section	Mr. Savuth Sothea

1st Interview for setting Action Plan	2nd Interview for Interim	3rd Interview for Final
Date: 25-05-2010	Date: 25-09-2010	Date: 15-12-2010
Sign:	Sign:	Sign:

○ **Action Plan**

C/P						JICA Advisor Team	
Objective item	Achievement Level		Measures	Interim Result	Final Result	Rating	Evaluation
	Current Level	Target Level					
(Task code TT6) No. 4 Spare parts Control	I do not understand the spare parts control.	**What?** Spare parts control **By When** 30-10-2010 **How Far?** I can control the spare parts management by myself.	**How?** - To cooperate with procurement and Administration section - To prepare the list in order to control spare parts apparently	- I collaborated with procurement and administration section for making a list of warehouse carry-out - I made the list of incoming and outgoing of watt hour meters that were broken or removed from the costumer's house to warehouse. - I manage all of T&D spare parts in warehouse to be in good order and I will try my best to study it more with procurement and administration section.	- I can manage spare parts and cooperate with procurement and administration almost 100% such as: ➢ Making list of receiving materials ➢ List of removed and installed meter conducted the suspension work ➢ List of checking consumer's houses before making a new connection work ➢ Make the list of proposal warehouse spare parts ➢ List of meter condition when we did the connection work to the new costumer ➢ Record of meter checking and testing of customer ➢ Even report list ➢ Table of disconnection and reconnection of the customers who have not yet paid the electric charge each month - I cooperated with procurement section to manage the spare parts in warehouse in good order and I will try to get more new experiences from JICA team.	A B C D E	➢ After his efforts, he can manage and control spare parts under cooperation with procurement and administration section. ➢ He understands how to keep good condition and organize spare parts now.

Division and Position	Name
Deputy Chief of T&D Section	Mr. Ret Soksamdy

1st Interview for setting Action Plan	2nd Interview for Interim	3rd Interview for Final
Date: 25-05-2010	Date: 22-09-2010	Date: 14-12-2010
Sign:	Sign:	Sign:

○ **Action Plan**

C/P						JICA Advisor Team	
Objective item	Achievement Level		Measures	Interim Result	Final Result	Rating	Evaluation
	Current Level	Target Level					
(Task code TT8) No. 4 Inspection of the construction work	I do not understand the inspection of construction work.	**What?** Inspection of Construction work **By When** 30-10-2010 **How Far?** I can conduct the inspection of construction work by myself.	**How?** - To cooperate with technical division, procurement and Administration section - To check the construction work whether it meets the standard of the construction or not	- I can inspect the construction work of T&D facility according to my own capacity and practice through the suggestions and recommendations from JICA Team.	- I can do the inspection of construction work properly with technical standard by my ability that I have complied with the recommendations and instructions from JICA team. - And I conducted the actual inspection of the construction work by EM construction in September 2010 such as: ➢ Inspecting of new pole installation ➢ Checking the depth of pole installing and pole foundation	A B C D E	➢ He understands what the points to check the construction work now are. ➢ He successfully conducted inspection in September.

Division and Position	Name
Member of T&D section	Mr. Thim Seang Hai

1st Interview for setting Action Plan	2nd Interview for Interim	3rd Interview for Final
Date: 25-05-2010	Date: 22-09-2010	Date: 14-12-2010
Sign:	Sign:	Sign:

○ **Action Plan**

C/P						JICA Advisor Team	
Objective item	Achievement Level		Measures	Interim Result	Final Result	Rating	Evaluation
	Current Level	Target Level					
(Task code TT8) No. 5 - Update of Facility Book	I do not understand how to update the facility book.	**What?** Update the Facility Book **By When** 01-10-2010 **How Far?** I can control and update the facility book by myself.	**How?** - To cooperate with technical, procurement and administration section - To make a list for control - To get the information from the contractor to know time, location and specification of installation	- I collaborated with technical section for making the list for control and got the information from the technical section about time, location of installation for revising the T&D map.	- After getting the instruction from JICA team, I could update the facility book very well such as: ➢ Single Line Diagram ➢ Geographical Map ➢ Managing original document	A B C D E	➢ He updated maps for operation and maintenance of distribution facilities. ➢ He understood how to manage the original.

Division and Position	Name
Member of T&D Section	Mr. Roem Navy

1st Interview for setting Action Plan	2nd Interview for Interim	3rd Interview for Final
Date: 25-05-2010	Date: 23-09-2010	Date: 15-12-2010
Sign:	Sign:	Sign:

○ **Action Plan**

C/P						JICA Advisor Team	
Objective item	Achievement Level		Measures	Interim Result	Final Result	Rating	Evaluation
	Current Level	Target Level					
(Task code TT8) No. 2 Construction of T&D Facility	I do not know how to construct T&D facility.	**What?** Construction work **By When** 30-10-2010 **How Far?** I can conduct the construction of T&D facility by myself.	**How?** - To cooperate with technical and procurement section - To communicate with customer - To communicate with Authorization - To calculate budget for the plan	- I communicated with customer. - I communicated with Authorization. - I made the budget for the plan of expense. - I collaborated with procurement section.	- After study and actual practicing, I can do the construction work of T&D facility well. - I went to study the location condition apparently. - I communicated with Authorization and customer. - I communicated with procurement and administration section. - I calculated the budget for the plan of expansion. - I understood the procedure of T&D construction work. - I clearly understood the specifications of cable and pole. - I will study the technical standards of T&D construction work and controlling of technical equipment.	➢ A ➢ B ➢ C ➢ D ➢ E	➢ He understands how to select the pole by technical calculation such as strength and length. ➢ He made an extension plan.

Division and Position	Name
Member of T&D Section	Mr. Ros Panha

1st Interview for setting Action Plan	2nd Interview for Interim	3rd Interview for Final
Date: 25-05-2010	Date: 25-09-2010	Date: 15-12-2010
Sign:	Sign:	Sign:

○ **Action Plan**

C/P						JICA Advisor Team	
Objective item	Achievement Level		Measures	Interim Result	Final Result	Rating	Evaluation
	Current Level	Target Level					
(Task code TT9) No. 1 Technical Review of Supply Application	I have no capacity to do the technical review of supply application	**What?** Technical Review of Supply Application **By When** 30-10-2010 **How Far?** I can understand and conduct the technical review of supply application by my self	**How?** - To study and know the electric equipment in the customer house - To know how much capacity of the electric equipment in the customer - To study how to calculate the necessary capacity of the transformer	- I understand well on the Technical review of supply application.	- After studying, I tried to research and understand. - I clearly understand the "technical review of supply application" now.	A B C D E	➢ He understands how to calculate the customer demand now. Ref: He moved to Warehouse in October.