6. HYDRO-MECHANICAL EQUIPMENT

6. HYDRO-MECHANICAL EQUIPMENT

The outline of the site survey results for hydro-mechanical equipment is as follows. Also, attached are the main features for the hydro-mechanical equipment.

Equipment	Wimalasurendra Hydropower Station	Old Laxapana Hydropower Station	Canyon Hydropower Station
Penstock	No significant defects	No significant defects Repair for the remote control of the penstock valve	Leakage from expansion joints
Spillway	Plan for regulating the spillway gates	Plan for regulating spillway gates	Installation of accesses to anchorage
Intake	Repairing the intake equipment by CEB	No significant defects	Plan for intake air valve modification
Bottom outlet	CEB Plans for repairing the needle valve	No significant defects	No significant defects
Tailrace	No significant defects	No gate	Repairing the tailrace gate by CEB
Other	-	-	-

Equipment	New Laxapana Hydropower Station	Polpitiya Hydropower Station
Penstock	Repair the drain and passages	Touch up painting for corroded portions
Spillway	Installation of accesses to anchorage	Touch up painting Drain holes at gate leafs Installation of accesses to anchorage Plan for a dam control system
Intake	Plan for Raking machine	Plan for Raking machine
Bottom outlet	No significant defects	No significant defects
Tailrace	No gate	No significant defects
Other	Plan for Removing sedimentation	Plan for Removing sedimentation

Table 6.1 Main Features of Hydro-mechanical Equipment

Power Station Capacity(MW)	**Wimalasurendra** 25 × 2	**Old Laxapana** 10 × 5	**Canyon** 30 × 2	**New Laxapana** 50 × 2	**Poipitiya** 37.5 × 2
Completion Date	1965 (39years)	Stage I, 1950 (54years) Stage II, 1958 (46years)	1983 (21years)	1974 (30years)	1969 (35years)
Reservoir Storage capacity (10^3m^3) Usable capacity (10^3m^3)	Castlereagh Reservoir 59,700 53,583	Norton Pond 394 245	Maussakelle Reservoir 14,714 107,929	Canyon Pond 92 629	Laxpana Pond 202 113
Dam Length (m) x Height (m)	Concrete Gravity 236.8 × 47.2	Concrete Gravity 103.0 × 28.7	Concrete Gravity 187.5 × 41.1	Concrete Gravity 182.9 × 27.4	Concrete Gravity 137.2 × 29.6
Headrace Tunnel Length (km)	6.1	2.6	4.1	5.6	7.7
Penstock					
Type	Welded, Ring support (wheel)	Spigot & socket, Ring support (wheel)	Welded, Ring support (slide)	Welded, Saddle support (concrete)	Mechanical joint, Saddle support (steel)
Lines	2	4	2	2	2
Length (m)	887.7	1,527.4	823.0	1,889.8	603.5
Diameter (m)	1.98 (78in)	1.22 (48in)	2.51 (99in)	1.68 (66in)	2.29 (90in)
Design head (m)	(227.4)	(472.4)	314.5(204.2)	724.8(541.0)	(259.1)
Material	JIS SM50	9.5 – 28.5mm	ASTM A537 CL1	SELCO 56CN	CASG 40.8 Grade B
Design thickness	17 – 23mm	SOUTH DURAHAM	12 -24mm	8 – 31mm	18 -27mm
Fabricator	SAKAI IRON WORKS	STEEL & IRON	B.V.S-JONNERET SWITZERLAND	GIOVANOLA FREES S.A	
Penstock Guard Valve	Penstock valve	Penstock valve	Tunnel inlet valve Penstock valve	Penstock valve	Penstock valve
Flow (m^3/s) / line	14	2.1 (Stage I) 3.25 (Stage II)	18	11.5	17

Power Station Capacity(MW)	**Wimalasurendra** 25 × 2	**Old Laxapana** 10 × 5	**Canyon** 30 × 2	**New Laxapana** 50 × 2	**Poipitiya** 37.5 × 2
Spillway Gate Type Quantity Width (m) x Height (m) Hoist Design flood	 Natural spillway Flash board 4ft × 14 Max. Flood level 1096.4m	 Natural spillway Max. Flood level 870.2m	 Radial Gate 3 10.7 × 4.6 Wire rope type Max. Flood level 1170.43m	 Radial Gate 2 12.2 × 8.8 Wire rope type Max. Flood level 963.17m	 Radial Gate 3 10.7 × 7.3 Wire rope type Max. Flood level 381m
Intake Equipment **Intake Gate** Intake Service Gate Width x Height Hoist Intake Guard Gate Width x Height Hoist	 Sliding gate 1.83m × 4.42m Overhead gantry crane Roller gate 1.83m × 3.96m	 Stoplogs (wooden) Width – 2.06m	 1-Roller Gate 4.11 m × 4.72 m Electric motor 1-Slide Gate	 Fixed wheel gate 3.2m × 3.2m Bulk head gate 3.2m × 3.2m	 Fixed wheel gate 4.11m × 4.72m Fixed wheel gate 4.11m × 4.72m
Intake Trashrack		Rotary screen	Moving Glory type	Fixed screen 03 Nos. 2.44m × 4.57m	Fixed screen 2.33m × 5.94m × 03
Raking Machine	No	By high pressure water spraying	No	No	No
Bottom Outlet Works	Hydraulic-operated Needle valve D=1.5m Guard gate	Stoplog gate – 02 nos Lifting by chain blocks	Hovel bunger valve D=2.43m	1.525m × 2.135m Control gate 1.525m × 2.135m Emergency gate Fixed wheel gate	Fixed wheel gate Electric motor

Power Station Capacity(MW)	**Wimalasurendra** 25 × 2	**Old Laxapana** 10 × 5	**Canyon** 30 × 2	**New Laxapana** 50 × 2	**Poipitiya** 37.5 × 2
Tailrace Gate Type Quantity Width x Height Hoist	 Slide Gate 2 Overhead gantry crane for stoplog gate Separate electric motor driven and bulk head gate	 No	 Slide Gate 2 Monorail hoist	 No	 Slide Gate 2
Other Hydro-mechanical Equipment	Trashrack placed inside of the intake with grab mechanism				
Remarks	Intake gate & structures completely repaired		There is a pipe piece in between the dam and the tunnel. Nearby the dam there is a butterfly valve. According to the reports, this intake has been designed for only one machine		

Attached are the rough rehabilitation costs for the hydro-mechanical equipment.

Table 6.2 Rehabilitation Work Cost of Hydro-mechanical Equipment

Hydropower Station	Rehabilitation Item	Cost Estimate (10^3 US$)
Wimalasurendra	New spillway gate(SR gate) Width 9.1m × Height 1.2 m 14 nos.	5,600
Old Laxapana	New spillway gate(SR gate) Width 9.1m × Height 1.2 m 8 nos.	3,200
	Repair for remote control at penstock valve	200
Canyon	Improving the air valve of the intake valve (an anti-negative pressure valve) Change the air valve position	300
New Laxapana	Intake Trash rake machine	500
Polpitiya	Intake Trash rake machine	500
Common	Removal Sedimentation of Canyon & Laxapana reservoir Dredging grab $1m^3$ Mobile crane 30t	100 300
	Dam control system of Canyon & Laxapana	600
	Robot for repainting the inside penstock Blasting machine & Painting machine	1,500
	Equipment for outside repainting machine Blasting machine & airless spray	200
Consulting fee		1,300
Contingency		1,400
Total cost		15,700

(Note)
The purchase of the robot for repainting the inside penstock will be discussed by CEB due to the expensive.

6.1 Wimalasurendra Hydropower Station

6.1.1 Site Survey

(1) Penstock

The exposed outer surface of the penstock was visually inspected for excessive leakage, corrosion, pitting, coating deficiency, etc.

<Appearance investigation>

The penstock’s exterior was visually inspected while the penstock was under full pressure in order to observe any leakage. Deformation of steel pipes, loosed bolts, anchor blocks and concrete saddles were visually inspected.

<Plate thickness measurements>

The shell plate thickness of the steel penstock was checked using an ultrasonic thickness meter at the mean of the anchor blocks.

<Vibration measurements>

Vibration of the steel penstock was checked using a vibration meter at the mean of the anchor blocks.

<Painting film thickness measurements>

Painting film thickness was checked using an electromagnetic coating thickness meter at the mean of the anchor blocks.

Table 6.3 Measurement Instrument

Measurement instrument	Type	Model
Plate thickness	Ultrasonic 0.1mm	JFE TI-50K
Vibration	Digital	Showa Model 1332A
Painting film thickness	Electromagnetic	Sanko SDM-3000T

(2) Gate and Trashrack

The gates and trashracks were visually inspected.

6.1.2 Penstock

(1) Present Status

The penstock was constructed in 1965 and has been in peroration for more than 39 years. No serious problems have been observed so far.

The penstock is 887.7m long and extends from the penstock valve house to the powerhouse.
General penstock data are as follows.

Type	:	Welded type, Ring support with wheel
No. of Penstock	:	2
Length	:	887.7m
Diameter	:	1.980 – 1.600m
Design head	:	227.4m (static design head)
Material	:	JIS SM50
Design thickness	:	17 – 23mm

Picture 6.1 Panorama view of penstock

Picture 6.2 Ring girder support with wheels

The collected data of the plate thickness for the penstock were consistent and reasonable. According to the data, there was no significant loss in metal due to corrosion.
Also, there were no significant vibrations in the penstock.

More specific information can be found on the attached checklist.

(2) Rehabilitation plan

May not be necessary

6.1.3 Flashboard of Spillway

(1) Present Status

The spillway was designed as an ungated ogee crest with 14 bays that are 9.1m in width. A 1.2m flashboard system was installed in the dam crest. This flashboard system was designed by Preece Cardew in 1982. The flashboards are consisted of 1.2m high timber gates. The flashboards were cleaned and painted by CEB.

However, the existing flashboards require a high degree of manual operation.during a flood. Furthermore, the reliability of controlling flashboards with shear pins is very low.

Therefore, CEB wishes to install a mechanical gate system that will regulate discharge.

(2) Rehabilitation Plan

The following gates were compared. The recommended gate is the SR gate (Obermeyer type).

- SR Gate (Obermeyer type)
- Rubber Dump Spillway Gate
- Steel Dump Spillway Gate

SR gates were developed in the USA and possess excellent characterikstics. Recently, SR gates have been installed in Japan.

The SR gate is composed of a steel gate leaf and air bag (bladder) made of rubber. The steel gate leaf can be operated by adjusting the amount of air in the air bags.

A comparison table of the spillway gates are attached..

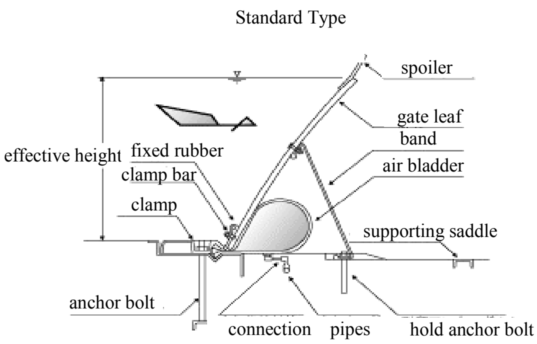


Figure 6.1 SR Gate (Obermeyer type)

- Discharge volume and water level control are possible
- A wide gate is possible by connecting units (1 air bladder +1 steel gate leaf)
- Sand durability during a flood is better than a rubber dam
- Occurrence of vibration is low, and there is no water level limitation for the overflow.
- Does not require a power supply in an emergency
- Simple structure that allows easy maintenance and excels efficiently economical

6.1.4 Intake Gate and Trashrack

(1) Present status

The intake tower is located on the right side bank of the reservoir. The intake equipment consists of intake gates, bulkhead gates, intake trashracks, trash rakes, and a gantry crane. That equipment has been repaired by CEB.

(2) Rehabilitation plan

May not be necessary

6.1.5 Bottom Outlet Works

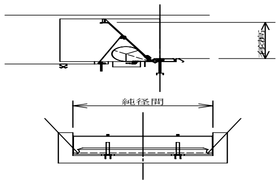
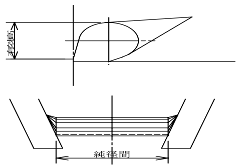
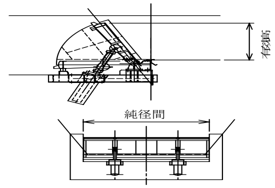
(1) Present status

The bottom outlet works consist of a roller gate and a needle valve. The needle valve was leaking at a rate of a few liters per seconds. The seals of the needle valve will be repaired by CEB.

(2) Rehabilitation Plan

May not be necessary

Table 6.4 Comparison Table of SR Gate, Rubber Dam and Steel Gate

	SR Gate (Obermeyer type)	Rubber Dam	Steel Damp Spillway Gate
Schematic diagram			
Basic structure	The gate is constructed of various units that are each respectively composed of a steel gate leaf and rubberized air bladder. The gate is risen using an air compressor. Lowering the gate is carried out by an automatic lowering device.	The inflate rubber dam is composed of rubberized air bladders. The rubber dam rise and lower mechanism is actuated with a pump for hydraulic systems or with an air compressor for pneumatic systems.	The gate leaf is composed of vertical and horizontal stiffeners. The rise and lower mechanism is provided with an oil cylinder.
Diameter of bladder	About 1/3 of weir height (steel gate leaf)	Same as height of weir	-
Width of weir	The gate is constructed of various units that are each respectively composed of a steel gate leaf and rubberized air bladder. (Previous result :296m)	Middle piers should be placed in intervals of about 40m and less.	Middle piers should be placed in intervals of about 40m and less.
Against falling objects	The air bladder is protected with a steel gate leaf against sharply edged flowing-down objects preventing damage.	The air bladders may received damage from sharply edged flowing-down objects. However, in the case when the air blabber is damaged by rolling stones of ordinary size, this problem can be solved by a means of using cushions.	The hydraulic cylinder protected by a steel gate leaf from flowing-down objects preventing damage.
Water flow control	The water flow can be easily adjusted in a large variety of ways.	Fine control of water flow is difficult due to that the gate height's water level changes with the up and downstream water level.	The water flow can be easily adjusted in a large variety of ways.

	SR Gate (Obermeyer type)	Rubber Dam	Steel Damp Spillway Gate
Vibration of gate leaves	Spoilers are used to solve the gate leaf vibration problem caused by overflow water.	Vibration may occur if water level exceeds the allowable overflow depth.	Spoilers are used to solve the gate leaf vibration problem caused by overflow water.
V-notch phenomenon	Does not occur	V-notch may occur if the rubber dam lies down	Does not occur
Air dryer	Necessary	Not Necessary	Not Necessary
Transportation and installation	Excels in workability in the process of design, manufacture, assembly, transport and installation, and requires no large-scale machinery.	Transportation and installation are difficult for large sized rubber dams.	Large-scale trucks and cranes are necessary for transportation and installation of large size gates,.

Picture 6.3 Repairing of Intake Equipment

Picture 6.4 Leakage from needle valve

6.1.6 Tailrace Gate

(1) Present Status

The tailrace gate is located outside the powerhouse.

(2) Rehabilitation Plan

May not be necessary

6.2 Old Laxapana Hydropower Station

6.2.1 Site Survey

(1) Penstock

The exposed outer surface of the penstock was visually inspected for excessive leakage, corrosion, pitting, coating deficiency, etc.

(2) Gates and Trashrack

The gates and trashracks were visually inspected.

6.2.2 Penstock

(1) Present Status

The penstock was constructed in 1950 and has been in operating for more than 54 years. No serious problems have been observed so far.

The penstock is 1,527.4m long and extends from the penstock valve house to the powerhouse.

General penstock data are as follows.

Type	:	Spigot & socket, Welded type, Ring support with wheel
No. of Penstock	:	4
Length	:	1,527.4m
Diameter	:	1.035 – 1.238m
Design head	:	472.4m (static design head)
Material	:	Unconfirmed
Design thickness	:	9.5 – 28.5mm

The collected data of the penstock's plate thickness was consistent and reasonable. According to the data, there was no significant loss of metal to corrosion and there were no significant vibrations discovered in the penstock.

For more specific information see the attached checklist.

Atomic Energy Authority inspected the penstock's thickness on October 2000 with an ultrasonic thickness gauge. There were no problems found.

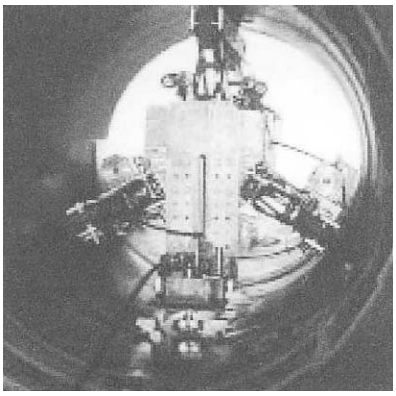
Picture 6.5 Panorama view penstock

Picture 6.6 Spigot & socket (1st stage)

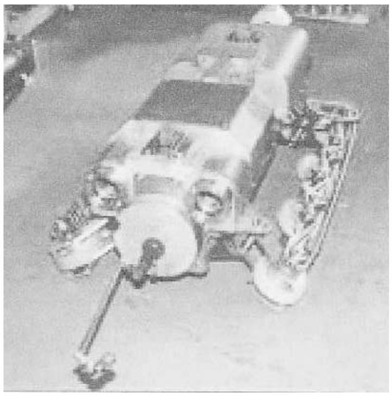
(2) Rehabilitation Plan

Repainting of the inner side of the penstock is difficult due to narrow space and the penstock inclines. Therefore, a blasting robot and painting system will be considered. The purchase of the robot will be discussed by the CEB due to the expensive.

An outside blasting and painting machine also will be considered.



Picture 6.7 Blasting machine



Picture 6.8 Painting machine

6.2.3 Spillway

(1) Present Status

The spillway is designed as a non-gated ogee crest with 8 bays that are 9.1m wide using 1.2m wide piers that supports the above bridge deck.

CEB plans to install the flashboards, similar to the Castlereagh dam flashboards, to increase of the reservoir capacity.

(2) Rehabilitation Plan

The most suitable gate type will be selected. The SR gate (Obermeyer type) is the most recommendable at this moment for regulating the gate at Norton dam.

To establish new gates the spillway capacity, influence on the surrounding area and safety of the existing structure must be first studied

Picture 6.9 Spillway of Norton Dam

A detailed study must be done before increasing the reservoir capacity and establishing new gates.

- To confirm the ability of the discharge capacity of spillway after the new gates are established.
- To confirm the need of EIA due to the increased reservoir capacity and pond area
- To confirm the safety of existing structures after new gates has been established

6.2.4 Intake Gate and Trashrack

(1) Present Status

The intake tower is located at the left side bank of the pond. The intake equipment consists of intake gates, bulkhead gates, intake trashracks and trash rakes. The trash rake is a rotary type with high pressure water cleaning system.

(2) Rehabilitation Plan

May not be necessary

6.2.5 Bottom Outlet Works

(1) Present Status

The bottom outlet is located in a tunnel at the left abutment (originally the diversion tunnel). The gate is a vertical lift gate, connected with screw driven rods powered by an electric motor.

(2) Rehabilitation Plan

May not be necessary

6.2.6 Tailrace Gate

(1) Present Status

No tailrace gate

6.3 Canyon Hydropower Station

6.3.1 Site Survey

(1) Penstock

The exposed outer surface of the penstock was visually inspected for excessive leakage, corrosion, pitting, deterioration, and deficiencies etc.

(2) Gates and Trashrack

Gates and trashracks were visually inspected for corrosion, deterioration, and deficiencies.

6.3.2 Penstock

(1) Present Status

The penstock was constructed in 1983 and has been in operation for more than 21 years. No serious problems have been observed so far.

The penstock is 823.0m long and extends from the penstock valve house to the powerhouse. General penstock data are as follows.

Type	:	Welded type, Ring support with slide shoe
No. of Penstock	:	2
Length	:	823.0m
Diameter	:	2.440 – 2.000m
Design head	:	314.5m (Max. design head)
Material	:	ASTM A537 CL1
Design thickness	:	12 – 24mm

Picture 6.10 Measuring for plate thickness

Picture 6.11 Check of slide shoe

The collected data of the penstock's plate thickness was consistent and reasonable. According to the data, there was no significant loss of metal to corrosion and there was no significant vibration present at penstock.

For more specific information see the attached checklist.

A leakage in the expansion joint will be repaired by CEB.

Picture 6.12 Leakage from expansion joint

(2) Rehabilitation Plan

May not be necessary

6.3.3 Spillway

(1) Present Status

The spillway in the center of the dam consists of 3 bays of gated ogee crested weir. The radial gates are 10.7m wide x 4.6m high. They are operated using a wire rope hoist mounted on the platforms over the piers. The hoists are a drum cable type driven by an electrical motor. The hoists can be manually cranked. A standby generator is provided adjacent to the gate No.1 hoist.

The gates were generally in good condition.

(2) Rehabilitation Plan

May not be necessary

6.3.4 Intake Gate and Trashrack

(1) Present Status

The intake tower is located at the dam. The intake equipment consists of intake gates, bulkhead gates, and intake trashracks.

(2) Rehabilitation Plan

May not be necessary

6.3.5 Bottom Outlet Works

(1) Present Status

The bottom outlet consists of a 2.44m diameter penstock through the dam. A fixed wheel type intake gate is located on the upstream face of the dam.

One branch leads to the scour outlet with a 2.44m Howell-Bunger sleeve valve ad hood. The other branch connects to the Canyon power station tunnel with a 3.4m diameter penstock. This is controlled using a butterfly valve that is operated by hydraulic cylinders.

(2) Rehabilitation Plan

May not be necessary

6.3.6 Intake Guard Valve

(1) Present Status

Anti-negative pressure valve is located just downstream of the butterfly valve.

The anti-negative pressure valve may open when the reservoir water level is low and intake discharge volume is large.

(2) Rehabilitation Plan

The anti-negative pressure valve position will be moved to the top of the roof. Or the position for oil and control units will be switched to other rooms.

6.3.7 Tailrace Gate

(1) Present Status

The tailrace gate is installed at the tailrace and is used when the turbines are being inspected or repaired. The slide gate with a bypass valve is used for a tailrace gate.

Tailrace gate was repaired by CEB.

Picture 6.13 Intake guard valve house

Picture 6.14 Repairing the tailrace gate by CEB

(2) Rehabilitation Plan

May not be necessary

6.4 New Laxapana Hydropower Station

6.4.1 Site Survey

(1) Penstock

The exposed outer surface of the penstock was visually inspected for excessive leakage, corrosion, pitting, deterioration, and deficiencies etc.

(2) Gates and Trashrack

The gate and trashrack were visually inspected for corrosion, deterioration, and deficiencies.

6.4.2 Penstock

(1) Present Status

Penstock was constructed in 1974 and has been in operation for more than 30 years. No serious problems have been observed so far.

The penstock is 1,889.8m long and extends from the penstock valve house to the powerhouse.

General penstock data are as follows.

Type	:	Welded type, Concrete saddle support
No. of Penstock	:	2
Length	:	1,889.8m
Diameter	:	1,700 – 1,500m
Design head	:	724.8m (Max. design head)
Material	:	SELCO 56CN
Design thickness	:	8 – 31mm

Picture 6.15 Panorama view

Picture 6.16 Touch up paint for welding joint by CEB

The collected data of the penstock's plate thickness were consistent and reasonable. According to the data, there was no significant loss of metal to corrosion and there was no significant vibrations present in the penstock.

For more specific information see the attached checklist.

(2) Rehabilitation Plan

Eroded drain gutters should be repaired immediately due to the high risk of concrete saddles sinking.

Deteriorated filler material between the concrete saddles and penstock should be changed due to the influence that is present to the expansion joint leak.

Picture 6.17 Repair work of drain

Picture 6.18 Filler material of concrete saddle

6.4.3 Spillway gate

(1) Present Status

The spillway in the center of the dam consists of 2 bays of gated ogee crested weir. The radial gates are 12.2m wide x 8.8m high. They are operated using a wire rope hoist mounted on the platforms over the piers. The hoists are a drum cable type driven by an electrical motor. The hoist can be manually cranked. The gates can be operated from the local control board or can be wounded up manually at each hoist. A standby generator is located in the house on the right side of the dam.

The gates were generally in good condition.

(2) Rehabilitation Plan

May not be necessary

6.4.4 Intake Gate and Trashrack

(1) Present Status

The intake tower is located on the right side bank of the pond. The intake equipment consists of intake gates, bulkhead gates, and intake trashracks. There was no intake trash rake machine.

(2) Rehabilitation Plan

Provisions for the intake rake machine or a movable trashrack will be considered.

- Movable trashrack type
- Rotary type trash rake machine
- Wire rope type trash rake machine

Item	Movable trashrack type	Rotary type trash rake machine	Wire rope type trash rake machine
Structure	Trashracks are exchanged regularly	Rakes will be installed on a chain that is controlled through turning	Rake that moves up and down using a wire rope winch
Characteristic	Structure is simple Cleaning method is reliable	Rotary turning the chain is a very stable operation Capable of disposing much debris	Best suited for high lifting ranges

(Note)

A study for remodeling and repairing the existing trashrack should be carried out separately.
Though a rotary type trash rake machine is recommended due to its efficiency, the decision should keep in consideration the conformity of the existing structures

6.4.5 Bottom Outlet Works

(1) Present Status

The bottom outlet is located on the right side of the spillway. It consists of controls and emergency fixed wheel gates operated by an electric motor. These gates are used for de-silting and lowering the reservoir water level for maintenance.

(2) Rehabilitation Plan

May not be necessary.

6.4.6 Sedimentation

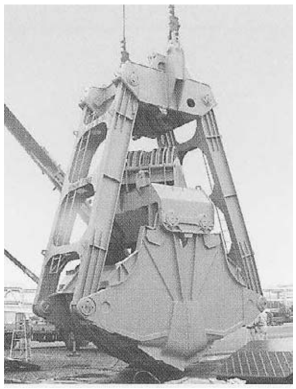
(1) Present Status

Due to the small size of the pond the silt around the intake and bottom outlet works should be removed often.

(2) Rehabilitation Plan

Currently methods for dredging using a garb and mobile carne are being examined. The grab and mobile crane will be used for removing silt around the intake and bottom outlet works etc. The silt will then be transported by CEB's dump trucks to a disposal area. CEB will look into method of transportation and the disposal area.

Picture 6.19 Sedimentation of reservoir



Picture 6.20 Plan for dredging by grab

6.5 Polpitiya Hydropower Station

6.5.1 Site Survey

(1) Penstock

The exposed outer surface of the penstock was visually inspected for excessive leakage, corrosion, pitting, deterioration, deficiencies etc.

(2) Gates and Trashrack

The gate and trashrack were visually inspected for corrosion, deterioration, and deficiencies.

6.5.2 Penstock

(1) Present Status

The penstock was constructed in 1969 and has been in operating for more than 35 years. No serious problems have been observed so far.

The penstock is 603.5m long and extends from the penstock valve house to the powerhouse. General penstock data are as follows.

Type	:	Mechanical joint, Saddle support (steel)
No. of Penstock	:	2
Length	:	603.5m
Diameter	:	2.250 – 2.000m
Design head	:	259.1m (static design head)
Material	:	CASG 40.8 Grade B
Design thickness	:	18 – 27mm

Picture 6.21 Panorama view of penstock

Picture 6.22 Mechanical joint

The collected data of the penstock's plate thickness were consistent and reasonable. According to the data, there was no significant loss of metal to corrosion, further, there were no significant vibrations present in the penstock.

For more specific information see the attached checklist.

Early touch up painting is recommended for extensively corroded areas on the welded joints and bottoms of the penstock.

Picture 6.23 Outside surface of welded joint

Picture 6.24 Outside surface of bottom

(2) Rehabilitation Plan

May not be necessary

6.5.3 Spillway Gate

(1) Present Status

The spillway in the center of the dam consists of 3 bays of gated ogee crested weir. The radial gates are 10.7m wide × 7.3m high. The gates are operated by using wire rope hoist mounted on the platforms over the piers. The hoists are a drum cable type driven by an electrical motor. The hoist can be manually cranked. The gates can be operated remotely from the Old Laxapana power station or can be wounded up manually using the local control board at each hoist.
The gates were generally in good condition.

The trunnion is an important part that bears the concentrate load during high pressure. The inspection and maintenance, such as a lubrication of trunnion parts, are necessary. It is recommended to install access bridges, ladders, stairways, handrails etc. to allow inspection.
Water tends accumulating on sections of gate arms and main girder was observed. It is recommended to regularly clean the drain holes or to provide new drain holes.
Touch up painting is also required for some corroded portions on the gate leaf.

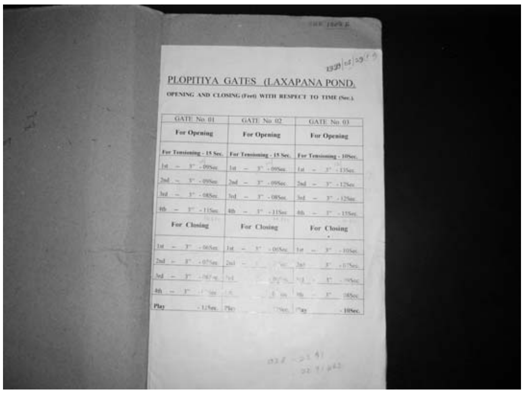
Picture 6.25 Trunnion requires access facility

Picture 6.26 Arm requires drain holes

(2) Rehabilitation Plan

The automatic gate operation system is under consideration due to the spillway gate being operated several times to discharge floods. The most suitable dam control method will investigated using Japan's experience.

Picture 6.27 Gate operation



PLOPITIYA GATES (LAXAPANA POND.

OPENING AND CLOSING (Feet) WITH RESPECT TO TIME (Sec.)

GATE No 01	GATE No 02	GATE No 03
For Opening	For Opening	For Opening
For Tensioning - 15 Sec.	For Tensioning - 15 Sec.	For Tensioning - 10Sec.
1st – 3" - 09Sec	1st – 3" - 09Sec	1st – 3" - 13Sec
2nd – 3" - 09Sec	2nd – 3" - 09Sec	2nd – 3" - 12Sec
3rd – 3" - 08Sec	3rd – 3" - 08Sec	3rd – 3" - 12Sec
4th – 3" - 11Sec	4th – 3" - 11Sec	4th – 3" - 13Sec
For Closing	For Closing	For Closing
1st – 3" - 06Sec	1st – 3" - 06Sec	1st – 3" - 10Sec
2nd – 3" - 07Sec	[illegible]	2nd – 3" - 07Sec
3rd – 3" - [illegible]	[illegible]	[illegible]
4th – 3" - [illegible]	[illegible]	4th – 3" - 08Sec
Play - 11Sec.	[illegible]	Play - 10Sec.

Picture 6.28 Gate operation table (manual operation)

6.5.4 Intake Gate and Trashrack

(1) Present Status

The intake equipment is located on the right bank of the pondage. The intake equipment consists of intake service gates, bulkhead gates and intake trashracks. There is no intake trash rake machine.

Air–entraining caused by vortexes decreases turbine efficiency, vortexes pull floating debris into the turbine (or onto the trashrack) creating the turbine operation to be rough.

Picture 6.29 Intake equipment

Picture 6.30 Vortex on the Surface

(2) Rehabilitation Plan

The following types of intake trash rake machines and a movable trashracks were compared.

- Movable trashrack type
- Rotary type trash rake machine
- Wire rope type trash rake machine

Though a rotary type trash rake machine is recommended due to its efficiency, the decision will be based upon the ability to conform with the existing structures.

A countermeasure against the vortex at the intake will be also investigated.

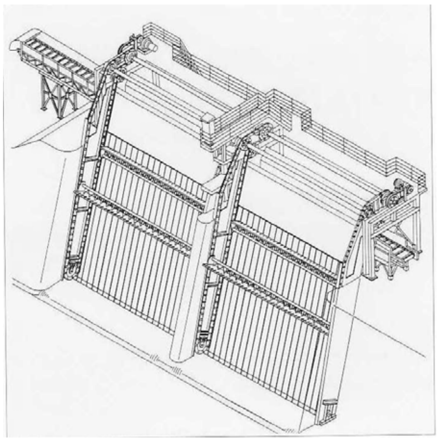


Figure 6.2 Rotary type trash rake machine

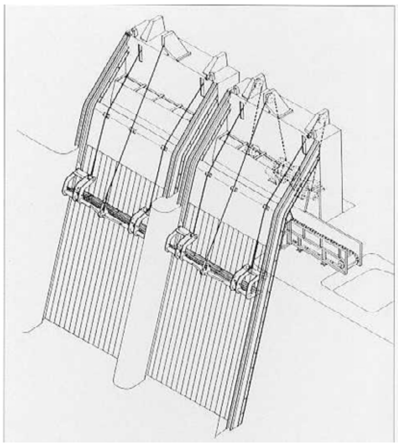


Figure 6.3 Wire rope type rotary rake machine

6.5.5 Bottom Outlet Works

(1) Present Status

The bottom outlet is located on the right side of the spillway. It is composed of controls and emergency fixed wheel gates operated by an electric motor. These gates are used for de-silting and lowering the reservoir water level for maintenance.

(2) Rehabilitation Plan

May not be necessary

6.5.6 Sedimentation

(1) Present status

Due to the small pondage size it is necessary to remove silt around the intake and bottom outlet works often.

(2) Rehabilitation Plan

Currently, methods of dredging by using grabs and mobile cranes are under investigation. The grab and mobile crane will be used for removing silt around the intake and bottom outlet works. The silt will then be transported by CEB's dump trucks to a disposal area.

Table 6.5 (1) Measurement Result

Power Station: Wimalasurendra 12th August 2004

Penstock: No.1

Measurement Point	Painting thickness(μm)					Plate thickness (mm)					Vibration (mm)	Remarks
	1	2	3	4	5	1	2	3	4	5		
No.1	200	211	281	245	263	17.6	17.7	18.1	18.1	17.8	0.018	
No.2	164	140	192	175	182	17.8	-	17.3	-	-	0.04	
No.3						17.5	18	17.5	17.2	17.7		
No.4	166	157	142	180	158	18.1	17.6	17.9	18.7	18	0.05	
N0.5						18.4	18.5	18.2	17.7	18.1	0.04	
No.6	120	168	138	146	157	20.5	20.7	20.4	20.7	20.3	0.04	
No.7	264	320	329	413	393	22.7	22.9	22.9	23.6	23.2	0.03	

Table 6.5 (2) Measurement Result												
Power Station: Old Laxapana Station			3rd August 2004									
Penstock: No.1												
Measurement Point	Painting thickness(μm)					Plate thickness（mm）					Vibration（mm）	Remarks
	1	2	3	4	5	1	2	3	4	5		
PVH-N0.1 AB	187	177	260	273	269	10.3	10.6	10.4	9.7	10.7	0.006	◆ Outside is dirty, but painting film is in good condi
No.1 AB-No.2 AB	347	257	301	316	225	14.9	14.1	14	14.3	14	0.01	◆ Leakage from Expansion joint
No.2 AB-No.3 AB	183	147	210	93	139	16.3	16.2	16.1	15.6	15.2	0.01	
No.3 AB-No.4 AB	261	398	320	242	298	20.7	20.8	20.7	20.8	20.8	0.01	◆ Outside is fine
No.4 AB-No.5 AB	177	182	221	293	136	24.1	23.1	23.6	24	24.3	0.01	
No.5 AB-No.6 AB	181	290	317	338	297	26	25.7	26.1	25.7	25.7	0.01	◆ Outside is fine
No.6 AB-No.7 AB	378	416	419	388	430	29.4	29.6	30.8	30.1	28.8	0.01	
No.7 AB-No.8 AB	311	281	364	349	381	-	-	-	30.8	-	0.01	◆ Outside is dirty
No.8 AB-No.9 AB	174	148	128	152	142	32.8	-	32.2	-	-	0.01	◆ Outside is dirty
No.9 AB-No.10 AB	119	111	175	166	227	33.6	33.7	33.8	34.5	33	0.01	
No.10 AB-PH	109	158	133	183	125	31.3	31.8	31.6	32.4	31.7	0.01	◆ Outside is fine

Table 6.5 (3) Measurement Result

Power Station: Canyon Station — 10th August 2004

Penstock: No.1

Measurement Point	Painting thickness(μm)					Plate thickness (mm)					Vibration (mm)	Remarks
	1	2	3	4	5	1	2	3	4	5		
No.1 AB-No.2 AB	124	137	121	149	126	13.2	13.2	13.2	13.2	13.2	0.15	♦ Leakage from Expansion Joint
No.2 AB-No.3 AB	146	173	154	143	146	14.2	14.2	14.2	14.3	14.3	0.03	
No.3 AB-No.4 AB	120	70	103	122	77	14.1	14.2	14.1	14.4	14.2	0.04	
No.4 AB-No.5 AB	149	116	112	160	123	16.4	16.9	16.6	16.5	16.5	0.012	
No.5 AB-No.6 AB	105	126	111	122	113	16.2	16.3	16.2	16.2	16.3	0.111	
No.6 AB-No.7 AB	113	114	112	163	128	18.3	18.3	18.3	18.4	18.3	0.014	
No.7 AB-No.8 AB	133	115	136	179	165	18.4	18.3	18.5	18.6	18.5	0.018	
No.8 AB-No.9 AB	156	73	152	170	188	20.5	20.4	20.5	20.4	20.5	0.022	
No.9 AB-No.10 AB	183	221	196	148	203	22.7	22.7	22.9	22.6	22.8	0.024	♦ Leakage from Expansion Joint
Steel Lining (intake valve)	151	153	152	127	141	11.3	11.4	11.6	11.4	11.3	0.02	

Table 6.5 (4) Measurement Result												
Power Station: New Laxapana Station				4th August 2004								
Penstock: No.1												
Measurement Point	Painting thickness(μm)					Plate thickness (mm)					Vibration (mm)	Remarks
	1	2	3	4	5	1	2	3	4	5		
PVH-N0.1AB	253	112	79	101	73	7.6	7.7	7.6	7.7	7.7	0	♦ Painting film is in good condition
No.1 AB-No.2 AB	164	90	126	119	113	8.9	8.6	8.5	8.8	7.8	0	♦ Outside is dirty
No.2 AB-No.3 AB	146	145	149	163	122	9.7	9.1	9.3	9.3	9.1	0.01	
No.3 AB-No.4 AB	111	82	99	91	98	10.5	10.3	10.2	10.2	10.5	0	
No.4 AB-No.5 AB	55	56	44	84	83	10	9.9	9.9	10.3	9.9	0	♦ Measured the thin painting film portion
No.5 AB-No.6 AB	104	96	139	119	127	11.5	11.5	10.6	11.6	11.5	0	
No.6 AB-No.7 AB	90	115	80	88	122	13.2	13.3	13.2	13.3	13.3	0	
No.7 AB-No.8 AB												♦ Measurement was omitted because
												the area was not in good condition
No.8 AB-No.9 AB	96	123	113	92	120	16.7	16.3	16.3	16.4	16.3	0	
No.9 AB-No.14 AB												♦ Measurement was omitted because
												the area was not in good condition
No.14 AB-No.15 AB	159	168	176	182	108	28.3	29.2	28.4	28.5	28.5	0	
No. 15AB-PH	67	131	66	61	78	29	28.8	29	28.9	28.9	0.01	

Table 6.5 (5) Measurement Result

Power Station: Polipitya Station 12th August 2004

Penstock: No.1

Measurement Point	Painting thickness(μm)					Plate thickness (mm)					Vibration (mm)	Remarks
	1	2	3	4	5	1	2	3	4	5		
No.1 AB-No.2 AB	161	199	285	263	195	18.4	18.1	18.2	18.2	17.8	0.044	
No.2 AB-No.3 AB												
No.3 AB-No.4 AB	142	151	134	185	161	17.4	-	-	17.9	-	0.014	
No.4 AB-No.5 AB												
No.5 AB-No.6 AB												
No.6 AB-No.7 AB												
No.7 AB-No.8 AB	126	162	89	131	124	18.1	-	-	18.4	18.1		♦ Welded and bottom portion were corroded
						26.7	26.3	26	-	25.2		
						26.5	27.1	27.4	26.6	-		
						26.5	26.5	26.1	26.4	26.4		

7. ELECTRO-MECHANICAL EQUIPMENT

7. ELECTRO-MECHANICAL EQUIPMENT

7.1 General

The CEB has been creating and carrying out its Rehabilitation Plan from the 1990s as a large-scale repair plan for the electro-mechanical equipment of the hydropower stations in the Kelani River Basin (Laxapana Complex).

This Rehabilitation Plan is divided into three steps, and the main object items are as follows.

Table 7.1 CEB's Rehabilitation Plan

Step	Status	Period	Main equipment for rehabilitation
Stage I	Finished	1994-95	Old Laxapana hydropower station Stage I(Unit 1-3) ・Governor ・Excitation equipment ・11kV main circuit ・Control equipment ・Protection equipment
Stage II	Finished	2002-03	Old Laxapana hydropower station Stage II（Unit 4, 5） ・Governor ・Excitation equipment ・11kV main circuit ・Controller ・Protection Polpitiya hydropower station (Unit 1, 2) ・Governor ・Excitation equipment ・12.5kV main circuit ・Control equipment ・Protection equipment ・132kV switchgear in switchyard
Stage III	Not carried out yet.	Undecided	Wimalasurendra hydropower station (Unit 1, 2) ・Governor ・Excitation equipment ・11kV main circuit ・Control equipment ・Protection equipment ・Repair of stator coil New Laxapana hydropower station (Unit 1, 2) ・Governor ・Excitation equipment ・12.5kV main circuit ・Control equipment ・Protection equipment ・132kV switchgear in switchyard

Rehabilitation Plan Stage I and II have been completed. However, there are no prospects yet for Rehabilitation Plan Stage III (hereinafter referred to as Stage III) because the CEB cannot obtain any cooperation for Stage III from donors.

The content of Stage III should be scrutinized, because a long time has passed since Stage III was prepared and some bases for rehabilitation items in Stage III were lost due to staff re-assignment, etc.

In this study, a realistic rehabilitation plan for the electro-mechanical equipment of the Laxapana Complex was established after confirming the validity of Stage III, first of all, and adding repair items required for three hydropower stations (Old Laxapana, Canyon, Polpitiya), which were excluded from the scope of Stage III.

The present overall status of the hydropower stations in the Kelani River Basin checked in the study is summarized as follows.

- No significant problems that limited the operations of each power station have been observed. However, some faults that may cause a big accident in the future were observed.
- Daily inspection and cleaning are carried out very carefully by the CEB, and of the equipment looks new considering its operation years. However, no planned overhaul has been carried out for the power stations since their commissioning date. No disassembly inspection has been performed other than that made in cases of trouble. For the reason mentioned above, the lifetime of the equipment is conjectured to be short compared with the same equipment in Japan for which overhauls are carried out periodically. In fact, the tendency to be superannuated beyond the elapsed years has been confirmed by the results of an efficiency test and collected records.
- The replacement criteria of the CEB for spare parts are based on manufacturers manuals. However, not enough spare parts are stocked. The shortage is caused by the slow correspondence of manufacturers and by the inadequate budget at the CEB. For these reasons, some equipment remains in operation despite some faults, such as leakage of water.

The main features of each power station are shown in Table 7.2.

Table 7.2 Facility Data of the Hydropower Stations in the Kelani River Basin

Hydropower Station		Wimalasurendra	Old Laxapana (Stage I)	Old Laxapana (Stage II)	Canyon	New Laxapana	Polpitiya
a. Number of Units	(Unit)	2	3 (Unit No. 1-3)	2 (Unit No. 4, 5)	2	2	2
b. Commissioning Year		1965	1950	1958	Unit 1: 1983 Unit 2: 1989	1974	1969
c. Turbine							
Type		Vertical Francis	Horizontal Pelton	Horizontal Pelton	Vertical Francis	Vertical Pelton	Vertical Francis
Normal Effective Head	(m)	219	449	449	195.8	519.4	264.0
Rated Output	(kW)	29,900	8,330	12,870	32,080kW at 195.8m	51,500	39,100
Rated Discharge	(m^3/s)	14	2.1	3.25	18	11.5	17
Rotating Speed	(rpm)	500	600	500	500	428.5	500
Elevation of W.T. center	(m)	865		389	956.5	384	107
Manufacturer		Neyrpic	English Electric Co.	Socite des forges et atleir Du cresent (Usines Schneider)	Fuji	Neyrpic	Dominion Engineering works Ltd. (Canada)
d. Generator							
Type		Conventional	Horizontal shaft	Horizontal shaft	Conventional	Semi Umbrella	Conventional
Rated Output	(kVA)	31,250	9,800	14,700	37,500	72,000	46,900
Power Factor	(%)	80%	85%	85%	85.0%	80%	80%
Rated Voltage	(kV)	11	11	11	12.5	12.5	12.5
Manufacturer		Le Material Electrique	The British Thomson Houston Co.	Le Material Electrique	Fuji	Alsthom	Canadian General Electric Company
e. Transformer							
Rated Capacity	(kVA)	10,700	13,330	5,333	38,000	24,000	17,900
Rated Voltage	(kV)	$132/\sqrt{3}/11$	$132/\sqrt{3}/11$	$132/\sqrt{3}/11$	132/12.5	$145/\sqrt{3}-132/\sqrt{3}/12.5$	$139/\sqrt{3}-125/\sqrt{3}/12.0$
Rated Ampere	(A)	140.4 / 1685	174.9/1212	70/485	125/1316	286.3-315 /1920	223.7-247.3 / 1492
Phase	(phase)	single	single	single	3	single	single
Type of Cooling		OFW	ONAN/ONAF	FOW	ONAF	ONAF	OFW
Manufacturer		Le Material Electrique	Alsthom (Common transformer for 1, 2, 3)	Le Material Electrique	Fuji	Alsthom Savoisiene	Canadian General Electric Company

7.2 Present Status of and Rehabilitation Plan for Wimalasurendra Hydropower Station

7.2.1 Mechanical Equipment

(1) Turbine

1) Deterioration diagnosis results

a) Maintenance and outage records

There are no major faults in turbines. The units have been operated for 40 years without a complete overhaul involving a total disassembly and reassembly.

b) Spare parts

A new spare runner is stored in the powerhouse. It has not been used since the commissioning date.

c) Simplified efficiency test

The operation without cavitation erosion after commissioning indicates good performance of the turbines. The simplified efficiency test was not implemented due to be the sufficient conditions of the turbines and the difficult accessibility of proper penstock locations where ultrasonic sensors are installed. Accessible places of the penstock are far from the powerhouse.

d) Visual inspection and interviews of maintenance personnel

No overhaul with disassembly for whole turbine components has been implemented since the commissioning date. An annual inspection over four weeks is performed every year in lieu of an overhaul.

2) Countermeasures

The replacement of the turbines is not necessary. It is recommended that overhauls are undertaken periodically. Consumables and damaged parts such as packing, wicket gate stem bushings and wearing rings should be replaced as soon as possible.

(2) Inlet Valve

1) Deterioration diagnosis results

a) Maintenance and outage records

Leakage of water from the valve seat and seal ring of the inlet valve was observed at this and the other power stations due to delays in their replacement. The normal replacement interval is 10 to 15 years depending on the silt concentration in the water.

b) Spare parts

The procurement of the necessary spare parts has been delayed.

c) Visual inspection and interviews of maintenance personnel

There is no major problem other than the leakage of water.

2) Countermeasures

The procurement and replacement of the spare valve seats and the seal rings is recommended. They should be prepared and replaced by the CEB.

(3) Governor

1) Deterioration diagnosis results

a) Maintenance and outage records

The governor is satisfactory for the operation.

b) Spare parts

It will be almost impossible to expect the same products, due to their discontinued production. There is no stock of spare parts such as control motors, switches, solenoid valves, etc.

c) Visual inspection and interviews of maintenance personnel

The CEB expects to replace the mechanical governor, including the wicket gate operation system if necessary.

The mechanical governing system is obsolete. Most of original automatic functions have been lost and the hydraulic turbines are operated manually.

2) Countermeasures

As mentioned above, the governor is the old-fashioned mechanical type and its production has been discontinued. If the governors experience a fault, a long turbine shutdown will result because it is very difficult to procure spare parts. And it is difficult to coordinate the present governor with numerical control equipment. Therefore it is recommended that the whole mechanical governor system is replaced with the latest numerical one.

(4) Other Auxiliary Equipment

1) Deterioration diagnosis results

a) Maintenance and outage records

Records are not well arranged. The water drainage system, compressed air system and grease lubrication system are deteriorating. The life of that auxiliary equipment is generally 25 to 40 years, and replacement is recommended at 30-year intervals. The power station has been operated for 40 years since its commissioning date.

b) Spare parts

It will be almost impossible to expect the same products due to their discontinued production.

c) Visual inspection and interview of maintenance personnel

The auxiliary equipment, such as drainage pumps, auxiliary pumps, air compressors, and brake systems, has been operated for 40 years. The CEB expects to replace them.

2) Countermeasures

Since the equipment has not been overhauled since the commissioning date, the leakage of water and air is increased by deterioration of the equipment. The auxiliary equipment is old-fashioned and spare parts are no longer available. The equipment is old enough to be replaced.

7.2.2 Electrical Equipment

(1) Generator

1) Deterioration diagnosis results

Detailed disassembly inspection records were not found.

The measured insulation resistance is shown below.

Table 7.3 Insulation Resistance of Generator Stators at the Wimalasurendra Hydropower Station

Measurement time		1 min. (M Ohm)	10 min. (M Ohm)	P.I.	Remarks
#1 Stator	Red phase-Earth	500	1,000	2.0	Date of measurement: Unit 1 23rd Mar. 23, 2003 Unit 2 27th Dec. 27, 2000 Measurement voltage: 5,000VDC
	Yellow phase-Earth	600	1,200	2.0	
	Blue-Earth	600	1,000	1.7	
#2 Stator	Red phase-Earth	425	1,200	2.8	
	Yellow phase-Earth	450	1,300	2.9	
	Blue-Earth	450	1,200	2.7	

Picture 7.1 Present Status of the Unit 1 Stator

The insulation resistance values of the stator coil satisfy the requirement of over 100M Ohm as specified by Japanese criteria. The polarization index values are over the 1.5 stated in the Japanese criteria, for all generators. Based on these findings, the status of the stator coils is judged to be "good."

A fault took place in 2002 on the Unit 1 stator coil, which was moved downward by 6mm at maximum. Only an emergency measure has been made to prevent further downward movement in the two years since the fault was found. The present status of the stator is shown in Picture 7.1.

It was found, in an investigation after the fault happened, that the downward movement was due to superannuated wedges, which caused a loose fit of the stator coil. There is concern that Unit No. 2 is deteriorating as well, because the wedge loosening was also found in that unit, although no similar failure has been experienced there.

The major spare parts are stocked at Wimalasurendra P/S.

2) Countermeasures

It is common for the stator coil and iron core of a 40-year old generator to be replaced immediately upon downward movement of the stator coil. However, the unit has been operated with the problem unsolved because it could not be shut down for a long time due to the tightness of power demand and the limited budget.

An 18-month shutdown would normally be necessary for the replacement of the coil and the iron core, as shown in Table 8.3. Considering the machine age of 40 years, the most economical option should be selected through a comparison study of the option of a total generator replacement (14-month shutdown—refer to Table 8.4).

In either case, the generator should be disassembled to confirm its actual dimensions because there are no useful drawings. However, in this disassembly inspection, there is concern that the generator shutdown period may become longer than the estimated period due to unforeseeable troubles or unskilled installation work. Therefore, the timing of disassembly inspection work should be determined by taking into account the reserve capacity for Sri Lankan power system and the hydrological situation.

It is not necessary for the specification of the generators to be changed, because the existing turbines are not to be replaced.

(2) Excitation Equipment

1) Deterioration diagnosis results

This excitation equipment is a DC exciter system. This type requires much maintenance work, such as frequent brush cleaning, and has low functional reliability compared with brush-less exciter systems, which are now more common.

An investigation showed the automatic voltage regulator in the excitation control unit to be out of order. Under these circumstances, operators at the Wimalasurendra hydropower station are controlling voltage manually since no spare parts are available for the automatic voltage regulator.

2) Countermeasures

The automatic voltage regulator in the excitation control unit is already a discontinued item, and is very difficult to procure. Moreover, deterioration is progressing in other control portions in the excitation equipment. Although it is possible to control the voltage manually for a while, an automatic voltage regulator should be employed for greater system voltage stability.

In the described situation, the deteriorated exciter controller should be replaced with the numerical type equipped with automatic voltage regulator, which is now more common, in order to improve the reliability of the power station and the stability of the system voltage.
Although the DC exciter itself is old-fashioned, few troubles have been shown in the record in recent years. Therefore, the replacement of the exciters should be carried out together with the generators.

(3) Generator Transformer

1) Deterioration diagnostic result

The insulation resistance values of the generator transformer and a generator stator have been measured in every annual inspection, which have been called "overhauls" by the CEB. However, the measuring methods differ from one inspection to another. Therefore, the measurement values have not been utilized in an effective manner. It is urgently required to standardize the measurement methods common to all the power stations.

The insulation resistance values of the Unit 1 and 2 transformers are the Wimalasurendra hydropower station are shown in Table 7.4 and 7.5.

Table 7.4 Insulation Resister of No. 1 Transformers at the Wimalasurendra Hydropower Station

Date		May 9, '02		Mar. 26, '04		Remarks
Measurement Time		1 min. (M Ohm)	10 min. (M Ohm)	1min. (M Ohm)	3 min. (M Ohm)	
Red Phase	HT-E	750	1,000	**140**	160	HT - High-voltage side terminal LT - Low-voltage side terminal E - Earth
	LT-E	340	375	350	400	
	HT-LT	675	900	320	360	
Yellow Phase	HT-E	300	330	**120**	125	
	LT-E	625	875	350	375	
	HT-LT	575	800	325	350	
Blue phase	HT-E	900	1,400	600	700	
	LT-E	350	390	210	230	
	HT-LT	1,000	1,400	700	800	

Table 7.5 Insulation Resister of No. 2 Transformers at the Wimalasurendra Hydropower Station

Date		29th Dec. 00		16thAug.03		Remarks
Measurement Time		1 min. (M Ohm)	3 min. (M Ohm)	3 min. (M Ohm)	10 min. (M Ohm)	
Red phase	HT-E	240	280	**155**	160	Legend: HT - High-voltage side terminal LT - Low-voltage side terminal E - Earth
	LT-E	600	650	350	375	
	HT-LT	550	710	300	325	
Yellow phase	HT-E	290	300	-	-	
	LT-E	700	780	-	-	
	HT-LT	650	800	-	-	
Blue phase	HT-E	260	295	**160**	170	
	LT-E	650	800	370	400	
	HT-LT	650	825	305	350	

Major spare parts are stocked at Wimalasurendra P/S.

2) Countermeasures

The following items are considered in view of the results shown in Table 7.4 and 7.5.

- Insulation resistance values are decreasing greatly in most transformers judging from the comparisons of the resistance between 1-minute values in 2002 and 2004 for Unit 1, and between 3-minute values in 2002 and 2004 for Unit 2.

- A few of the 1-minute values are close to 100M Ohm, which is the lower limit for a judgment as a "defect" in the criteria in Japan. Therefore, the deterioration of the transformers is accelerated considerably.

It is an urgent matter that all of the transformers be replaced.

(4) Other Electric Equipment

1) Deterioration diagnostic results and countermeasures

The 11kV circuit breaker has caused an annual average of 3.5 operation accidents. Deterioration has been also reported on the other equipment of the 11kV main circuit.

The 11kV main circuit, which includes the circuit breaker and cables, is important equipment that directly affects the reliability of the power station in spite of the small cost allocation in the power station. The circuit equipment should be completely replaced in view of the accelerated deterioration that has occurred in the equipment and the shortage of the spare parts.

The 132kV switchgears have been in operation now for 25 to 33 years. Since the lifetime of switchgear is normally 25 years, all the switchgears have exceeded their designed lifetime. Accordingly, it has been judged that all 132kV switchgears have reached the time for their replacement.

7.2.3 Control Equipment

(1) Control and Protection Equipment

1) Deterioration diagnosis results

One-man control of start-up, stop and paralleling of the turbine-generator has not been available in recent years. Therefore, the governor and the excitation equipment have been operated manually by operators. The well-trained operators have carried out their missions efficiently to minimize the sequence operation time. The main switchboard room is arranged well so that all the equipment — not only the control equipment of the turbine, the generator, and the transmission line and protection equipment but also other equipment such as the control desk, auxiliary power panel, and battery charging system — could be located compactly. (Refer to Appendix C-3 List of Control Room Layout.)

It will be next to impossible to expect replacement with the same control and protection equipment, due to the discontinuation of its production. Procurement of the spare parts is very difficult. The CEB expects to replace all of the control and protection systems with new systems to avoid trouble such as relay failures or malfunctions due to the deterioration of the parts now in use. In addition, the standard lifetime of the electrolytic condensers on the relays is 12 years, by J-POWER standards. This power station could be judged to have already reached the replacement time for the entire control and protection system.
(Refer to Appendix C-3 Summary for Investigation.)

2) Countermeasures

The best option for the control and protection system of this power station is to improve operational reliability, introducing the latest technology into all of the equipment of the power station control and protection system, not by making partial repairs of 40-year-old parts. In fact, the CEB replaced the control and protection systems with new numerical systems prior to 2003 at two power stations, Old Laxapana and Polpitiya, which are included in this study.

Considering the efficient operation of the whole water basin system, the entire control and protection systems of this power station should also be replaced with new ones having performance equal to or greater than those of the two power stations mentioned above.

The scope of the replacement should be as shown below.

a) Control equipment:

Supervisory and control board for turbine, generator, generator transformer, switchyard, transmission line, auxiliary circuit
Governor control board
Excitation control board
Control desk

b) Protection equipment:

Protection for turbine, generator, generator transformer, switchyard, transmission line

c) Spare parts:

Spare parts for the above control equipment and protection device

The configuration of the control and protection system for Wimalasurendra hydropower station is shown in Figure 7.1.

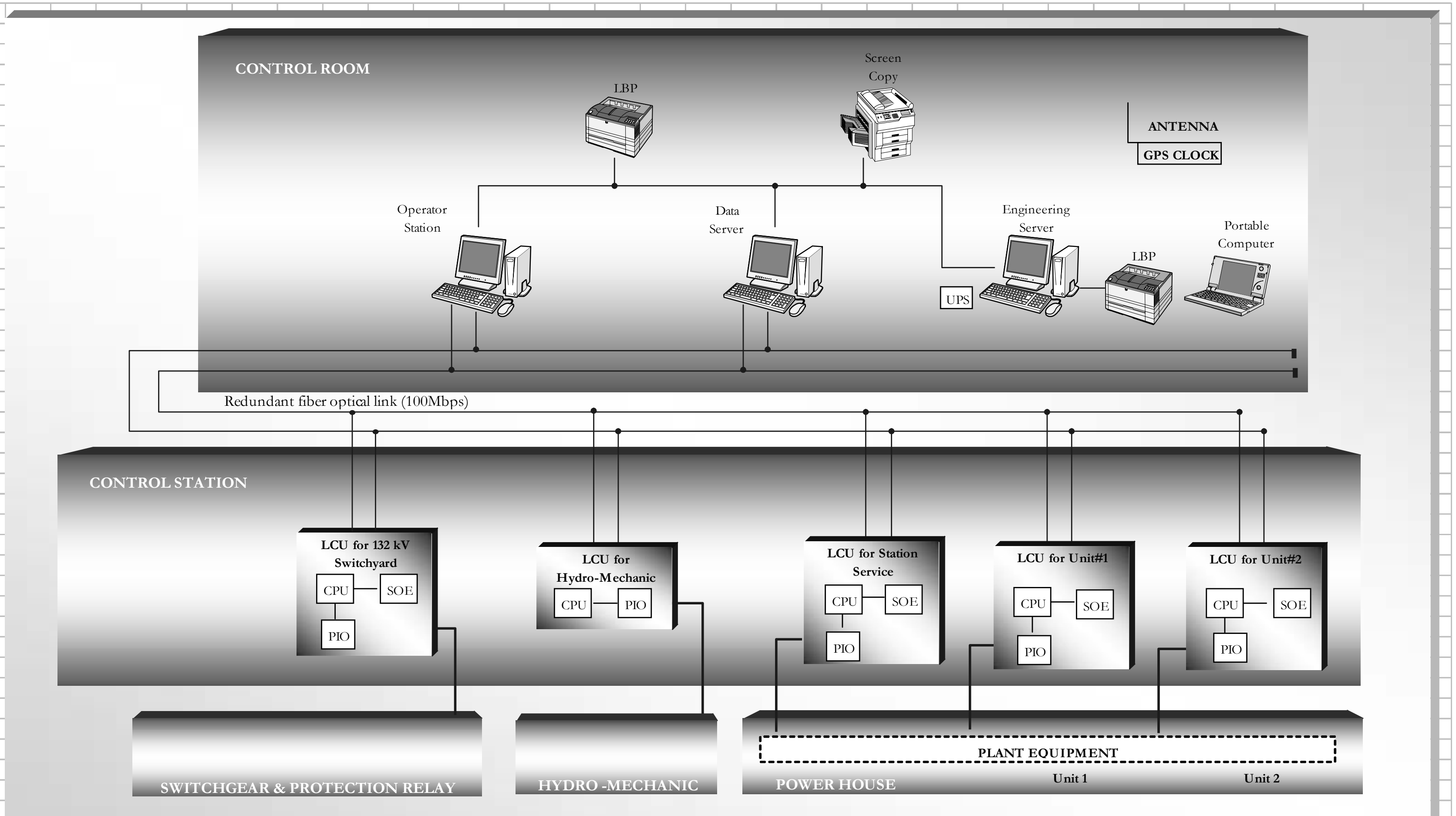


Figure 7.1 Control System Configuration for Wimalasuaendra Hydropower Station

SOE : Sequence of Event Printer
UPS : Uninterrptible Power Supply
LCU : Local Control Unit
GPS : Global Positioning System (time reference for SCADA system time synchronization)
: Multiwire cables (parallel communication)
: Serial transmission link
: Area boundary
LBP : Laser Beam Printer
PIO : Process Input Output
: Controller, Communication Equipment

(2) Control Power Source Equipment

1) Deterioration diagnosis results

This equipment has been well maintained (maintenance and inspection have been implemented every two weeks) and has operated in good condition despite the fact that this equipment has been in operation for more than 40 years. However, the spare parts of each device are in short supply, so that recovery work following failures and breakdowns of the equipment is becoming more difficult. The CEB expects to replace this equipment.

2) Countermeasures

The 220V battery and battery charger of the control power source, which includes the control and power cables, should be replaced at the same time of the replacement of the power station control and protection system. An uninterruptible power supply system should be installed at the same time also to improve the reliability of the control and protection system.

(3) Communication Equipment

1) Deterioration diagnosis results

The microwave signal system is not used for signal transmission for transmission line protection, but a power line carrier system is used for signal transmission. However, the capacity of the power line carrier system is inadequate for data transmission.

There is no remote display of the dam water level, which is reported by telephone.

2) Countermeasures

The CEB expects to operate the Wimalasurendra hydropower station from the Old Laxapana hydropower station by the Supervisory Control and Data Accusation (SCADA) system. Therefore, the communication line OPGW should be installed between both hydropower stations of Old Laxapana and Wimalasurendra.

It will be necessary to study in a detailed design stage an interface with the communication equipment as well as the items for the remote control of the control and protection equipment of the power stations.

(4) Dam Distribution Equipment

1) Deterioration diagnostic results

The electric power used at Castlereagh Dam is supplied from WPS- Dickoya feeder. Though the line is currently operated without any problems, it is deteriorating.

2) Countermeasures

Although it is not necessary to replace existing equipment at present, a study of future replacement should be started by the CEB.

7.3 Present Status of and Rehabilitation Plan for Old Laxapana hydropower station

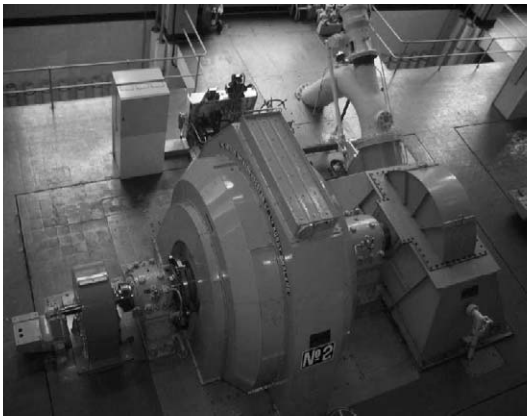
7.3.1 Mechanical Equipment

(1) Turbine

1) Deterioration diagnosis results

a) Maintenance and suspension records

Old Laxapana P/S Stage I (Units 1 to 3): Picture 7.2 shows an overview of the turbine and generator of the Stage I (Units 1 to 3) at the Old Laxapana hydropower station. The Stage I (Units 1 to 3) turbines are equipped with a very obsolete mechanism for energy dissipation. Instead of a deflector, which is currently the most popular mechanism, a diffuser with a couple of vanes has been installed in the needle rod as shown in Picture 7.3. The diffuser will dissipate energy when the machine is quickly stopped.



Picture 7.2 Turbine and Generator of Old Laxapana Stage I (Unit 2)

Brake disks were installed in place of braking jet nozzles in the previous renovation.

The material of the runner is 18% Cr– 8% Ni stainless steel. The runner is composed of 22 buckets.

Picture 7.3 Diffuser and Needle of Old Laxapana Stage I

On twelve occasions, repairs have been performed on six runners of Stage I, i.e. three operating and three spare runners, over 12 years, according to the record. Repair work on the runners is carried out approximately once a year. However, individual detailed records on six runners are not available.

Consequently, it is roughly estimated that repair works have been performed nine times in 54 years, assuming each runner has been repaired every six years and the six runners have been repaired equally.

Repeating weld repairs increase the residual stress and worsen the cracks and ruptures that are observed on the runner bucket in Stage I (Units 1 to 3). Pictures 7.4 to 7.6 indicate runner cracks and repairs.

Picture 7.4 Repairing of Runner Crack of Old Laxapana Stage I

Fortunately, skilled technicians repair the runner bucket cracks by welding at the powerhouse maintenance shop. They intently support the maintenance of the equipment in these circumstances, without new spare parts.

Old Laxapana hydropower station Stage II (Units 4 and 5):
The Stage II turbines (Units 4 and 5) are equipped with an ordinary deflector, that is currently the most common such mechanism.

Cavitation erosion on the runner bucket has been repaired by welding at the powerhouse maintenance shop. However, cavitation erosion is less serious than that in Stage I (Units 1 to 3). The material of the runner is 13 % Cr–4% Ni stainless steel. The runner is composed of 18buckets. Runner cracks are not revealed by visual inspection.

Picture 7.5 Repaired Runner Bucket of Old Laxapana Stage I

Picture 7.6 Indication of Runner Crack at Old Laxapana Stage I

b) Spare parts

Old Laxapana hydropower station Stage I (Units 1 to 3):
The original manufacturer (English Electric Co.) went out of business many years ago. New spare parts are no longer available. Three used spare runners have been repaired and are stored in the powerhouse. Other components are also repaired at the maintenance shop.

Old Laxapana P/S Stage II (Units 4 and 5):
New spare parts were not seen. Two used spare runners have been repaired and are stored in the powerhouse. Other components are also repaired at the maintenance shop.

c) Simplified efficiency test

Old Laxapana hydropower station Stage I (Units 1 to 3):
The simplified efficiency test, which was implemented at Unit 1 using a portable ultrasonic flow meter, revealed remarkably low efficiency even considering the 54 years operation, as shown in Figure 2 in Appendix C-1. The test result suggests the deterioration of needle tips and nozzles as well as the malfunctioning of the correlation between needle and diffuser openings, which is likely caused by the previous governor replacement or maintenance in 1995.

It also suggests that the maintenance of the existing machines is very difficult due to the absence of the original design documents and installation test records.
Additionally, the present operation procedure to control two needles simultaneously provides lower turbine efficiency under a partial load, in comparison with the procedure to control them separately.

Old Laxapana hydropower station Stage II (Units 4 and 5):
The simplified efficiency test, which was implemented at Unit 4 using an ultrasonic flow meter, indicates slightly lower efficiency even in consideration of the power station's 46 years operation, as shown in Figure 3 in Appendix C-1. The deterioration of needle tips and nozzles is suggested by the result. However, the efficiency level is better than that of Stage I (Units 1 to 3), which suggests allowing the turbine operation to continue for now.

Additionally, the present operation procedure to control two needles simultaneously provides lower turbine efficiency under a partial load, in comparison with the procedure to control them separately.

d) Visual inspection and hearing from maintenance personnel

Old Laxapana hydropower station Stage I (Units 1 to 3):
As mentioned above, the design and structure of the Pelton turbines are obsolete. Remarkably low efficiency is observed in the simplified efficiency test at this site. The Pelton turbines and accessories have been operated without an overhaul, but with partial disassembly, for 54 years.

The CEB requested a partial or total replacement of the equipment.

Old Laxapana hydropower station Stage II (Units 4 and 5):
The turbine is available for operation for the time being.

2) Countermeasures

Old Laxapana hydropower station Stage I (Units 1 to 3):
It is recommended that a complete replacement is made of the hydraulic turbines, inlet valves, governors and associated accessories if the results of economical analysis are feasible.

Appendix C-2 describes a few studies for estimating the unit specification after rehabilitation. In consideration of the high plant factor of the power plant as well as the requirements of the CEB, it was decided to pursue the possibility of increasing the total turbine output in regard to the unit expansion with three 9MW units.

Appendix C-2 shows the study on the waterway (headrace tunnel, penstock and surge chamber), loss head, effective head and unit efficiency. However, most of the design data and drawings at the installation stage with respect to the waterway condition and loss head as well as effective head are missing. Therefore, the present loss head and effective head are estimated on the basis of the measured head loss obtained in the simplified efficiency test.

The turbine efficiency of the existing unit has deteriorated remarkably, as clarified in the simplified efficiency test (Appendix C-1). Therefore, the present turbine discharge is required to be more than that of the design stage to obtain the maximum output of the power station.

It was reported that a bursting sound was heard when the units were shut down. This suggests air was sucked into the penstock in the existing units when the water level of surge chamber, i.e., the upper reservoir, was lower. It is speculated that compressed air in the penstock flowed upward, resulting in the bursting sound at the surge chamber, due to the limited waterway capacity and the improper elevation of penstock inlet.

In consideration of the air suction mentioned above, it has been concluded that greater discharge than the present amount should not be recommend.

Consequently, studies on the proper unit capacity and quantities were implemented based on the collected brochures and data at the installation stage.

Unit output of 9MW was selected rather than the 8MW of the existing unit. Table 13 and 14 in Appendix C-2 show the specifications of the turbine and generator, respectively. A turbine efficiency comparison of the 9MW plan and the existing unit is shown in Figure 4 of Appendix C-2.

When the rehabilitated three units of the 9MW and existing two units (Units 4 and 5) are operated in parallel, the maximum discharge is estimated to be 14.32 m^3/s, as shown in Table 9 of Appendix C-2. Table 9 of Appendix C-2 indicates that this discharge is less than the estimated discharge of 14.64 m^3/s when existing 5 units are operated at maximum load in parallel. Consequently, the unit specification with three 9MW units (total output of 27 MW) is favorable under the conditions of the allowable maximum discharge.

According to the surge chamber water level calculation, air suction into the penstock also may occur under the condition of a lower water level of the upper reservoir in the case of the 3 units of the 9MW plan. Then it is recommended to define the operation range of the upper reservoir. The calculation result and recommendation are described in Chapter 5.7.

Following the above studies, the number of units (two units or three units) has been compared. The advantages and disadvantages of each plan are compared in Table 11 of Appendix C-2.

With respect to the plan for two units of 13.5 MW, the total axial length of the turbine and generator is longer than the existing unit span (9.8 m), resulting in a conflict with the existing Unit 4.

In addition, it is necessary to implement penstock modification (from three branches to two branches) and foundation excavation.

In view of the three units of 9MW plan, the existing foundation and penstock can be applied with minor modification, resulting in the cheaper rehabilitation cost.
Consequently, it is recommended to apply three units of the 9MW plan to the rehabilitation of Stage I.

However, due to the lack of existing drawings and data, it is necessary to check the dimensions and make new drawings of the existing layouts and foundations. Then it is strongly recommended to disassemble one unit and precisely confirm the dimensions and layouts prior to the detailed design.

Old Laxapana hydropower station Stage II (Units 4 and 5):
It is recommended that present equipment continues to be used. Spare parts should be procured in a timely manner.

(2) Inlet Valves

1) Deterioration diagnosis results

a) Maintenance and outage records

Old Laxapana hydropower station Stage I (Units 1 to 3):
An obsolete center balance type inlet valve (CB valve) is installed in place of the usual spherical valve. It often failed to close due to control system malfunctions.

It is reported in the maintenance records that the rotating speed soared to 694 m^{-1} when the machine was stopped because the inlet valve (MIV) failed to close.

The configuration of the CB valve is more complicated than that of the usual spherical valve, resulting in more malfunctioning due to the long operation period. However, an individual maintenance record has not been kept as repeated repairs have been implemented.

Old Laxapana hydropower station Stage II (Units 4 and 5):
Spherical valves are installed. Inlet valves (MIV) have no major problems except leakage-water from the valve seat and seal ring as at other power stations.

b) Spare parts

Old Laxapana hydropower station Stage I (Units 1 to 3):
New spare parts are not available because the procurement is very difficult.

Old Laxapana hydropower station Stage II (Units 4 and 5):
New spare parts are not available.

c) Visual inspection and hearing from maintenance personnel

Old Laxapana hydropower station Stage I (Units 1 to 3):
CEB requested the replacement of inlet valves.

Old Laxapana hydropower station Stage II (Units 4 and 5):
Procurement of spare parts is necessary.

2) Countermeasure

Old Laxapana hydropower station Stage I (Units 1 to 3):
Replacement of the inlet valves is recommended from the present center balance type to the spherical one.

Old Laxapana hydropower station Stage II (Units 4 and 5):
Replacement of the inlet valves is not necessary because the spherical type is currently used, while it is recommended that the valve seats and seal rings are replaced periodically. Necessary parts will be prepared and replacement carried out by the CEB.

(3) Governors

1) Deterioration diagnosis results

a) Maintenance and suspension records

Old Laxapana hydropower station Stage I (Units 1 to 3):
Governors, oil pressure systems, compressed air systems, inlet valve control and associated control valves were replaced in 1995. However, existing servomotors for diffusers, needles and inlet valves have been used without renewal. Oil and air pressures have been maintaining the original 24 bars.

Oil levels are reported to be decreasing in the accumulators.

b) Spare parts

Old Laxapana hydropower station Stage I (Units 1 to 3):
The CEB renewed spare parts in 1995. But there are no control motors in stock.

Old Laxapana hydropower station Stage II (Units 4 and 5):
The CEB renewed spare parts in 2003. But there are no solenoid valves in stock.

c) Visual inspection and interviews of maintenance personnel

Old Laxapana hydropower station Stage I (Units 1 to 3):
Both pressured water from the penstock and pressured oil are used to control the needle and diffuser servomotors. It seems that insufficient adjustment or misalignment due to the complicated operating mechanism might result in unsatisfactory turbine operation characteristics.

Old Laxapana hydropower station Stage II (Units 4 and 5):
There is no major problem.

2) Countermeasures

Old Laxapana hydropower station Stage I (Units 1 to 3):
In order to increase the reliability of the turbine control, it is recommended that the governors, including oil pressure systems and compressed air systems, should be replaced. The governor should be able to control the correlation of the openings between the deflector and the needle optimally.

Old Laxapana hydropower station Stage II (Units 4 and 5):
Governor replacement is not necessary. It is recommended that the governor continues in operation with replenishing by spare parts.

(4) Other Auxiliary Equipment

1) Deterioration diagnosis results

a) Maintenance and suspension records

Old Laxapana hydropower station Stage I (Units 1 to 3):
The failures of the cooling water system has caused a shortage of oil cooling water and high turbine bearing temperatures. Cleaning the coolers has often been necessary.
Lubrication systems of main bearings and compressed air systems have deteriorated.

Old Laxapana hydropower station Stage II (Units 4 and 5):
The failures of cooling water system are almost the same as those of Stage I (Units 1 to 3).

b) Spare parts

Old Laxapana hydropower station Stage I (Units 1 to 3):
Procurement of new spare parts is difficult.

Old Laxapana hydropower station Stage II (Units 4 and 5):
Procurement of new spare part is difficult.

c) Visual inspection and interviews of maintenance personnel

Old Laxapana hydropower station Stage I (Units 1 to 3):
The CEB expects the cooling water supply system, lubrication oil system and compressed air system to be replaced.

Old Laxapana hydropower station Stage II (Units 4 and 5):
The CEB expects the compressed air system for generator brake to be replaced.

2) Countermeasures

Old Laxapana hydropower station Stage I (Units 1 to 3):
It is recommended that the cooling water supply system, lubrication oil system and compressed air system for the generator brake are replaced. In order to prevent the temperature of the bearings for the turbine and generator from rising, it is necessary to reexamine the existing troubles and produce a design to supply the sufficient cooling water.

Old Laxapana hydropower station Stage II (Units 4 and 5):
It is recommended that the compressed air system for generator brake is replaced. However, the CEB should repair and replace the cooling water supply system and the lubrication system.

7.3.2 Electrical Equipment

(1) Generators

1) Deterioration diagnosis results

As with the Wimalasurendra hydropower station, detailed disassembly inspection records were not found.

The original B-type stator coils in Unit 1 to 3 were replaced in 1978 with F-type coils, which can withstand higher temperatures. Moreover, the stator coil of Unit 2 was rewound due to a breakdown in 1998.

Table 7.6 Insulation Resister of Generator Stators at the Old Laxapana Hydropower Station

Measurement time		1 min. (M Ohm)	10 min. (M Ohm)	P.I.	Remarks
#1 Stator	Red phase - Earth	1,280	3,120	2.44	Year of measurement: 2004 Legend: R, Y, B - Red phase, yellow phase and blue phase E - Earth
	Yellow phase - Earth	1,250	2,860	2.29	
	Blue phase - Earth	1,600	4,360	2.73	
#2 Stator	Red phase - Earth	1,280	3,120	2.44	
	Yellow phase - Earth	1,250	2,860	2.29	
	Blue phase - Earth	1,600	4,360	2.73	
#3 Stator	Red phase - Earth	1,710	4,860	2.84	
	Yellow phase - Earth	1,670	4,780	2.86	
	Blue phase - Earth	1,660	4,440	2.67	
#4 Stator	Red phase - Earth	380	-	-	
	Yellow phase - Earth	362	-	-	
	Blue phase - Earth	354	-	-	
	R, Y, B - E	117	240	2.05	
#5 Stator	Red phase - Earth	540	1,210	2.24	
	Yellow phase - Earth	515	1,810	3.51	
	Blue phase - Earth	496	1,130	2.28	

The insulation resistance values of the stator coil satisfy the level of over 100M Ohm as specified by Japanese criteria. The polarization index values are over the 1.5 specified in Japanese criteria in all generators. Based on these conditions, the status of the stator coils is judged to be "good". The conditions of Unit No. 4 are estimated to be similar to those of Unit No. 5 even though the records of each phase were not found, because no fault has occurred in the last two years and the polarization index values in the three-phases package exceed 1.5.

As for other parts, the stator core temperatures of Unit 2 and 3 maintain a high level around 90˚ Centigrade. Since this temperature level is below the maximum temperature of the F-type coil, further operation will be feasible by continuing to observe the temperature.
The main spare parts are stocked at the Old Laxapana hydropower station.

2) Countermeasures

Though the replacement of generators including the excitation equipment is not necessary independent form that of the turbines under the current conditions, the generators should be replaced if the turbine is replaced as described in the article 7.3.1 because of the following reasons.

- The generators have already been operated for more than its lifetime and the superannuation has been progressing. Therefore, the replacement of the generators will also be essential in the near future after the turbines are replaced. The total shutdown period of the power station can be minimized if the generators and the turbines are replaced simultaneously.

- The generator bearing should be modified to match with the modified thrust, which will be changed if the turbines are replaced. A wide scope of the modification will be necessary regarding the generator bearing mechanism, especially if the output of the turbines increases.

- In the case of the turbine output increasing, the generator should be replaced to match the turbine output.

It is necessary for the generators to increase the output from 9.8MVA to 11MVA together with increase of the turbine output.

(2) Generator transformer

1) Deterioration diagnostic results and a countermeasure

Insulation resistance is shown below.

Table 7.7 Insulation Resistance of Generator Transformers for Units 1, 2, and 3 at the Old Laxapana Hydropower Station

Measurement Time		1 min. (M Ohm)	Remarks
Red phase	HT-E	2,160	Measurement voltage: Unknown Legend: HT - High-voltage side terminal LT - Low-voltage side terminal E - Earth
	LT-E	3,000	
	HT-LT	3,420	
Yellow phase	HT-E	2,160	
	LT-E	3,000	
	HT-LT	3,420	
Blue phase	HT-E	2,160	
	LT-E	3,000	
	HT-LT	3,420	

Table 7.8 Insulation Resistance of Unit 4 Generator Transformers at the Old Laxapana Hydropower Station

Measurement Time		1 min. (M Ohm)	Remarks
Red phase	HT-E	1,610	Measurement voltage: Unknown Legend: HT - High-voltage side terminal LT - Low-voltage side terminal E - Earth
	LT-E	2,700	
	HT-LT	4,000	
Yellow phase	HT-E	1,610	
	LT-E	2,700	
	HT-LT	4,000	
Blue phase	HT-E	1,610	
	LT-E	2,700	
	HT-LT	4,000	

Table 7.9 Insulation Resistance of Unit 5 Generator Transformers at the Old Laxapana Hydropower Station

Measurement Time		1 min. (M Ohm)	Remark
Red phase	HT-E	545	Measurement voltage: Unknown Legend: HT - High-voltage side terminal LT - Low-voltage side terminal E - Earth
	LT-E	236	
	HT-LT	795	
Yellow phase	HT-E	570	
	LT-E	212	
	HT-LT	800	
Blue phase	HT-E	545	
	LT-E	226	
	HT-LT	805	

All coil insulation resistance values are over 100M Ohm.

No abnormalities were found in visual inspections. No trouble was caused by a fault of the generator transformers, according to the records for the last two years.

It has been judged that the transformers can be operated normally for a while. However, it is difficult to diagnose deterioration correctly by such inspection alone. It is recommended that deterioration diagnostic data be collected by suitable methods, such as through the installation of an automatic temperature recorder, period oil gas analysis, etc. in order to provide data for a decision on future replacement.

The total capacity of the transformer connected to Units 1, 2 and 3 is 40MVA and that of the replaced generators is 33MVA. The existing transformer has enough capacity even after replacement of the turbines and the generators.

There are not enough spare parts for the transformer at the Old Laxapana hydropower station. The CEB needs to assure a suitable budget and needs to stock the spare parts.

(3) Other electric equipment

1) Deterioration diagnostic results and a countermeasure

The replacement of the 11kV main circuit was carried out in the CEB's Rehabilitation Plan Stage I and II. No appreciable trouble was found in these installations during the investigations in the study.

As far as external visual inspections are concerned, no trouble was observed. No trouble caused by a fault of the switchgear has occurred, according to the records for the last two years. It will be possible to use the 11kV and 135kV circuit for a while.

As for other equipment, low operational reliability was found in the bearing lubrication pump. This trouble is caused not only by deterioration of the equipment but also by an improper motor system design. The lubrication pump system uses AC and DC motors. The system is far too outdated to be reliable. The system often causes the pump to stop in the case of an AC auxiliary circuit failure. The stop would be unavoidable because it is difficult for the system to select one adequate motor out of those involved in the AC auxiliary circuit failure. This stoppage will directly affect the reliability of the power station. For this reason, it is necessary to make a system change by introducing a double DC motor or double AC motor with an inverter to supply AC power from a DC battery in the case of the generator replacement option.

The status of the spare parts for the "other electric equipment" is the same as that for the generator transformer in Old Laxapana hydropower station. The CEB needs to assure a suitable budget and needs to stock the spare parts.

7.3.3 Control Equipment

(1) Control and Protection Equipment

1) Deterioration diagnosis results

The control and protection equipment was replaced with numerical type equipment in 1994 to 1995 and in 2003. The batteries were replaced in 1994 and, subsequently, modernization has been in progress. Two sets of numerical-type control and protection equipment are installed. The first set, SCADA No. 1, is used for Unit 1, Unit 2, Unit 3 and the powerhouse utility source. The second set, SCADA No.2 is used for Unit 4, Unit 5 and the switchyard.

The old control and protection equipment is still installed in the old control room following the installation of the new controller and protection devices. (Refer to Appendix C-3 List of Control Room Layout.) Almost all the functions of these old controllers and protection devices became useless since the numerical type was employed in 2003. The remote-control desk of the New Laxapana hydropower station, the supervisory board for the Norton and Laxapana dams, and a microwave communication board are still in use. Four operators are using Cathode-Ray Tube (CRT) installed in the old control room to control the turbines and the generators with assistance from additional personnel (one chief operator and two equipment surveillance operators). The replaced control and protection equipment for the turbines, the generators (including the governors and excitation equipment), the main circuit, transmission line, auxiliary circuit, the battery charger and the motor control center (MCC) (Refer to Appendix C-3 List of Control Room Layout) is installed in the new control room. Only the replaced general-purpose switchboard is installed in the turbine-generator room.

As some spare parts for the replaced numerical- type control and protection equipment are in short supply and some parts are kept un-recovered. An urgent plan for the recovery is necessary (Refer to Appendix C-3 Summary for Investigation).

There are also old-fashioned remote-control desks for the Canyon, Polpitiya, and Wimalasurendra hydropower stations in the old control room. However, there is no record of using the old-fashioned control desks. The CEB expects to install new remote-control systems for all power stations in the Kelani River Basin in the future. When a communication facility is completed between the Polpitiya hydropower station and the Old Laxapana hydropower station, the Polpitiya hydropower station can be controlled by the existing remote-control numerical system.

The state display in the control panel for the Polpitiya -Laxapana transmission line is not normal. It will be necessary to study the control and protection equipment so as to coordinate with the existing governor and the excitation equipment when the hydraulic turbines and generators are replaced.

2) Countermeasures

Continuous normal operation will be possible as a whole for the new control and protection equipment replaced. Therefore the replacement is not required. However, the above-mentioned abnormal state display comes about due to trouble of the integrated circuit board, and the CEB faces many difficulties in solving the problem. Since the new equipment it is still within the guarantee period, the CEB should request the equipment contractor to fulfill the guarantee clause.

(2) Control Power Source Equipment

1) Deterioration diagnostic results

The batteries of this equipment at the Old Laxapana hydropower station Stage I (Units 1 to 3) and Stage II (Units 4 and 5) were replaced in 1994 and 2004, respectively. However, two battery chargers have been operated for more than 45 years, and one of them is out of order. Ground phenomenon is observed on the positive terminal side of a direct-current (DC) control power source.

An uninterruptible power supply system is installed and operates normally.

2) Countermeasures

The failed battery charger should be urgently restored by the CEB in order to improve the operational reliability of the power station. The CEB should also be urged to investigate and repair the ground phenomenon on the positive terminal side.

(3) Communication Equipment

1) Deterioration diagnostic result

A microwave signal system is not used for transmission line protection signals; rather, a power line carrier system is used for the signal transmission. However, the capacity of the power line carrier system is inadequate for data transmission.

The water levels of the related dams are confirmed by remote display and telephone calls.
In addition, the communication equipment serves also as the communication equipment for the neighboring New Laxapana hydropower station.

2) Countermeasures

The CEB expects to shift all power stations in the Kelani River Basin to a remote control system by using the SCADA system from the Old Laxapana power station. The OPGW communication line will be installed between the Old Laxapana hydropower station and others at the time of the replacement of the turbines and generators, as shown in Figure 7.2, SCADA System Connected to Old Laxapana hydropower station. A highly reliable communication network will be established by installing the OPGW communication line and will make possible remote control of the relevant hydropower stations from the Old Laxapana hydropower station. It will be necessary to study in the detailed design stage the interface with the communication equipment as well as the items of remote control of the control and protection equipment at the concerned power stations.

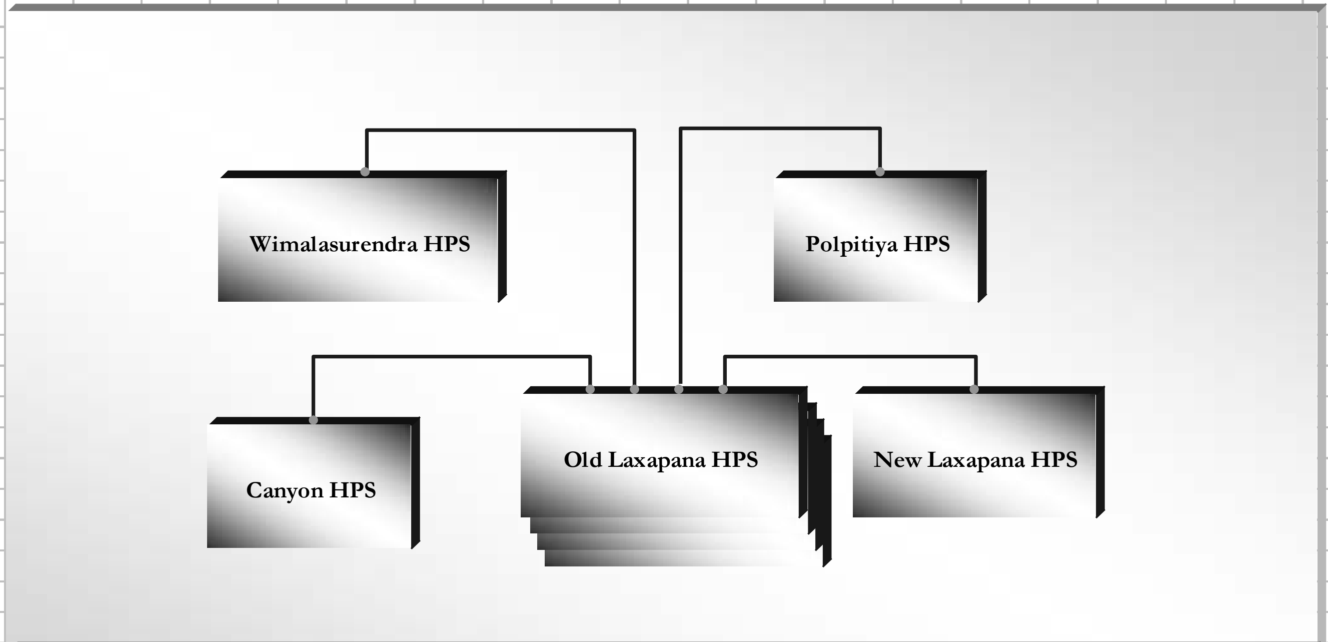


Figure 7.2 SCADA System Connected to the Old Laxapana Hydro Power Station (HPS)

Note: Connecting cable between each HPS is the optical ground wire (OPGW) of the communication line

(4) Dam Distribution Equipment

1) Deterioration diagnostic results

The electric power used at Norton Dam is fed from the Norton district grid via a distribution line. Though the dam distribution line is currently operated normally, its deterioration is apparent.

2) Countermeasures

Although it is not necessary to replace the line, a study of the future replacement should be started by the CEB.

7.4 Present Status of and Rehabilitation Plan for Canyon hydropower station

7.4.1 Mechanical Equipment

(1) Turbine

1) Deterioration diagnosis results

a) Maintenance and suspension records

The units are being operated satisfactorily. It is reported that no major deterioration is observed on turbines.

Shear pin failures (approximate five times per year) are reported likely due to the damage of inlet trash rack. Four failures were reported from January to August, 2004. The trash rack should be checked and repaired as soon as possible.

The carbon rings of the shaft seal are replaced approximately every two years.

b) Spare parts

A used spare runner is stored in the powerhouse.

c) Simplified efficiency test

The simplified efficiency test was not implemented because the turbines are rather new and are operated without any appreciable failure. Also, Unit 1 and Unit 2 at the Canyon hydropower station have been operated for the shortest period, at 21 years and 15 years, of the five hydropower stations.

Meanwhile, the model test and installation test reports are kept properly and high efficiency is confirmed and reported in those.

d) Visual inspection and hearing from maintenance personnel

The operation condition is satisfactory other than a shear pin failure. There is no request for rehabilitation from the CEB.

2) Countermeasures

Periodic maintenance and repair are recommended without replacement. Timely procurement of spare parts is essential.

It is recommended that the equipment is overhauled due to the passage of 21 years for Unit 1 and 15 years for Unit 2 since their commissioning dates.

(2) Inlet valve

1) Deterioration diagnosis results

a) Maintenance and suspension records

Large amount of leakage (approximate 0.5 liter/s by observation) from the valve seat has been observed as at other power stations. The valve seat has not experienced replacement with spare parts at least since 1993. A disassembled valve seat is stored in the powerhouse. It is reported that repair welding has been done at intervals of more than five years.

b) Spare parts

The lack of spare valve seats and seal rings causes significant leakage from the inlet valve.

c) Visual inspection and hearing from maintenance personnel

Spare parts are in short supply.

2) Countermeasures

It is not necessary to replace the inlet valve. Timely procurement of spare parts is essential. The CEB should prepare necessary parts and implement replacement.

(3) Governor

1) Deterioration diagnosis results

a) Maintenance and suspension records

Although the governor is an obsolete mechanical type, its operating condition is good.

b) Spare parts

Necessary spare parts are stocked.

c) Visual inspection and interviews of maintenance personnel

There is no major problem and no request for rehabilitation from the CEB.

2) Countermeasures

Replacement is not necessary. The CEB should repair when necessary.

(4) Other auxiliary equipment

1) Deterioration diagnosis results

a) Maintenance and suspension records

There is no major problem.

b) Spare parts

Necessary spare parts are stocked.

c) Visual inspection and interviews of maintenance personnel

There are no major problem and no request for replacement from the CEB.

2) Countermeasures

Replacement is not necessary.

7.4.2 Electrical Equipment

(1) Generator

1) Deterioration diagnosis results and countermeasures

The insulation resistance values of the stator coil satisfy the level of over 100M Ohm specified by Japanese criteria. The polarization index values in all generators are over the 1.5 specified by Japanese criteria. Based on these conditions, the status of the stator coils is judged to be "good."

Table 7.10 Insulation Resister of Generator Stators at Canyon Hydropower Station

Measurement time		1 min. (M Ohm)	10 min. (M Ohm)	P.I.	Remarks
#1 Stator	Red phase – Earth	3,000	14,000	4.67	Year of measurement: 2004
	Yellow phase - Earth	4,000	15,750	3.94	
	Blue phase - Earth	4,500	22,500	5.00	
#2 Stator	Red phase – Earth	3,500	11,000	3.14	
	Yellow phase - Earth	3,000	8,000	2.67	
	Blue phase - Earth	3,400	11,200	3.29	

Even though some peeled insulating materials and a loose wedge were recognized in the generator of Unit 1, this unit has been operated with emergency measures taken. At the Canyon hydropower station, Units 1 and 2 have been operated for 21 and 15 years since their commissioning dates. An overhaul is recommended for each unit by the CEB. Re-wedging of Unit 1 is also recommended.
The insulation resistance values of the generator transformers are shown below.

Table 7.11 Insulation Resistance of Generator Transformers at the Canyon Hydropower Station

Measurement Time		1 min. (M Ohm)	10 min. (M Ohm)	P.I.	Remarks
Red phase	HT - E	2,000	9,000	4.5	Measurement voltage: 5,000V Legend: HT - High-voltage side terminal LT - Low-voltage side terminal E - Earth
	LT - E	2,000	6,500	3.3	
Yellow phase	HT - E	2,500	8,500	3.4	
	LT - E	2,000	6,000	3.0	
Blue phase	HT - E	2,000	7,000	3.5	
	LT - E	2,500	6,000	2.4	
	HT - LT	-	2,000	-	

Table 7.12 Insulation Resistance of Generator Transformers at the Canyon Hydropower Station

Measurement Time		1 min. (M Ohm)	10 min. (M Ohm)	P.I.	Remarks
Red phase	HT - E	4,000	6,000	4.5	Date of measurement: Feb. 3, Measurement voltage: 5,000V Legend: HT - High-voltage side terminal LT - Low-voltage side terminal E - Earth
	LT - E	3,500	9,000	3.3	
Yellow phase	HT - E	3,500	6,500	3.4	
	LT - E	2,500	8,500	3.0	
Blue phase	HT - E	3,000	6,000	3.5	
	LT - E	2,000	7,000	2.4	
	HT - LT	-	4,000	-	

The insulation resistance values of the coil satisfy the level of over 100M Ohm specified as the Japanese criteria. The polarization index values of all generator transformers are over the 1.5 stated as the Japanese criteria. From these conditions, the status of the stator coils is judged to be "good."

Since other equipment is rather new and is being operated without any appreciable failure, it is not necessary to replace it.

7.4.3 Control Equipment

(1) Control and Protection Equipment

1) Deterioration diagnosis results

There are two sets of control equipment, which include the protection equipment and the auxiliary circuit control equipment. One set is used for Unit 1 and the other is used for Unit 2. (Refer to Appendix C-3.) This power station, in which electromagnetic-type control equipment is mostly used for relays, uses a one-man control type. Electromagnetic type relays have been partially repaired and maintained stability in the routine maintenance and operation.

The control display instruments are kept in good condition, except for some failed displays. As the trouble recorder and the temperature recorder are out of order, these records are kept in a daily handwritten report.

The procurement of some spare parts for the relays takes an extended time. The CEB's site engineers expect to replace the control and protection equipment with numerical-type equipment. They also expect the controller for the diesel engine generator to be repaired.
Overall, continuous normal operations will be possible for the control and protection equipment. Therefore, the replacement of the control and protection equipment is unnecessary.

2) Countermeasures

Though the control and protection equipment requires no urgent replacement for a while, it is to be replaced by numerical-type equipment. The replacement time should be studied by the CEB to improve the operational reliability within the next 10 years.

(2) Control Power Source Equipment

1) Deterioration diagnosis results

Two sets of batteries are installed for two hydraulic turbine and generator sets. The batteries for Unit 1 and Unit 2 were manufactured by Oldham AG and Yuasa Co., respectively. Since the products from Oldham AG have a tendency to experience corrosion in the terminals, the CEB's site engineers expect to replace the equipment.

2) Countermeasures

The 220V batteries for control power source equipment directly affect the operational reliability of the power station. Therefore, the Oldham AG batteries for Unit 1 should be replaced. These batteries have already passed the service life of 20 years specified by J-POWER standards. Those replacement times should be studied by the CEB, taking above situation into consideration.

(3) Communication Equipment

1) Deterioration diagnosis results

A microwave signal system is not used for signal transmission for the transmission line protection, but a power line carrier system is used for that purpose. However, the capacity of the power line carrier system is inadequate for data transmission.
There is no remote display of the dam water level; rather, this is reported by a telephone call.

A new telephone system manufactured by Siemens is used for the station telephone service.

2) Countermeasures

The CEB expects to shift all power stations in the Kelani River Basin to a remote control system by using the SCADA system of the Old Laxapana power station.

The OGPW communication line will be installed between the Canyon hydropower station and the Old Laxapana hydropower station. It will be necessary to study at the detailed design stage an interface with the communication equipment as well as the items of remote control of the controller and protection equipment at the concerned power stations.

(4) Dam Distribution Equipment

1) Deterioration diagnosis results

The electric power source at the Moussakelle Dam is fed from the neighboring district grid via a distribution line. Though the dam distribution line is currently operated normally, its deterioration is apparent.

2) Countermeasures

Although it is not necessary to replace the line, a study of future replacement should be started by the CEB.

7.5 Present Status of and Rehabilitation Plan for the New Laxapana hydropower station

7.5.1 Mechanical Equipment

(1) Turbine

1) Deterioration diagnosis results

a) Maintenance and suspension records

It is reported that no harmful cavitation erosion has been observed on the runner buckets. Oil leakage from the needle servomotor packing is accumulated in the temporary containers.

b) Spare parts

One used runner is stored as a spare in the powerhouse.

c) Simplified efficiency test

The simplified efficiency test, which was carried out for Unit 2 using a portable ultra-sonic flow meter, revealed a higher efficiency than the guaranteed values, as shown in Figure 5 in Appendix C-1. However, it tends to indicate a strong correlation with the guaranteed value. This reflects the superior original design and proper maintenance during 30 years operation.

The maximum unit output of the generator is currently limited to 50MW. The installation test report and the simplified efficiency test result suggest that it is possible to operate up to 57MW of original generator output if the needle servomotor is more completely opened. However, 57MW operation is not recommended due to the possibility of cavitation erosion.

d) Visual Inspection and Hearing from Maintenance Personnel

The turbine maintains its original performance even after 30 years operation.

2) Countermeasures

Higher oil pressure may be applied to servomotors due to the replacement of governors. In this case, it is recommended that the needle and deflector servomotors are replaced.

(2) Inlet Valve

1) Deterioration diagnosis results

a) Maintenance and suspension records

Leakage of water from the valve seat of the inlet valve has been observed, as at the other power stations, due to replacement delays.

A needle-type drain valve is preferable, while the present one is a gate type.

b) Spare parts

The procurement of spare valve seats and seal rings seems to be difficult due to the high prices as well as the poor responsiveness of the original manufacture.

c) Visual Inspection and Hearing from Maintenance Personnel

The delayed procurement of spare parts causes the excessive leakage.

2) Countermeasure

It is recommended that periodical maintenance and repair including replacement of the valve seats and seal rings are carried out. Replacement of the present gate type drain valve with a needle-type valve is also recommended.

Necessary parts will be prepared and replacement done by the CEB.

(3) Governors

1) Deterioration diagnosis results

a) Maintenance and suspension records

The governor is an obsolete mechanical type. However, it is reported that the maintenance is easy and there has been no harmful malfunction.

b) Spare parts

The procurement of spare parts is difficult due to the suspension of production of mechanical-type governors. It is reported that switches and speeder springs are in short supply.

c) Visual inspection and interviews of maintenance personnel

The CEB expects to replace the governors.

2) Countermeasures

It is recommended that the mechanical-type governors are replaced with numerical-type governors when the generator is replaced in order to increase reliability.

(4) Other Auxiliary Equipment

1) Deterioration diagnosis results

a) Maintenance and suspension records

The compressed air system, the grease lubrication system and the water supply system are deteriorating.

b) Spare parts

Procurement of new spare parts is difficult.

c) Visual inspection and interviews of maintenance personnel

The CEB expects to replace the compressed air system, grease lubrication system and water supply system.

2) Countermeasures

It is recommended that the compressed air system, grease lubrication system and water supply system are replaced.

7.5.2 Electrical Equipment

(1) Generator

1) Deterioration diagnosis results

There is no record of detailed disassembly inspection. Major trouble records are as follows.

- Because of a dielectric breakdown in Unit 1, the stator coil was replaced in 1980.
- Because unusually low voltage of part of the rotor coil was recognized in a voltage sharing test on a rotor, that part of the rotor coil in Unit 1 was replaced in 2001.

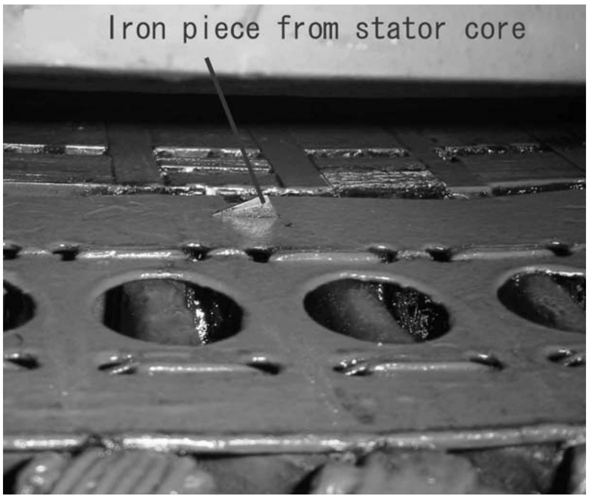
The insulation resistance values of the stator coil satisfy the level of over 100M Ohm specified by Japanese criteria. The polarization index values in all generators are over the 1.5 specified by Japanese criteria. Based on these conditions, the status of the stator coils is judged to be "good."

Table 7.13 Insulation Resistance of Generator Stators at the New Laxapana Hydropower Station

Measurement Time		1 min. (M Ohm)	10 min. (M Ohm)	P.I.	Remarks
#1 Stator	Red phase - Earth	905	2920	3.23	Year of measurement: 2004
	Yellow phase - Earth	830	2,960	3.57	
	Blue phase - Earth	840	3,500	4.17	
#2 Stator	Red phase - Earth	850	2,200	2.59	
	Yellow phase - Earth	765	2,380	3.11	
	Blue phase –-Earth	1,420	3,200	2.25	

There is no problem in the generators from the electrical point of view. But from the mechanical point of view, they have some serious problems.

- It was found that a piece of piled core iron slipped out of the stator core in February 2004. It seems that a loose stator clamp and/or superannuation of the iron core caused the slippage. Picture 7.7 shows the accident. There is concern that the iron piece may cause serious damage to the generator, resulting in a long-term operation stoppage. Further, wedge loosening was found also on stator in the both units as well as in the generators at the Wimalasurendra hydropower station.



Picture 7.7 Slipped iron piece

- Both units have a problem with oil leaking from generator bearings. Leaking oil is conveyed by the rotor-cooling fan and adheres to the stator. The adhesion of oil accelerates damage and softening of the insulating material on the stator. Dust stuck to the leaked oil on the stator can harm generator performance by further deteriorating the insulation and reducing cooling efficiency.
  The location of the oil leakage has never been identified because it requires the complete disassembly of the generator.
  As a countermeasure against the leakage, the CEB shuts down the generator twice each month and cleans the stator.

Major spare parts are stocked in the New Laxapana hydropower station.

2) Countermeasures

The replacement of the generator is recommended for the following reasons.

The CEB desires more reliable methods and shorter shutdown periods than possible with repair work such as re-wedging the coil. The CEB regards the New Laxapana hydropower station as the most important power station in the Kelani River basin because the output is the largest among the power stations in the basin and the function to control frequency is available only at the New Laxapana hydropower station.

However, the generator should be disassembled to measure its actual dimensions. This is because there are no useful drawings for the replacement. In this disassembly inspection, there is concern that the generator shutdown period may become longer than the estimated period due to unforeseeable troubles or unskilled installation work. Therefore, the timing of the disassembly inspection work should be determined taking into account the reserve capacity of the Sri Lankan power system and the hydrological situation.

It is not necessary for the specifications of the generators because the existing turbines are not to be replaced.

(2) Excitation Equipment

1) Deterioration diagnosis results and countermeasures

This excitation equipment is a DC-exciter system. This type requires a great deal of maintenance work, such as frequent brush cleaning, and has low functional reliability compared with brush-less exciter systems, which are currently the most common.

Therefore, the replacement of the exciters should be carried out together with the generators.

(3) Generator transformer

1) Deterioration diagnosis results and countermeasure

Insulation resistance of the generator transformers is shown below.

Table 7.14 Insulation Resistance of Generator Transformers at the New Laxapana Hydropower Station

Measurement Time		1 min. (M Ohm)	10 min. (M Ohm)	P.I.	Remarks
Red phase	HT-E	700	1,180	1.7	Measurement voltage: Unknown
	LT-E	840	1,189	1.3	
	HT-LT	1,161	2,840	2.4	Legend:
Yellow phase	HT-E	895	2,100	2.5	HT - High-voltage side terminal
	LT-E	800	1,350	1.7	LT - Low-voltage side terminal
	HT-LT	1,780	3,140	1.8	E - Earth
Blue phase	HT-E	1,030	2,280	2.2	
	LT-E	955	1,700	1.8	
	HT-LT	2,040	3,820	1.9	

Table 7.15 Insulation Resistance of Generator Transformers at the New Laxapana Hydropower Station

Measurement Time		1 min. (M Ohm)	10 min. (M Ohm)	P.I.	Remarks
Red phase	HT-E	1,540	2,340	1.5	Date of measurement: Unknown Measurement voltage: Unknown Legend: HT - High-voltage side terminal E - Earth
	LT-E	1,220	3,460	2.8	
	HT-LT	3,220	5,500	1.7	
Yellow phase	HT-E	1,090	2,060	1.9	
	LT-E	995	2,780	2.8	
	HT-LT	2,160	3,540	1.6	
Blue phase	HT-E	1,370	3,950	2.9	
	LT-E	1,280	3,420	2.7	
	HT-LT	2,520	5,400	2.1	

The insulation resistance values of the coil are over 100M Ohm.

No abnormalities were found in visual inspections. No trouble was caused by a fault of the generator transformer, according to the records for the last two years.

From these values, the condition of the transformer coils is judged to be "good."

However, it is difficult to diagnose deterioration correctly by visual inspection alone. It is recommended that deterioration diagnostic data should be collected by suitable methods such as installation of an automatic temperature recorder, periodic oil gas analysis, etc., for the purpose of judging materials for future replacement.

The major spare parts are stocked at the New Laxapana hydropower station.

(4) Other Electric Equipment

1) Deterioration diagnosis results

The 12.5kV circuit, including the auxiliary circuit, has been operated since the commission date. Superannuation has been progressing. Therefore, the replacement of the circuit should be carried out along with that of the generators.
With respect to the 132kV circuit, no abnormality was found on the switchgears of the circuit.

No trouble has occurred on the 132kV circuit during the last two years, according to the records. The switchgears have operated for 19 years and 23 years but have not yet reached their time of replacement. It is possible to continue to use the 135kV circuit.

The transformer for the auxiliary circuit has experienced no trouble that would prevent continuing with normal operation. However, PCB is used as the insulation oil in the transformer. In view of environmental concerns, the PCB transformer should be replaced at the earliest opportunity. The CEB is responsible for storing PCB insulation oil in an appropriate place at the power station and for strictly preventing any eventual leakage to the environment.

7.5.3 Control Equipment

(1) Control and Protection Equipment

1) Deterioration diagnosis results

This plant is of a one-man control type and is remotely controlled from the Old Laxapana plant. Two operators are in the control room (refer to Appendix C-3 List of Control Room Layout), and other two operators are on the generator floor. They supervise the operational conditions of the governor equipment, the excitation equipment, etc. The control and protection equipment in the control room is old-fashioned and consists mostly of electromagnetic relays and a few numerical lockout relays. The governor equipment is of the mechanical type, which is operated at a permanent speed droop (SD) of 5%. The excitation equipment is of a sub-exciter system type, which uses rotation amplifier (Amply-dyne). This power station is an important plant in that it performs the frequency control for the power system. Therefore, improving the reliability of control and protection equipment is indispensable.

The electrolytic condensers used for the relays exceed the standard life of 12 years specified by J-POWER standards. Therefore, it is essential to replace all of the control and protection equipment with state-of-the-art equipment in order to improve its operational reliability.

2) Countermeasures

The best choice is to introduce the latest technologies for all control and protection equipment components in order to enhance operation reliability, rather than making partial replacements or repairs. The CEB replaced the old equipment with numerical-type equipment in 2003 in the Old Laxapana and Polpitiya hydropower stations. When the efficient management of the entire river system is taken into consideration, the equipment of this power station should also be replaced with new equipment of a grade equal to or higher than that of the Old Laxapana and Polpitiya hydropower stations.
The scope of the replacement is shown below.

a) Control equipment:

Supervisory and control board for turbine, generator, generator transformer, switchyard, transmission line, and auxiliary circuit

Governor control board

Excitation control board

Control desk

b) Protection equipment:

Protection for turbine, generator, generator transformer, switchyard, and transmission line

c) Spare parts:

Spare parts for the above control equipment and protection device

The configuration of the control and protection system for New Laxapana hydropower station is shown in Figure 7.3.

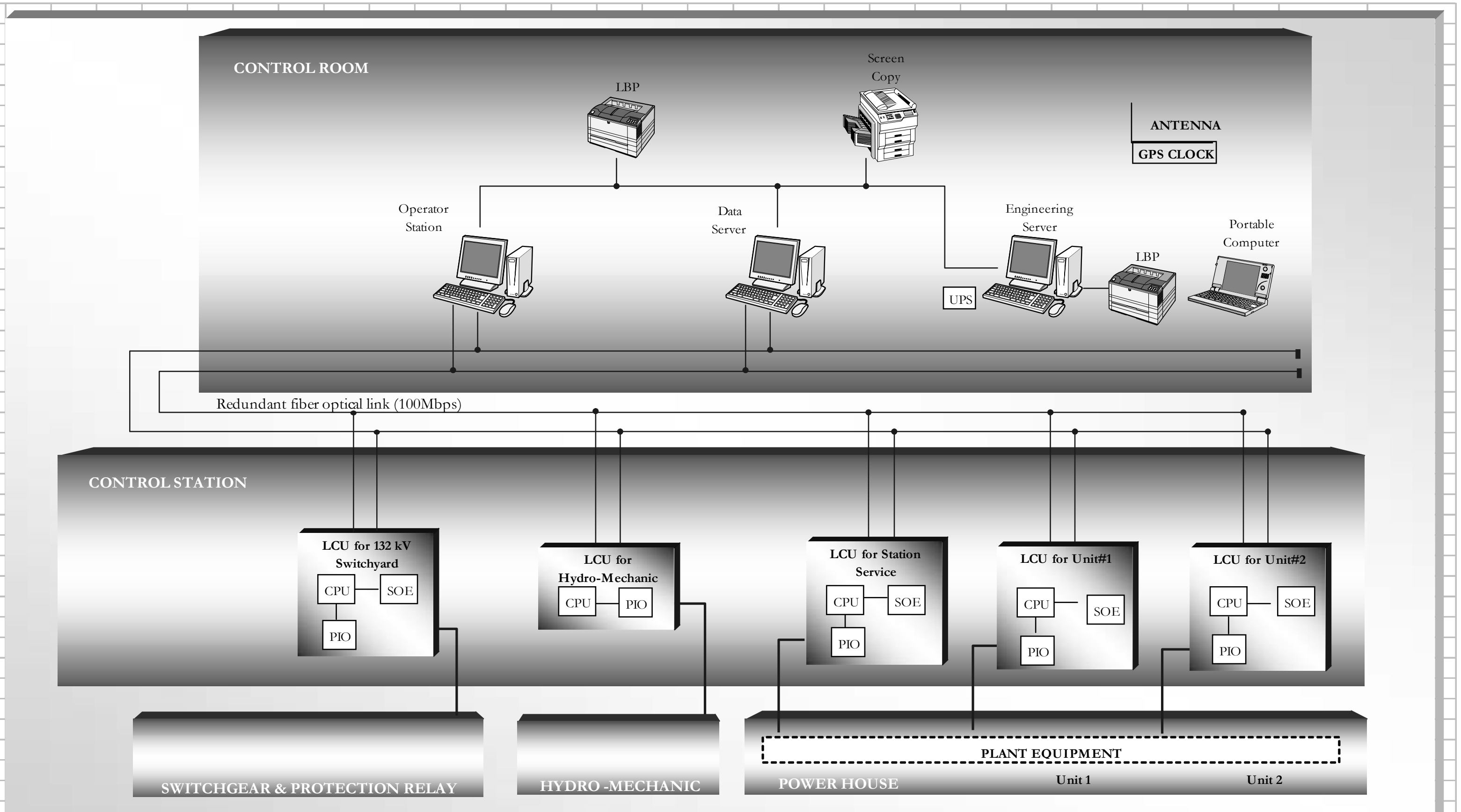


Figure 7.3 Control System Configuration for New Laxapana Hydropower Station

SOE : Sequence of Event Printer
UPS : Uninterrptible Power Supply
LCU : Local Control Unit
GPS : Global Positioning System (the time reference for SCADA system time synchronization)
: Multiwire cables (parallel communication)
: Serial transmission link
: Area boundary
LBP : Laser Beam Printer
PIO : Process Input Output
: Controller, Communication Equipment

(2) Control Power Source Equipment

1) Deterioration diagnostic result

The control power source batteries were replaced in 1989 and have been used normally in a good condition. However, since only one battery and battery charger set is available, the reliability of the control power source is insufficient. Moreover, the CEB expects to replace both because they have been in use for more than 20 years.

2) Countermeasures

The 220V battery and charger for the control power source should be replaced and uninterruptible power source equipment should be installed to enhance the reliability of the plant when the above-mentioned control and protection equipment is replaced.

(3) Communication Equipment

1) Deterioration diagnostic result

The communication equipment of this plant is that used with the Old Laxapana plant.
(Refer to 7.3.3 (3)).

2) Countermeasures

(Refer to 7.3.3 (3)).

(4) Dam Distribution Equipment

1) Deterioration diagnostic result

The electric power used at Canyon Dam is fed from the neighboring district grid via a distribution line. Though the dam distribution line is currently operated normally, its deterioration is apparent.
Emergency diesel generator has been operated for 30 years, its deterioration is apparent.

2) Countermeasures

Although it is not necessary to replace the line, a study of its future replacement should be started by the CEB.

7.6 Present Status of and Rehabilitation Plan for Polpitiya hydropower station

7.6.1 Mechanical Equipment

(1) Turbines

1) Deterioration diagnosis results

a) Maintenance and suspension records

The units have been operated only at generator outputs of 5MW, 32MW and 37.5MW, due to turbine vibration. An inspection at 5MW output with a wicket gate opening of 16% and at 37.5 MW with a wicket gate opening of 72% indicated very noisy operation (approximately 100dB, as estimated through listening). However, no remarkable vibration was identified.

According to simplified efficiency test, a small turbine shaft run-out of 0.05mm was confirmed in an operating range from 36MW generator output with estimated net head of 248.6m to 4.86MW with an estimated net head of 260.1m. The submergences were between – 4.43m and – 3.95m at that time.

The existing test report on aeration relevant to the modified air supply pipes at the installation stage indicated a couple of aeration tests to decrease the vibration. It is reported that the inlet configuration of the draft pipe was modified from cylindrical to circular, which is reported to provide reduced vibration. The original manufacturer (Dominion Engineering Works) recommended the limited operation of 5MW, 32MW, and 37.5MW, in 1975.

Picture 7.8 Crack in Guide Ring for Wicket Gate Operating Mechanism of Polpitiya Turbine

In addition to the vibration, following problems were reported.

- Cracks were found on the guide ring for wicket gate operating mechanism as shown in Picture 7.8. They were caused by the concentration of stress at the welded joint of the guide ring and were repaired by welding. There remains a risk of renewed cracking.

- Turbine shear pin failures were reported seven times from 2002 to August of 2004. They seem to be caused by the failure of the intake trash rack.

- The seal carbon of the turbine shaft has worn very quickly, resulting in a large amount of leakage (approximate 3 to 4 liters/s, estimated by visual observation) and this keeps the draft pipe bolts in water at all times. This seems to accelerate bolt corrosion.

The records indicate turbine repairs and replacements as shown in Table 7.16.

Table 7.16 Turbine Repair Record

Item	Date		Remarks
	Unit 1	Unit 2	
Runner	-----	Aug. 7, '90	
Runner	July 20, '96	-----	Repair work of wicket gate, operation structure, lever, link, etc., included.
Runner	-----	Nov. 15, '97	Wearing ring, bearing of wicket gate, facing plate, etc., included.
Runner	-----	May 13, '02	

The runners have been replaced every four or five years and repaired repeatedly. Repair records before 1990 are not available. Picture 7.9 shows a runner repair.

Picture 7.9 Repair Welding of Polpitiya Runner

The upper guide bearing of the generator was replaced on Jan. 20, 1988. The turbine bearing has not been replaced since the commissioning date.
A cooling water shortage has been reported. This results in a failure due to high bearing temperature and a shaft seal alarm causing a turbine trip.

The repair record of bearing oil coolers are shown in Table 7.17. This confirms that repair work was carried out repeatedly.

Table 7.17 Bearing Oil Cooler Repair Record

Item	Date		Remarks
	Unit No.1	Unit No.2	
TGB	-----	Feb. 24, '03	
TGB, LGB, T & UGB	Sept. 1, '03		
T & UGB	-----	Jan.12, '04	

Where:
TGB: Turbine guide bearing
LGB: Lower guide bearing of generator
T & UGB: Thrust bearing and upper guide bearing of generator

b) Spare parts

One turbine bearing, one wicket gate and one used runner are stored in the powerhouse. The used runner was under repair.

c) Simplified efficiency test

The result of the simplified efficiency test, which was carried out on Unit 2, shows lower efficiency than the typical Francis turbine even considering this turbine's 36 years of operation. The results are shown in Figure 4 in Appendix C-1. The maximum efficiency was measured at a generator output of 36MW. It was reported that 40MW was the maximum generator output at the initial stage.

d) Visual inspection and hearing from maintenance personnel

Both turbines are operated only at generator outputs of 5MW, 32MW, and 37.5MW. It seems that the vibration is caused by the original characteristics of the turbine.

In "The Vibration Test Report" issued on 2003 by the CEB Mahaweli River Complex, the vibration frequency clearly corresponds to the frequency spectrum of rotational speed (8.33Hz) and multiples of that speed. This suggests that the runner seal configuration of the original design has some problems.

The submergence became deeper because the two units were in operation with a large amount of discharge. Considering this, some latent vibration problems may exist with shallow submergences and larger generator outputs than 37.5MW, such as 40 MW. In addition to making this inspection, it is necessary to analyze the history of the vibration problem and the operating conditions.

The turbine submergence will increase approximately 10m after completion of the Broadlands Project. Natural aeration into the draft tube, which minimize the vortex around the outlets of the runners and to control the vibration, will be impossible under these conditions. And it is supposed that vibration will increase to a high level in the situation.

2) Countermeasures

Concerning the circumstances as described, if the result of economical analysis shows feasibility, it is recommend that the turbines and accessories are replaced entirely, apart from embedded parts such as spiral cases, stay rings and embedded piping.

Appendix C-2 describes the studies on the specification of the new turbine after replacement. It is recommended that the turbine output is increased to 40MW. However, it is necessary to study the waterways in further detail.

The thrust bearing of the generator should be replaced along with the turbine because the turbine hydraulic thrust is expected to increase due to the new turbine.

The proper timing of the turbine replacement will be studied by the CEB.

(2) Inlet Valve

1) Deterioration diagnosis results

a) Maintenance and suspension record

The main inlet valve (MIV) has no major problem except water leakage from the valve seat ring. However, it is reported that the interaction with the control valve causes an oscillation of the valve disk at a 50% opening of the inlet valve due to the increased leakage.

b) Spare parts

A shortage of spare parts, such as valve seat and seal ring, is reported

c) Visual inspection and interviews of maintenance personnel

There is the shortage of spare parts.

2) Countermeasures

It is recommended to procure spare parts and replace deteriorated parts immediately.
Necessary parts will be prepared and replaced by the CEB.

(3) Governor

1) Deterioration diagnosis results

a) Maintenance and suspension records

The governor was replaced in 2003; this included turbine servomotors and the governor control cubicle. The oil pressure was changed to a high level such as 15.5MPa (155bar). However, some failures, such as low oil levels and pressure drops, still happen.

b) Spare parts

Shortage are reported related to the proximity switch, pressure switch, level switch, solenoid valve, and filter pump set.

c) Visual inspection and hearing from maintenance personnel

The function of the governor may be insufficient.

2) Countermeasures

It is recommended that the existing governors are modified when the turbines are replaced. Modification of the pressure oil cylinder of the governor should be studied due to the limited capacity of the existing cylinder.

Necessary modifications will be implemented by the CEB.

(4) Other Auxiliary Equipment

1) Deterioration diagnosis results

a) Maintenance and suspension records

A shortage of cooling water is reported. However, this is not harmful to turbine operation.
Meanwhile, deterioration is reported with respect to the cooling water supply system, drainage system, service air system and grease lubrication system.

b) Spare parts

A shortage of spare parts is reported related to the above-mentioned deteriorated equipment.

c) Visual inspection and interviews of maintenance personnel

The CEB expects to replace the cooling water supply system, drainage system, brake air system and grease lubrication system.

2) Countermeasures

It is recommended that the cooling water supply system, drainage system, brake air system and grease lubrication system are replaced.
The brake air system will be prepared and replacement carried out by the CEB.

7.6.2 Electrical Equipment

(1) Generator and Excitation Equipment

1) Deterioration diagnosis results and countermeasures

Detailed disassembly inspection records were not found.

The insulation resistance values of the stator coil are at the level of over 100M Ohm specified by Japanese criteria. Polarization index values were not confirmed because there is no record of 10-minute values for the insulation resistance. The yellow-phase insulation resistance value in Unit 1 decreased by half from January to September 2003. Therefore, the value needs to be observed continuously. The other coils are judged to be in "good" condition.

Table 7.18 Insulation Resistance of Generator Stators at the Polpitiya Hydropower Station

Date		Jan. 23, '03	Sept. 2, '03	Apr. 28, '03	Remarks
Measurement time		1 min. (M Ohm)	1 min. (M Ohm)	1 min. (M Ohm)	
#1 Stator	R-E	1,170	900	-	
	Y-E	1,900	700	-	
	B-E	1,110	900	-	
#2 Stator	R-E	-	-	1,000	
	Y-E	-	-	1,000	
	B-E	-	-	1,000	

Considering the condition of the stator insulation and the age of the generators, it is not necessary to replace the generators at the same time of turbine replacement. But the following countermeasures should be taken before the turbine replacement.

- The generator bearings should be modified to match the modified thrust, which would be changed by a turbine replacement.
- Detailed generator deterioration diagnosis should be carried out before the turbine replacement. However, in this diagnosis, there is a concern that the generator shutdown period may become longer than the estimated period due to unforeseeable trouble or unskilled installation work.

The excitation equipment was replaced in 2003 and no problem was observed.

There are not enough spare parts for the generator and excitation equipment. The CEB needs to assure a suitable budget and needs to stock the spare parts.

(2) Generator Transformers

1) Deterioration diagnosis results and countermeasures

The insulation resistance values of Unit 1 and Unit 2 transformers at the Polpitiya hydropower station are shown in Table 7.19 and 7.20.

Table 7.19 Insulation Resistance of No.1 Transformers at the Polpitiya Hydropower Station

Date		Mar. 4, '02	Jan. 23, '03	Mar. 4, '03	June 17, ' 04	Remarks
Measurement time		1 min. (M Ohm)	1 min. (M Ohm)	1 min. (M Ohm)	1 min. (M Ohm)	
Red phase	HT-E	590	590	490	325	Legend: HT - High-voltage side terminal LT - Low-voltage side terminal E – Earth
	LT-E	425	468	408	225	
	HT-LT	700	545	640	450	
Yellow phase	HT-E	360	426	365	325	
	LT-E	390	444	394	225	
	HT-LT	500	462	555	450	
Blue phase	HT-E	250	240	200	80	
	LT-E	400	442	398	190	
	HT-LT	550	458	650	290	

Table 7.20 Insulation Resistance of No.1 Transformers at the Polpitiya Hydropower Station

Date		Mar. 4, '02	Jan. 23, '03	Mar. 4, '03	Remarks
Measurement time		1 min. (M Ohm)	1 min. (M Ohm)	1 min. (M Ohm)	
Red phase	HT-E	150	90	70	Legend: HT - High-voltage side terminal LT - Low-voltage side terminal E - Earth
	LT-E	350	200	180	
	HT-LT	400	300	210	
Yellow phase	HT-E	150	300	200	
	LT-E	290	350	300	
	HT-LT	400	600	400	
Blue phase	HT-E	190	200	68	
	LT-E	350	500	130	
	HT-LT	700	700	200	

2) Countermeasures

Three insulation resistance values are less than 100M Ohm, which is the minimal level for a judgment of "defect" in terms of the criteria in Japan, and there is no transformer whose insulation resistance value exceeds 500M Ohm. The insulation resistance values have been decreasing significantly in all transformers, judging from the comparisons of the resistance values between 2002 and 2004.

Since deterioration was found in the coil in all generator transformers, the urgent replacement of all transformers is recommended.

There are not enough spare parts for the transformers. The CEB needs to ensure a suitable budget and needs to stock the spare parts.

(3) Other Electrical Equipment

1) Deterioration diagnosis results and countermeasures

The 12.5kV and 132kV switchgears were replaced in the last refurbishing. No appreciable trouble was found in these installations during the study's investigations.

The auxiliary circuit transformers have no trouble continuing with normal operation. However, PCB is used for insulation oil in these transformers. In view of environmental concerns, the PCB transformers should be replaced at the earliest convenience. The CEB is responsible for storing

PCB insulation oil in an appropriate place in the power station and for strictly preventing any eventual leakage to the environment.

There are not enough spare parts for this category of other electric equipment. The CEB needs to ensure a suitable budget and needs to stock the spare parts.

7.6.3 Control Equipment

(1) Control and Protection Equipment

1) Deterioration diagnostic results

The control and protection equipment was replaced with numerical-type equipment, which is similar to that of the Old Laxapana hydropower station, in 2003. To install the same type of equipment would be ideal due to ease of operation and maintenance as well as common use of spare parts.

However, it will be necessary to study the control and protection equipment in order to coordinate the control equipment with the existing governor and the excitation equipment when the hydraulic turbines and generators are replaced.

The replaced equipment (refer to Appendix C-3 List of Control Room Layout) of the latest numerical-type is designed so as to remotely controllable from the Old Laxapana hydropower station, but is not yet in use because the communication system has not been completed yet.

There are not enough spare parts for the equipment. This problem was caused by an improper clause for spare parts in the replacement contracts (refer to Appendix C-3 Summary for Investigation).

2) Countermeasures

As a whole, the control and protection equipment, which replaced in the same period as that of the Old Laxapana hydropower station in 2003, is capable of normal operation for now. And replacement or repair is not required.

(2) Control Power Source Equipment

1) Deterioration diagnostic result

The control power source batteries were replaced in 1998. A ground phenomenon was observed on the positive terminal side of a DC control power source.

An uninterruptible power supply system equipment is installed and is operation.

2) Countermeasures

It is necessary to investigate and repair the ground phenomenon in the positive terminal side in order to enhance the reliability of the power station.

(3) Communication Equipment

1) Deterioration diagnostic result

A microwave signal system is not used for signal transmission for transmission line protection, but a power line carrier system is used for signal transmission. However, the capacity of the power line carrier system is inadequate for data-transmission.

The control and protection equipment replaced in 2003 is designed to be remotely controllable from the Old Laxapana hydropower station by means of a SACADA system, but is not yet in use because the communication system has not been completed yet.

2) Countermeasures

The CEB expects to operate the Polpitiya hydropower station by means of a SCADA system from the Old Laxapana plant. Therefore, the OPGW communication line will be installed between the hydropower stations. It will be necessary to study in the detailed design stage an interface with the communication equipment as well as details for the remote control of the control and protection equipment of the Polpitiya power station

(4) Dam Distribution Equipment

1) Deterioration diagnostic result

The electric power used at Laxapana Dam is supplied from the auxiliary circuit of the Old Laxapana plant. Though the circuit is currently operating normally without any trouble, deterioration is apparent.

2) Countermeasures

Although it is not necessary to replace existing circuit at present, a study of future replacement should be started by the CEB.

8. REHABILITATION PLAN

8. REHABILITATION PLAN

8.1 General

In line with the study described in Chapters 5 to 7, the results of deterioration diagnosis in the study are shown in Table 8.1, with the ODA loan need and phase of implementation indicated. The cost and schedule of the recommended rehabilitation plan are shown in Tables 8.2, 8.3 and 8.4. The result, cost and schedule have already been confirmed with the Generation Project Branch of the CEB.

Table 8.1 Present Condition of Each Hydro Power Station of the Laxapana Complex (Including Civil and Hydro-mechanical Equipment)

Legend: Deterioration Level

A: Immediate rehabilitation is required.
B: Rehabilitation is required as soon as possible.
C: Rehabilitation is desirable if conditions, such as budget, allow.
D: Repair will be required in the future.
E: There is no need for a measure, or observation is required.
X: To be investigated further (or unknown)

Necessity of ODA Loan

O: Necessary
NN: Not Necessary

Phase of Implementation

SV: Purchase and installation can be started immediately
- The scope and range of the rehabilitation are clear.
- The cost can be estimated precisely.
- The specification is already prepared or can be prepared immediately

DD: Detailed design work can be started immediately.
- The scope and range of the rehabilitation is almost clear except for details.
- The cost can be estimated.
- The detailed design is necessary before implementing rehabilitation work.

IN: More detailed inspections, which include disassembly investigation, are needed
- The scope and range of the rehabilitation are not clear.
- The cost cannot be estimated.
- Further inspections are necessary before the detailed design.

Notes:

*1 The equipment is used to control and monitor the turbines, generators, transformers, switchyard and auxiliary circuit.
*2 The equipment is used to protect the turbines, generators, transformers, switchyard and auxiliary circuit.

Table 8.1	Items	No.	Level	ODA	Phase
Common					
Canyon and Laxapana pond	- Removal sedimentation from the ponds Dredging grab $1m^3$ Mobile crane 30t	1 lot	C	O	SV
Canyon and Laxapana dam	- Dam control system	2 lots	C	O	SV
Penstock and so on	- Robot for repainting the inside of penstock Blasting and painting machine	1 lot	C	O	SV
General use	- Small blasting and painting machine	1 lot	B	O	SV

Table 8.1	Items	No.	Level	ODA	Phase
Wimalasurendra					
Investigation (hydro-mech.)	- Investigation for modification of spillway	1	A	O	IN
Inspection before the rehabilitation	- Disassemble inspection for the electro-mechanical equipment	1	A	O	SV
Turbine	In conjunction with the governors replacement - Wicket gate stem - Wicket gate stem packing - Wicket gate servomotor - Shaft seal packing - Facing plate in bottom ring - Whole stationary wearing ring	2	A	O	DD
Inlet valve	In conjunction with governors replacement - Modification of the controllers	2	A	NN	-
	- Seals	2	A	NN	-
Governor	- Whole	2	A	O	DD
Pressure oil supply system	In conjunction with the governors replacement - Whole	2	A	O	DD
Air supply system for governor	In conjunction with the governors replacement - Whole	2	A	O	DD
Air supply system for brake	In conjunction with the generators replacement - Whole	2	A	O	DD
Grease lubrication system	In conjunction with the governors replacement - Whole	2	A	O	DD
Water supply system	In conjunction with the generators replacement - Whole	2	A	O	DD
Drainage system	- Whole	2	A	O	DD
Generator	Repair or replacement Case 1: Repair (rewinding and replacement of the core) Case 2: Replacement	2	A	O	DD
Exciter	Repair or replacement in conjunction with the generators Case 1: Repair Case 2: Replacement	2	A	O	DD
AVR	- Whole	2	A	O	DD
Generator transformer	- Whole	7	A	O	SV
11kV main circuit	- Whole	2	A	O	SV
132kV switchgear	- Whole	6	B	O	SV
Plant control equipment	- Whole *1	4 lots	A	O	DD
Protection equipment	- Whole *2	4 lots	A	O	DD
LV auxiliary circuit	- Whole	1	A	O	DD
Control power source equipment	- Whole - Installation of UPS	1	A	O	DD
Diesel generator	- Inspection and repair for control equipment of diesel generator	1	C	NN	-
Communication equipment	- Installation of OPGW and new communication equipment between WPS and Old Laxapana P/S	1	C	O	DD
Dam distribution equipment		1	D	-	-
Dam (hydro-mech.. and civil)	- Modification of spillway	14	B	O	IN
Dam (civil)	- Re-drilling of drainage relief holes	-	A	NN	-

Table 8.1	Items	No.	Level	ODA	Phase
Wimalasurendra					
Headrace tunnel (civil)	- Possible collapse	-	A	NN	-
Outlet (civil)	- Turbulent	-	X	NN	-

Table 8.1	Items	No.	Level	ODA	Phase
Old Laxapana	(Stage I)				
Investigation (hydro-mech.)	- Investigation for installation of flashboard	1	A	O	IN
Inspection before the rehabilitation	- Disassembly inspection for electro-mechanical equipment	1	A	O	SV
Turbine	- Whole	3	A	O	DD
Inlet valve	- Whole	3	A	O	DD
Governor	In conjunction with turbines replacement - Whole	3	A	O	DD
Pressure oil supply system	In conjunction with turbines replacement - Whole	3	A	O	DD
Air supply system for governor	In conjunction with turbines replacement - Whole	3	A	O	DD
Air supply system for brake	In conjunction with generators replacement - Whole	3	A	O	DD
Oil lubrication system	In conjunction with generators replacement - Whole	3	A	O	DD
Water supply system	In conjunction with generators replacement - Whole	3	A	O	DD
Generator	In conjunction with turbines replacement - Whole	3	A	O	DD
Exciter	In conjunction with generators replacement - Whole	3	A	O	DD
AVR	In conjunction with generators replacement - Whole	3	A	O	DD
Generator transformer		4	D	-	-
11kV main circuit	In conjunction with generators replacement - Whole	3	A	O	DD
132kV switchgear	- Repair for operation mechanism of isolators	13	C	NN	-
Control equipment for Units 1, 2, 3	In conjunction with turbines and generators replacement - Modification	3 lots	C	NN	-
Control equipment for switchyard and auxiliary circuit	In conjunction with communication equipment modification - Modification	2 lots	C	NN	-
Protection equipment for Units 1, 2, 3	In conjunction with turbines and generators replacement - Modification	3 lots	C	NN	-
Protection equipment for switchyard and auxiliary circuit	In conjunction with communication equipment modification - Modification	2 lots	C	NN	-
LV auxiliary circuit		1	E	-	-
Control power source equipment	- Repair for positive-side ground phenomenon	1	C	NN	-

Table 8.1	Items	No.	Level	ODA	Phase
Old Laxapana	(Stage I)				
Diesel generator		1	E	-	-
Communication equipment	In conjunction with communication equipment modification in other power station in Laxapana complex - Modification	1	C	NN	-
SCADA System	- Modification and installation of some equipment	1	C	O	DD
Dam distribution equipment		1	D	-	-
Dam (hydro-mech. and civil)	- Installation of flashboard	8	C	O	IN
Penstock valve (hydro-mech.)	- Remote control system	1	C	O	DD
Right abutment of Dam (civil)	- Leakage	-	X	-	-
Surge tank (civil)	- Turbulence and explosive noise	-	X	-	-

Table 8.1	Items	No.	Level	ODA	Phase
Old Laxapana	(Stage II)				
Inspection before the rehabilitation	- Disassembly inspection	1	E	-	-
Turbine		2	D	-	-
Inlet valve	- Seals	2	A	NN	-
Governor		2	E	-	-
Pressure oil supply system		2	E	-	-
Air supply system for governor		2	E	-	-
Air supply system for brake	In conjunction with Stage I generator replacement - Whole	2	A	O	DD
Oil lubrication system	- Modification	2	C	NN	-
Water supply system	In conjunction with the Stage I generator replacement - Whole	2	C	NN	-
Generator		2	D	-	-
Exciter		2	D	-	-
AVR		2	E	-	-
Generator transformer		7	D	-	-
11kV main circuit		2	E	-	-
Plant control equipment	*1	3 lots	E	-	-
Protection equipment	*2	3 lots	E	-	-
LV auxiliary circuit		1	E	-	-

Table 8.1	Items	No.	Level	ODA	Phase
Canyon					
Inspection before the rehabilitation	- Disassembly inspection	1	E	-	-
Turbine	- Repair	2	C	NN	-
Inlet valve	- Seals	2	A	NN	-
Governor		2	D	-	-
Pressure oil supply system		2	D	-	-
Air supply system for governor		2	D	-	-
Air supply system for brake		2	D	-	-
Lubrication system		2	D	-	-
Water supply system		2	D	-	-
Drainage system	- Modification for the controller	2	C	NN	-
Generator	- Repair of the generators	2	C	NN	-
Exciter		2	D	-	-
AVR		2	D	-	-
Generator transformer		2	D	-	-
Spare generator transformer	- Inspection	1	C	NN	-
12.5kV main circuit	- Purchase of spare parts	2	C	NN	-
132kV switchgear		3	D	-	-
Plant control equipment	*1	4 lots	D	-	-
Protection equipment	*2	4 lots	D	-	-
LV auxiliary circuit		1	D	-	-
Control power source equipment	- Inspection for the battery in Unit 1	1	C	NN	-
Diesel generator	- Inspection for control equipment for diesel generator	1	C	NN	-
Communication equipment	- Installation of OPGW and new communication equipment between Canyon and Old Laxapana P/S	1	C	O	DD
Dam distribution equipment		1	D	-	-
Penstock (civil)	- Erosion in foundation of anchor block concrete	-	C	NN	-
Tailrace (civil)	- Displacement in retaining wall concrete	-	X	NN	-
Intake valve (hydro-mech.)	- Modification of air valve of intake valve	1	B	O	DD

Table 8.1	Items	No.	Level	ODA	Phase
New Laxapana					
Investigation (hydro-mech.)	- Investigation for raking machine and access bridge for intake	1	A	O	IN
Inspection before rehabilitation	- Disassembly inspection	1	A	O	SV
Turbine	In conjunction with the governors replacement - Guide vane servomotors	2	A	O	DD
Inlet valve	In conjunction with the governors replacement - Modification for the controllers	2	B	NN	-
	- Seals	2	A	NN	-
Governor	- Whole	2	A	O	DD
Pressure oil supply system	In conjunction with governors replacement - Whole	2	A	O	DD
Air supply system for governor	In conjunction with governors replacement - Whole	2	A	O	DD
Air supply system for brake	In conjunction with generators replacement - Whole	2	A	O	DD
Grease lubrication system	In conjunction with governors replacement - Whole	2	A	O	DD
Water supply system	In conjunction with generators replacement - Whole	2	A	O	DD
Generator	- Whole	2	A	O	DD
Exciter	In conjunction with governors replacement - Whole	2	A	O	DD
AVR	In conjunction with generators replacement - Whole	2	A	O	DD
Generator transformer		7	D	-	-
12.5kV main circuit	- The circuit breaker for auxiliary circuit and auxiliary transformer	2	A	O	DD
132kV switchgear	- Repair for operation mechanism of isolators	9	C	NN	-
Plant control equipment	In conjunction with generators replacement - Whole *1	4 lots	A	O	DD
Protection equipment	In conjunction with generators replacement - Whole *2	4 lots	A	O	DD
LV auxiliary circuit	In conjunction with generators replacement - Whole	1	A	O	DD
Control power source equipment	- Whole - Installation of UPS	1	A	O	DD
Diesel generator		1	D	-	-
Communication equipment		1	D	-	-
Dam distribution equipment		1	D	-	-
Dam (civil)	- Cavity in foundation rock	-	B	NN	-
Surge tank vicinities (civil)	- Leakage	-	X	NN	-
Penstock (civil)	- Erosion in foundation of anchor block concrete	-	C	NN	-
Tailrace (civil)	- Erosion in concrete wall		C	NN	-
Intake (hydro-mech.)	- Raking machine and access bridge	1	C	O	IN

Table 8.1	Items	No.	Level	ODA	Phase
Polpitiya					
Investigation	- Disassembly inspection for electro-mechanical equipment	1	A	O	IN
Investigation (hydro-mech.)	- Investigation for raking machine and access bridge for intake	1	A	O	IN
Turbine	- Whole the turbines except embedded parts	2	B	O	IN
Inlet valve	In conjunction with governors modification - Modification for controllers	2	B	NN	-
	- Seals	2	A	NN	
Governor	In conjunction with turbines replacement - Modification	2	B	NN	-
Pressure oil supply system	In conjunction with turbines replacement - Modification	2	B	NN	-
Air supply system for governor	In conjunction with turbines replacement - Modification	2	B	NN	-
Air supply system for brake	In conjunction with generators repair - Modification	2	C	NN	-
Grease lubrication system	In conjunction with turbines replacement - Whole	2	B	O	IN
Water supply system	- Whole	2	B	O	IN
Drainage system	- Whole	2	B	O	IN
Generator	In conjunction with turbines replacement - Thrust bearing	2	B	O	IN
Exciter		2	D	-	-
AVR		2	E	-	-
Generator transformer	- Whole	7	A	O	SV
12.5kV main circuit	- Auxiliary transformer	2	A	O	SV
132kV switchgear		12	E	-	-
Control equipment for the Unit 1, 2	In conjunction with turbines replacement - Modification	2 lots	C	NN	-
Control equipment for the switchyard and the auxiliary circuit	In conjunction with communication equipment modification - Modification	2 lots	C	NN	-
Protection equipment for Units 1, 2	In conjunction with turbines replacement - Modification	2 lots	C	NN	-
Protection equipment for switchyard and auxiliary circuit	In conjunction with communication equipment modification - Modification	2 lots	C	NN	-
LV auxiliary circuit		1	E	-	-
Control power source equipment	- Repair for the ground phenomenon at positive side	1	C	NN	-
Diesel generator		1	E	-	-
Communication equipment	- Installation of OPGW and new communication equipment between Polpitiya and Old Laxapana P/S	1	C	O	DD
Dam distribution equipment		1	D	-	-
Dam (civil)	Installation of rain gauge station	-	B	O	DD
Spillway (civil)	Reinforcement of spillway	-	X	-	-
Intake (hydro-mech.)	Plan for raking machine and access bridge	1	C	O	IN
Intake (civil)	Vortex	-	X	NN	-
Penstock (civil)	Erosion in foundation of anchor block concrete	-	C	NN	-
Powerhouse (civil)	Landslide	-	X	NN	-
Powerhouse (civil)	Leakage in wall concrete	-	C	NN	-
Tailrace (civil)	Erosion in concrete wall	-	C	NN	-

Table 8.2 Cost of the Rehabilitation Plan
(Including civil and hydro-mechanical equipment)

Notice: Recommended rehabilitation plan is shown in green.

Common rehabilitation Matrix

Table 7.4		Deterioration Level		
		A	B	C
Phase of Implementation	SV		- Small blasting and painting machine for general use Total cost: US$200,000	- Removal of sedimentation from Canyon and Laxapana ponds Dredging grab Mobile crane - Dam control system for Canyon and Laxapana pond - Robot for repainting the inside of penstock Total cost: US$2,500,000
	DD			
	IN			

Estimated cost of the recommended rehabilitation plan in this table

Item	Cost
Total cost of items in green, above	US$2,700,000
Engineering fee (10%)	US$300,000
Contingency (10%)	US$300,000
Total cost	US$3,300,000

Wimalasurendra Rehabilitation Matrix

Table 8.2		Deterioration Level A	B	C
Phase of Implementation	SV	- Disassembly inspection Total Cost: US$1,200,000 - Generator transformer - 11kV main circuit Total cost: US$1,800,000	- 132kV switchgear Total cost: US$3,200,000	
	DD	- Turbine (replacement of some parts) - Governor - Pressure oil supply system - Air supply system for governor - Air supply system for brake - Grease lubrication system - Water supply system - Drainage system - Generator: Case 1: Repair Case 2: Replacement - Exciter and AVR - Plant control equipment - Protection equipment - LV auxiliary circuit - Control power source Total cost of case1: US$8,900,000 Total cost of case 2: US$12,800,000		- Communication equipment Total cost: US$400,000
	IN	- Investigation for modification of spillway Total Cost: US$300,000	- Modification of spillway [Reference] Cost: US$5,600,000	

Estimated cost of the recommended rehabilitation plan in this table

Item	Cost of Case 1	Cost of Case 2
Total cost of items in green, above (excluding the cost of investigation and disassembly inspection)	US$14,300,000	US$18,200,000
Engineering fee (10%)	US$1,500,000	US$1,900,000
Cost of investigation	US$300,000	US$300,000
Cost of disassembly inspection	US$1,200,000	US$1,200,000
Contingency (10%)	US$1,600,000	US$2,000,000
Total cost	US$18,900,000	US$23,600,000

Old Laxapana (Stage I) Rehabilitation Matrix

Table 8.2		Deterioration Level		
		A	B	C
Phase of Implementation	SV	Disassembly inspection Total cost: US$1,200,000		
	DD	- Turbine - Inlet valve - Governor - Pressure oil supply system - Air supply system for governor - Air supply system for brake - Oil lubrication system - Water supply system - Generator - Exciter - AVR - 11kV main circuit Total cost: US$12,400,000		- Communication equipment Total cost: US$200,000 - Repair for remote control system of the penstock valve Total cost: US$200,000
	IN	- Investigation for Installation of flashboard Total cost: US$300,000	- Flashboard [Reference] Cost: US$3,200,000	

Old Laxapana (Stage II) Rehabilitation Matrix

Table 8.2		Deterioration Level		
		A	B	C
Phase of Implementation	SV			
	DD	- Air supply system for brake Total cost: US$100,000		
	IN			

Estimated cost of the recommended rehabilitation plan in this table

Item	Cost
Total cost of items in green, above, in Old Laxapana P/S Stage I (excluding the cost of investigation and disassembly inspection)	US$12,600,000
Total cost of items in green, above, in Old Laxapana P/S Stage II	US$100,000
Engineering fee (10%)	US$1,300,000
Cost of investigation	US$300,000
Cost of disassembly inspection	US$1,200,000
Contingency (10%)	US$1,500,000
Total cost (The cost includes the cost of rehabilitation plan of Old Laxapana Stage II.)	US$17,000,000

Canyon Rehabilitation Matrix

Table 8.2		Deterioration Level		
		A	B	C
Phase of Implementation	SV			
	DD		- Modification of air valve of intake valve Total cost: US$300,000	- Communication equipment Total cost: US$400,000
	IN			

Estimated cost of the recommended rehabilitation plan on this sheet

Item	Cost
Total cost of items in green, above	US$700,000
Engineering fee (10%)	US$100,000
Contingency (10%)	US$100,000
Total cost	US$900,000

New Laxapana Rehabilitation Matrix

Table 8.2		Deterioration Level		
		A	B	C
Phase of Implementation	SV	- Disassemble inspection Total cost: US$1,400,000		
	DD	- Turbine (Replacement of some parts) - Governor - Pressure oil supply system - Air supply system for governor - Grease lubrication system - Air supply system for brake - Water supply system - Generator - Exciter - AVR - 2.5kV main circuit - Plant control equipment - Protection equipment - LV auxiliary circuit - Control power source Total cost: US$15,800,000		
	IN	- Investigation for raking machine and access bridge Total cost: US$500,000		- Raking machine and access bridge [Reference] Cost: Unknown

Estimated cost of the recommended rehabilitation plan on this sheet

Item	Cost
Total cost of items in green, above (excluding the cost of investigation)	US$15,800,000
Engineering fee (10%)	US$1,600,000
Cost of investigation	US$500,000
Cost of disassembly inspection	US$1,400,000
Contingency (10%)	US$1,800,000
Total cost	US$21,100,000

Polpitiya Rehabilitation Matrix

Table 8.2		Deterioration Level		
		A	B	C
Phase of Implementation	SV	- Generator transformer 12.5kV main circuit Total cost: US$2,100,000		
	DD		- Installation of rain gauge station Total cost: US$600,000	- Communication equipment Total cost: US$400,000
	IN	- Investigation for the turbine Total cost: US$1,400,000 - Investigation for raking machine and access bridge Total cost: US$500,000	- Turbine - Grease lubrication system - Water supply system - Drainage system - Generator (Parts replacement) [Reference] Cost: US$10,00,000	- Raking machine and access bridge [Reference] Cost: Unknown

Estimated cost of the recommended rehabilitation plan on this sheet

Item	Cost
Total cost of items in green, above (excluding the cost of investigation)	US$3,100,000
Engineering fee (10%)	US$400,000
Cost of investigation items in green, above	US$1,900,000
Contingency (10%)	US$600,000
Total cost	US$6,000,000

Total cost of recommended rehabilitation plan

Common		US$3,300,000
Wimalasurendra	US$18,900,000	US$23,600,000
Old Laxapana Stage I (including the cost for Stage II)		US$17,000,000
Canyon		US$900,000
New Laxapana		US$21,100,000
Polpitiya		US$6,000,000
Total cost	US$67,200,000	US$71,900,000

Table 8.3 Schedule of the Rehabilitation Plan (Case 1)

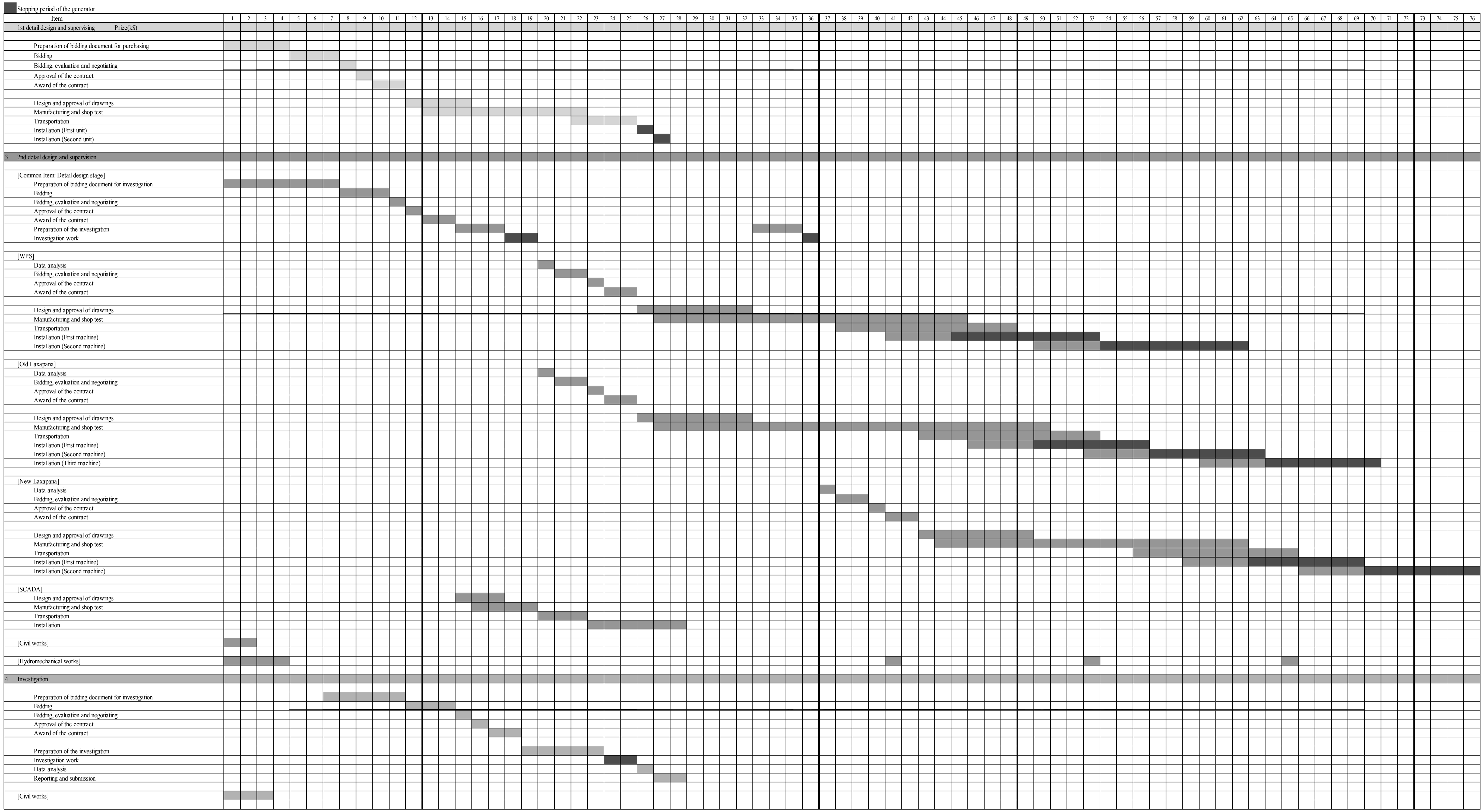
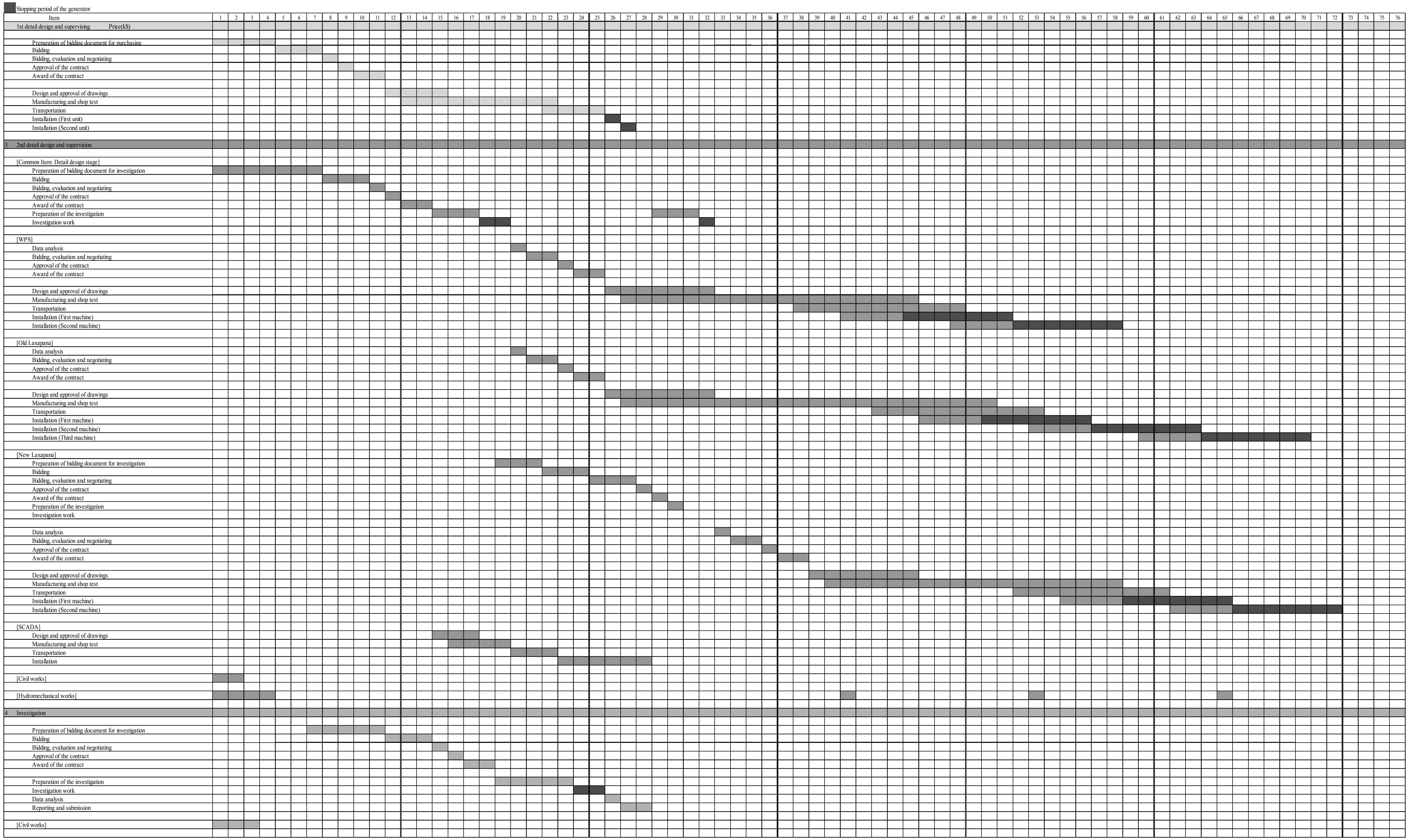


Table 8.4 Schedule of the Rehabilitation Plan (Case 2)



9. MAINTENANCE MANAGEMENT

9. MAINTENANCE MANAGEMENT

9.1 Civil Structures

9.1.1 Present Status

During the site visits, an interview was conducted to understand the present status of operations and maintenance for civil structures at the Laxapana Complex.

For spillway gates, CEB has prepared spillway rating curves for each dam that has a spillway gate equipped. The spillway rating curves indicate the relationship between the reservoir water level, the discharge at the spillway and the height of the open gate. The spillway rating curves are important for CEB in monitoring how spillway gates operate during floods. All spillway gates monitored operated properly except in some cases at the Laxapana Reservoir where overtopping and rise in water levels had occurred. The overtopping and rise in water levels were caused by gate trouble and heavy rain.

CEB has not carried out a periodic maintenance inspection and structure diagnosis on the civil structures in the Laxapana Complex. In addition, there is no inspection manual present, which lists the structures to be inspected, inspection items, frequency and procedures etc.

9.1.2 Recommended Inspection Manual

An inspection manual for civil structures inspection has been prepared and attached to this report. This manual is based on J-POWER's manual, which specifies the frequency and check items of the patrol, inspection, measurement, etc for civil structures. It may be necessary to review and revise the manual to the actual circumstances at Laxapana complex.

J-POWER has conducted structural diagnosis when it is necessary. In recent years, JSCE (Japan Society of Civil Engineers) has issued a structural diagnosis guideline for concrete structures, which describes the basic concepts of the structural diagnosis. However, if the guideline is applied to the hydropower plant, details for structural diagnosis of the plant must be specified. In this chapter, only the concepts of the structural diagnosis are presented.

The main purpose of structural diagnosis is to forecast future deterioration of concrete structures, which could be caused by neutralization, salt injury, chemical reaction, alkali-aggregate reaction and fatigue through physical testing and obtain data that will be useful in estimating the proper timing for measures to be implemented. In order to achieve this, each structure’s level of importance has to be decided taking account the social and economical impact. For example, a dam is very important due to the massive impact of it collapsing. On the other hand, a collapsed gutter around a powerhouse is will not have a great impact lowering its importance. With this, it is necessary to classify the structures into categories of importance for maintenance works.

Structures that are classified as important should be examined through a physical property test. Such as an unconfined compression test for concrete which should be done in intervals of several years in order to obtain the deterioration curve of the structure. Figure 8.1 shows an image of the deterioration curve. This deterioration curve would suggest a proper timing for measures to be implemented.

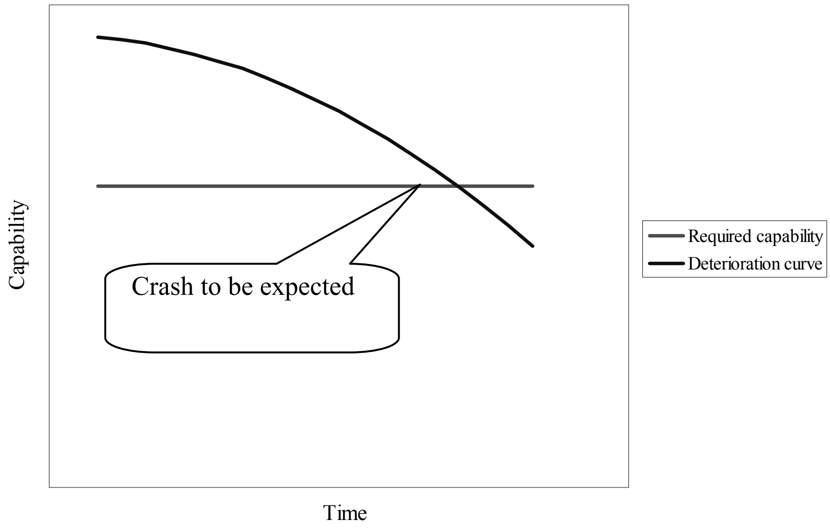


Figure 9.1 Image of Deterioration Curve

It is not necessary to conduct a physical test on non-important structures. However, the specified maintenance works stated in the inspection manual should be performed for these structures.

9.2 Hydromechanical Equipment

9.2.1 Present Status

CEB has listed the following repairs conducted. The repairs listed were mainly for the Laxapana Complex. These repairs were conducted by CEB directly. Due to restrictions in budget, labour and suspension, some works could not satisfy all the requirements for repair.

(1) Penstock Repair Work

- Touch up painting at places of corrosion on welded parts (New Laxapana)
- Repaired leakage at the expansion joints (New Laxapana)
- Measured the thickness of the old penstock (Old Laxapana)

(2) Gate and Screen

1) Spillway gate

- Replacement of the wire rope for hoisting equipment (Polpitiya)
- Touch up painting at places of corrosion (Polpitiya)
- Cleaning and painting of the flush board (Wimalasurendra)
- Annual test of gate operation (Canyon)

2) Intake gate

- Repaired Intake gate, Bulkhead gate, Trashrack and Gantry crane (Wimalasurendra)
- Repair plan created for needle valve (Wimalasurendra)

3) Tailrace gate

- Repaired tailrace gate (Canyon)

4) Screen

- Repaired Intake trashrack (Polpitiya)

9.2.2 Recommendations for Maintenance

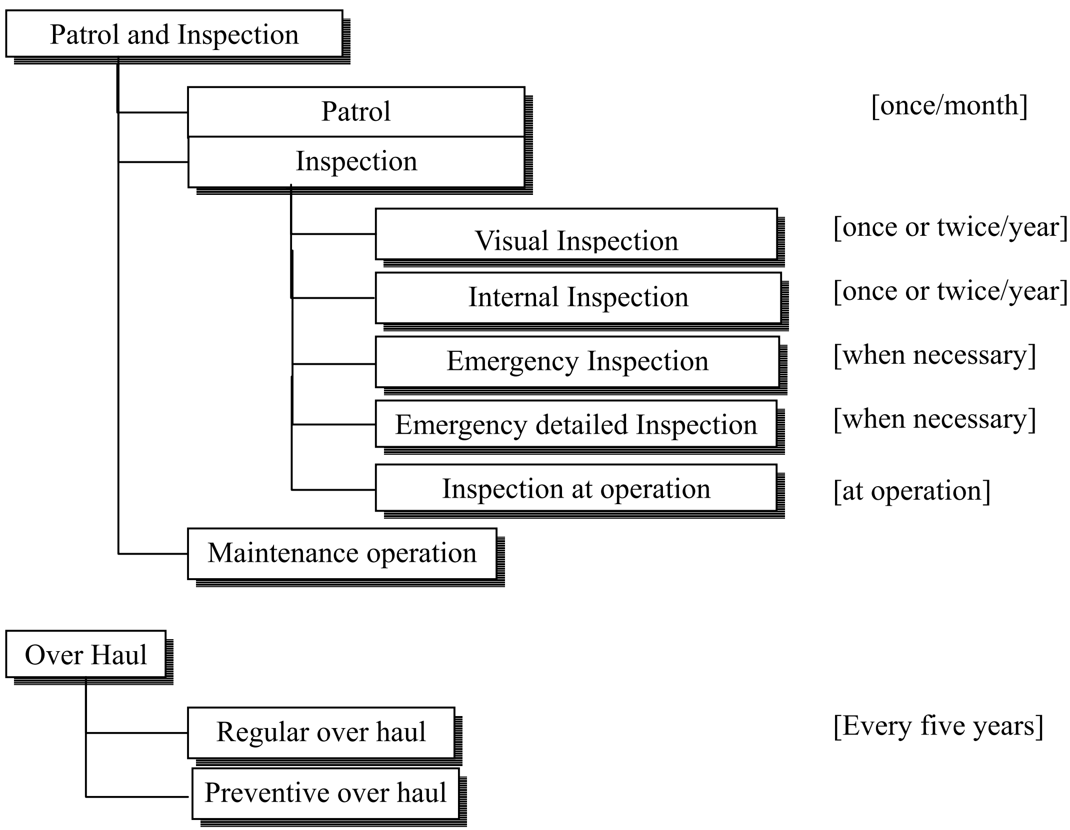
(1) Recommended Operation and Maintenance Manual

CEB has conducted the above repair works on the hydromechanical equipment. However, periodic patrols and inspections must be performed in order to prevent any accident and to prolong the life of the aging equipment.

The general system of patrol and inspection by J-Power is shown below. This system contains periodic patrols, visual inspections, internal inspections and emergency inspection based on safety regulations. These days, J-Power has carried out the deterioration diagnose for identifying deteriorated equipment in past years in order to supplement the conventional patrol and inspection.

It is recommended to create an O&M manual for CEB hydro-mechanical equipment that refers to J-Power's manual.

Example: J-Power's Inspection and maintenance of hydromechanical equipment



(2) Important Matters on Maintenance

Generally, the life of steel structures such as hydro-mechanical equipment depends on corrosion and metal fatigue. This is especially so for the hydro-mechanical equipment which requires re-painting to prolong the life of the equipment. Along with this, the maintenance of hoisting equipment of the spillway gate, including the wire rope and the auxiliary power, are important in preventing accidents at time of discharge,

Along with the periodic inspection of the hydromechanical equipment, the maintenance of the stairs, ladders and handrail which provides access to the spillway gate's trunnion and inspection gallery around penstock should be performed.

9.2.3 Technical Documents on Maintenance

The technical documents concerning the maintenance of the hydro-mechanical equipment is attached at the end of this report.

(1) Maintenance on Hydromechanical Equipment

This section is one of the excerpts from the maintenance regulations mentioned in the "Technical Standard for Gates and Penstocks" and was adjusted for use with the hydro-mechanical equipment in the Hydropower station.

(2) Inspection Manual

This manual is one of the excerpts from the inspection items on the penstock and radial gate mentioned in J-Power's manual on periodic patrols and inspections for hydro-mechanical equipment.

(3) Deterioration Monitoring Manual

This manual is an excerpt of a monitoring manual from J-Power's Deterioration Monitoring Manual for Hydro-mechanical equipment.

(4) Re-painting Manual

This manual is an excerpt of a re-painting manual from J-Power's Re-painting Manual for Hydro-mechanical equipment.

9.3 Electro-mechanical Equipment

9.3.1 Present Status

The inspection for the electro-mechanical equipment in CEB is divided into a scheduled inspection and unscheduled, similarly used in Japan. Furthermore, scheduled inspections are divided into daily inspections, monthly inspections, and overhaul.

It can be stated that daily inspection is "Cleaning and Data collection", monthly inspection is "Cleaning and Visual inspection", overhaul is "Characteristics inspection and Replacement of consumption articles."

(1) Daily Inspection

Daily inspection is basically cleaning and daily inspection at the shutdown period during normal operation. Data collection is carried out every hour using a daily data sheet in the operation room in each power station. Each power station’s data sheet in the Laxapana Complex should be different. Listed below are the inspection items of Polpitiya power station for reference.

- Oil pressure of the brake and governor systems
- Water pressure in the spiral case
- Location of guide vanes and the limitations
- Voltage and current of field circuits
- Voltage, current, active power, reactive power and power factor of generators
- Oil and winding temperatures of the generator transformer
- Water flow of the generator transformer
- Voltage and current of the auxiliary circuits
- Voltage, current of the D.C. circuit
- Voltage, current, active power and reactive power of transmission lines
- Energy production of each generator, and energy consumption of the auxiliary circuit (Once / day)

(2) Monthly Inspection

The date of monthly inspection is decided every month. The inspection is basically twice a month. Inspection items for the Canyon power station are shown in Appendix C-4 for reference. Most items listed in the monthly inspection are visual inspections. Furthermore, some special inspection items are applied to the following power stations.

- Wimalasurendra hydropower station; downward movement of coil in the stator was discovered in 2002. This fault has not been completely repaired. Visual inspection of the coil position has been carried out during monthly inspection since discovery.
- New Laxapana hydropower station; a leakage-oil from the bearing have sprayed on the stator in the generator. Visual inspection and cleaning the stator is carried out during the monthly inspection.

- Polpitiya hydropower station; the main shaft seal of the hydraulic turbine has rapidly worn out due to inflow of silt and sand during the rainy season. Replacing the seal is carried out during the monthly inspection.

(3) Overhaul

Overhaul is characterized as measurement of equipment, such as insulation resistance, oil inspection and disassembly inspection of auxiliary equipment, etc. Major overhaul items for the Canyon hydropower station are shown in Appendix C-4 for reference.

9.3.2 The Issue of the Maintenance Work for Electro-mechanical Equipment

(1) Daily Inspection

Daily inspection should be frequent.

From mechanical point of view, recording temperatures during operation is important to help maintain the rotating equipment. A data logger is a useful way to record the temperature during operation. However, some data loggers stop at the power station due to the shortage of record sheets.

On the daily data sheet, columns for entering the temperature of equipment are less than the columns for electrical values, such as voltage, current, active and reactive power.

The number of columns for the electrical value is sufficient for daily inspection.

(2) Monthly Inspection

CEB specifies the items of monthly inspection on for each power station and carries out the whole items and keeps the records in power station adequately. The items and frequency of the monthly inspection are adequate.

For control and protection relay equipment, it is necessary to marshal data from characteristic tests to confirm if it is within the tolerance for each setting value of each instrument and protection relay. Further, it is also necessary to marshal a record of start and stop sequence tests of all of the equipment during operation at the end of the monthly inspection.

(3) Overhaul

Some measurement procedures are not precisely formulated. For example, measurement times of an insulation resistance use records which are based on different measurement times in the same unit. Normally, it is difficult to use the results on the records from different measurement times as data of deterioration diagnosis. Different measurement times seem to be caused by inadequate inspection time under times of tight power demand and supply balance and are also affected due to the lack of an original inspection manual for each power station.

Furthermore, the disassembly inspection for the generator and hydro-turbine are not carried out in the periodical overhaul. For these reasons, minor faults, which have left small impacts inside the equipment, have been left without any repair.

As for the control and protection relay equipment, it is necessary to carry out the same items for control and protection relay equipment such as monthly inspection.
Further, it is necessary to perform the load rejection test during operation, and to marshal data from the test.

9.3.3 Recommended Frequency and Items for Maintenance Works

(1) Daily Inspection

All data loggers should restart from the power station, which was equipped with loggers, as soon as possible.

CEB should consider adding the following temperature columns into the daily data sheets for the power station without data logger.

- Oil temperature of turbine, upper, lower and thrust bearing

- Coil temperature of stator

(2) Monthly Inspection and Overhaul

It seems that monthly inspection items and overhaul is based on the manufacturer's instructions. Generally the inspection items listed in the manufacturer's instruction are not enough to conduct a deterioration diagnosis for electro-mechanical equipment. All power utility companies in Japan are equipped with original inspection items and manuals for monthly inspection and overhaul. Their inspection items are based on information from not only the manufacturer's instructions but also from past experiences, such as records of installation and disassembly and accident recovery works. The inspection items and frequency in J-Power are shown in Appendix C-5. The "Periodical inspection" from J-Power inspections is similar to the CEB's monthly inspection and overhaul.

It is important to build up an original inspection manual for overhaul at each power station. An original inspection manual allows CEB to not only properly conduct procedures for each inspection, but also allows common sense concerning the overhaul to enter in. This is why common sense among everyone concerned is the foundation of safety.

If possible the manual should be simple. The manual J-Power used at the simplified efficiency test on Unit 1 in Old Laxapana hydropower station is show in Appendix C-5.

10. ECONOMIC AND FINANCIAL ANALYSIS

10. ECONOMIC AND FINANCIAL ANALYSIS

10.1 Economic Analysis

The economic and financial analysis is focused on Wimalasurendra P/S (40 years old), Old Laxapana P/S (54 years old) and New Laxapana P/S (30 years old), for which replacement of the main electrical equipment is being planned.

Since hydro power stations have an actual lifetime beyond their accounting lifetime, the consultant has determined rehabilitation plans in consideration of actual lifetime. In consideration of this actual lifetime and in line with the results of other power stations around the world and based on J-POWER's experience, the lifetimes of the typical civil structure and electro-mechanical equipment are established as follows:

	Accounting lifetime	Actual lifetime
Civil structure	50 years	100 years
Electro-mechanical equipment	35 years	Main equipment: 50 years Others: 25 years

The rehabilitation plan is thoroughly considered from the technical standpoint, and when two or more rehabilitation plans can be considered, they should be analyzed for every case in regard to differences in improved generating efficiency, outage time, future operation and maintenance cost and so on. The detailed rehabilitation plans of each power station, as the object of economic analysis, are described in Chapter [7. ELECTRO-MECHANICAL EQUIPMENT]. Regarding the main equipment, the rehabilitation plan is summarized as follows:

(1) Wimalasurendra P/S

Case 1: Repair of generator; replacement of stator coils and cores.
Subsequently, the generator is used with continuous maintenance.

Case 2: Replacement of generator.

(2) Old Laxapana P/S

Replacement of hydraulic turbines and generators

(3) New Laxapana P/S

Replacement of generators

10.1.1 Estimate of Economic Benefits

The consultant assumed that an alternative thermal power plant will be required when if rehabilitation is not carried out — a plant that can meet peak demand, and its construction cost and operation and maintenance cost including fuel cost will be considered as a benefit in this analysis. A gas turbine type power plant has been chosen as the alternative thermal power plant for this analysis.

To calculate the economic benefit of kW-Value and kWh-Value, kW-Value adjustment factor of 1.13788 and kWh-Value adjustment factor of 0.98454 can be used to adjust the energy loss of hydro power and gas turbine power generation respectively. Detailed calculations are as shown in Table 10.1.

Thus, the output of each plant adjusted for kW-Value is set up as follows.

Power Station	Capacity	Alternative Gas Turbine Plant
Wimalasurendra	50MW (25MW*2)	57.0MW
Old Laxapana (Stage I)	25MW (8.33MW*3)	28.5MW
New Laxapana	100MW (50MW*2)	113.8MW

The construction cost, O&M cost and accounting lifetime of a plant with these characteristics are as follows, assuming gas turbine plants of 35MW for Wimalasurendra P/S and Old Laxapana (Stage I) P/S, and a 105MW plant for New Laxapana P/S based on data from "Long Term Generation Expansion Plan 2005-2019" (LTGEP).

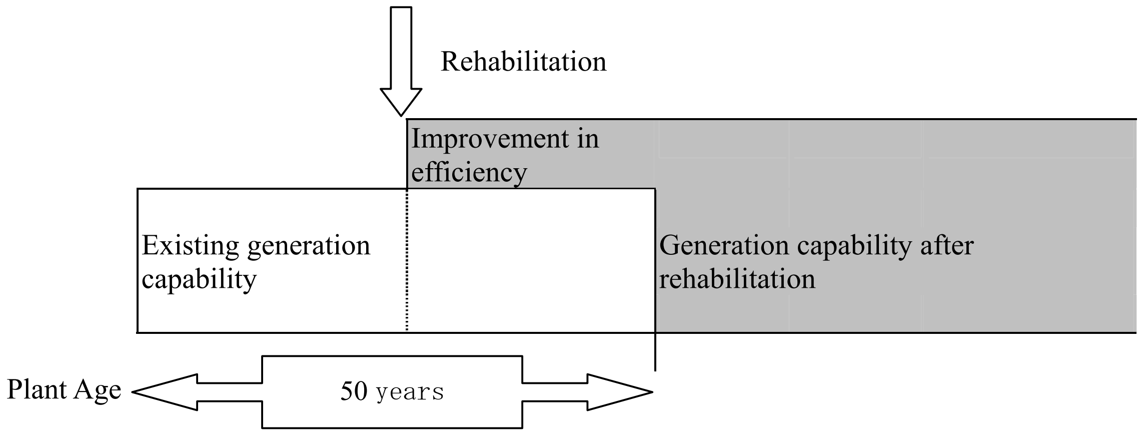
	Wimalasurendra Old Laxapana (Stage I)	New Laxapana P/S
Pure Construction Cost	US$ 586.6 /kW	US$398.9/kW
Fixed O&M Cost	US$ 6.29/kWh/year	US$ 4.75/kWh/year
Variable O&M Cost	US$ 0.420/kWh	US$ 0.315/kWh
Accounting Lifetime	20 years	20 years

Thus, kW-Value of US$ 85.56/kW and a kWh-Value of US$ 95.42/MWh are indicated for Wimalasurendra P/S and Old Laxapana (Stage I) P/S, and a kW-value of US$ 58.72/kW and kWh-Value of US$ 72.01/MWh are indicated for New Laxapana P/S as shown in Table 10.2. The benefit is calculated in consideration of the power generation capability of each plant as follows;

Power Station	kW-Value	kWh-Value
Wimalasurendra(50MW)		
(Annual Generation; 112GWh)		
Before Rehabilitation	4,278	10,687
After Rehabilitation Case1	4,278 (Improved 0%)	10,687(Improved 0%)
After Rehabilitation Case2	4,278 (Improved 0%)	10,794 (Improved 1%)
Old Laxapana (Stage I) (25MW)		
(Annual Generation; 143GWh)		
Before Rehabilitation	2,139	13,645
After Rehabilitation	2,310 (Improved 8%)	15,009 (Improved 10%)
New Laxapana(100MW)		
(Annual Generation; 552GWh)		
Before Rehabilitation	5,872	39,751
After Rehabilitation	5,872 (Improved 0%)	40,148(Improved 1%)

The illustration of the benefit of rehabilitation is shown in the following figure. The improvement in efficiency through rehabilitation is considered to be the benefit to up an actual lifetime of main electrical equipment of 50 years. It is considered that the rehabilitation project recovers the capability of each unit after it is51 years old, so the total power generation capability is considered a benefit.

< The benefit of rehabilitation >



As for Old Laxapana P/S, however, it is already more than 54 years old, so the benefit of efficiency improvement through rehabilitation is considered to begin immediately after the rehabilitation is completed.

The reductions of kW-Value and the production affected by outages during the rehabilitation are deducted from benefit of each plant. The outage periods and reduction of production corresponding to the term of the rehabilitation project are shown in Table 10.3 for Case1 and Table 10.4 for Case2 of Wimalasurendra P/S.

10.1.2 Estimate of Economic Costs

The estimated pure construction cost is in foreign currency and local currency, with the foreign currency portion accounting for 90% of the project cost. The local currency portion is calculated as an economic cost by a conversion factor which, based on discussions with CEB, was determined to be 0.9. The economic construction cost is shown in the table below and in Table 10.5. As for the rehabilitation of Wimalasurendra P/S Case1, it will not be completed thorough rehabilitation, so it is plausible that some amount of repair cost will be required. Therefore, the consultant estimates US$1 million every five years as repair cost. And the cost of common items is divided among five power stations with the following percentage; 5% for Wimalasurendra P/S, 30% for Old Laxapana (Stage I) P/S, 30% for Canyon P/S, 30% for New Laxapana P/S and 5% for Polpitiya P/S.

(Unit: US$1,000)

Pure Construction Cost

Power Station	Total Amount	Foreign Currency Portion	Local Currency Portion
Wimalasurendra			
(Case1)	19,066	17,159	1,907
(Case2)	23,766	21,389	2,377
Old Laxapana (Stage I)	17,990	16,191	1,799
New Laxapana	22,090	19,881	2,209

(Unit: US$1,000)

Economic Cost

Power Station	Total Amount	Foreign Currency Portion	Local Currency Portion
Wimalasurendra			
(Case1)	18,875 repair cost of US$1 million every 5 years	17,159	1,716
(Case2)	23,528	21,389	2,139
Old Laxapana (Stage I)	17,810	16,191	1,619
New Laxapana	21,869	19,881	1,988

The operation and maintenance cost (O&M cost) consists of personnel costs and equipment procurement costs in consideration of the actual cost. A 10% reduction of the O&M cost can be assumed when the main equipment is replaced by the rehabilitation project. These O&M costs are shown in Table 10.6 for Wimalasurendra P/S Case 1 and 2, Table 10.7 for Old Laxapana (Stage I) P/S, and Table 10.8 for New Laxapana P/S.

10.1.3 Result of Economic Evaluation

Three indices, surplus benefit (B-C), benefit cost ratio (B/C) and economic internal rate of return (EIRR), are calculated, and the consultant judges the feasibility from the economic standpoint. That is, the project is judged to be feasible when the surplus benefit (B-C) is positive, the benefit cost ratio (B/S) is grater than 1, and the economic internal rate of return (EIRR) is more than the discount rate. The discount rate was set as 10% upon discussion with CEB for this evaluation. The results of calculation are as follows and as shown in Table 10.9 to Table 10.11.

Power Station	B-C	B/C	EIRR	Reference
Wimalasurendra				
(Case1)	US$45,087,000	3.95	21.91%	Table 10.9.1
(Case2)	US$44,008,000	3.52	20.49%	Table 10.9.2
Old Laxapana (Stage I)	US$87,018,000	7.26	45.60%	Table 10.10
New Laxapana	US$50,083,000	4.39	15.65%	Table 10.11

These calculation results prove that each of the rehabilitation plans is feasible from the economic point of view.

Regarding Wimalasurendra P/S, the Case1 rehabilitation plan, in which repairs are made as required, shows better economic outcome than Case2 based on calculations because the initial investment is smaller. But in Case1, the generator is not replaced. Therefore, to analyze future trouble involving other equipment, which in an indefinite factor, the consultant tried some cases in which a US$5 million per year as special repair cost, with the same outage term is added, used the result for comparison with Case2. As the results of this trial indicate, which are as shown in Table 10.12.1 to Table 10.12.4, the surplus benefit is reversed between 62 and 63 years. Case2 (scheduled replacement) is more economical when the special repairs are needed before the unit is 62 years old. On the other hand, Case1 (repair as required) is more economical if the special repairs are needed after it is 63 years old.

10.2 Sensitivity Analysis of EIRR

10.2.1 Sensitivity of Project Costs

Sensitivity analysis has been done for the cases in which the cost of the rehabilitation project is changed, and it has been verified that every project maintains economical feasibility against some rate of change because of the original stable economic feasibility. As a trial calculation, the change rates that make B-C minus, B/C less than 1, or EIRR less than 10% are as follows; when the project cost increases by 293% for Wimalasurendra P/S Case1, by 250% for Wimalasurendra P/S Case2, by 623% for Old Laxapana (Stage I) P/S, and by 339% for New Laxapana P/S. The details are shown in Table 10.13.

10.2.2 Sensitivity of Fuel Price

Sensitivity analysis is carried out for the cases in which the fuel price of the alternative thermal plant changes. But the economic feasibility of the cases are not affected by a change in the fuel price. Even if fuel price falls to less than US$10/bbl, each project can maintain economic feasibility. The details are shown in Table 10.14.

10.2.3 The Limiting Time of without Project

The consultant analyzed the sensitivity of the timing and economic efficiency on the assumption that no rehabilitation will be done until power plant completely breaks down and functionally stops.
It is assumed that all generating units of each P/S will be replaced successively upon the breakdown of one unit. That is, to replace the two units of Wimalasurendra P/S and New Laxapana P/S, and the three units of Old Laxapana (Stage I) P/S, preparation for their purchase is begun upon the breakdown of the first unit. Conditions to study are as follows:

- The outage period is set on condition that the replacement of first unit starts 44 months after first unit is broken.

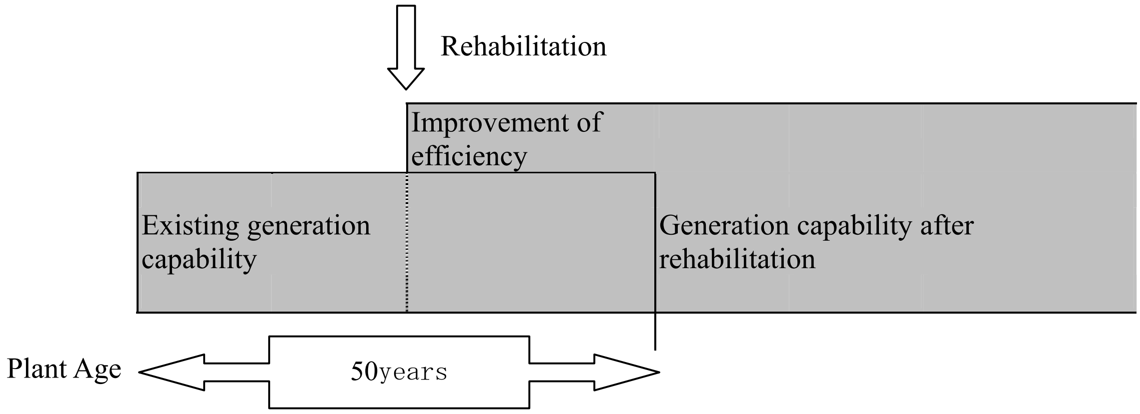
Power Station	Unit1	Unit2	Unit3
Wimalasurendra	44months(Crash) +7months (Replacement)	7months (Replacement)	-
Old Laxapana (Stage I)	44months(Crash) +7months (Replacement)	7months (Replacement)	7months (Replacement)
New Laxapana	44months(Crash) +7months (Replacement)	7months (Replacement)	-

- Construction cost is same as that of a scheduled replacement.

- Replacement is carried out successively from the broken-down unit.

In this analysis, benefit by existing equipment that is before rehabilitation is also considered. The same thing is applied to the cost. The benefit is illustrated in the figure below.

< Benefit of rehabilitation >



The loss of kW-Value and produced energy by outage period are shown in Table 10.15.

To continue operating without rehabilitation and await a crash with outage brings an enhanced the risk of blackouts. As stated in the LTGEP, once a blackout takes place, the economic cost of not supplying energy (Cost of Energy Not Served) occurs (US$0.74/kWh). In this evaluation, as shown in Table 10.16, Table 10.17 and Table 10.18, a changed rate of LOLP (Loss of Load Probability) effected by an outage from crash one unit of each power plant has been computed by CEB, and the consultant calculated the increased outage risk (outage period) as Cost of Energy Not Served on the ERR calculation table. The average changed rate of LOLP for 10 years (2010-2019) is used here. However, this Cost of Energy Not Served is of course considered in the year of the crash, but is the smaller cost of this Cost of Energy Not Served and the cost of a new gas turbine thermal plant construction and its operation after the second year. The calculation result is shown in Figure10.1 Table 10.19, Table 10.20 and Table 10.21 and below.

Wimalasurendra P/S

In the case of a crash accompanying an outage at the plant 50 years old (2014), its value (B-C) becomes larger than that of the scheduled replacement. That means, if a crash occurs and replacement of the unit becomes necessary before it is 50 years old, implementing scheduled replacement is preferable.

Old Laxapana (Stage I) P/S

In the case of a crash accompanying an outage at the plant 65 years old (2015), its value (B-C) becomes larger than that of the scheduled replacement. That means, if a crash occurs and replacement of the unit becomes necessary before it is 65 years old, implementing scheduled replacement is preferable.

New Laxapana P/S

In the case of a crash accompanying an outage at the plant 46 years old (2020), its value (B-C) becomes larger than that of the scheduled replacement. That means, if a crash occurs and replacement of the unit becomes necessary before it is 46 years old, implementing scheduled replacement is preferable.

10.3 Financial Analysis

The financial internal rate of return (FIRR) is calculated by comparing the financial cost and financial benefit of the rehabilitation plan.

10.3.1 Estimate of Financial Benefit

Assumed income from electricity sales based on the electricity unit price is used as a financial benefit. Here, Rs7.68 /kWh, the average price indicated in Statistical Digest 2003, is used as the basis. This includes 15% value-added tax (VAT), which is paid to government but mostly returned to CEB. Sales energy is calculated after deduction of a 19.2% loss from overall generation.

10.3.2 Estimate of Financial Cost

The financial cost is estimated for the construction cost and O&M cost at a financial price. A 15% VAT is added to both foreign and local currency portions of the pure construction cost. Moreover, a custom duty of 3% and surcharge of 10% are also added to the foreign portion. The estimation results are shown below and Table 10.22.

(Unit: US$1,000)

Pure Construction Cost			
Power Station	Total Amount	Foreign Currency Portion	Local Currency Portion
Wimalasurendra			
(Case1)	19,066	17,159	1,907
(Case2)	23,766	21,389	2,377
Old Laxapana (Stage I)	17,990	16,191	1,799
New Laxapana	22,090	19,881	2,209

(Unit: US$1,000)

Financial Cost			
Power Station	Total Amount	Foreign Currency Portion	Local Currency Portion
Wimalasurendra			
(Case1)	24,550 repair cost of US$1 million in every 5 years	22,358	2,193
(Case2)	30,602	27,869	2,733
Old Laxapana (Stage I)	23,165	21,096	2,069
New Laxapana	28,444	25,904	2,540

10.4 Result of Financial Evaluation

The financial internal rate of return (FIRR) has been calculated, and the consultant has judged feasibility from the financial standpoint. The calculation results are as follows and shown in Table 10.23, Table 10.24 and Table 10.25.

Power Station	FIRR	Reference
Wimalasurendra		
Case1	14.15%	Table 10.23.1
Case2	12.82%	Table 10.23.2
Old Laxapana (Stage I)	28.86%	Table 10.24
New Laxapana	14.23%	Table 10.25

These calculation results indicate that all of the rehabilitation plans are sufficiently feasible based on financial evaluation.

10.5 Sensitivity Analysis of FIRR

10.5.1 Sensitivity of Project Costs

For the case in which the project cost of the rehabilitation project is changed, sensitivity analysis was carried out.

Cases in which the cost changes from plus 50% to minus 50% and the rate at which FIRR 10% were calculated. The results are shown in Table 10.26.

The marginal rate of increasing the cost to be financially valuable is 66% for Wimalasurendra P/S Case1, 45% for Case 2, 257% for Old Laxapana (Stage I) P/S, and 187% for New Laxapana P/S. This means each project is sufficiently feasible when the project cost changes regarding FIRR, as expected.

10.5.2 Sensitivity of Electricity Price

Sensitivity analysis was carried out for cases in which the electricity price is changed.

Cases in which the electricity price changes from 50% to minus 50% and the rate that yields FIRR of 10% were calculated. The results are shown in Table 10.27.

The marginal rate of declining electricity price to be financially viable is minus 40% for Wimalasurendra P/S Case1, minus 31% for Case 2, minus 71% for Old Laxapana (Stage I) P/S, and 65% for New

Laxapana P/S. This means mean each project is sufficiently feasible in relation to changing electricity price in FIRR as expected.

10.6 ODA Finance

10.6.1 Analysis of ODA Finance

A revenue source to the fund the project was assumed to be supplied mainly from Official Development Assistance (ODA). The payment capability was analyzed by the consultant. Loan conditions were configured as follows:

Loan Condition		Ground
Foreign Finance:	90% of project cost	Electro-Mechanical Equipment occupies major portion of the project cost and it will be imported.
	1.5% annual interest rate 30 year repayment period (including 10 year grace period)	Quoted from JBIC general Loan condition for category Lower - Middle income countries (GNI over US$736 under US$1,415).
Local Finance:	10% of project cost	
	13% annual interest rate 20 year repayment period (including 4year grace period)	Quoted from status report of loan and sources. Ref; Table 10.28

Income tax of 35% is imposed on net profit for the year if the project has a net profit during the most recent five years.

As a measure of ODA finance analysis, three have been calculated. These are DSCR (Debt Service Coverage Ratio), ROI (Return on Investment), and LLCR (Loan Life Coverage Ratio). The calculation results are shown below. Though ROI is not very high because of low foreign loan interest rates, both DSCR and LLCR exceed the standard rate of around 1.5%, which indicates high repayment capability. The detail are shown in Table 10.29, Table 10.30 and Table 10.31.

Power Station	DSCR	ROI	LLCR
Wimalasurendra			
Case1	3.365	8.3%	2.996
Case2	2.772	8.3%	2.473
Old Laxapana (Stage I)	6.227	8.4%	5.328
New Laxapana	7.515	8.6%	5.577

10.7 Sensitivity Analysis of ODA Finance

10.7.1 Sensitivity Analysis of Electricity Price

The cases in which the electricity price changes from 50% to minus 50% have been calculated. The results are shown in Table 10.32.

The results indicated that each project is sufficiently feasible in regarding to changing electricity price as expected.

The marginal rate decline of electricity prices to be economically viable is minus 70% for Wimalasurendra P/S Case1, minus 64% for Case 2, minus 82% for Old Laxapana (Stage I) P/S, and plus 84% for New Laxapana P/S.

10.7.2 Sensitivity Analysis of Foreign Loan Condition

Cases in which the interest rate on foreign loan changes from 1% to 15% have been calculated. The results are shown in Table 10.33.

The results show that each project is sufficiently feasible in regard to change in the interest rate as expected.

The marginal rate for economic viability is 12% for Wimalasurendra P/S Case1, 10% for Case 2, 29% for Old Laxapana (Stage I) P/S, and 10% for New Laxapana P/S.

Table 10.1 Adjustment Factor, Power Value and Energy Value

Calculation of Power (kW) and Energy (kWh) Adjustment Factors

Item	Hydropower System		Gas Turbine Power Generation System	
Station Use	0.50%	a	2.00%	e
Forced Outage	0.50%	b	8.00%	f
Planned Outage	1.90%	c	8.20%	g
Transmission Loss	4.00%	d	1.00%	h
kW-Adjustment Factor	-		1.13788	i
kWh-Adjustment Factor	-		0.98454	j

Note:
1. i =(1-a)*(1-b)*(1-c)*(1-d)/(1-e)*(1-f)*(1-g)*(1-h)
2. j =(1-a)*(1-d)/(1-e)*(1-h)

Table 10.2 Power Value and Energy Value

Calculation of Power Value (kW-Value)

Item	Unit	Gas Turbine Power Generation System 35MW	Gas Turbine Power Generation System 105MW	
kW Construction Cost*1	US$/kW	586.6	398.9	a
Plant Life	Years	20	20	b
Discount Rate	%	10.00%	10.00%	c
Capital Recovery Factor		0.11746	0.11746	d
Fixed OM Cost	US$/kW/yr	6.29	4.75	e
Power Value (KW-Value)	US$/kW	85.56	58.72	f

Note: 1. f = (e+a*d)*(kW-adjustment Factor.)

Calculation of Energy Value (kWh-Value)

Item	Unit	Gas Turbine Power Generation System 35MW	Gas Turbine Power Generation System 105MW	
Fuel Type		Auto Diesel		
Fuel Price*1	US¢/Gcal	3,030	3,030	a
Heat Content	kcal/kg	10,550	10,550	b
Thermal Efficiency	%	28.10%	30.10%	c
Heat Rate	kcal/kWh	3,060.0	2,310.0	d
Fuel Amount	kg/kWh	0.29005	0.21896	e
Fuel Cost	US$/kWh	0.09272	0.06999	f
Variable OM Cost	US¢/kWh	0.420	0.315	g
Energy Value (kWh-Value)	US$/MWh	95.42	72.01	h

Note: 1. h = (f+g/100)*(kWh-adjustment Factor) *1,000
2. *1 US$42.70/bbl at Colombo

Table 10.3 Outage Term (1)

Outage Term of Wimalasurendra P/S Pmax = 50 MW (2units) [shaded] Outage for Rehabilitation

Case 1

Year	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Loss	Loss(US$1,000) per Year	Unit
	E (2003) (MWh)	4,892	3,922	6,867	8,976	12,204	11,129	6,805	4,403	4,315	5,599	5,246	8,748	83,106			
	Adjusted E (MWh)	6,593	5,286	9,254	12,097	16,447	14,998	9,171	5,934	5,815	7,546	7,070	11,789	112,000			
	Max. E by 1 unit (MWh)	18,600	16,800	18,600	18,000	18,600	18,000	18,600	18,600	18,000	18,600	18,000	18,600	219,000			
2006	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2007	Outage (days)	0	0	0	0	0	30	0	0	0	0	0	0	30	kW loss	-176	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2008	Outage (days)	0	28	0	0	0	0	0	0	0	0	0	0	28	kW loss	-164	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2009	Outage (days)	0	0	0	0	0	0	0	0	30	31	30	31	122	kW loss	-715	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2010	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,139	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2011	Outage (days)	31	28	0	0	0	0	0	0	0	0	0	0	59	kW loss	-346	US$1,000/year
	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2012	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year

Outage Term of Old Laxapana Stage I P/S Pmax = 50 MW

Stage I 25 MW (3 units) Stage II 25 MW (2 units)

Year	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Loss	Loss(US$1,000) per Year	Unit
	E (2003) (MWh)	12,632	10,139	18,583	23,176	28,999	28,556	23,616	19,375	15,680	16,491	13,982	20,632	231,861			
	Adjusted E (MWh)	15,582	12,506	22,922	28,588	35,770	35,224	29,130	23,899	19,341	20,342	17,247	25,450	286,000			
	Max. E by St.I & 2 unit (MWh)	31,000	28,000	31,000	30,000	31,000	30,000	31,000	31,000	30,000	31,000	30,000	31,000	365,000			
2006	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2007	Outage (days)	0	0	0	0	0	0	31	0	0	0	0	0	31	kW loss	-61	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2008	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2009	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2010	Outage (days)	0	28	31	30	31	30	31	31	30	31	30	31	334	kW loss	-652	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-4,770	-5,055	0	0	0	0	0	0	-9,825	kWh loss	-938	US$1,000/year
2011	Outage (days)	31	28	31	30	31	30	31	31	30	31	0	0	304	kW loss	-594	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-4,770	-5,055	0	0	0	0	0	0	-9,825	kWh loss	-938	US$1,000/year
2012	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year

Outage Term of New Laxapana P/S Pmax = 100 MW (2 units)

Year	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Loss	Loss(US$1,000) per Year	Unit
	E (2003) (MWh)	25,765	18,036	17,341	17,520	51,778	50,576	47,604	44,100	52,626	43,561	48,275	48,589	465,771			
	Adjusted E (MWh)	30,535	21,375	20,551	20,764	61,364	59,939	56,417	52,264	62,369	51,626	57,212	57,584	552,000			
	Max. E by 1 unit (MWh)	37,200	33,600	37,200	36,000	37,200	36,000	37,200	37,200	36,000	37,200	36,000	37,200	438,000			
2006	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2007	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2008	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	31	31	kW loss	-249	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	-20,384	-20,384	kWh loss	-1,468	US$1,000/year
2009	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2010	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2011	Outage (days)	0	0	31	30	31	30	31	31	30	31	30	31	306	kW loss	-2,461	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-24,164	-23,167	-19,217	-15,064	-25,518	-14,426	-20,528	-20,384	-162,468	kWh loss	######	US$1,000/year
2012	Outage (days)	31	28	31	30	0	0	0	0	0	0	0	0	120	kW loss	-965	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year

Table 10.4 Outage Term (2)

Outage Term of Wimalasurendra P/S Pmax = 50 MW (2units) [shaded] Outage for Rehabilitation

Case 2

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total		
E (2003) (MWh)		4,892	3,922	6,867	8,976	12,204	11,129	6,805	4,403	4,315	5,599	5,246	8,748	83,106		
Adjusted E (MWh)		6,593	5,286	9,254	12,097	16,447	14,998	9,171	5,934	5,815	7,546	7,070	11,789	112,000	Loss(US$1,000) per Year	
Max. E by 1 unit (MWh)		18,600	16,800	18,600	18,000	18,600	18,000	18,600	18,600	18,000	18,600	18,000	18,600	219,000		
2006	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2007	Outage (days)	0	0	0	0	0	30	0	0	0	0	0	0	30	kW loss	-176 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2008	Outage (days)	0	28	0	0	0	0	0	0	0	0	0	0	28	kW loss	-164 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2009	Outage (days)	0	0	0	0	0	0	0	0	30	31	30	31	122	kW loss	-715 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2010	Outage (days)	31	28	31	30	31	30	31	31	30	31	0	0	304	kW loss	-1,781 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2011	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2012	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year

Outage Term of Old Laxapana Stage I P/S Pmax = 50 MW
Stage I 25 MW (3 units) Stage II 25 MW (2 units)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total		
E (2003) (MWh)		12,632	10,139	18,583	23,176	28,999	28,556	23,616	19,375	15,680	16,491	13,982	20,632	231,861		
Adjusted E (MWh)		15,582	12,506	22,922	28,588	35,770	35,224	29,130	23,899	19,341	20,342	17,247	25,450	286,000	Loss(US$1,000) per Year	
Max. E by St.I & 2 unit (MWh)		31,000	28,000	31,000	30,000	31,000	30,000	31,000	31,000	30,000	31,000	30,000	31,000	365,000		
2006	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2007	Outage (days)	0	0	0	0	0	0	31	0	0	0	0	0	31	kW loss	-61 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2008	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2009	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2010	Outage (days)	0	28	31	30	31	30	31	31	30	31	30	31	334	kW loss	-652 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-4,770	-5,055	0	0	0	0	0	0	-9,825	kWh loss	-938 US$1,000/year
2011	Outage (days)	31	28	31	30	31	30	31	31	30	31	0	0	304	kW loss	-594 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-4,770	-5,055	0	0	0	0	0	0	-9,825	kWh loss	-938 US$1,000/year
2012	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year

Outage Term of New Laxapana P/S Pmax = 100 MW (2 units)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total		
E (2003) (MWh)		25,765	18,036	17,341	17,520	51,778	50,576	47,604	44,100	52,626	43,561	48,275	48,589	465,771		
Adjusted E (MWh)		30,535	21,375	20,551	20,764	61,364	59,939	56,417	52,264	62,369	51,626	57,212	57,584	552,000	Loss(US$1,000) per Year	
Max. E by 1 unit (MWh)		37,200	33,600	37,200	36,000	37,200	36,000	37,200	37,200	36,000	37,200	36,000	37,200	438,000		
2006	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2007	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2008	Outage (days)	0	0	0	0	0	0	0	31	0	0	0	0	31	kW loss	-249 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	-15,064	0	0	0	0	-15,064	kWh loss	-1,085 US$1,000/year
2009	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year
2010	Outage (days)	0	0	0	0	0	0	0	0	0	0	30	31	61	kW loss	-491 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	-20,528	-20,384	-40,912	kWh loss	-2,946 US$1,000/year
2011	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,936 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-24,164	-23,167	-19,217	-15,064	-25,518	-14,426	-20,528	-20,384	-162,468	kWh loss	-11,700 US$1,000/year
2012	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0 US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0 US$1,000/year

Table 10.5 Pure Construction Cost & Economic Cost

Foreign portion is estimated to be 90% of total cost
Pure construction cost of local portion is calculated into Economic cost by conversion factor 0.90

Wimalasurendra P/S

Case 1 (Repair as required) (Unit: US$1,000)

Item	Pure Construction Cost			Economic Cost		
	Total	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion
1. Total Cost	19,066	17,159	1,907	18,875	17,159	1,716
2. Annual Disbursement						
2006	1,157	1,041	116	1,145	1,041	104
2007	4,724	4,251	472	4,676	4,251	425
2008	1,053	947	105	1,042	947	95
2009	7,630	6,867	763	7,554	6,867	687
2010	4,058	3,653	406	4,018	3,653	365
2011	349	314	35	346	314	31
2012	94	85	9	93	85	8

As repair cost 1,000 (US$1,000) in every 5years

Case 2(Scheduled replace) (Unit: US$1,000)

Item	Pure Construction Cost			Economic Cost		
	Total	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion
1. Total Cost	23,766	21,389	2,377	23,528	21,389	2,139
2. Annual Disbursement						
2006	1,257	1,131	126	1,245	1,131	113
2007	5,868	5,281	587	5,809	5,281	528
2008	1,346	1,212	135	1,333	1,212	121
2009	9,712	8,741	971	9,615	8,741	874
2010	5,137	4,624	514	5,086	4,624	462
2011	445	400	44	441	400	40
2012	0	0	0	0	0	0

Old Laxapana Stage I P/S (Unit: US$1,000)

Item	Pure Construction Cost			Economic Cost		
	Total	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion
1. Total Cost	17,990	16,191	1,799	17,810	16,191	1,619
2. Annual Disbursement						
2006	716	645	72	709	645	64
2007	4,323	3,891	432	4,280	3,891	389
2008	176	159	18	175	159	16
2009	8,077	7,270	808	7,997	7,270	727
2010	2,699	2,429	270	2,672	2,429	243
2011	1,907	1,717	191	1,888	1,717	172
2012	90	81	9	89	81	8

New Laxapana P/S

Item	Pure Construction Cost			Economic Cost		
	Total	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion
1. Total Cost	22,090	19,881	2,209	21,869	19,881	1,988
2. Annual Disbursement						
2006	935	842	94	926	842	84
2007	5,295	4,766	530	5,242	4,766	477
2008	230	207	23	228	207	21
2009	277	250	28	275	250	25
2010	10,013	9,011	1,001	9,912	9,011	901
2011	5,222	4,699	522	5,169	4,699	470
2012	118	106	12	117	106	11

Table 10.6 O & M Cost of Wimalasurendra P/S

	Unit				
Personal Cost (technician)	Rs/year	13,200,000			
Average Personal Salary	Rs/year	200,000			
Number of Person for Wimalasurendra PS	Person	66			
Parts Procurement Cost	Rs/year	4,000,000			
Total		17,200,000			
	(US$)	166,032	=	**170**	(US$1,000)

(Parts Procurement cost ; 2millionRs/year for 1 unit.)

Adjustment factor for case1 (Repair as Required)		0%			
	(US$)	166,032	=	**170**	(US$1,000)
Adjustment factor for case2 (Scheduled Replace)		-10%			
	(US$)	149,428	=	**150**	(US$1,000)

Table 10.7 O & M Cost of Old Laxapana P/S

	Unit				
Personal Cost (technician)	Rs/year	22,800,000			
Average Personal Salary	Rs/year	200,000			
Number of Person for Old Laxapana PS	Person	114			
Parts Procurement Cost	Rs/year	6,000,000			
Total		28,800,000			
	(US$)	278,006	=	**280**	(US$1,000)

(Parts Procurement cost ; 2millionRs/year for 1 unit.)

Adjustment factor for Scheduled Replace		-10%			
	(US$)	250,206	=	**250**	(US$1,000)

Table 10.8 O & M Cost of New Laxapana P/S

	Unit				
Personal Cost (technician)	Rs/year	9,200,000			
Average Personal Salary	Rs/year	200,000			
Number of Person for New Laxapana PS	Person	46			
Parts Procurement Cost	Rs/year	4,000,000			
Total		13,200,000			
	(US$)	127,420	=	**130**	(US$1,000)

(Parts Procurement cost ; 2millionRs/year for 1 unit.)

Adjustment factor for Scheduled Replace		-10%			
	(US$)	114,678	=	**110**	(US$1,000)

Table 10.9.1 Calculation of Economic Evaluation Indices

Wimalasurendra P/S Case 1（Repair as Required）

(Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	42	2006	1,145	0	1,145	0	0	0	0	0	-1,145
	43	2007	4,676	0	4,676	0	-176	0	0	-176	-4,852
	44	2008	1,042	0	1,042	0	-164	0	0	-164	-1,206
	45	2009	7,554	0	7,554	0	-715	0	0	-715	-8,269
	46	2010	4,018	0	4,018	0	-2,139	0	0	-2,139	-6,157
1	47	2011	346	0	346	0	-346	0	0	-346	-692
2	48	2012	93	0	93	0	0	0	0	0	-93
3	49	2013		0	0	0		0		0	0
4	50	2014		0	0	0		0		0	0
5	51	2015	1,000	170	1,170	4,278		10,687		14,965	13,795
6	52	2016		170	170	4,278		10,687		14,965	14,795
7	53	2017		170	170	4,278		10,687		14,965	14,795
8	54	2018		170	170	4,278		10,687		14,965	14,795
9	55	2019		170	170	4,278		10,687		14,965	14,795
10	56	2020	1,000	170	1,170	4,278		10,687		14,965	13,795
11	57	2021		170	170	4,278		10,687		14,965	14,795
12	58	2022		170	170	4,278		10,687		14,965	14,795
13	59	2023		170	170	4,278		10,687		14,965	14,795
14	60	2024		170	170	4,278		10,687		14,965	14,795
15	61	2025	1,000	170	1,170	4,278		10,687		14,965	13,795
16	62	2026		170	170	4,278		10,687		14,965	14,795
17	63	2027		170	170	4,278		10,687		14,965	14,795
18	64	2028		170	170	4,278		10,687		14,965	14,795
19	65	2029		170	170	4,278		10,687		14,965	14,795
20	66	2030	1,000	170	1,170	4,278		10,687		14,965	13,795
21	67	2031		170	170	4,278		10,687		14,965	14,795
22	68	2032		170	170	4,278		10,687		14,965	14,795
23	69	2033		170	170	4,278		10,687		14,965	14,795
24	70	2034		170	170	4,278		10,687		14,965	14,795
25	71	2035	1,000	170	1,170	4,278		10,687		14,965	13,795
26	72	2036		170	170	4,278		10,687		14,965	14,795
27	73	2037		170	170	4,278		10,687		14,965	14,795
28	74	2038		170	170	4,278		10,687		14,965	14,795
29	75	2039		170	170	4,278		10,687		14,965	14,795
30	76	2040	1,000	170	1,170	4,278		10,687		14,965	13,795
31	77	2041		170	170	4,278		10,687		14,965	14,795
32	78	2042		170	170	4,278		10,687		14,965	14,795
33	79	2043		170	170	4,278		10,687		14,965	14,795
34	80	2044		170	170	4,278		10,687		14,965	14,795
35	81	2045	1,000	170	1,170	4,278		10,687		14,965	13,795
36	82	2046		170	170	4,278		10,687		14,965	14,795
37	83	2047		170	170	4,278		10,687		14,965	14,795
38	84	2048		170	170	4,278		10,687		14,965	14,795
39	85	2049		170	170	4,278		10,687		14,965	14,795
40	86	2050	1,000	170	1,170	4,278		10,687		14,965	13,795
41	87	2051		170	170	4,278		10,687		14,965	14,795
42	88	2052		170	170	4,278		10,687		14,965	14,795
43	89	2053		170	170	4,278		10,687		14,965	14,795
44	90	2054		170	170	4,278		10,687		14,965	14,795
45	91	2055	1,000	170	1,170	4,278		10,687		14,965	13,795
46	92	2056		170	170	4,278		10,687		14,965	14,795
47	93	2057		170	170	4,278		10,687		14,965	14,795
48	94	2058		170	170	4,278		10,687		14,965	14,795
49	95	2059		170	170	4,278		10,687		14,965	14,795
50	96	2060	1,000	170	1,170	4,278		10,687		14,965	13,795
	Total		28,875	7,820	36,695	196,780	-3,539	491,602	0	684,842	648,147
In the condition of a discount rate of 10 %:											
Present value: (B-C)					15,307					60,394	45,087
Internal rate of return (EIRR):											21.91%
B/C											3.95

Table 10.9.2 Calculation of Economic Evaluation Indices

Wimalasurendra P/S Case 2（Scheduled Replace）

(Unit: US$1,000)

			Cost			Benefit					
Year in order	Plant Age	Year	Replace	Operation & Maintenance	Total	Power Benefit	Power Loss	Energy Benefit	Energy Loss	Total	Balance
	42	2006	1,245	0	1,245	0	0	0	0	0	-1,245
	43	2007	5,809	0	5,809	0	-176	0	0	-176	-5,985
	44	2008	1,333	0	1,333	0	-164	0	0	-164	-1,497
	45	2009	9,615	0	9,615	0	-715	0	0	-715	-10,330
	46	2010	5,086	-9	5,077	0	-1,781	49	0	-1,732	-6,809
1	47	2011	441	-20	421	0	0	107	0	107	-314
2	48	2012	0	-20	-20	0	0	107	0	107	127
3	49	2013		-20	-20	0		107		107	127
4	50	2014		-20	-20	0		107		107	127
5	51	2015		150	150	4,278		10,794		15,072	14,922
6	52	2016		150	150	4,278		10,794		15,072	14,922
7	53	2017		150	150	4,278		10,794		15,072	14,922
8	54	2018		150	150	4,278		10,794		15,072	14,922
9	55	2019		150	150	4,278		10,794		15,072	14,922
10	56	2020		150	150	4,278		10,794		15,072	14,922
11	57	2021		150	150	4,278		10,794		15,072	14,922
12	58	2022		150	150	4,278		10,794		15,072	14,922
13	59	2023		150	150	4,278		10,794		15,072	14,922
14	60	2024		150	150	4,278		10,794		15,072	14,922
15	61	2025		150	150	4,278		10,794		15,072	14,922
16	62	2026		150	150	4,278		10,794		15,072	14,922
17	63	2027		150	150	4,278		10,794		15,072	14,922
18	64	2028		150	150	4,278		10,794		15,072	14,922
19	65	2029		150	150	4,278		10,794		15,072	14,922
20	66	2030		150	150	4,278		10,794		15,072	14,922
21	67	2031		150	150	4,278		10,794		15,072	14,922
22	68	2032		150	150	4,278		10,794		15,072	14,922
23	69	2033		150	150	4,278		10,794		15,072	14,922
24	70	2034		150	150	4,278		10,794		15,072	14,922
25	71	2035		150	150	4,278		10,794		15,072	14,922
26	72	2036		150	150	4,278		10,794		15,072	14,922
27	73	2037		150	150	4,278		10,794		15,072	14,922
28	74	2038		150	150	4,278		10,794		15,072	14,922
29	75	2039		150	150	4,278		10,794		15,072	14,922
30	76	2040		150	150	4,278		10,794		15,072	14,922
31	77	2041		150	150	4,278		10,794		15,072	14,922
32	78	2042		150	150	4,278		10,794		15,072	14,922
33	79	2043		150	150	4,278		10,794		15,072	14,922
34	80	2044		150	150	4,278		10,794		15,072	14,922
35	81	2045		150	150	4,278		10,794		15,072	14,922
36	82	2046		150	150	4,278		10,794		15,072	14,922
37	83	2047		150	150	4,278		10,794		15,072	14,922
38	84	2048		150	150	4,278		10,794		15,072	14,922
39	85	2049		150	150	4,278		10,794		15,072	14,922
40	86	2050		150	150	4,278		10,794		15,072	14,922
41	87	2051		150	150	4,278		10,794		15,072	14,922
42	88	2052		150	150	4,278		10,794		15,072	14,922
43	89	2053		150	150	4,278		10,794		15,072	14,922
44	90	2054		150	150	4,278		10,794		15,072	14,922
45	91	2055		150	150	4,278		10,794		15,072	14,922
46	92	2056		150	150	4,278		10,794		15,072	14,922
47	93	2057		150	150	4,278		10,794		15,072	14,922
48	94	2058		150	150	4,278		10,794		15,072	14,922
49	95	2059		150	150	4,278		10,794		15,072	14,922
50	96	2060		150	150	4,278		10,794		15,072	14,922
	Total		23,528	6,811	30,339	196,780	-2,836	496,994	0	690,938	660,599
In the condition of a discount rate of 10 %:											
Present value: (B-C)					17,491					61,499	44,008
Internal rate of return (EIRR):											20.49%
B/C											3.52

Table 10.10 Calculation of Economic Evaluation Indices

Old Laxapana Stage I P/S

(Unit: US$1,000)

			Cost			Benefit					
Year in order	Plant Age	Year	Replace	Operation & Maintenance	Total	Power Benefit	Power Loss	Energy Benefit	Energy Loss	Total	Balance
	56	2006	709	0	709	0	0	0	0	0	-709
	57	2007	4,280	0	4,280	0	-61	0	0	-61	-4,341
	58	2008	175	0	175	0	0	0	0	0	-175
	59	2009	7,997	0	7,997	0	0	0	0	0	-7,997
	60	2010	2,672	-3	2,668	257	-652	1,668	-938	334	-2,334
1	61	2011	1,888	-19	1,869	1,476	-594	9,589	-938	9,534	7,665
2	62	2012	89	250	339	2,310	0	15,009	0	17,320	16,980
3	63	2013		250	250	2,310		15,009		17,320	17,070
4	64	2014		250	250	2,310		15,009		17,320	17,070
5	65	2015		250	250	2,310		15,009		17,320	17,070
6	66	2016		250	250	2,310		15,009		17,320	17,070
7	67	2017		250	250	2,310		15,009		17,320	17,070
8	68	2018		250	250	2,310		15,009		17,320	17,070
9	69	2019		250	250	2,310		15,009		17,320	17,070
10	70	2020		250	250	2,310		15,009		17,320	17,070
11	71	2021		250	250	2,310		15,009		17,320	17,070
12	72	2022		250	250	2,310		15,009		17,320	17,070
13	73	2023		250	250	2,310		15,009		17,320	17,070
14	74	2024		250	250	2,310		15,009		17,320	17,070
15	75	2025		250	250	2,310		15,009		17,320	17,070
16	76	2026		250	250	2,310		15,009		17,320	17,070
17	77	2027		250	250	2,310		15,009		17,320	17,070
18	78	2028		250	250	2,310		15,009		17,320	17,070
19	79	2029		250	250	2,310		15,009		17,320	17,070
20	80	2030		250	250	2,310		15,009		17,320	17,070
21	81	2031		250	250	2,310		15,009		17,320	17,070
22	82	2032		250	250	2,310		15,009		17,320	17,070
23	83	2033		250	250	2,310		15,009		17,320	17,070
24	84	2034		250	250	2,310		15,009		17,320	17,070
25	85	2035		250	250	2,310		15,009		17,320	17,070
26	86	2036		250	250	2,310		15,009		17,320	17,070
27	87	2037		250	250	2,310		15,009		17,320	17,070
28	88	2038		250	250	2,310		15,009		17,320	17,070
29	89	2039		250	250	2,310		15,009		17,320	17,070
30	90	2040		250	250	2,310		15,009		17,320	17,070
31	91	2041		250	250	2,310		15,009		17,320	17,070
32	92	2042		250	250	2,310		15,009		17,320	17,070
33	93	2043		250	250	2,310		15,009		17,320	17,070
34	94	2044		250	250	2,310		15,009		17,320	17,070
35	95	2045		250	250	2,310		15,009		17,320	17,070
36	96	2046		250	250	2,310		15,009		17,320	17,070
37	97	2047		250	250	2,310		15,009		17,320	17,070
38	98	2048		250	250	2,310		15,009		17,320	17,070
39	99	2049		250	250	2,310		15,009		17,320	17,070
40	100	2050		250	250	2,310		15,009		17,320	17,070
	Total		17,810	9,728	27,538	91,824	-1,307	596,628	-1,875	685,269	657,732
In the condition of a discount rate of 10 %:											
Present value: (B-C)					13,910					100,927	87,018
Internal rate of return (EIRR):											45.60%
B/C											7.26

Table 10.11 Calculation of Economic Evaluation Indices

New Laxapana P/S

(Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	32	2006	926	0	926	0	0	0	0	0	-926
	33	2007	5,242	0	5,242	0	0	0	0	0	-5,242
	34	2008	228	0	228	0	-249	0	-1,468	-1,717	-1,945
	35	2009	275	0	275	0	0	0	0	0	-275
	36	2010	9,912	0	9,912	0	0	0	0	0	-9,912
	37	2011	5,169	-3	5,167	0	-2,461	50	-11,700	-14,111	-19,278
1	38	2012	117	-17	100	0	-965	331	0	-634	-734
2	39	2013		-20	-20	0		398		398	418
3	40	2014		-20	-20	0		398		398	418
4	41	2015		-20	-20	0		398		398	418
5	42	2016		-20	-20	0		398		398	418
6	43	2017		-20	-20	0		398		398	418
7	44	2018		-20	-20	0		398		398	418
8	45	2019		-20	-20	0		398		398	418
9	46	2020		-20	-20	0		398		398	418
10	47	2021		-20	-20	0		398		398	418
11	48	2022		-20	-20	0		398		398	418
12	49	2023		-20	-20	0		398		398	418
13	50	2024		-20	-20	0		398		398	418
14	51	2025		110	110	5,872		40,148		46,020	45,910
15	52	2026		110	110	5,872		40,148		46,020	45,910
16	53	2027		110	110	5,872		40,148		46,020	45,910
17	54	2028		110	110	5,872		40,148		46,020	45,910
18	55	2029		110	110	5,872		40,148		46,020	45,910
19	56	2030		110	110	5,872		40,148		46,020	45,910
20	57	2031		110	110	5,872		40,148		46,020	45,910
21	58	2032		110	110	5,872		40,148		46,020	45,910
22	59	2033		110	110	5,872		40,148		46,020	45,910
23	60	2034		110	110	5,872		40,148		46,020	45,910
24	61	2035		110	110	5,872		40,148		46,020	45,910
25	62	2036		110	110	5,872		40,148		46,020	45,910
26	63	2037		110	110	5,872		40,148		46,020	45,910
27	64	2038		110	110	5,872		40,148		46,020	45,910
28	65	2039		110	110	5,872		40,148		46,020	45,910
29	66	2040		110	110	5,872		40,148		46,020	45,910
30	67	2041		110	110	5,872		40,148		46,020	45,910
31	68	2042		110	110	5,872		40,148		46,020	45,910
32	69	2043		110	110	5,872		40,148		46,020	45,910
33	70	2044		110	110	5,872		40,148		46,020	45,910
34	71	2045		110	110	5,872		40,148		46,020	45,910
35	72	2046		110	110	5,872		40,148		46,020	45,910
36	73	2047		110	110	5,872		40,148		46,020	45,910
37	74	2048		110	110	5,872		40,148		46,020	45,910
38	75	2049		110	110	5,872		40,148		46,020	45,910
39	76	2050		110	110	5,872		40,148		46,020	45,910
40	77	2051		110	110	5,872		40,148		46,020	45,910
41	78	2052		110	110	5,872		40,148		46,020	45,910
42	79	2053		110	110	5,872		40,148		46,020	45,910
43	80	2054		110	110	5,872		40,148		46,020	45,910
44	81	2055		110	110	5,872		40,148		46,020	45,910
45	82	2056		110	110	5,872		40,148		46,020	45,910
46	83	2057		110	110	5,872		40,148		46,020	45,910
47	84	2058		110	110	5,872		40,148		46,020	45,910
48	85	2059		110	110	5,872		40,148		46,020	45,910
49	86	2060		110	110	5,872		40,148		46,020	45,910
50	87	2061		110	110	5,872		40,148		46,020	45,910
	Total		21,869	3,811	25,680	217,271	-3,676	1,490,635	-13,168	1,691,062	1,665,382
In the condition of a discount rate of 10 %:											
Present value: (B-C)					14,760					64,843	50,083
Internal rate of return (EIRR):											15.65%
B/C											4.39

Table 10.12.1 Calculation of Economic Evaluation Indices

Wimalasurendra P/S Case 1（Repair as Required）
with special repair 1 (Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	42	2006	1,145	0	1,145	0	0	0	0	0	-1,145
	43	2007	4,676	0	4,676	0	-176	0	0	-176	-4,852
	44	2008	1,042	0	1,042	0	-164	0	0	-164	-1,206
	45	2009	7,554	0	7,554	0	-715	0	0	-715	-8,269
	46	2010	4,018	0	4,018	0	-2,139	0	0	-2,139	-6,157
1	47	2011	346	0	346	0	-346	0	0	-346	-692
2	48	2012	93	0	93	0	0	0	0	0	-93
3	49	2013		0	0	0		0		0	0
4	50	2014		0	0	0		0		0	0
5	51	2015	1,000	170	1,170	4,278		10,687		14,965	13,795
6	52	2016		170	170	4,278		10,687		14,965	14,795
7	53	2017		170	170	4,278		10,687		14,965	14,795
8	54	2018		170	170	4,278		10,687		14,965	14,795
9	55	2019		170	170	4,278		10,687		14,965	14,795
10	56	2020	1,000	170	1,170	4,278		10,687		14,965	13,795
11	57	2021		170	170	4,278		10,687		14,965	14,795
12	58	2022		170	170	4,278		10,687		14,965	14,795
13	59	2023		170	170	4,278		10,687		14,965	14,795
14	60	2024		170	170	4,278	0	10,687	0	14,965	14,795
15	61	2025	1,000	170	1,170	4,278	-176	10,687	0	14,789	13,619
16	62	2026	**5,000**	170	5,170	4,278	-164	10,687	0	14,801	9,631
17	63	2027		170	170	4,278	-715	10,687	0	14,250	14,080
18	64	2028		170	170	4,278	-2,139	10,687	0	12,826	12,656
19	65	2029		170	170	4,278	-346	10,687	0	14,619	14,449
20	66	2030	1,000	170	1,170	4,278	0	10,687	0	14,965	13,795
21	67	2031		170	170	4,278		10,687		14,965	14,795
22	68	2032		170	170	4,278		10,687		14,965	14,795
23	69	2033		170	170	4,278		10,687		14,965	14,795
24	70	2034		170	170	4,278		10,687		14,965	14,795
25	71	2035	1,000	170	1,170	4,278		10,687		14,965	13,795
26	72	2036		170	170	4,278		10,687		14,965	14,795
27	73	2037		170	170	4,278		10,687		14,965	14,795
28	74	2038		170	170	4,278		10,687		14,965	14,795
29	75	2039		170	170	4,278		10,687		14,965	14,795
30	76	2040	1,000	170	1,170	4,278		10,687		14,965	13,795
31	77	2041		170	170	4,278		10,687		14,965	14,795
32	78	2042		170	170	4,278		10,687		14,965	14,795
33	79	2043		170	170	4,278		10,687		14,965	14,795
34	80	2044		170	170	4,278		10,687		14,965	14,795
35	81	2045	1,000	170	1,170	4,278		10,687		14,965	13,795
36	82	2046		170	170	4,278		10,687		14,965	14,795
37	83	2047		170	170	4,278		10,687		14,965	14,795
38	84	2048		170	170	4,278		10,687		14,965	14,795
39	85	2049		170	170	4,278		10,687		14,965	14,795
40	86	2050	1,000	170	1,170	4,278		10,687		14,965	13,795
41	87	2051		170	170	4,278		10,687		14,965	14,795
42	88	2052		170	170	4,278		10,687		14,965	14,795
43	89	2053		170	170	4,278		10,687		14,965	14,795
44	90	2054		170	170	4,278		10,687		14,965	14,795
45	91	2055	1,000	170	1,170	4,278		10,687		14,965	13,795
46	92	2056		170	170	4,278		10,687		14,965	14,795
47	93	2057		170	170	4,278		10,687		14,965	14,795
48	94	2058		170	170	4,278		10,687		14,965	14,795
49	95	2059		170	170	4,278		10,687		14,965	14,795
50	96	2060	1,000	170	1,170	4,278		10,687		14,965	13,795
	Total		33,875	7,820	41,695	196,780	-7,079	491,602	0	681,303	639,608
In the condition of a discount rate of 10 %:											
Present value: (B-C)					15,982					59,984	44,001
Internal rate of return (EIRR):											21.79%
B/C											3.75

Case 2
Present value: (B-C) 44,008

Balance (Case1-Case2) -7.0

Table 10.12.2 Calculation of Economic Evaluation Indices

Wimalasurendra P/S Case 1（Repair as Required）
with special repair 2

(Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	42	2006	1,145	0	1,145	0	0	0	0	0	-1,145
	43	2007	4,676	0	4,676	0	-176	0	0	-176	-4,852
	44	2008	1,042	0	1,042	0	-164	0	0	-164	-1,206
	45	2009	7,554	0	7,554	0	-715	0	0	-715	-8,269
	46	2010	4,018	0	4,018	0	-2,139	0	0	-2,139	-6,157
1	47	2011	346	0	346	0	-346	0	0	-346	-692
2	48	2012	93	0	93	0	0	0	0	0	-93
3	49	2013		0	0	0		0		0	0
4	50	2014		0	0	0		0		0	0
5	51	2015	1,000	170	1,170	4,278		10,687		14,965	13,795
6	52	2016		170	170	4,278		10,687		14,965	14,795
7	53	2017		170	170	4,278		10,687		14,965	14,795
8	54	2018		170	170	4,278		10,687		14,965	14,795
9	55	2019		170	170	4,278		10,687		14,965	14,795
10	56	2020	1,000	170	1,170	4,278		10,687		14,965	13,795
11	57	2021		170	170	4,278		10,687		14,965	14,795
12	58	2022		170	170	4,278		10,687		14,965	14,795
13	59	2023		170	170	4,278		10,687		14,965	14,795
14	60	2024		170	170	4,278		10,687		14,965	14,795
15	61	2025	1,000	170	1,170	4,278	0	10,687	0	14,965	13,795
16	62	2026		170	170	4,278	-176	10,687	0	14,789	14,619
17	63	2027	**5,000**	170	5,170	4,278	-164	10,687	0	14,801	9,631
18	64	2028		170	170	4,278	-715	10,687	0	14,250	14,080
19	65	2029		170	170	4,278	-2,139	10,687	0	12,826	12,656
20	66	2030	1,000	170	1,170	4,278	-346	10,687	0	14,619	13,449
21	67	2031		170	170	4,278	0	10,687	0	14,965	14,795
22	68	2032		170	170	4,278		10,687		14,965	14,795
23	69	2033		170	170	4,278		10,687		14,965	14,795
24	70	2034		170	170	4,278		10,687		14,965	14,795
25	71	2035	1,000	170	1,170	4,278		10,687		14,965	13,795
26	72	2036		170	170	4,278		10,687		14,965	14,795
27	73	2037		170	170	4,278		10,687		14,965	14,795
28	74	2038		170	170	4,278		10,687		14,965	14,795
29	75	2039		170	170	4,278		10,687		14,965	14,795
30	76	2040	1,000	170	1,170	4,278		10,687		14,965	13,795
31	77	2041		170	170	4,278		10,687		14,965	14,795
32	78	2042		170	170	4,278		10,687		14,965	14,795
33	79	2043		170	170	4,278		10,687		14,965	14,795
34	80	2044		170	170	4,278		10,687		14,965	14,795
35	81	2045	1,000	170	1,170	4,278		10,687		14,965	13,795
36	82	2046		170	170	4,278		10,687		14,965	14,795
37	83	2047		170	170	4,278		10,687		14,965	14,795
38	84	2048		170	170	4,278		10,687		14,965	14,795
39	85	2049		170	170	4,278		10,687		14,965	14,795
40	86	2050	1,000	170	1,170	4,278		10,687		14,965	13,795
41	87	2051		170	170	4,278		10,687		14,965	14,795
42	88	2052		170	170	4,278		10,687		14,965	14,795
43	89	2053		170	170	4,278		10,687		14,965	14,795
44	90	2054		170	170	4,278		10,687		14,965	14,795
45	91	2055	1,000	170	1,170	4,278		10,687		14,965	13,795
46	92	2056		170	170	4,278		10,687		14,965	14,795
47	93	2057		170	170	4,278		10,687		14,965	14,795
48	94	2058		170	170	4,278		10,687		14,965	14,795
49	95	2059		170	170	4,278		10,687		14,965	14,795
50	96	2060	1,000	170	1,170	4,278		10,687		14,965	13,795
	Total		33,875	7,820	41,695	196,780	-7,079	491,602	0	681,303	639,608

In the condition of a discount rate of 10 %:			
Present value: (B-C)	15,921	60,021	44,100
Internal rate of return (EIRR):			21.81%
B/C			3.77
Case 2			
Present value: (B-C)			44,008
Balance (Case1-Case2)			**91.7**

Table 10.13 Economical Sensitivity of Construction Cost

	Const. Cost	Evaluation Indices EIRR	B/C	B-C (US$1,000)
Wimalasurendra P/S Case 1 (Repair as Required)				
Case-A	50%	18.05%	2.63	37,434
Case-B	30%	19.38%	3.04	40,495
Base Case	0%	21.91%	3.95	45,087
Case-C	-30%	25.46%	5.64	49,679
Case-D	-50%	28.89%	7.89	52,740
Trial Case	293%	10.03%	1.00	238
Wimalasurendra P/S Case2 (Scheduled Replace)				
Case-A	50%	16.73%	2.34	35,263
Case-B	30%	18.02%	2.70	38,761
Base Case	0%	20.49%	3.52	44,008
Case-C	-30%	24.03%	5.02	49,256
Case-C	-50%	27.52%	7.03	52,754
Trial Case	250%	10.03%	1.00	281
Old Laxapana Stage I P/S				
Case-A	50%	35.50%	4.84	80,063
Case-B	30%	38.89%	5.58	82,845
Base Case	0%	45.60%	7.26	87,018
Case-C	-30%	55.73%	10.37	91,191
Case-D	-50%	66.34%	14.51	93,972
Trial Case	623%	10.04%	1.00	360
New Laxapana P/S				
Case-A	50%	14.20%	2.93	42,703
Case-B	30%	14.72%	3.38	45,655
Base Case	0%	15.65%	4.39	50,083
Case-C	-30%	16.81%	6.28	54,511
Case-D	-50%	17.78%	8.79	57,463
Trial Case	339%	10.00%	1.00	45

Table 10.14 Economical Sensitivity of Fuel Price

	Auto Diesel Price (US$/bbl)	Evaluation Indices EIRR	B/C	B-C (US$1,000)
Wimalasurendra P/S Case 1 （Repair as Required）				
Case-A	40.00	21.91%	3.95	45,087
Case-B	35.00	20.46%	3.44	37,377
Base Case	42.70	21.91%	3.95	45,087
Case-C	30.00	20.88%	3.26	34,640
Case-D	25.00	18.34%	2.79	27,342
Trial Case	1.00	11.34%	1.21	3,272
Wimalasurendra P/S Case2（Scheduled Replace）				
Case-A	50.00	21.68%	3.94	51,449
Case-B	35.00	19.11%	3.07	36,180
Base Case	42.70	20.49%	3.52	44,008
Case-C	30.00	18.14%	2.78	31,085
Case-D	25.00	17.10%	2.49	25,990
Trial Case	1.00	10.56%	1.09	1,550
Old Laxapana Stage I P/S				
Case-A	40.00	44.14%	6.88	81,723
Case-B	35.00	41.27%	6.17	71,858
Base Case	42.70	45.60%	7.26	87,018
Case-C	30.00	38.36%	5.47	62,130
Case-D	25.00	34.88%	4.75	52,127
Trial Case	1.00	13.22%	1.35	4,802
New Laxapana P/S				
Case-A	40.00	15.45%	4.16	46,608
Case-B	35.00	15.05%	3.72	40,180
Base Case	42.70	15.65%	4.39	50,083
Case-C	30.00	14.57%	3.28	33,694
Case-D	25.00	14.03%	2.85	27,236
Trial Case	3.90	10.00%	1.00	6

Table 10.15 Outage Term (3)
(Replace After Crash)

outage for installation
outage caused by crash

Outage Term of Wimalasurendra P/S Pmax = 50 MW (2units)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total			
E (2003) (MWh)		4,892	3,922	6,867	8,976	12,204	11,129	6,805	4,403	4,315	5,599	5,246	8,748	83,106			
Adjusted E (MWh)		6,711	5,380	9,420	12,313	16,741	15,266	9,335	6,040	5,919	7,680	7,196	12,000	114,000	Loss(US$1,000) per Year		
Max. E by 1 unit (MWh)		18,600	16,800	18,600	18,000	18,600	18,000	18,600	18,600	18,000	18,600	18,000	18,600	219,000			
2006	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,139	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2007	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,139	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2008	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,139	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2009	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,139	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2010	Outage (days)	31	28	31	30	31	30	31	31	30	31	0	0	304	kW loss	-1,781	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2011	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2012	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year

*Condition
Unit1 crash (Jan.2006)
2 units replacement (Unit1:Sep2009-Mar2010, Unit2:Apr2010-Oct2010)
44 months is necessary before beginning installation for investigation & preparation.

Outage Term of Old Laxapana Stage I P/S Pmax = 50 MW
Stage I 25 MW (3 units) Stage II 25 MW (2 units)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total			
E (2003) (MWh)		12,632	10,139	18,583	23,176	28,999	28,556	23,616	19,375	15,680	16,491	13,982	20,632	231,861			
Adjusted E (MWh)		15,200	12,200	22,361	27,888	34,895	34,362	28,417	23,314	18,868	19,844	16,825	24,827	279,000	Loss(US$1,000) per Year		
Max. E by St.I & 2 unit (MWh)		31,000	28,000	31,000	30,000	31,000	30,000	31,000	31,000	30,000	31,000	30,000	31,000	365,000			
2006	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-713	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-3,895	-4,221	0	0	0	0	0	0	-8,116	kWh loss	-774	US$1,000/year
2007	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-713	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-3,895	-4,221	0	0	0	0	0	0	-8,116	kWh loss	-774	US$1,000/year
2008	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-713	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-3,895	-4,221	0	0	0	0	0	0	-8,116	kWh loss	-774	US$1,000/year
2009	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-713	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-3,895	-4,221	0	0	0	0	0	0	-8,116	kWh loss	-774	US$1,000/year
2010	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-713	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-3,895	-4,221	0	0	0	0	0	0	-8,116	kWh loss	-774	US$1,000/year
2011	Outage (days)	31	28	31	30	31	0	0	0	0	0	0	0	151	kW loss	-295	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-3,895	0	0	0	0	0	0	0	-3,895	kWh loss	-372	US$1,000/year
2012	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year

*Condition
Unit1 crash (Jan.2006)
3units replacement (Unit1:Sep2009-Mar2010, Unit2:Apr2010-Oct2010, Unit3: Nov2010-May2011)
44 months necessary before beginning installation for investigation & preparation.

Outage Term of New Laxapana P/S Pmax = 100 MW (2 units)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total			
E (2003) (MWh)		25,765	18,036	17,341	17,520	51,778	50,576	47,604	44,100	52,626	43,561	48,275	48,589	465,771			
Adjusted E (MWh)		25,833	18,084	17,387	17,566	51,915	50,709	47,730	44,216	52,765	43,676	48,402	48,717	467,000	Loss(US$1,000) per Year		
Max. E by 1 unit (MWh)		37,200	33,600	37,200	36,000	37,200	36,000	37,200	37,200	36,000	37,200	36,000	37,200	438,000			
2006	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year
2007	Outage (days)	0	0	31	30	31	30	31	31	30	31	30	31	306	kW loss	-2,461	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-14,715	-14,235	-10,530	-7,016	-16,224	-6,476	-12,002	-11,517	-92,715	kWh loss	-6,677	US$1,000/year
2008	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,936	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-14,715	-14,235	-10,530	-7,016	-16,224	-6,476	-12,002	-11,517	-92,715	kWh loss	-6,677	US$1,000/year
2009	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,936	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-14,715	-14,235	-10,530	-7,016	-16,224	-6,476	-12,002	-11,517	-92,715	kWh loss	-6,677	US$1,000/year
2010	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,936	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-14,715	-14,235	-10,530	-7,016	-16,224	-6,476	-12,002	-11,517	-92,715	kWh loss	-6,677	US$1,000/year
2011	Outage (days)	31	28	31	30	31	30	31	31	30	31	30	31	365	kW loss	-2,936	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	-14,715	-14,235	-10,530	-7,016	-16,224	-6,476	-12,002	-11,517	-92,715	kWh loss	-6,677	US$1,000/year
2012	Outage (days)	0	0	0	0	0	0	0	0	0	0	0	0	0	kW loss	0	US$1,000/year
	Loss of Energy (MWh)	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh loss	0	US$1,000/year

*Condition
Unit1 crash (Mar2007)
2 units replacement (Unit1:Nov2010-May2011, Unit2:Jun2011-Dec2011)
44 months is necessary before beginning installation for investigation & preparation.

Table 10.16 Cost of Energy Not Served Wimalasurendra P/S

Wimalasurendra P/S		Average Cost for 10 years (2006-2015)				16,756 US$1,000
		Unit P	*25 MW*			
<<Condition : Crash occurs 2010>>		*Station P*	*50 MW*			
I Peak demand in	2010	2,484 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.040 %	0.204	0.124		
III Increased risk of blackout		0.146 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		6,440,913 US$			=	**6,441 US$1,000**
<<Condition : Crash occurs 2011>>						
I Peak demand in	2011	2,684 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.021 %	0.106	0.064		
III Increased risk of blackout		0.07665 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		3,653,740 US$			=	**3,654 US$1,000**
<<Condition : Crash occurs 2012>>						
I Peak demand in	2012	2,900 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.018 %	0.097	0.061		
III Increased risk of blackout		0.0657 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		3,383,813 US$			=	**3,384 US$1,000**
<<Condition : Crash occurs 2013>>						
I Peak demand in	2013	3,131 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.025 %	0.143	0.093		
III Increased risk of blackout		0.09125 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		5,074,099 US$			=	**5,074 US$1,000**
<<Condition : Crash occurs 2014>>						
I Peak demand in	2014	3,380 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.021 %	0.122	0.080		
III Increased risk of blackout		0.07665 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		4,601,208 US$			=	**4,601 US$1,000**
<<Condition : Crash occurs 2015>>						
I Peak demand in	2015	3,647 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.100 %	0.708	0.509		
III Increased risk of blackout		0.363175 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		23,523,106 US$			=	**23,523 US$1,000**
<<Condition : Crash occurs 2016>>						
I Peak demand in	2016	3,933 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.100 %	0.745	0.545		
III Increased risk of blackout		0.365 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		25,495,279 US$			=	**25,495 US$1,000**
<<Condition : Crash occurs 2017>>						
I Peak demand in	2017	4,240 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.111 %	0.882	0.660		
III Increased risk of blackout		0.40515 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		30,508,767 US$			=	**30,509 US$1,000**
<<Condition : Crash occurs 2018>>						
I Peak demand in	2018	4,570 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.115 %	0.946	0.717		
III Increased risk of blackout		0.417925 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		33,920,130 US$			=	**33,920 US$1,000**
<<Condition : Crash occurs 2019>>						
I Peak demand in	2019	4,923 MW	without	with		
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.097 %	0.812	0.618		
III Increased risk of blackout		0.35405 day/y				
IV Adjustment (day to hour)		24 h				
V Cost of Energy Not Served		0.74 US$/kWh				
Annual Cost of ENS : I*III*IV*V		30,955,470 US$			=	**30,955 US$1,000**

LOLP was calculated by CEB on the base 2004.
Since the calculation can be done only in case of station outage, change of LOLP is corrected by unit power / station power
"Without rehabilitation" means one of the unit can not be operated due to crash.

Table 10.17 Cost of Energy Not Served Old Laxapana Stage I P/S

Old Laxapana Stage I P/S		Average Cost for 10 years (2006-2015)				5,917	US$1,000
		Unit P	*8.33 MW*				
<<Condition : Crash occurs 2010>>		*Station P*	*50 MW*				
I Peak demand in	2010	2,484 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.014 %	0.209	0.124			
III Increased risk of blackout		0.05168765 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		2,280,244 US$			=	**2,280**	**US$1,000**
<<Condition : Crash occurs 2011>>							
I Peak demand in	2011	2,684 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.007 %	0.109	0.064			
III Increased risk of blackout		0.02736405 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		1,304,385 US$			=	**1,304**	**US$1,000**
<<Condition : Crash occurs 2012>>							
I Peak demand in	2012	2,900 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.006 %	0.100	0.061			
III Increased risk of blackout		0.02371551 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		1,221,444 US$			=	**1,221**	**US$1,000**
<<Condition : Crash occurs 2013>>							
I Peak demand in	2013	3,131 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.009 %	0.146	0.093			
III Increased risk of blackout		0.03222877 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		1,792,131 US$			=	**1,792**	**US$1,000**
<<Condition : Crash occurs 2014>>							
I Peak demand in	2014	3,380 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.007 %	0.125	0.080			
III Increased risk of blackout		0.02736405 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		1,642,631 US$			=	**1,643**	**US$1,000**
<<Condition : Crash occurs 2015>>							
I Peak demand in	2015	3,647 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.035 %	0.719	0.509			
III Increased risk of blackout		0.1276989 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		8,271,150 US$			=	**8,271**	**US$1,000**
<<Condition : Crash occurs 2016>>							
I Peak demand in	2016	3,933 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.035 %	0.757	0.545			
III Increased risk of blackout		0.12891508 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		9,004,729 US$			=	**9,005**	**US$1,000**
<<Condition : Crash occurs 2017>>							
I Peak demand in	2017	4,240 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.039 %	0.896	0.660			
III Increased risk of blackout		0.14350924 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		10,806,590 US$			=	**10,807**	**US$1,000**
<<Condition : Crash occurs 2018>>							
I Peak demand in	2018	4,570 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.040 %	0.959	0.717			
III Increased risk of blackout		0.14715778 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		11,943,796 US$			=	**11,944**	**US$1,000**
<<Condition : Crash occurs 2019>>							
I Peak demand in	2019	4,923 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.034 %	0.823	0.618			
III Increased risk of blackout		0.12465845 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		10,899,197 US$			=	**10,899**	**US$1,000**

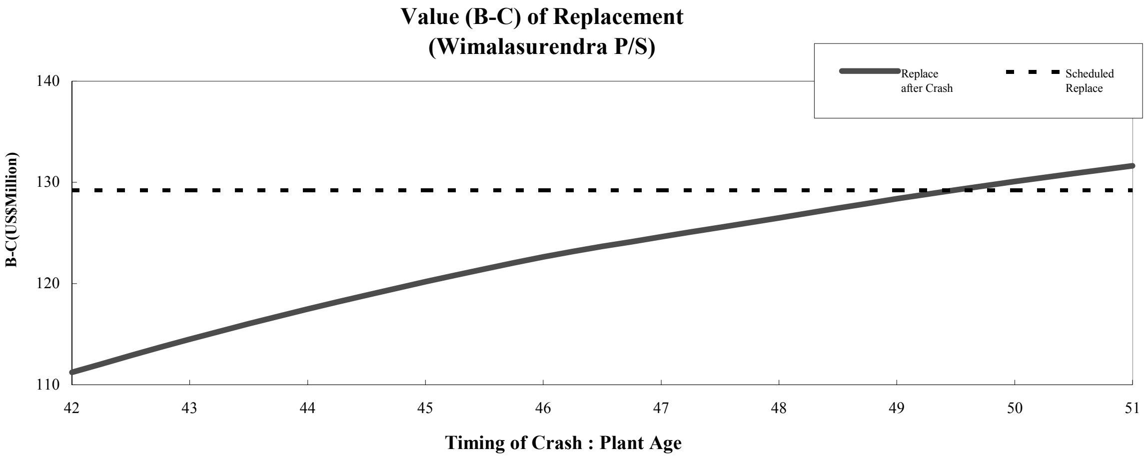
LOLP was calculated by CEB on the base 2004.
Since the calculation can be done only in case of station outage, change of LOLP is corrected by unit power / station power
"Without rehabilitation" means one of the unit can not be operated due to crash.

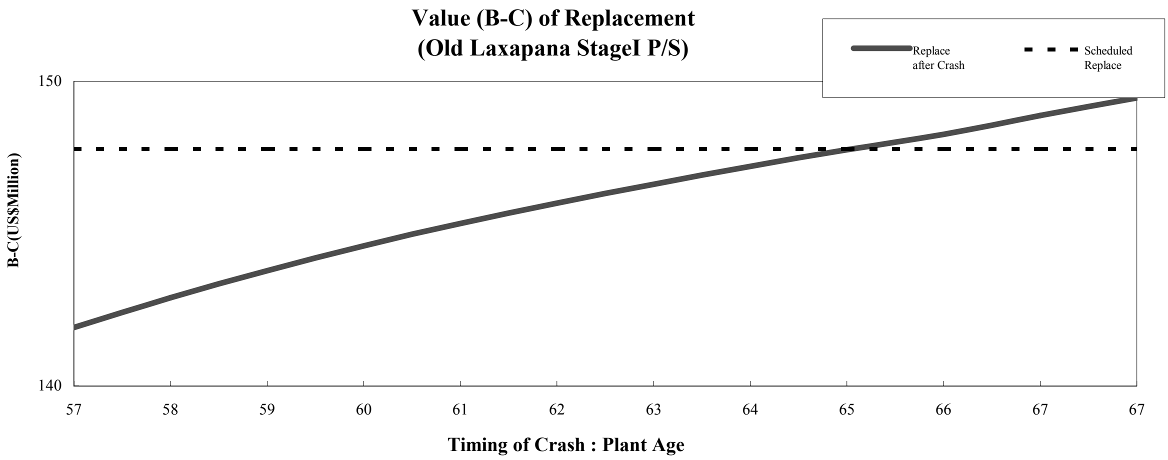
Table 10.18 Cost of Energy Not Served New Laxapana P/S

New Laxapana P/S		Average Cost for 10 years (2006-2015)				43,991	US$1,000
		Unit P	*50 MW*				
<<Condition : Crash occurs 2010>>		*Station P*	*100 MW*				
I Peak demand in	2010	2,484 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.116 %	0.356	0.124			
III Increased risk of blackout		0.4234 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		18,678,647 US$			=	**18,679**	**US$1,000**
<<Condition : Crash occurs 2011>>							
I Peak demand in	2011	2,684 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.063 %	0.190	0.064			
III Increased risk of blackout		0.22995 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		10,961,220 US$			=	**10,961**	**US$1,000**
<<Condition : Crash occurs 2012>>							
I Peak demand in	2012	2,900 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.054 %	0.169	0.061			
III Increased risk of blackout		0.1971 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		10,151,438 US$			=	**10,151**	**US$1,000**
<<Condition : Crash occurs 2013>>							
I Peak demand in	2013	3,131 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.072 %	0.237	0.093			
III Increased risk of blackout		0.2628 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		14,613,404 US$			=	**14,613**	**US$1,000**
<<Condition : Crash occurs 2014>>							
I Peak demand in	2014	3,380 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.060 %	0.200	0.080			
III Increased risk of blackout		0.219 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		13,146,307 US$			=	**13,146**	**US$1,000**
<<Condition : Crash occurs 2015>>							
I Peak demand in	2015	3,647 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.262 %	1.033	0.509			
III Increased risk of blackout		0.9563 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		61,940,240 US$			=	**61,940**	**US$1,000**
<<Condition : Crash occurs 2016>>							
I Peak demand in	2016	3,933 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.262 %	1.069	0.545			
III Increased risk of blackout		0.9563 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		66,797,632 US$			=	**66,798**	**US$1,000**
<<Condition : Crash occurs 2017>>							
I Peak demand in	2017	4,240 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.287 %	1.234	0.660			
III Increased risk of blackout		1.04755 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		78,883,029 US$			=	**78,883**	**US$1,000**
<<Condition : Crash occurs 2018>>							
I Peak demand in	2018	4,570 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.290 %	1.297	0.717			
III Increased risk of blackout		1.0585 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		85,911,247 US$			=	**85,911**	**US$1,000**
<<Condition : Crash occurs 2019>>							
I Peak demand in	2019	4,923 MW	without	with			
II Change of LOLP ((Without - With rehabilitation)*Unit P/Station P)		0.247 %	1.112	0.618			
III Increased risk of blackout		0.90155 day/y					
IV Adjustment (day to hour)		24 h					
V Cost of Energy Not Served		0.74 US$/kWh					
Annual Cost of ENS : I*III*IV*V		78,824,752 US$			=	**78,825**	**US$1,000**

LOLP was calculated by CEB on the base 2004.
Since the calculation can be done only in case of station outage, change of LOLP is corrected by unit power / station power
"Without rehabilitation" means one of the unit can not be operated due to crash.

Figure 10.1 Comparison of Scheduled Replace and Replace after Crash





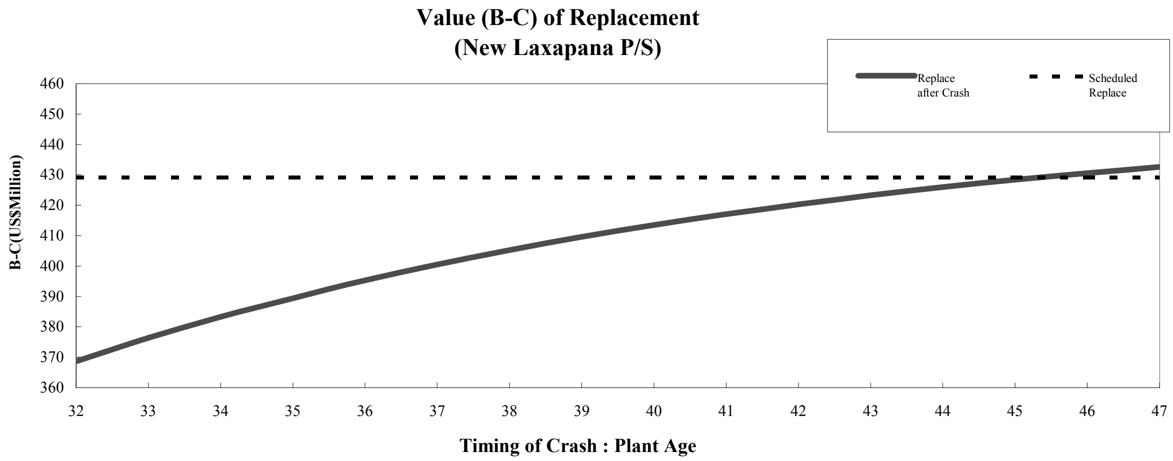


Table10.19.1 Calculation of Economic Evaluation Indices
Wimalasurendra P/S Replace after Crash (1)

Wimalasurendra P/S Replacement after Crash (1)

128,375

Crash occurs in 2013 (Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Cost of Energy Not Served	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	42	2006			170	170	4,278		10,687		14,965	14,795
	43	2007			170	170	4,278		10,687		14,965	14,795
	44	2008			170	170	4,278		10,687		14,965	14,795
	45	2009			170	170	4,278		10,687		14,965	14,795
	46	2010			170	170	4,278		10,687		14,965	14,795
	47	2011			170	170	4,278		10,687		14,965	14,795
	48	2012			170	170	4,278		10,687		14,965	14,795
	49	2013		16,756	170	16,926	4,278		10,687		14,965	-1,961
	50	2014	5,809		85	5,894	4,278	-2,139	10,687	0	12,826	6,931
	51	2015	1,333		85	1,418	4,278	-2,139	10,687	0	12,826	11,408
	52	2016	9,615		85	9,700	4,278	-2,139	10,687	0	12,826	3,126
	53	2017	5,086		140	5,226	4,278	-1,781	10,687	0	13,183	7,958
1	54	2018	441		150	591	4,278		10,687		14,965	14,374
2	55	2019			150	150	4,278		10,687		14,965	14,815
3	56	2020			150	150	4,278		10,687		14,965	14,815
4	57	2021			150	150	4,278		10,687		14,965	14,815
5	58	2022			150	150	4,278		10,687		14,965	14,815
6	59	2023			150	150	4,278		10,687		14,965	14,815
7	60	2024			150	150	4,278		10,687		14,965	14,815
8	61	2025			150	150	4,278		10,687		14,965	14,815
9	62	2026			150	150	4,278		10,687		14,965	14,815
10	63	2027			150	150	4,278		10,687		14,965	14,815
11	64	2028			150	150	4,278		10,687		14,965	14,815
12	65	2029			150	150	4,278		10,687		14,965	14,815
13	66	2030			150	150	4,278		10,687		14,965	14,815
14	67	2031			150	150	4,278		10,687		14,965	14,815
15	68	2032			150	150	4,278		10,687		14,965	14,815
16	69	2033			150	150	4,278		10,687		14,965	14,815
17	70	2034			150	150	4,278		10,687		14,965	14,815
18	71	2035			150	150	4,278		10,687		14,965	14,815
19	72	2036			150	150	4,278		10,687		14,965	14,815
20	73	2037			150	150	4,278		10,687		14,965	14,815
21	74	2038			150	150	4,278		10,687		14,965	14,815
22	75	2039			150	150	4,278		10,687		14,965	14,815
23	76	2040			150	150	4,278		10,687		14,965	14,815
24	77	2041			150	150	4,278		10,687		14,965	14,815
25	78	2042			150	150	4,278		10,687		14,965	14,815
26	79	2043			150	150	4,278		10,687		14,965	14,815
27	80	2044			150	150	4,278		10,687		14,965	14,815
28	81	2045			150	150	4,278		10,687		14,965	14,815
29	82	2046			150	150	4,278		10,687		14,965	14,815
30	83	2047			150	150	4,278		10,687		14,965	14,815
31	84	2048			150	150	4,278		10,687		14,965	14,815
32	85	2049			150	150	4,278		10,687		14,965	14,815
33	86	2050			150	150	4,278		10,687		14,965	14,815
34	87	2051			150	150	4,278		10,687		14,965	14,815
35	88	2052			150	150	4,278		10,687		14,965	14,815
36	89	2053			150	150	4,278		10,687		14,965	14,815
37	90	2054			150	150	4,278		10,687		14,965	14,815
38	91	2055			150	150	4,278		10,687		14,965	14,815
39	92	2056			150	150	4,278		10,687		14,965	14,815
40	93	2057			150	150	4,278		10,687		14,965	14,815
41	94	2058			150	150	4,278		10,687		14,965	14,815
42	95	2059			150	150	4,278		10,687		14,965	14,815
43	96	2060			150	150	4,278		10,687		14,965	14,815
	Total		22,284		8,205	47,244	235,281	-8,198	587,785	0	814,867	767,623

In the condition of a discount rate of 10 %:			
Present value: (B-C)	17,433	145,808	128,375
Scheduled Replace			129,212
Balance			-837

Table10.19.2 Calculation of Economic Evaluation Indices
Wimalasurendra P/S Replace after Crash (2)

Wimalasurendra P/S Replacement after Crash (2)

130,083

Crash occurs in 2014

(Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Cost of Energy Not Served	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	42	2006			170	170	4,278		10,687		14,965	14,795
	43	2007			170	170	4,278		10,687		14,965	14,795
	44	2008			170	170	4,278		10,687		14,965	14,795
	45	2009			170	170	4,278		10,687		14,965	14,795
	46	2010			170	170	4,278		10,687		14,965	14,795
	47	2011			170	170	4,278		10,687		14,965	14,795
	48	2012			170	170	4,278		10,687		14,965	14,795
	49	2013			170	170	4,278		10,687		14,965	14,795
	50	2014		16,756	170	16,926	4,278		10,687		14,965	-1,961
	51	2015	5,809		85	5,894	4,278	-2,139	10,687	0	12,826	6,931
	52	2016	1,333		85	1,418	4,278	-2,139	10,687	0	12,826	11,408
	53	2017	9,615		85	9,700	4,278	-2,139	10,687	0	12,826	3,126
	54	2018	5,086		140	5,226	4,278	-1,781	10,687	0	13,183	7,958
1	55	2019	441		150	591	4,278		10,687		14,965	14,374
2	56	2020			150	150	4,278		10,687		14,965	14,815
3	57	2021			150	150	4,278		10,687		14,965	14,815
4	58	2022			150	150	4,278		10,687		14,965	14,815
5	59	2023			150	150	4,278		10,687		14,965	14,815
6	60	2024			150	150	4,278		10,687		14,965	14,815
7	61	2025			150	150	4,278		10,687		14,965	14,815
8	62	2026			150	150	4,278		10,687		14,965	14,815
9	63	2027			150	150	4,278		10,687		14,965	14,815
10	64	2028			150	150	4,278		10,687		14,965	14,815
11	65	2029			150	150	4,278		10,687		14,965	14,815
12	66	2030			150	150	4,278		10,687		14,965	14,815
13	67	2031			150	150	4,278		10,687		14,965	14,815
14	68	2032			150	150	4,278		10,687		14,965	14,815
15	69	2033			150	150	4,278		10,687		14,965	14,815
16	70	2034			150	150	4,278		10,687		14,965	14,815
17	71	2035			150	150	4,278		10,687		14,965	14,815
18	72	2036			150	150	4,278		10,687		14,965	14,815
19	73	2037			150	150	4,278		10,687		14,965	14,815
20	74	2038			150	150	4,278		10,687		14,965	14,815
21	75	2039			150	150	4,278		10,687		14,965	14,815
22	76	2040			150	150	4,278		10,687		14,965	14,815
23	77	2041			150	150	4,278		10,687		14,965	14,815
24	78	2042			150	150	4,278		10,687		14,965	14,815
25	79	2043			150	150	4,278		10,687		14,965	14,815
26	80	2044			150	150	4,278		10,687		14,965	14,815
27	81	2045			150	150	4,278		10,687		14,965	14,815
28	82	2046			150	150	4,278		10,687		14,965	14,815
29	83	2047			150	150	4,278		10,687		14,965	14,815
30	84	2048			150	150	4,278		10,687		14,965	14,815
31	85	2049			150	150	4,278		10,687		14,965	14,815
32	86	2050			150	150	4,278		10,687		14,965	14,815
33	87	2051			150	150	4,278		10,687		14,965	14,815
34	88	2052			150	150	4,278		10,687		14,965	14,815
35	89	2053			150	150	4,278		10,687		14,965	14,815
36	90	2054			150	150	4,278		10,687		14,965	14,815
37	91	2055			150	150	4,278		10,687		14,965	14,815
38	92	2056			150	150	4,278		10,687		14,965	14,815
39	93	2057			150	150	4,278		10,687		14,965	14,815
40	94	2058			150	150	4,278		10,687		14,965	14,815
41	95	2059			150	150	4,278		10,687		14,965	14,815
42	96	2060			150	150	4,278		10,687		14,965	14,815
	Total		22,284		8,225	47,264	235,281	-8,198	587,785	0	814,867	767,603
In the condition of a discount rate of 10 %:												
Present value: (B-C)						16,002					146,085	130,083
Scheduled Replace												129,212
Balance												**871**

Table 10.20.1 Calculation of Economic Evaluation Indices
Old Laxapana Stage I P/S Replace after Crash (1)

147,757 **Old Laxapana Stage I P/S Replacement after Crash (1)**

Crash in 2015 (Unit: US$1,000)

			Cost				Benefit					
Year in order	Plant Age	Year	Replace	Cost of Enegy Not Served	Operation & Maintenance	Total	Power Benefit	Power Loss	Energy Benefit	Energy Loss	Total	Balance
	56	2006			280	280	2,139		13,645		15,784	15,504
	57	2007			280	280	2,139		13,645		15,784	15,504
	58	2008			280	280	2,139		13,645		15,784	15,504
	59	2009			280	280	2,139		13,645		15,784	15,504
	60	2010			280	280	2,139		13,645		15,784	15,504
	61	2011			280	280	2,139		13,645		15,784	15,504
	62	2012			280	280	2,139		13,645		15,784	15,504
	63	2013			280	280	2,139		13,645		15,784	15,504
	64	2014			280	280	2,139		13,645		15,784	15,504
	65	2015		5,917	280	6,197	2,139	0	13,645	0	15,784	9,587
	66	2016	4,247		187	4,433	2,139	-713	13,645	-774	14,297	9,863
	67	2017	210		187	397	2,139	-713	13,645	-774	14,297	13,900
	68	2018	8,091		187	8,277	2,310	-713	13,645	-774	14,468	6,190
	69	2019	2,719		206	2,925	2,310	-713	14,062	-774	14,885	11,960
1	70	2020	1,922		241	2,163	2,310	-295	14,820	-372	16,463	14,300
2	71	2021			250	250	2,310		15,009		17,320	17,070
3	72	2022			250	250	2,310		15,009		17,320	17,070
4	73	2023			250	250	2,310		15,009		17,320	17,070
5	74	2024			250	250	2,310		15,009		17,320	17,070
6	75	2025			250	250	2,310		15,009		17,320	17,070
7	76	2026			250	250	2,310		15,009		17,320	17,070
8	77	2027			250	250	2,310		15,009		17,320	17,070
9	78	2028			250	250	2,310		15,009		17,320	17,070
10	79	2029			250	250	2,310		15,009		17,320	17,070
11	80	2030			250	250	2,310		15,009		17,320	17,070
12	81	2031			250	250	2,310		15,009		17,320	17,070
13	82	2032			250	250	2,310		15,009		17,320	17,070
14	83	2033			250	250	2,310		15,009		17,320	17,070
15	84	2034			250	250	2,310		15,009		17,320	17,070
16	85	2035			250	250	2,310		15,009		17,320	17,070
17	86	2036			250	250	2,310		15,009		17,320	17,070
18	87	2037			250	250	2,310		15,009		17,320	17,070
19	88	2038			250	250	2,310		15,009		17,320	17,070
20	89	2039			250	250	2,310		15,009		17,320	17,070
21	90	2040			250	250	2,310		15,009		17,320	17,070
22	91	2041			250	250	2,310		15,009		17,320	17,070
23	92	2042			250	250	2,310		15,009		17,320	17,070
24	93	2043			250	250	2,310		15,009		17,320	17,070
25	94	2044			250	250	2,310		15,009		17,320	17,070
26	95	2045			250	250	2,310		15,009		17,320	17,070
27	96	2046			250	250	2,310		15,009		17,320	17,070
28	97	2047			250	250	2,310		15,009		17,320	17,070
29	98	2048			250	250	2,310		15,009		17,320	17,070
30	99	2049			250	250	2,310		15,009		17,320	17,070
31	100	2050			250	250	2,310		15,009		17,320	17,070
	Total		17,188		11,307	34,412	101,898		656,552		751,834	717,421

In the condition of a discount rate of 10 %:

Present value: (B-C)	9,932			157,689	147,757
Scheduled Replace					147,774
Balance					-17

Table 10.20.2 Calculation of Economic Evaluation Indices
Old Laxapana Stage I P/S Replace after Crash (2)

148,255 **Old Laxapana Stage I P/S Replacement after Crash (2)**

Crash in 2016 (Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Cost of Enegy Not Served	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	56	2006			280	280	2,139		13,645		15,784	15,504
	57	2007			280	280	2,139		13,645		15,784	15,504
	58	2008			280	280	2,139		13,645		15,784	15,504
	59	2009			280	280	2,139		13,645		15,784	15,504
	60	2010			280	280	2,139		13,645		15,784	15,504
	61	2011			280	280	2,139		13,645		15,784	15,504
	62	2012			280	280	2,139		13,645		15,784	15,504
	63	2013			280	280	2,139		13,645		15,784	15,504
	64	2014			280	280	2,139		13,645		15,784	15,504
	65	2015			280	280	2,139		13,645		15,784	15,504
	66	2016		5,917	280	6,197	2,139	0	13,645	0	15,784	9,587
	67	2017	4,247		187	4,433	2,139	-713	13,645	-774	14,297	9,863
	68	2018	210		187	397	2,310	-713	13,645	-774	14,468	14,071
	69	2019	8,091		187	8,277	2,310	-713	13,645	-774	14,468	6,190
	70	2020	2,719		206	2,925	2,310	-713	14,062	-774	14,885	11,960
1	71	2021	1,922		241	2,163	2,310	-295	14,820	-372	16,463	14,300
2	72	2022			250	250	2,310		15,009		17,320	17,070
3	73	2023			250	250	2,310		15,009		17,320	17,070
4	74	2024			250	250	2,310		15,009		17,320	17,070
5	75	2025			250	250	2,310		15,009		17,320	17,070
6	76	2026			250	250	2,310		15,009		17,320	17,070
7	77	2027			250	250	2,310		15,009		17,320	17,070
8	78	2028			250	250	2,310		15,009		17,320	17,070
9	79	2029			250	250	2,310		15,009		17,320	17,070
10	80	2030			250	250	2,310		15,009		17,320	17,070
11	81	2031			250	250	2,310		15,009		17,320	17,070
12	82	2032			250	250	2,310		15,009		17,320	17,070
13	83	2033			250	250	2,310		15,009		17,320	17,070
14	84	2034			250	250	2,310		15,009		17,320	17,070
15	85	2035			250	250	2,310		15,009		17,320	17,070
16	86	2036			250	250	2,310		15,009		17,320	17,070
17	87	2037			250	250	2,310		15,009		17,320	17,070
18	88	2038			250	250	2,310		15,009		17,320	17,070
19	89	2039			250	250	2,310		15,009		17,320	17,070
20	90	2040			250	250	2,310		15,009		17,320	17,070
21	91	2041			250	250	2,310		15,009		17,320	17,070
22	92	2042			250	250	2,310		15,009		17,320	17,070
23	93	2043			250	250	2,310		15,009		17,320	17,070
24	94	2044			250	250	2,310		15,009		17,320	17,070
25	95	2045			250	250	2,310		15,009		17,320	17,070
26	96	2046			250	250	2,310		15,009		17,320	17,070
27	97	2047			250	250	2,310		15,009		17,320	17,070
28	98	2048			250	250	2,310		15,009		17,320	17,070
29	99	2049			250	250	2,310		15,009		17,320	17,070
30	100	2050			250	250	2,310		15,009		17,320	17,070
	Total		17,188		11,337	34,442	101,898		655,187		750,469	716,027

In the condition of a discount rate of 10 %:

Present value: (B-C)	9,280	157,536	148,255
Scheduled Replace			147,774
Balance			**481**

Table 10.21.1 Calculation of Economic Evaluation Indices
New Laxapana P/S Replace after Crash (1)

New Laxapana P/S Replacement after Crash (1)

Crash occur in 2019 (Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Cost of Enegy Not Served	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	32	2006			130	130	5,872		39,751		45,623	45,493
	33	2007			130	130	5,872		39,751		45,623	45,493
	34	2008			130	130	5,872		39,751		45,623	45,493
	35	2009			130	130	5,872		39,751		45,623	45,493
	36	2010			130	130	5,872		39,751		45,623	45,493
	37	2011			130	130	5,872		39,751		45,623	45,493
	38	2012			130	130	5,872		39,751		45,623	45,493
	39	2013			130	130	5,872		39,751		45,623	45,493
	40	2014			130	130	5,872		39,751		45,623	45,493
	41	2015			130	130	5,872		39,751		45,623	45,493
	42	2016			130	130	5,872		39,751		45,623	45,493
	43	2017			130	130	5,872		39,751		45,623	45,493
	44	2018			130	130	5,872		39,751		45,623	45,493
	45	2019		43,991	130	44,121	5,872		39,751		45,623	1,502
	46	2020	5,199		65	5,264	5,872	-2,461	39,751	-6,677	36,485	31,221
	47	2021	275		65	340	5,872	-2,936	39,751	-6,677	36,010	35,671
	48	2022	397		65	462	5,872	-2,936	39,751	-6,677	36,010	35,548
	49	2023	9,974		65	10,039	5,872	-2,936	39,751	-6,677	36,010	25,971
	50	2024	5,213		65	5,278	5,872	-2,936	39,867	-6,677	36,126	30,848
1	51	2025	0		110	110	5,872		40,148		46,020	45,910
2	52	2026			110	110	5,872		40,148		46,020	45,910
3	53	2027			110	110	5,872		40,148		46,020	45,910
4	54	2028			110	110	5,872		40,148		46,020	45,910
5	55	2029			110	110	5,872		40,148		46,020	45,910
6	56	2030			110	110	5,872		40,148		46,020	45,910
7	57	2031			110	110	5,872		40,148		46,020	45,910
8	58	2032			110	110	5,872		40,148		46,020	45,910
9	59	2033			110	110	5,872		40,148		46,020	45,910
10	60	2034			110	110	5,872		40,148		46,020	45,910
11	61	2035			110	110	5,872		40,148		46,020	45,910
12	62	2036			110	110	5,872		40,148		46,020	45,910
13	63	2037			110	110	5,872		40,148		46,020	45,910
14	64	2038			110	110	5,872		40,148		46,020	45,910
15	65	2039			110	110	5,872		40,148		46,020	45,910
16	66	2040			110	110	5,872		40,148		46,020	45,910
17	67	2041			110	110	5,872		40,148		46,020	45,910
18	68	2042			110	110	5,872		40,148		46,020	45,910
19	69	2043			110	110	5,872		40,148		46,020	45,910
20	70	2044			110	110	5,872		40,148		46,020	45,910
21	71	2045			110	110	5,872		40,148		46,020	45,910
22	72	2046			110	110	5,872		40,148		46,020	45,910
23	73	2047			110	110	5,872		40,148		46,020	45,910
24	74	2048			110	110	5,872		40,148		46,020	45,910
25	75	2049			110	110	5,872		40,148		46,020	45,910
26	76	2050			110	110	5,872		40,148		46,020	45,910
27	77	2051			110	110	5,872		40,148		46,020	45,910
28	78	2052			110	110	5,872		40,148		46,020	45,910
29	79	2053			110	110	5,872		40,148		46,020	45,910
30	80	2054			110	110	5,872		40,148		46,020	45,910
31	81	2055			110	110	5,872		40,148		46,020	45,910
32	82	2056			110	110	5,872		40,148		46,020	45,910
33	83	2057			110	110	5,872		40,148		46,020	45,910
34	84	2058			110	110	5,872		40,148		46,020	45,910
35	85	2059			110	110	5,872		40,148		46,020	45,910
36	86	2060			110	110	5,872		40,148		46,020	45,910
37	87	2061			110	110	5,872		40,148		46,020	45,910
	Total		21,057		6,215	71,263	328,843	-14,206	2,240,863	-33,383	2,522,117	2,450,854
In the condition of a discount rate of 10 %:												
Present value: (B-C)						16,810					445,203	428,393

Scheduled Replace	429,101
Balance	**-709**

Table 10.21.2 Calculation of Economic Evaluation Indices
New Laxapana P/S Replace after Crash (2)

New Laxapana P/S Replacement after Crash (2)

Crash occur in 2020 (Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Cost of Enegy Not Served	Cost: Operation & Maintenance	Cost: Total	Benefit: Power Benefit	Benefit: Power Loss	Benefit: Energy Benefit	Benefit: Energy Loss	Benefit: Total	Balance
	32	2006			130	130	5,872		39,751		45,623	45,493
	33	2007			130	130	5,872		39,751		45,623	45,493
	34	2008			130	130	5,872		39,751		45,623	45,493
	35	2009			130	130	5,872		39,751		45,623	45,493
	36	2010			130	130	5,872		39,751		45,623	45,493
	37	2011			130	130	5,872		39,751		45,623	45,493
	38	2012			130	130	5,872		39,751		45,623	45,493
	39	2013			130	130	5,872		39,751		45,623	45,493
	40	2014			130	130	5,872		39,751		45,623	45,493
	41	2015			130	130	5,872		39,751		45,623	45,493
	42	2016			130	130	5,872		39,751		45,623	45,493
	43	2017			130	130	5,872		39,751		45,623	45,493
	44	2018			130	130	5,872		39,751		45,623	45,493
	45	2019			130	130	5,872		39,751		45,623	45,493
	46	2020		43,991	130	44,121	5,872		39,751		45,623	1,502
	47	2021	5,199		65	5,264	5,872	-2,461	39,751	-6,677	36,485	31,221
	48	2022	275		65	340	5,872	-2,936	39,751	-6,677	36,010	35,671
	49	2023	397		65	462	5,872	-2,936	39,751	-6,677	36,010	35,548
	50	2024	9,974		65	10,039	5,872	-2,936	39,751	-6,677	36,010	25,971
	51	2025	5,213		97	5,310	5,872	-2,936	39,867	-6,677	36,126	30,816
1	52	2026	0		110	110	5,872		40,148		46,020	45,910
2	53	2027			110	110	5,872		40,148		46,020	45,910
3	54	2028			110	110	5,872		40,148		46,020	45,910
4	55	2029			110	110	5,872		40,148		46,020	45,910
5	56	2030			110	110	5,872		40,148		46,020	45,910
6	57	2031			110	110	5,872		40,148		46,020	45,910
7	58	2032			110	110	5,872		40,148		46,020	45,910
8	59	2033			110	110	5,872		40,148		46,020	45,910
9	60	2034			110	110	5,872		40,148		46,020	45,910
10	61	2035			110	110	5,872		40,148		46,020	45,910
11	62	2036			110	110	5,872		40,148		46,020	45,910
12	63	2037			110	110	5,872		40,148		46,020	45,910
13	64	2038			110	110	5,872		40,148		46,020	45,910
14	65	2039			110	110	5,872		40,148		46,020	45,910
15	66	2040			110	110	5,872		40,148		46,020	45,910
16	67	2041			110	110	5,872		40,148		46,020	45,910
17	68	2042			110	110	5,872		40,148		46,020	45,910
18	69	2043			110	110	5,872		40,148		46,020	45,910
19	70	2044			110	110	5,872		40,148		46,020	45,910
20	71	2045			110	110	5,872		40,148		46,020	45,910
21	72	2046			110	110	5,872		40,148		46,020	45,910
22	73	2047			110	110	5,872		40,148		46,020	45,910
23	74	2048			110	110	5,872		40,148		46,020	45,910
24	75	2049			110	110	5,872		40,148		46,020	45,910
25	76	2050			110	110	5,872		40,148		46,020	45,910
26	77	2051			110	110	5,872		40,148		46,020	45,910
27	78	2052			110	110	5,872		40,148		46,020	45,910
28	79	2053			110	110	5,872		40,148		46,020	45,910
29	80	2054			110	110	5,872		40,148		46,020	45,910
30	81	2055			110	110	5,872		40,148		46,020	45,910
31	82	2056			110	110	5,872		40,148		46,020	45,910
32	83	2057			110	110	5,872		40,148		46,020	45,910
33	84	2058			110	110	5,872		40,148		46,020	45,910
34	85	2059			110	110	5,872		40,148		46,020	45,910
35	86	2060			110	110	5,872		40,148		46,020	45,910
36	87	2061			110	110	5,872		40,148		46,020	45,910
	Total		21,057		6,267	71,315	328,843	-14,206	2,240,466	-33,383	2,521,720	2,450,404
In the condition of a discount rate of 10 %:												
Present value: (B-C)						15,405					446,004	430,599

Scheduled Replace 429,101

Balance **1,498**

Table 10.22 Pure Construction Cost & Financial Cost

Foreign portion is estimated to be	90%	of total cost	
Custom Duty (for F.C.)			3%
Surcharge (for F.C)			10%
VAT			15%

Wimalasurendra P/S

Case 1 (Repair as required) (Unit: US$1,000)

Item	Pure Construction Cost			Financial Cost		
	Total	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion
1. Total Cost	19,066	17,159	1,907	24,550	22,358	2,193
2. Annual Disbursement						
2006	1,157	1,041	116	1,490	1,357	133
2007	4,724	4,251	472	6,082	5,539	543
2008	1,053	947	105	1,355	1,234	121
2009	7,630	6,867	763	9,825	8,948	877
2010	4,058	3,653	406	5,226	4,759	467
2011	349	314	35	450	410	40
2012	94	85	9	122	111	11
			As repair cost 1,000 (US$1,000) in every 5years			

Case 2(Scheduled replace) (Unit: US$1,000)

Item	Pure Construction Cost			Financial Cost		
	Total	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion
1. Total Cost	23,766	21,389	2,377	30,602	27,869	2,733
2. Annual Disbursement						
2006	1,257	1,131	126	1,619	1,474	145
2007	5,868	5,281	587	7,556	6,881	675
2008	1,346	1,212	135	1,733	1,579	155
2009	9,712	8,741	971	12,506	11,389	1,117
2010	5,137	4,624	514	6,615	6,024	591
2011	445	400	44	573	522	51
2012	0	0	0	0	0	0

Old Laxapana P/S Stage I

Item	Pure Construction Cost			Financial Cost		
	Total	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion
1. Total Cost	17,990	16,191	1,799	23,165	21,096	2,069
2. Annual Disbursement						
2006	716	645	72	923	840	82
2007	4,323	3,891	432	5,567	5,070	497
2008	176	159	18	227	207	20
2009	8,077	7,270	808	10,401	9,472	929
2010	2,699	2,429	270	3,475	3,164	310
2011	1,907	1,717	191	2,456	2,237	219
2012	90	81	9	116	106	10

New Laxapana P/S

Item	Pure Construction Cost			Financial Cost		
	Total	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion
1. Total Cost	22,090	19,881	2,209	28,444	25,904	2,540
2. Annual Disbursement						
2006	935	842	94	1,204	1,097	108
2007	5,295	4,766	530	6,819	6,210	609
2008	230	207	23	296	270	26
2009	277	250	28	357	325	32
2010	10,013	9,011	1,001	12,893	11,741	1,151
2011	5,222	4,699	522	6,724	6,123	600
2012	118	106	12	152	138	14

Table 10.23.1 Calculation of Financial Evaluation Indices

Wimalasurendra P/S Case 1（Repair as Required）

(Unit: US$1,000)

			Cost			Benefit					
Year in order	Plant Age	Year	Replace	Operation & Maintenance	Total	Energy Generation (MWh)	Loss due to Outage	Energy Sales (MWh)	Energy Revenue	Total	Balance
	42	2006	1,490	0	1,490	0		0	0	0	-1,490
	43	2007	6,082	0	6,082	0	0	0	0	0	-6,082
	44	2008	1,355	0	1,355	0	0	0	0	0	-1,355
	45	2009	9,825	0	9,825	0	0	0	0	0	-9,825
	46	2010	5,226	0	5,226	0	0	0	0	0	-5,226
1	47	2011	450	0	450	0	0	0	0	0	-450
2	48	2012	122	0	122	0		0	0	0	-122
3	49	2013		0	0	0		0	0	0	0
4	50	2014		0	0	0		0	0	0	0
5	51	2015	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
6	52	2016		170	170	112,000		90,496	7,715	7,715	7,545
7	53	2017		170	170	112,000		90,496	7,715	7,715	7,545
8	54	2018		170	170	112,000		90,496	7,715	7,715	7,545
9	55	2019		170	170	112,000		90,496	7,715	7,715	7,545
10	56	2020	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
11	57	2021		170	170	112,000		90,496	7,715	7,715	7,545
12	58	2022		170	170	112,000		90,496	7,715	7,715	7,545
13	59	2023		170	170	112,000		90,496	7,715	7,715	7,545
14	60	2024		170	170	112,000		90,496	7,715	7,715	7,545
15	61	2025	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
16	62	2026		170	170	112,000		90,496	7,715	7,715	7,545
17	63	2027		170	170	112,000		90,496	7,715	7,715	7,545
18	64	2028		170	170	112,000		90,496	7,715	7,715	7,545
19	65	2029		170	170	112,000		90,496	7,715	7,715	7,545
20	66	2030	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
21	67	2031		170	170	112,000		90,496	7,715	7,715	7,545
22	68	2032		170	170	112,000		90,496	7,715	7,715	7,545
23	69	2033		170	170	112,000		90,496	7,715	7,715	7,545
24	70	2034		170	170	112,000		90,496	7,715	7,715	7,545
25	71	2035	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
26	72	2036		170	170	112,000		90,496	7,715	7,715	7,545
27	73	2037		170	170	112,000		90,496	7,715	7,715	7,545
28	74	2038		170	170	112,000		90,496	7,715	7,715	7,545
29	75	2039		170	170	112,000		90,496	7,715	7,715	7,545
30	76	2040	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
31	77	2041		170	170	112,000		90,496	7,715	7,715	7,545
32	78	2042		170	170	112,000		90,496	7,715	7,715	7,545
33	79	2043		170	170	112,000		90,496	7,715	7,715	7,545
34	80	2044		170	170	112,000		90,496	7,715	7,715	7,545
35	81	2045	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
36	82	2046		170	170	112,000		90,496	7,715	7,715	7,545
37	83	2047		170	170	112,000		90,496	7,715	7,715	7,545
38	84	2048		170	170	112,000		90,496	7,715	7,715	7,545
39	85	2049		170	170	112,000		90,496	7,715	7,715	7,545
40	86	2050	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
41	87	2051		170	170	112,000		90,496	7,715	7,715	7,545
42	88	2052		170	170	112,000		90,496	7,715	7,715	7,545
43	89	2053		170	170	112,000		90,496	7,715	7,715	7,545
44	90	2054		170	170	112,000		90,496	7,715	7,715	7,545
45	91	2055	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
46	92	2056		170	170	112,000		90,496	7,715	7,715	7,545
47	93	2057		170	170	112,000		90,496	7,715	7,715	7,545
48	94	2058		170	170	112,000		90,496	7,715	7,715	7,545
49	95	2059		170	170	112,000		90,496	7,715	7,715	7,545
50	96	2060	1,000	170	1,170	112,000		90,496	7,715	7,715	6,545
	Total		34,550	7,820	42,370	5,152,000	0	4,162,816	354,902	354,902	312,532
In the condition of a discount rate of 10 %:											
Present value: (B-C)					19,392					32,312	12,920
Internal rate of return (FIRR):											14.15%
B/C											1.67

Table10.23.2 Calculation of Financial Evaluation Indices

Wimalasurendra P/S Case 2（Scheduled Replace）

(Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Operation & Maintenance	Cost: Total	Benefit: Energy Generation (MWh)	Benefit: Loss due to Outage	Benefit: Energy Sales (MWh)	Benefit: Energy Revenue	Benefit: Total	Balance
	42	2006	1,619	0	1,619	0	0	0	0	0	-1,619
	43	2007	7,556	0	7,556	0	0	0	0	0	-7,556
	44	2008	1,733	0	1,733	0	0	0	0	0	-1,733
	45	2009	12,506	0	12,506	0	0	0	0	0	-12,506
	46	2010	6,615	0	6,615	513	0	415	35	35	-6,580
1	47	2011	573	0	573	1,120	0	905	77	77	-496
2	48	2012	0	0	0	1,120	0	905	77	77	77
3	49	2013		0	0	1,120		905	77	77	77
4	50	2014		0	0	1,120		905	77	77	77
5	51	2015		150	150	113,120		91,401	7,790	7,790	7,640
6	52	2016		150	150	113,120		91,401	7,790	7,790	7,640
7	53	2017		150	150	113,120		91,401	7,790	7,790	7,640
8	54	2018		150	150	113,120		91,401	7,790	7,790	7,640
9	55	2019		150	150	113,120		91,401	7,790	7,790	7,640
10	56	2020		150	150	113,120		91,401	7,790	7,790	7,640
11	57	2021		150	150	113,120		91,401	7,790	7,790	7,640
12	58	2022		150	150	113,120		91,401	7,790	7,790	7,640
13	59	2023		150	150	113,120		91,401	7,790	7,790	7,640
14	60	2024		150	150	113,120		91,401	7,790	7,790	7,640
15	61	2025		150	150	113,120		91,401	7,790	7,790	7,640
16	62	2026		150	150	113,120		91,401	7,790	7,790	7,640
17	63	2027		150	150	113,120		91,401	7,790	7,790	7,640
18	64	2028		150	150	113,120		91,401	7,790	7,790	7,640
19	65	2029		150	150	113,120		91,401	7,790	7,790	7,640
20	66	2030		150	150	113,120		91,401	7,790	7,790	7,640
21	67	2031		150	150	113,120		91,401	7,790	7,790	7,640
22	68	2032		150	150	113,120		91,401	7,790	7,790	7,640
23	69	2033		150	150	113,120		91,401	7,790	7,790	7,640
24	70	2034		150	150	113,120		91,401	7,790	7,790	7,640
25	71	2035		150	150	113,120		91,401	7,790	7,790	7,640
26	72	2036		150	150	113,120		91,401	7,790	7,790	7,640
27	73	2037		150	150	113,120		91,401	7,790	7,790	7,640
28	74	2038		150	150	113,120		91,401	7,790	7,790	7,640
29	75	2039		150	150	113,120		91,401	7,790	7,790	7,640
30	76	2040		150	150	113,120		91,401	7,790	7,790	7,640
31	77	2041		150	150	113,120		91,401	7,790	7,790	7,640
32	78	2042		150	150	113,120		91,401	7,790	7,790	7,640
33	79	2043		150	150	113,120		91,401	7,790	7,790	7,640
34	80	2044		150	150	113,120		91,401	7,790	7,790	7,640
35	81	2045		150	150	113,120		91,401	7,790	7,790	7,640
36	82	2046		150	150	113,120		91,401	7,790	7,790	7,640
37	83	2047		150	150	113,120		91,401	7,790	7,790	7,640
38	84	2048		150	150	113,120		91,401	7,790	7,790	7,640
39	85	2049		150	150	113,120		91,401	7,790	7,790	7,640
40	86	2050		150	150	113,120		91,401	7,790	7,790	7,640
41	87	2051		150	150	113,120		91,401	7,790	7,790	7,640
42	88	2052		150	150	113,120		91,401	7,790	7,790	7,640
43	89	2053		150	150	113,120		91,401	7,790	7,790	7,640
44	90	2054		150	150	113,120		91,401	7,790	7,790	7,640
45	91	2055		150	150	113,120		91,401	7,790	7,790	7,640
46	92	2056		150	150	113,120		91,401	7,790	7,790	7,640
47	93	2057		150	150	113,120		91,401	7,790	7,790	7,640
48	94	2058		150	150	113,120		91,401	7,790	7,790	7,640
49	95	2059		150	150	113,120		91,401	7,790	7,790	7,640
50	96	2060		150	150	113,120		91,401	7,790	7,790	7,640
	Total		30,602	6,900	37,502	5,208,513	0	4,208,479	358,684	358,684	321,181
In the condition of a discount rate of 10 %:											
Present value: (B-C)					22,620					32,799	10,179
Internal rate of return (FIRR):											12.82%
B/C											1.45

Table 10.24 Calculation of Financial Evaluation Indices

Old Laxapana Stage I P/S

(Unit: US$1,000)

Year in order	Plant Age	Year	Cost: Replace	Cost: Operation & Maintenance	Cost: Total	Benefit: Energy Generation (MWh)	Benefit: Loss due to Outage	Benefit: Energy Sales (MWh)	Benefit: Energy Revenue	Benefit: Total	Balance
	56	2006	923	0	923	0	0	0	0	0	-923
	57	2007	5,567	0	5,567	0	0	0	0	0	-5,567
	58	2008	227	0	227	0	0	0	0	0	-227
	59	2009	10,401	0	10,401	0	0	0	0	0	-10,401
	60	2010	3,475	28	3,503	17,478	-9,825	6,183	527	527	-2,975
1	61	2011	2,456	160	2,616	100,497	-9,825	73,263	6,246	6,246	3,630
2	62	2012	116	250	366	157,300	0	127,098	10,836	10,836	10,469
3	63	2013		250	250	157,300		127,098	10,836	10,836	10,586
4	64	2014		250	250	157,300		127,098	10,836	10,836	10,586
5	65	2015		250	250	157,300		127,098	10,836	10,836	10,586
6	66	2016		250	250	157,300		127,098	10,836	10,836	10,586
7	67	2017		250	250	157,300		127,098	10,836	10,836	10,586
8	68	2018		250	250	157,300		127,098	10,836	10,836	10,586
9	69	2019		250	250	157,300		127,098	10,836	10,836	10,586
10	70	2020		250	250	157,300		127,098	10,836	10,836	10,586
11	71	2021		250	250	157,300		127,098	10,836	10,836	10,586
12	72	2022		250	250	157,300		127,098	10,836	10,836	10,586
13	73	2023		250	250	157,300		127,098	10,836	10,836	10,586
14	74	2024		250	250	157,300		127,098	10,836	10,836	10,586
15	75	2025		250	250	157,300		127,098	10,836	10,836	10,586
16	76	2026		250	250	157,300		127,098	10,836	10,836	10,586
17	77	2027		250	250	157,300		127,098	10,836	10,836	10,586
18	78	2028		250	250	157,300		127,098	10,836	10,836	10,586
19	79	2029		250	250	157,300		127,098	10,836	10,836	10,586
20	80	2030		250	250	157,300		127,098	10,836	10,836	10,586
21	81	2031		250	250	157,300		127,098	10,836	10,836	10,586
22	82	2032		250	250	157,300		127,098	10,836	10,836	10,586
23	83	2033		250	250	157,300		127,098	10,836	10,836	10,586
24	84	2034		250	250	157,300		127,098	10,836	10,836	10,586
25	85	2035		250	250	157,300		127,098	10,836	10,836	10,586
26	86	2036		250	250	157,300		127,098	10,836	10,836	10,586
27	87	2037		250	250	157,300		127,098	10,836	10,836	10,586
28	88	2038		250	250	157,300		127,098	10,836	10,836	10,586
29	89	2039		250	250	157,300		127,098	10,836	10,836	10,586
30	90	2040		250	250	157,300		127,098	10,836	10,836	10,586
31	91	2041		250	250	157,300		127,098	10,836	10,836	10,586
32	92	2042		250	250	157,300		127,098	10,836	10,836	10,586
33	93	2043		250	250	157,300		127,098	10,836	10,836	10,586
34	94	2044		250	250	157,300		127,098	10,836	10,836	10,586
35	95	2045		250	250	157,300		127,098	10,836	10,836	10,586
36	96	2046		250	250	157,300		127,098	10,836	10,836	10,586
37	97	2047		250	250	157,300		127,098	10,836	10,836	10,586
38	98	2048		250	250	157,300		127,098	10,836	10,836	10,586
39	99	2049		250	250	157,300		127,098	10,836	10,836	10,586
40	100	2050		250	250	157,300		127,098	10,836	10,836	10,586
	Total		23,165	9,938	33,102	6,252,675	-19,651	5,036,283	429,370	429,370	396,267
In the condition of a discount rate of 10 %:											
Present value: (B-C)					17,802					63,532	45,730
Internal rate of return (FIRR):											28.86%
B/C											3.57

Table 10.25 Calculation of Financial Evaluation Indices

New Laxapana P/S

(Unit: US$1,000)

			Cost			Benefit					
Year in order	Plant Age	Year	Replace	Operation & Maintenance	Total	Energy Generation (MWh)	Loss due to Outage	Energy Sales (MWh)	Energy Revenue	Total	Balance
	32	2006	1,204	0	1,204	0	0	0	0	0	-1,204
	33	2007	6,819	0	6,819	0	0	0	0	0	-6,819
	34	2008	296	0	296	0	-20,384	-16,471	-1,404	-1,404	-1,700
	35	2009	357	0	357	0	0	0	0	0	-357
	36	2010	12,893	0	12,893	0	0	0	0	0	-12,893
	37	2011	6,724	-3	6,721	690	-162,468	-130,717	-11,144	-11,144	-17,865
1	38	2012	152	-17	135	4,600	0	3,717	317	317	182
2	39	2013		-20	-20	5,520		4,460	380	380	400
3	40	2014		-20	-20	5,520		4,460	380	380	400
4	41	2015		-20	-20	5,520		4,460	380	380	400
5	42	2016		-20	-20	5,520		4,460	380	380	400
6	43	2017		-20	-20	5,520		4,460	380	380	400
7	44	2018		-20	-20	5,520		4,460	380	380	400
8	45	2019		-20	-20	5,520		4,460	380	380	400
9	46	2020		-20	-20	5,520		4,460	380	380	400
10	47	2021		-20	-20	5,520		4,460	380	380	400
11	48	2022		-20	-20	5,520		4,460	380	380	400
12	49	2023		-20	-20	5,520		4,460	380	380	400
13	50	2024		-20	-20	5,520		4,460	380	380	400
14	51	2025		110	110	557,520		450,476	38,405	38,405	38,295
15	52	2026		110	110	557,520		450,476	38,405	38,405	38,295
16	53	2027		110	110	557,520		450,476	38,405	38,405	38,295
17	54	2028		110	110	557,520		450,476	38,405	38,405	38,295
18	55	2029		110	110	557,520		450,476	38,405	38,405	38,295
19	56	2030		110	110	557,520		450,476	38,405	38,405	38,295
20	57	2031		110	110	557,520		450,476	38,405	38,405	38,295
21	58	2032		110	110	557,520		450,476	38,405	38,405	38,295
22	59	2033		110	110	557,520		450,476	38,405	38,405	38,295
23	60	2034		110	110	557,520		450,476	38,405	38,405	38,295
24	61	2035		110	110	557,520		450,476	38,405	38,405	38,295
25	62	2036		110	110	557,520		450,476	38,405	38,405	38,295
26	63	2037		110	110	557,520		450,476	38,405	38,405	38,295
27	64	2038		110	110	557,520		450,476	38,405	38,405	38,295
28	65	2039		110	110	557,520		450,476	38,405	38,405	38,295
29	66	2040		110	110	557,520		450,476	38,405	38,405	38,295
30	67	2041		110	110	557,520		450,476	38,405	38,405	38,295
31	68	2042		110	110	557,520		450,476	38,405	38,405	38,295
32	69	2043		110	110	557,520		450,476	38,405	38,405	38,295
33	70	2044		110	110	557,520		450,476	38,405	38,405	38,295
34	71	2045		110	110	557,520		450,476	38,405	38,405	38,295
35	72	2046		110	110	557,520		450,476	38,405	38,405	38,295
36	73	2047		110	110	557,520		450,476	38,405	38,405	38,295
37	74	2048		110	110	557,520		450,476	38,405	38,405	38,295
38	75	2049		110	110	557,520		450,476	38,405	38,405	38,295
39	76	2050		110	110	557,520		450,476	38,405	38,405	38,295
40	77	2051		110	110	557,520		450,476	38,405	38,405	38,295
41	78	2052		110	110	557,520		450,476	38,405	38,405	38,295
42	79	2053		110	110	557,520		450,476	38,405	38,405	38,295
43	80	2054		110	110	557,520		450,476	38,405	38,405	38,295
44	81	2055		110	110	557,520		450,476	38,405	38,405	38,295
45	82	2056		110	110	557,520		450,476	38,405	38,405	38,295
46	83	2057		110	110	557,520		450,476	38,405	38,405	38,295
47	84	2058		110	110	557,520		450,476	38,405	38,405	38,295
48	85	2059		110	110	557,520		450,476	38,405	38,405	38,295
49	86	2060		110	110	557,520		450,476	38,405	38,405	38,295
50	87	2061		110	110	557,520		450,476	38,405	38,405	38,295
	Total		28,444	3,811	32,255	20,699,770	-182,852	16,577,669	1,413,334	1,413,334	1,381,079
In the condition of a discount rate of 10 %:											
Present value: (B-C)					19,170					55,096	35,926
Internal rate of return (FIRR):											14.23%
B/C											2.87

Table 10.26 Financial Sensitivity of Hydro Power Construction Cost

	Const. Cost	Evaluation Indices FIRR
Wimalasurendra P/S Case 1 （Repair as Required）		
Case-A	50%	10.80%
Case-B	25%	12.25%
Base Case	0%	14.15%
Case-C	-25%	16.80%
Case-D	-50%	20.92%
Trial Case	66%	10.03%
Wimalasurendra P/S Case2（Scheduled Replace）		
Case-A	50%	16.34%
Case-B	20%	14.34%
Base Case	0%	12.82%
Case-C	-20%	11.08%
Case-D	-50%	7.85%
Trial Case	45%	10.00%
Old Laxapana Stage I P/S		
Case-A	50%	21.37%
Case-B	20%	25.30%
Base Case	0%	28.86%
Case-C	-20%	33.65%
Case-D	-50%	45.34%
Trial Case	257%	10.00%
New Laxapana P/S		
Case-A	50%	12.63%
Case-B	20%	13.51%
Base Case	0%	14.23%
Case-C	-20%	15.07%
Case-D	-50%	16.75%
Trial Case	187%	10.01%

Table 10.27 Financial Sensitivity of Electricity Tariff

	E.Tariff	Evaluation Indices
		FIRR
Wimalasurendra P/S Case 1 （Repair as Required）		
Case-A	50%	17.95%
Case-B	20%	15.80%
Base Case	0%	14.15%
Case-C	-20%	12.25%
Case-D	-50%	8.67%
Trial Case	-40%	10.00%
Wimalasurendra P/S Case2（Scheduled Replace）		
Case-A	50%	9.76%
Case-B	25%	11.08%
Base Case	0%	12.82%
Case-C	-25%	15.27%
Case-D	-50%	19.14%
Trial Case	-31%	10.00%
Old Laxapana Stage I P/S		
Case-A	50%	37.92%
Case-B	20%	32.74%
Base Case	0%	28.86%
Case-C	-20%	24.55%
Case-D	-50%	16.96%
Trial Case	-71%	10.35%
New Laxapana P/S		
Case-A	50%	15.74%
Case-B	20%	14.92%
Base Case	0%	14.23%
Case-C	-20%	13.35%
Case-D	-50%	11.47%
Trial Case	-65%	10.02%

Table 10.28 Consolidated Loans and Sources to CEB at End of 1999

Item	Number of Loans	Principal Amount (Rs. Million)	Principal Amount (%)	Balance at December 31, 1999 (Rs. Million)	Balance at December 31, 1999 (%)
Destination					
Generation	27	46,829	75.2	19,225	64.0
Transmission	25	13,221	21.2	8,318	27.7
Distribution	4	1,863	3.0	1,024	3.4
Corporate	2	366	0.6	263	0.9
Distribution of LECO*1	3	2	0.0	1,192	4.0
Total	61	62,281	100.0	30,022	100.0
Sources					
JBIC (OECF)		31,724	50.9	8,843	29.5
JBIC (OECF)		9,609	15.4	7,857	26.2
IDA		6,500	10.4	3,577	11.9
ADB		5,695	9.1	3,735	12.4
Others		5,418	8.7	4,210	14.0
MDB		2,000	3.2	800	2.7
DST		1,335	2.1	1,000	3.3
Total		62,281	100.0	30,022	100.0

Source: Sri Lanka Power Sector Restructuring Project, Financial-Volume 1- Main Report, April 2001, Ministry of Power and Energy
Note: *1 Lanka Electricity Company

Remark: Terms of loans range as follows.
Interest rate: 0.0 to 13.5 % per annum
Repayment period: 3 to 40 years (20 years on average)

Table 10.29.1 Cash Flow Statement: Case of ODA Finance

Wimalasurendra PS

Case1 (Unit: US$1000)

Year in order		Year	Financial Flow: Capital Investment Fund	Foreign Fund: Principal Payment	Foreign Fund: Interest	Local Fund: Principal Payment	Local Fund: Interest	Profit & Loss Flow: Sales Revenue*2	Expense: O&M	Expense: Depre-ciation*3	Expense: Interest	Income before Tax	Income Tax*4	Income after Tax	Cash Flow: Revenue	Expense: O&M	Expense: Tax	Debt Service: Principal	Debt Service: Interest	Net Cash Flow	Debt Service Coverage Ratio
1		2006	1,490		20		19	0	0		39				0	0	0		39	-39	
2		2007	6,082		102		98	0	0		201				0	0	0		201	-201	
3		2008	1,355		121		116	0	0		237				0	0	0		237	-237	
4		2009	9,825		253		244	0	0		497				0	0	0		497	-497	
5		2010	5,226		324	153	292	0	0		616	-616	0	-616	0	0	0	153	616	-768	0.000
6		2011	450		330	153	278	0	0		608	-608	0	-608	0	0	0	153	608	-760	0.000
7	1	2012			330	153	258	0	0	928	588	-1,516	0	-1,516	0	0	0	153	588	-740	0.000
8	2	2013			330	153	238	0	0	928	568	-1,496	0	-1,496	0	0	0	153	568	-721	0.000
9	3	2014			330	153	218	0	0	928	548	-1,476	0	-1,476	0	0	0	153	548	-701	0.000
10	4	2015			330	153	198	7,715	170	928	528	6,089	132	5,957	7,715	170	132	153	528	6,732	10.886
11	5	2016		1,099	313	153	179	7,715	170	928	492	6,125	2,144	3,982	7,715	170	2,144	1,252	492	3,657	3.097
12	6	2017		1,099	297	153	159	7,715	170	489	456	6,601	2,310	4,291	7,715	170	2,310	1,252	456	3,527	3.066
13	7	2018		1,099	280	153	139	7,715	170	489	419	6,637	2,323	4,314	7,715	170	2,323	1,252	419	3,551	3.125
14	8	2019		1,099	264	153	119	7,715	170	489	383	6,674	2,336	4,338	7,715	170	2,336	1,252	383	3,575	3.186
15	9	2020		1,099	247	153	99	7,715	170	489	347	6,710	2,349	4,362	7,715	170	2,349	1,252	347	3,598	3.251
16	10	2021		1,099	231	153	79	7,715	170	489	310	6,746	2,361	4,385	7,715	170	2,361	1,252	310	3,622	3.318
17	11	2022		1,099	214	153	60	7,715	170	489	274	6,783	2,374	4,409	7,715	170	2,374	1,252	274	3,645	3.389
18	12	2023		1,099	198	153	40	7,715	170	489	238	6,819	2,387	4,432	7,715	170	2,387	1,252	238	3,669	3.463
19	13	2024		1,099	181	153	20	7,715	170	489	201	6,855	2,399	4,456	7,715	170	2,399	1,252	201	3,693	3.541
20	14	2025		1,099	165	153	0	7,715	170	489	165	6,892	2,412	4,480	7,715	170	2,412	1,252	165	3,716	3.623
21	15	2026		1,099	148		0	7,715	170	489	148	6,908	2,418	4,490	7,715	170	2,418	1,099	148	3,880	4.109
22	16	2027		1,099	132		0	7,715	170	489	132	6,925	2,424	4,501	7,715	170	2,424	1,099	132	3,890	4.160
23	17	2028		1,099	115		0	7,715	170	489	115	6,941	2,429	4,512	7,715	170	2,429	1,099	115	3,901	4.212
24	18	2029		1,099	99		0	7,715	170	489	99	6,958	2,435	4,523	7,715	170	2,435	1,099	99	3,912	4.265
25	19	2030		1,099	82		0	7,715	170	489	82	6,974	2,441	4,533	7,715	170	2,441	1,099	82	3,923	4.319
26	20	2031		1,099	66		0	7,715	170	489	66	6,991	2,447	4,544	7,715	170	2,447	1,099	66	3,933	4.376
27	21	2032		1,099	49		0	7,715	170	489	49	7,007	2,453	4,555	7,715	170	2,453	1,099	49	3,944	4.433
28	22	2033		1,099	33		0	7,715	170	489	33	7,024	2,458	4,565	7,715	170	2,458	1,099	33	3,955	4.493
29	23	2034		1,099	16		0	7,715	170	489	16	7,040	2,464	4,576	7,715	170	2,464	1,099	16	3,965	4.554
30	24	2035		1,099	0		0	7,715	170	489	0	7,057	2,470	4,587	7,715	170	2,470	1,099	0	3,976	4.617
															Average DSCR (Debt Service Coverage Ratio):						3.365
		Total	24,428	21,986	5,602	2,443	2,854	162,021	3,570		Return on Investment (ROI):			**8.3%**	Loan Life Debt Service Coverage Ratio (LLCR)*1:						**2.996**

Note: *1 Discounted at 2.65% of weighted average interest rate.
*2 Net sales revenue including VAT (value added tax)
*3 Interest during construction was capitalized in deferred assets and amortized it during five years after inauguration.
*4 Imposed 35% of income tax on net profit which subtracted net deficits if the project entity had net deficits during the nearest past five years.

Table 10.29.2 Cash Flow Statement: Case of ODA Finance

Wimalasurendra PS

Case 2

(Unit: US$1000)

Year in order		Year	Financial Flow: Capital Investment Fund	Foreign Fund: Principal Payment	Foreign Fund: Interest	Local Fund: Principal Payment	Local Fund: Interest	Profit & Loss Flow: Sales Revenue*2	Expense: O&M	Expense: Depre-ciation*3	Expense: Interest	Income before Tax	Income Tax*4	Income after Tax	Cash Flow: Revenue	Expense: O&M	Expense: Tax	Debt Service: Principal	Debt Service: Interest	Net Cash Flow	Debt Service Coverage Ratio
1		2006	1,619		22		21	0	0		43				0	0	0		43	-43	
2		2007	7,556		124		119	0	0		243				0	0	0		243	-243	
3		2008	1,733		147		142	0	0		289				0	0	0		289	-289	
4		2009	12,506		316		304	0	0		620				0	0	0		620	-620	
5		2010	6,615		405	191	366	35	0		771	-736	0	-736	35	0	0	191	771	-927	0.037
6		2011	573		413	191	348	77	0		761	-684	0	-684	77	0	0	191	761	-875	0.081
7	1	2012			413	191	323	77	0	1,158	736	-1,817	0	-1,817	77	0	0	191	736	-851	0.083
8	2	2013			413	191	298	77	0	1,158	712	-1,792	0	-1,792	77	0	0	191	712	-826	0.085
9	3	2014			413	191	274	77	0	1,158	687	-1,767	0	-1,767	77	0	0	191	687	-801	0.088
10	4	2015			413	191	249	7,790	150	1,158	662	5,821	0	5,821	7,790	150	0	191	662	6,787	8.956
11	5	2016		1,377	392	191	224	7,790	150	1,158	616	5,866	1,712	4,154	7,790	150	1,712	1,568	616	3,743	2.714
12	6	2017		1,377	372	191	199	7,790	150	612	571	6,457	2,260	4,197	7,790	150	2,260	1,568	571	3,241	2.515
13	7	2018		1,377	351	191	174	7,790	150	612	525	6,503	2,276	4,227	7,790	150	2,276	1,568	525	3,270	2.562
14	8	2019		1,377	331	191	149	7,790	150	612	480	6,548	2,292	4,256	7,790	150	2,292	1,568	480	3,300	2.611
15	9	2020		1,377	310	191	124	7,790	150	612	434	6,594	2,308	4,286	7,790	150	2,308	1,568	434	3,330	2.663
16	10	2021		1,377	289	191	99	7,790	150	612	389	6,639	2,324	4,316	7,790	150	2,324	1,568	389	3,359	2.716
17	11	2022		1,377	269	191	75	7,790	150	612	343	6,685	2,340	4,345	7,790	150	2,340	1,568	343	3,389	2.773
18	12	2023		1,377	248	191	50	7,790	150	612	298	6,730	2,356	4,375	7,790	150	2,356	1,568	298	3,418	2.832
19	13	2024		1,377	227	191	25	7,790	150	612	252	6,776	2,372	4,404	7,790	150	2,372	1,568	252	3,448	2.894
20	14	2025		1,377	207	191	-0	7,790	150	612	207	6,821	2,387	4,434	7,790	150	2,387	1,568	207	3,478	2.959
21	15	2026		1,377	186		-0	7,790	150	612	186	6,842	2,395	4,447	7,790	150	2,395	1,377	186	3,682	3.356
22	16	2027		1,377	165		-0	7,790	150	612	165	6,863	2,402	4,461	7,790	150	2,402	1,377	165	3,696	3.396
23	17	2028		1,377	145		-0	7,790	150	612	145	6,883	2,409	4,474	7,790	150	2,409	1,377	145	3,709	3.437
24	18	2029		1,377	124		-0	7,790	150	612	124	6,904	2,416	4,488	7,790	150	2,416	1,377	124	3,723	3.480
25	19	2030		1,377	103		-0	7,790	150	612	103	6,925	2,424	4,501	7,790	150	2,424	1,377	103	3,736	3.524
26	20	2031		1,377	83		-0	7,790	150	612	83	6,945	2,431	4,514	7,790	150	2,431	1,377	83	3,749	3.569
27	21	2032		1,377	62		-0	7,790	150	612	62	6,966	2,438	4,528	7,790	150	2,438	1,377	62	3,763	3.615
28	22	2033		1,377	41		-0	7,790	150	612	41	6,987	2,445	4,541	7,790	150	2,445	1,377	41	3,776	3.662
29	23	2034		1,377	21		-0	7,790	150	612	21	7,007	2,453	4,555	7,790	150	2,453	1,377	21	3,790	3.711
30	24	2035		1,377	-0		-0	7,790	150	612	-0	7,028	2,460	4,568	7,790	150	2,460	1,377	-0	3,803	3.762
		Total	30,602	27,542	7,005	3,060	3,563	163,934	3,150												

Average DSCR (Debt Service Coverage Ratio): 2.772

Return on Investment (ROI): **8.3%**

Loan Life Debt Service Coverage Ratio (LLCR)*1: **2.473**

Note:
*1 Discounted at 2.65% of weighted average interest rate.
*2 Net sales revenue including VAT (value added tax)
*3 Interest during construction was capitalised in deferred assets and amortised it during five years after inauguration.
*4 Imposed 35% of income tax on net profit which subtracted net deficits if the project entity had net deficits during the nearest past five years.

Table 10.30 Cash Flow Statement: Case of ODA Finance

Old Laxapana StageI P/S

(Unit: US$1000)

Year in order		Year	Financial Flow					Profit & Loss Flow							Cash Flow						Debt
			Capital	Foreign Fund		Local Fund		Sales	Expense			Income	Income	Income	Revenue	Expense		Debt Service		Net	Service
			Investment Fund	Principal Payment	Interest	Principal Payment	Interest	Revenue*2	O&M	Depre-ciation*3	Interest	before Tax	Tax*4	after Tax		O&M	Tax	Principal	Interest	Cash Flow	Coverage Ratio
1		2006	923		12		12	0	0		24				0	0	0		24	-24	
2		2007	5,567		88		84	0	0		172				0	0	0		172	-172	
3		2008	227		91		87	0	0		178				0	0	0		178	-178	
4		2009	10,401		231		223	0	0		454				0	0	0		454	-454	
5		2010	3,475		278	145	249	527	28		527	-28	0	-28	527	28	0	145	527	-172	0.743
6		2011	2,456		311	145	262	6,246	160		573	5,513	1,920	3,593	6,246	160	1,920	145	573	3,448	5.803
7	1	2012	116		313	145	245	10,836	250	849	557	9,179	3,213	5,967	10,836	250	3,213	145	557	6,671	10.500
8	2	2013			313	145	226	10,836	250	849	539	9,198	3,219	5,979	10,836	250	3,219	145	539	6,683	10.780
9	3	2014			313	145	207	10,836	250	849	520	9,217	3,226	5,991	10,836	250	3,226	145	520	6,695	11.075
10	4	2015			313	145	188	10,836	250	849	501	9,236	3,233	6,003	10,836	250	3,233	145	501	6,708	11.388
11	5	2016		1,042	297	145	169	10,836	250	849	466	9,270	3,245	6,026	10,836	250	3,245	1,187	466	5,687	4.439
12	6	2017		1,042	281	145	151	10,836	250	463	432	9,690	3,392	6,299	10,836	250	3,392	1,187	432	5,575	4.443
13	7	2018		1,042	266	145	132	10,836	250	463	398	9,725	3,404	6,321	10,836	250	3,404	1,187	398	5,597	4.532
14	8	2019		1,042	250	145	113	10,836	250	463	363	9,759	3,416	6,344	10,836	250	3,416	1,187	363	5,620	4.625
15	9	2020		1,042	235	145	94	10,836	250	463	329	9,794	3,428	6,366	10,836	250	3,428	1,187	329	5,642	4.722
16	10	2021		1,042	219	145	75	10,836	250	463	294	9,828	3,440	6,388	10,836	250	3,440	1,187	294	5,665	4.824
17	11	2022		1,042	203	145	56	10,836	250	463	260	9,863	3,452	6,411	10,836	250	3,452	1,187	260	5,687	4.930
18	12	2023		1,042	188	145	38	10,836	250	463	225	9,897	3,464	6,433	10,836	250	3,464	1,187	225	5,709	5.042
19	13	2024		1,042	172	145	19	10,836	250	463	191	9,932	3,476	6,456	10,836	250	3,476	1,187	191	5,732	5.159
20	14	2025		1,042	156	145	0	10,836	250	463	156	9,966	3,488	6,478	10,836	250	3,488	1,187	156	5,754	5.283
21	15	2026		1,042	141		0	10,836	250	463	141	9,982	3,494	6,488	10,836	250	3,494	1,042	141	5,909	5.994
22	16	2027		1,042	125		0	10,836	250	463	125	9,997	3,499	6,498	10,836	250	3,499	1,042	125	5,919	6.070
23	17	2028		1,042	109		0	10,836	250	463	109	10,013	3,505	6,508	10,836	250	3,505	1,042	109	5,929	6.148
24	18	2029		1,042	94		0	10,836	250	463	94	10,029	3,510	6,519	10,836	250	3,510	1,042	94	5,940	6.227
25	19	2030		1,042	78		0	10,836	250	463	78	10,044	3,516	6,529	10,836	250	3,516	1,042	78	5,950	6.309
26	20	2031		1,042	63		0	10,836	250	463	63	10,060	3,521	6,539	10,836	250	3,521	1,042	63	5,960	6.394
27	21	2032		1,042	47		0	10,836	250	463	47	10,076	3,526	6,549	10,836	250	3,526	1,042	47	5,970	6.480
28	22	2033		1,042	31		0	10,836	250	463	31	10,091	3,532	6,559	10,836	250	3,532	1,042	31	5,980	6.570
29	23	2034		1,042	16		0	10,836	250	463	16	10,107	3,537	6,569	10,836	250	3,537	1,042	16	5,990	6.662
30	24	2035		1,042	0		0	10,836	250	463	0	10,123	3,543	6,580	10,836	250	3,543	1,042	0	6,001	6.756
															Average DSCR (Debt Service Coverage Ratio):						6.227
		Total	23,165	20,848	5,233	2,316	2,630	266,833	6,188		Return on Investment (ROI):			**8.4%**	Loan Life Debt Service Coverage Ratio (LLCR)*1:						**5.328**

Note:
*1 Discounted at 2.65% of weighted average interest rate.
*2 Net sales revenue including VAT (value added tax)
*3 Interest during construction was capitalized in deferred assets and amortized it during five years after inauguration.
*4 Imposed 35% of income tax on net profit which subtracted net deficits if the project entity had net deficits during the nearest past five years.

Table 10.31 Cash Flow Statement: Case of ODA Finance

New Laxapana P/S

(Unit: US$1000)

			Financial Flow					Profit & Loss Flow							Cash Flow						Debt
Year in order		Year	Capital Investment Fund	Foreign Fund		Local Fund		Sales Revenue*2	Expense			Income before Tax	Income Tax*4	Income after Tax	Revenue	Expense		Debt Service		Net Cash Flow	Service Coverage Ratio
				Principal Payment	Interest	Principal Payment	Interest		O&M	Depre-ciation*3	Interest					O&M	Tax	Principal	Interest		
1		2006	1,204		16		16	0	0		32				0	0	0		32	-32	
2		2007	6,819		108		104	0	0		213				0	0	0		213	-213	
3		2008	296		112		108	-1,404	0		220				-1,404	0	0		220	-1,625	
4		2009	357		117		113	0	0		230				0	0	0		230	-230	
5		2010	12,893		291	178	257	0	0		548	-548	0	-548	0	0	0	178	548	-726	0.000
6		2011	6,724		382	178	322	-11,144	-3		704	-11,845	0	-11,845	-11,144	-3	0	178	704	-12,023	-12.642
7	1	2012	152		384	178	300	317	-17	958	684	-1,309	0	-1,309	317	-17	0	178	684	-529	0.387
8	2	2013			384	178	277	380	-20	958	661	-1,219	0	-1,219	380	-20	0	178	661	-439	0.477
9	3	2014			384	178	254	380	-20	958	638	-1,196	0	-1,196	380	-20	0	178	638	-416	0.491
10	4	2015			384	178	231	380	-20	958	615	-1,173	0	-1,173	380	-20	0	178	615	-393	0.505
11	5	2016		1,280	365	178	208	380	-20	958	573	-1,131	0	-1,131	380	-20	0	1,458	573	-1,630	0.197
12	6	2017		1,280	346	178	185	380	-20	569	530	-699	0	-699	380	-20	0	1,458	530	-1,588	0.201
13	7	2018		1,280	326	178	162	380	-20	569	488	-657	0	-657	380	-20	0	1,458	488	-1,546	0.206
14	8	2019		1,280	307	178	139	380	-20	569	446	-614	0	-614	380	-20	0	1,458	446	-1,503	0.210
15	9	2020		1,280	288	178	116	380	-20	569	404	-572	0	-572	380	-20	0	1,458	404	-1,461	0.215
16	10	2021		1,280	269	178	92	380	-20	569	361	-530	0	-530	380	-20	0	1,458	361	-1,419	0.220
17	11	2022		1,280	250	178	69	380	-20	569	319	-488	0	-488	380	-20	0	1,458	319	-1,376	0.225
18	12	2023		1,280	230	178	46	380	-20	569	277	-445	0	-445	380	-20	0	1,458	277	-1,334	0.231
19	13	2024		1,280	211	178	23	380	-20	569	234	-403	0	-403	380	-20	0	1,458	234	-1,292	0.237
20	14	2025		1,280	192	178	0	38,405	110	569	192	37,535	5,146	32,388	38,405	110	5,146	1,458	192	31,499	20.093
21	15	2026		1,280	173		0	38,405	110	569	173	37,554	13,144	24,410	38,405	110	13,144	1,280	173	23,699	17.313
22	16	2027		1,280	154		0	38,405	110	569	154	37,573	13,151	24,422	38,405	110	13,151	1,280	154	23,711	17.540
23	17	2028		1,280	134		0	38,405	110	569	134	37,592	13,157	24,435	38,405	110	13,157	1,280	134	23,724	17.773
24	18	2029		1,280	115		0	38,405	110	569	115	37,611	13,164	24,447	38,405	110	13,164	1,280	115	23,736	18.013
25	19	2030		1,280	96		0	38,405	110	569	96	37,631	13,171	24,460	38,405	110	13,171	1,280	96	23,749	18.259
26	20	2031		1,280	77		0	38,405	110	569	77	37,650	13,177	24,472	38,405	110	13,177	1,280	77	23,761	18.513
27	21	2032		1,280	58		0	38,405	110	569	58	37,669	13,184	24,485	38,405	110	13,184	1,280	58	23,774	18.774
28	22	2033		1,280	38		0	38,405	110	569	38	37,688	13,191	24,497	38,405	110	13,191	1,280	38	23,786	19.042
29	23	2034		1,280	19		0	38,405	110	569	19	37,707	13,198	24,510	38,405	110	13,198	1,280	19	23,799	19.318
30	24	2035		1,280	0		0	38,405	110	569	0	37,727	13,204	24,522	38,405	110	13,204	1,280	0	23,811	19.603
															Average DSCR (Debt Service Coverage Ratio):						7.515
		Total	28,444	25,600	6,211	2,844	3,023	414,792	951		Return on Investment (ROI):			**8.6%**	Loan Life Debt Service Coverage Ratio (LLCR)*1:						**5.577**

Note: *1 Discounted at 2.65% of weighted average interest rate.
*2 Net sales revenue including VAT (value added tax)
*3 Interest during construction was capitalized in deferred assets and amortized it during five years after inauguration.
*4 Imposed 35% of income tax on net profit which subtracted net deficits if the project entity had net deficits during the nearest past five years.

Table 10.32 Loan Finance Sensitivity of Electricity Tariff

		DSCR	LLRC
Wimalasurendra P/S	**Case 1（Repair as Required）**		
Case-A	50%	4.830	4.311
Case-B	25%	3.906	3.481
Base Case	0%	3.291	2.928
Case-C	-25%	2.659	2.375
Case-D	-50%	1.708	1.544
Trial Case	-70%	1.097	1.008
Wimalasurendra P/S	**Case2（Scheduled Replace）**		
Case-A	50%	3.949	3.521
Case-B	20%	3.206	2.853
Base Case	0%	2.698	2.408
Case-C	-20%	2.187	1.962
Case-D	-50%	1.421	1.292
Trial Case	-64%	1.091	1.001
Old Laxapana Stage I P/S			
Case-A	50%	9.229	7.896
Case-B	20%	7.409	6.338
Base Case	0%	6.195	5.300
Case-C	-20%	4.981	4.261
Case-D	-50%	3.161	2.703
Trial Case	-82%	1.224	1.046
New Laxapana P/S			
Case-A	50%	11.189	8.284
Case-B	20%	8.989	6.663
Base Case	0%	7.523	5.582
Case-C	-20%	6.057	4.502
Case-D	-50%	3.859	2.880
Trial Case	-84%	1.378	1.039

Table 10.33 Loan Finance Sensitivity of Foreign Loan Condition

		ROI	DSCR	LLRC
Wimalasurendra P/S	**Case 1（Repair as Required）**			
Case-A	1.0%	7.8%	3.435	3.109
Base Case	1.5%	8.3%	3.291	2.928
Case-B	5.0%	11.6%	2.651	1.992
Case-C	10.0%	16.3%	2.205	1.244
Case-D	15.0%	21.1%	1.946	0.816
Trial Case	12.0%	18.2%	2.130	1.070
Wimalasurendra P/S	**Case2（Scheduled Replace）**			
Case-A	1.0%	7.9%	2.828	2.550
Base Case	1.5%	8.3%	2.698	2.408
Case-B	5.0%	11.6%	2.185	1.664
Case-C	10.0%	16.4%	1.835	1.054
Case-D	15.0%	21.1%	1.639	0.689
Trial Case	10.0%	16.4%	1.880	1.080
Old Laxapana Stage I P/S				
Case-A	1.0%	7.9%	6.659	5.590
Base Case	1.5%	8.4%	6.195	5.300
Case-B	5.0%	11.7%	4.553	3.780
Case-C	10.0%	16.4%	3.578	2.565
Case-D	15.0%	21.2%	3.047	1.897
Trial Case	29.0%	34.4%	2.300	1.036
New Laxapana P/S				
Case-A	1.0%	8.1%	7.616	6.114
Base Case	1.5%	8.6%	7.523	5.582
Case-B	5.0%	11.9%	6.817	2.966
Case-C	10.0%	16.7%	6.028	1.176
Case-D	15.0%	21.4%	5.453	0.403
Trial Case	10.0%	16.7%	6.022	1.175

11. ENVIRONMENTAL IMPACT ASSESSMENT

11. ENVIRONMENTAL IMPACT ASSESSMENT

11.1 Awareness of Environmental and Social Issues in Sri Lanka

There are some development projects that have not been promoted smoothly because of citizens' objections. Probable environmental and/or social issues have been raised as reasons to object. Those projects include not only electric power generation projects, which are vulnerable to criticism, such as the Upper Kotmale Hydropower Project and Coal Fired Thermal Development Project, West Coast, but also other various kinds of projects such as road construction, mine development, shrimp cultivation, etc.

Views raised by the projects opponents can be summarized after studying some cases.

- The project has problems regarding the natural environment.
- The project has problems regarding the social environment (especially resettlement plan, compensation, etc.).
- An alternative plan has not been studied though it seems a better option.
- Communication with the residents has not been sufficient.

The lessons that have been learned from the above are: An EIA report should have clear description based on scientific grounds regarding the natural environment. Regarding the social environment, it should include an appropriate resettlement plan (if necessary) and concrete plans for compensation for the loss of residents' livelihood. The procedure through by the priority option has been selected because of its advantages in view of the natural and social environment should be explained. In addition, it is necessary to carry out consultations with the stakeholders from an early stage to obtain their trust and understanding.

However, the rehabilitation of hydropower stations in the Kelani River basin does not aim to install additional structures or facilities but rather to maintain or replace the existing facilities. Additionally, an alternative study may not be required because of the characteristics of the rehabilitation work.

It is tenuous that the Environmental Impact Assessment (EIA) is necessary for the implementation of this rehabilitation project according to the institutional framework in Sri Lanka.

11.2 Institutional and Legal Framework in Sri Lanka

11.2.1 Governmental Institutions

The Ministry of Environment and Natural Resources handles environmental issues in Sri Lanka, and there are six agencies under the Ministry:

- Central Environmental Authority (CEA)
- State Timber Corporation
- Geological Survey & Mines Bureau
- Forest Department
- Department of Wildlife Conservation
- Department of National Zoological Gardens

11.2.2 Environmental Laws and Regulations

National Environmental Act No. 47 of 1980 (NEA) is Sri Lanka's basic national charter for protection and management of the environment. Regulation on tolerance limits for effluents, regulation on noise control and other regulations are issued under the Act. The framework of the Environmental Impact Assessment (EIA) procedure is also stipulated in the Act.

Other main acts related to the environment are these:

- Agrarian Development Act
- Fauna and Flora Protection Ordinance
- Forest Ordinance
- Mines and Minerals Act
- National Heritage Wildness Areas Act
- Coast Conservation Act
- Marine Pollution Prevention Act
- Fisheries and Aquatic Resources Act

11.3 Procedure of Environmental Impact Assessment

The NEA was amended by Act No. 56 of 1988 to include a provision relating to environmental impact assessment (EIA) contained in Part IV C of the statute entitled 'Approval of Projects'. The details are stipulated in the National Environmental Regulations (Procedure for Approval of Projects). The EIA procedure is specified by an Act and the Regulations as follows:

- The Minister may specify the state agency which shall be the Project Approving Agency (PAA).
- A project proponent of any proposed project shall submit to the PAA preliminary information on the project requested by the appropriate PAA.
- The PAA shall convey in writing to the project proponent the Terms of Reference within 30 days in the case of an Environmental Impact Assessment Report from the date of acknowledging receipt of the preliminary information.
- Upon receipt of an Environmental Impact Assessment Report, the PAA shall, within 14 days, determine whether the matters referred to by the Terms of Reference are addressed and, if the Report is determined to be inadequate, the PAA shall require the project proponent to make necessary amendments and re-submit the report, together with the required number of copies.
- Upon receipt of the Report, the PAA shall submit a copy thereof to the Authority and by prompt notice published in the Gazette and in one national newspaper published daily in the Shinhala, Tamil and English languages invite the public to make written comments, if any, thereon to the PAA within 30 days from the date of the first appearance of the notice, either in the Gazette or in the newspaper.
- It shall be the duty of the PAA, upon completion of the period of public inspection or public hearing, if held, to forward to the project proponent comments received for review and response, within six days. The project proponent shall respond to such comments in writing to the PAA.

- Upon receipt of such responses, the PAA shall with the concurrence of the Authority within 30 days either

  (i) grant approval for the implementation of the proposed project to specified conditions; or

  (ii) refuse approval for the implementation of the proposed project, with reasons for doing so.

The following guidelines are issued by the CEA for the good practice of the EIA:

- Guidance for Implementing the Environmental Impact Assessment (EIA) Process

  No.1: A General Guide for Project Approving Agency (PAA)
  No.2: A General Guide for Conducting Environmental Scoping

The statement on public hearings in the guideline is as follows:

A public hearing may be held at the discretion of the PAA when it thinks that it would be in the public interest to do so. A variety of situations may fall within the meaning of "public interest," and these cannot be exhaustively defined. Factors for the PAA to consider are:

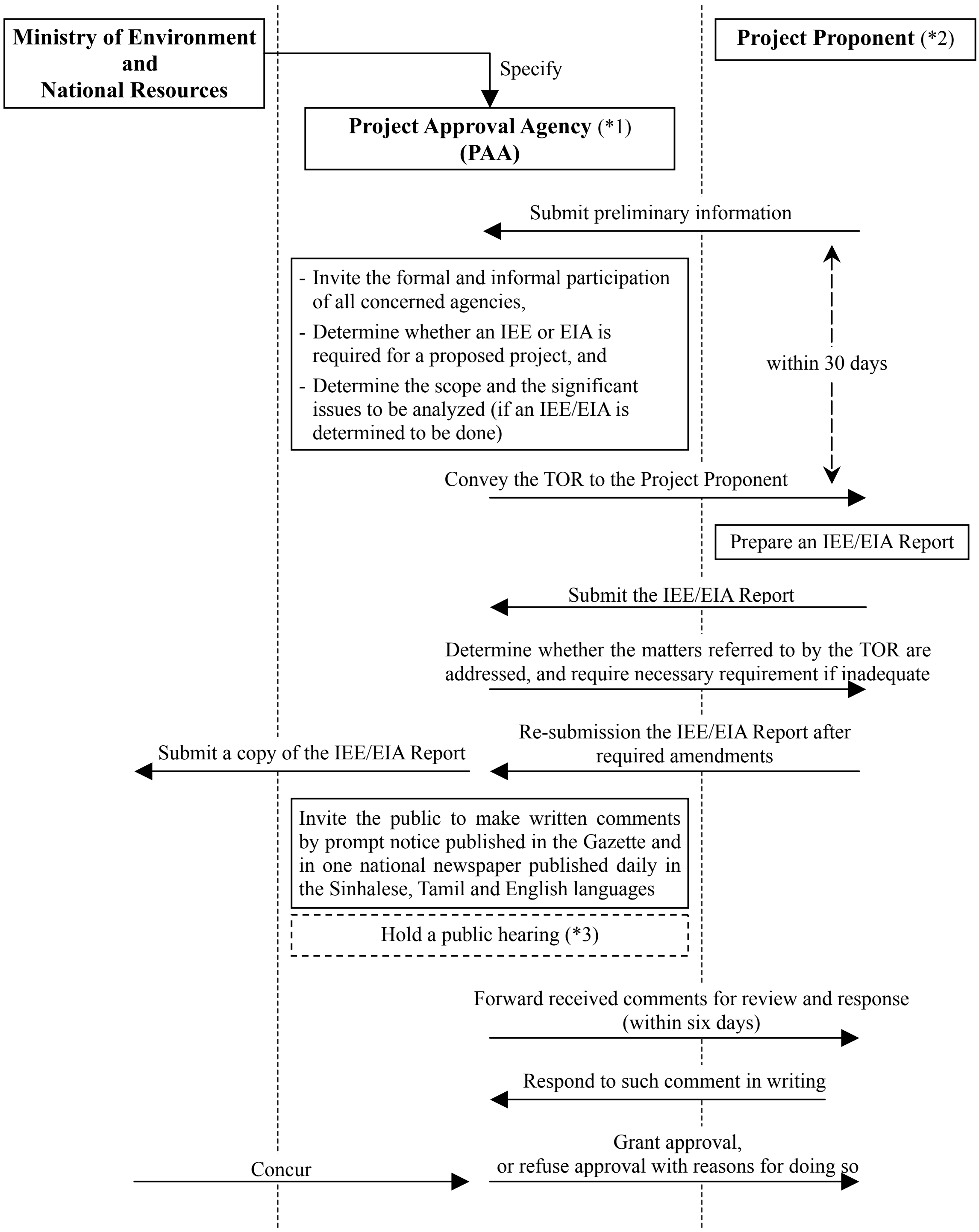
- whether a proposed prescribed project is highly controversial, whether more expressions of public views are essential to make decision;

- whether the proposed prescribed project might cause unusual national regional impacts;

- whether it might threaten a nationally important environmentally sensitive area;

- whether a formal request for a public hearing has been requested by an interested party.

EIA Flow



*1: It is Central Environmental Authority (CEA) in this study
*2: It is CEB in this study
*3: In case of being judged by the PAA to be necessary

11.4 Environmental Impact Assessment for the Rehabilitation of Hydropower Stations in the Kelani River Basin

At this time, it is difficult to judge whether an Initial Environmental Examination (IEE) or EIA is required for the rehabilitation of hydropower stations in the Kelani River basin to obtain approval for the project implementation. The Study Team unofficially consulted with a CEA officer who is in charge of the Upper Kotmale Hydropower Project about the necessity of an IEE or EIA for the rehabilitation during the first study period in Sri Lanka of this study. Then the Study Team obtained an unofficial comment that an IEE or EIA might not be required. Anyway, the necessity of an IEE or EIA should be reconfirmed according to “10.3 Procedure of Environmental Impact Assessment” prior to implementing the rehabilitation.

According to the government notifications in June 24 1993, development work in an area within 100m of an existing reservoir is classified as a project that is required to be approved by the Project Approving Agency (PAA), based on the National Environmental Act. That is to say, the rehabilitation of hydropower stations in the Kelani River basin corresponds to a project which is required to receive approval by the PAA. Part of the government notification is as follows.

- Gazette Extraordinary of the Democratic Socialist Republic of Sri Lanka - 1993.06.24
  --- omission ---

- Part II, All projects and undertakings listed in Part I irrespective of their magnitudes and irrespective of whether they are located in the coastal zone or not, if located wholly or partly with in the areas specified in Part III of the Schedule.

- Part III, --- omission ---, 2. Within the following areas whether or not the areas are wholly or partly within the Coastal Zone: --- omission ---

- any reservation beyond the full supply level of a reservoir. --- omission ---

- “reservoir” means an expanse of water resulting from man made constructions across a river or a stream to store or regulate water. Its environs will include that area extending up to a distance of 100 meters from full supply level of the reservoir inclusive of all islands falling within the reservoir.