Appendixes

APPENDIX A

List of Existing Hydropower Station in Indonesia

APPENDIX A : **List of Existing Hydropower Stations in Indonesia**

1 Java

As of 2009

No.	Nama of Station	Area	Installed Year	Installed capacity (MW)	Designed Annual Energy (GWh)
1	Jelok	Central Java	1938	21.0	97.0
2	Ketenger	Central Java	1939	7.0	31.0
3	Timo	Central Java	1963	12.0	31.0
4	Garung	Central Java	1983	26.0	48.0
5	Wonogiri	Central Java	1983	12.0	33.0
6	Soedirman (Mrica)	Central Java	1989	185.0	580.0
7	Kedungombo	Central Java	1992	23.0	74.0
8	Wadaslintang	Central Java	1988	16.0	92.0
9	Plengan	Weat Java	1922/62	5.2	23.0
10	Ubrug	Weat Java	1924/50	17.0	55.0
11	Lamajan	Weat Java	1924	19.0	71.0
12	Kracak	Weat Java	1927	17.0	60.0
13	Parakan Kondang	Weat Java	1955	10.0	53.0
14	Cikalong	Weat Java	1961	19.0	65.0
15	Saguling	Weat Java	1987	700.0	2,156.0
16	Cirata	Weat Java	1989	500.0	1,332.0
17	Cirata-2nd stage	Weat Java	1997	500.0	1,332.0
18	Mandalan	East Java	1955	23.0	77.0
19	Siman	East Java	1955	11.0	54.0
20	Sutami (Karangkates)	East Java	1973	105.0	488.0
21	Wlingi	East Java	1979	54.0	167.0
22	Lodoyo	East Java	1983	4.5	37.0
23	Sengguruh	East Java	1989	29.0	99.0
24	Tulung Agung	East Java	1993	36.0	184.0
25	Selorejo	East Java	1973	4.5	20.0
26	Wonorejo	East Java	2002	6.3	32.0
	Total Java			**2,362.5**	**7,291.0**

2 Sumatra

No.	Nama of Station	Province	Installed Year	Installed capacity (MW)	Designed Annual Energy (GWh)
1	Tangga	North Sumatra	1983	317.0	2,054.0
2	Siguragura	North Sumatra	1983	286.0	1,868.0
3	Renun-1	North Sumatra	2005	82.0	618.0
4	Sipansihaporas-1	North Sumatra	2005	33.0	135.0
5	Sipansihaporas-2	North Sumatra	2005	17.0	69.0
6	Batang Agam	West Sumatra	1976	11.0	21.0
7	Maninjau-1	West Sumatra	1983	68.0	270.0
8	Singkarak	West Sumatra	1998	175.0	986.0
9	Kotapanjang	West Sumatra	1998	114.0	542.0
10	Tes-1	South Sumatra	1991	16.0	87.0
11	Besai-1	South Sumatra	2001	90.0	402.0
12	Batu Tegi	South Sumatra	2001	24.0	51.0
13	Musi-1	South Sumatra	2006	210.0	1,120.0
	Total Sumatra			**1,443.0**	**8,223.0**

3 Sulawesi

No.	Nama of Station	Province	Installed Year	Installed capacity (MW)	Designed Annual Energy (GWh)
1	Tonsea lama	North Sulawesi	1981	14.0	58.0
2	Tanggari-1	North Sulawesi	1988	17.0	90.0
3	Tanggari-2	North Sulawesi	1998	19.0	92.0
4	Larona	South Sulawesi	1978	165.0	-
5	Bakaru (1st Stage)	South Sulawesi	1991	126.0	999.0
6	Bili-Bili	South Sulawesi	2005	11.0	70.0
	Total Sulawesi			**352.0**	**1,309.0**

4 Kalimantan

No.	Nama of Station	Province	Installed Year	Installed capacity (MW)	Designed Annual Energy (GWh)
1	Riam Kanan	East Kalimantan	1972	30.0	136.0
	Total Kalimantan			**30.0**	**136.0**

	Total Indonesia			**4,187.5**	**16,959.0**

Source : Prepared by Study Team based on ANNEX 3 List of Planned and Existing Projects of The Preparatory Study for Project for the Master Plan Study of Hydropower Development in Republic of Indonesia (March 2009)

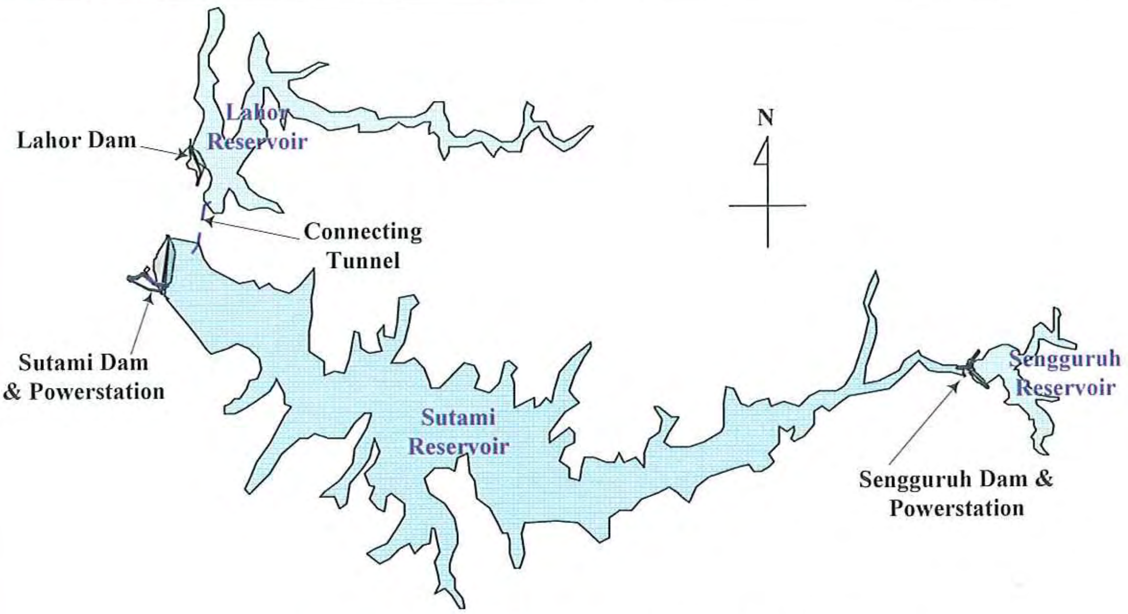
APPENDIX B

Principal Feature of Priority Hydropower Stations

APPENDIX B1 PRINCIPAL FEATURE OF SUTAMI HYDROPOWER STATION

Project Name	Sutami Hydropower Station
Project Location	East Java Province
Installed Capacity	105 MW (35 MW x 3 units)

Layout Outline



General Layout Plan of Sutami Power Station

Dam &Powerhouse

Powerhouse

Table B-1 Principal Features of Sutami Hydropower Station

No.	Structures	Description
1	**Civil Works**	
1.1	Reservoir	-Catchment's area: 2,050 km2 -HWL: El.272.5 m -LWL: El.246.0 m -Gross reservoir capacity: 343 MCM -Effective reservoir capacity: 253 MCM
1.2	Dam	-Type: Rock fill dam with center core -Dam height: 100m -Dam crest length: 810m -Dam crest elevation: El.279m -Dam volume: 6.16 MCM
1.3	Spillway	-Type: Side spillway + Ogee crest gated spillway Side spillway: Overflow crest elevation: El. 272.5 m Effective overflow weir width: 50 m Ogee crest gated spillway: Overflow crest elevation: El.267 m Effective overflow weir width: 10 m
1.4	Connection tunnel	-Type: Concrete lined and circular section tunnel -Inner diameter: 3.0m / 2.5m -Tunnel length: 822m
1.5	Powerhouse	-Type: Above ground type
2.	**Hydro-mechanical Eqipment**	
2.1	Intake trash racks (Screen)	- Type: Fixed - Quantities: 3 sets - Clear span: 8.00 m - Clear height: 13.90 m
2.2	Intake gates and hoists	- Gate type: Fixed wheel gate - Quantities: 3 sets - Clear span: 3.40 m - Clear height: 3.40 m - Type of hoist: 1 Motor – 2 Drum
2.3	Steel penstock and surgetank	- Quantities: 3 lanes - Penstock diameter x Length: 3.4-3.2 m x 229/224/192 m - Surgetank diameter x Length: 7.0 m x 52.2m
2.4	Draft tube gates and hoists	- Gate type: Slide gate - Quantities: 1 lot - Clear span: 3.80 m - Clear height: 3.17 m - Type of hoist: Gantry crane

3.	**Generating Equipment**	
3.1	Water turbine	- Number of units: 3 units - Turbine output: 36,000 kW - Type of turbine: Vertical Francis type - Net head: 78 m - Water discharge: 53.5 m^3/s - Speed: 250 r.p.m. - Manufacturer: Toshiba, Japan
3.2	Generator	- Number of units: 3 units - Output: 39,000kVA - Type of generator: Semi-Umbrella type - Voltage: 11 kV - Power factor: 0.9 - Frequency: 50 Hz. - Manufacturer: Toshiba, Japan
3.3	Main transformer	- Number of units: 3 units - Output: 39,000kVA - Voltage: 11/154 kV - Manufacturer: Toshiba, Japan

Table B-2 Principal Features of Lahor Dam

	Structures	Description
1.	**Civil Works**	
1.1	Reservoir	-Catchment's area: 160 km2 -HWL: El.272.7 m -LWL: El.246.0 m -Gross reservoir capacity: 36.1 MCM
1.2	Dam	-Type: Rock fill dam with center core -Dam height: 75.4 m -Dam crest length: 443 m -Dam crest elevation: El.278 m -Dam volume: 1.67 MCM
1.3	Spillway	-Type: Side spillway -Overflow crest elevation: El. 272.7 m Effective overflow weir width: 35 m

APPENDIX B2 PRINCIPAL FEATURE OF WLINGI HYDROPOWER STATION

Project Name	Wlingi Hydropower Station
Project Location	East Java Province
Installed Capacity	54 MW (27 MW x 2 units)

Layout Outline

General Layout of Wlingi Power Station

Table B-3 Principal Features of Wlingi Hydropower Station

	Structures	Description
1.	**Civil Works**	
1.1	Reservoir	-Catchment's area: 2,890 km2 incl. Sutami dam -HWL: El.163.5 m -LWL: El.162.0 m -Gross reservoir capacity: 24 MCM -Effective reservoir capacity: 5.2 MCM -Annual mean inflow: 109.1 m^3/s
1.2	Dam	-Type: Rock fill dam with center core and earth fill dam -Dam height: 28.5m -Dam crest length: 717m -Dam crest elevation: El.167.5m -Dam volume: 0.61 MCM -Dam design flood: 2,824 m^3/s
1.3	Spillway	-Type: Ogee crest gated spillway -Radial gates: 10m (H) x 10 m(W) x 4 nos
1.4	Powerhouse	-Type: Above ground type
2.	**Hydro-mechanical Equipment**	
2.1	Intake trash racks (Screen)	- Type: Fixed - Quantities: 4 sets - Clear span: 10.50 m - Clear height: 10.00 m
2.2	Mechanical racks	- Type: Trash car - Quantities: 2 sets
2.3	Intake gates	- Gate type: Fixed wheel gates - Quantities: 4 sets - Clear span: 9.50 m - Clear height: 8.50 m - Type of hoist: 1 Motor – 2 Drum
2.4	Draft tube gates and hoists	- Gate type: Slide gate with gantry crane - Quantities: 4 sets - Clear span: 6.20 m - Clear height: 6.54 m - Type of hoist: Gantry crane

3.	**Generating Equipment**	
3.1	Water turbine	- Number of units: 2 units - Turbine output: 27,800kW - Type of turbine: Vertical Kaplan type - Net head: 22 m - Water discharge: 149 m^3/s - Speed: 143 r.p.m. - Manufacturer: Toshiba, Japan
3.2	Generator	- Number of units: 2 units - Output: 30,000kVA - Type of generator: Umbrella type - Voltage : 11 kV - Power factor: 0.9 - Frequency: 50 Hz. - Manufacturer: Meidensha, Japan
3.3	Main transformer	- Number of units: 2 units - Output: 30,000kVA - Voltage : 11/154 kV - Manufacturer: Meidensha, Japan

APPENDIX B3 PRINCIPAL FEATURE OF SOEDIRMAN (MRICA) HYDROPOWER STATION

Project Name	Soedirman (Mrica) Hydropower Station
Project Location	Central Java Province
Installed Capacity	201 MW (67 MW x 3 units)

Layout Outline

General Layout of Soedirman (Mrica) Dam & Power Station

Soedirman Power Station

Table B-4 Principal Features of Soedirman (Mrica) Hydropower Station

	Structures	Description
1.	**Civil Works**	
1.1	Reservoir	-Catchments area: 1,022 km^2 -Max. flood water level: El. 234.50 m -HWL: El.231.00 m (cores. 1,250 ha of reservoir area) -LWL: El.224.50 m -Gross reservoir capacity: 148.29 MCM -Effective reservoir capacity: 46.30 MCM -Dead reservoir capacity: 101.99 MCM
1.2	Dam	-Type: Rock fill dam with center core -Dam height: 95.0 m -Dam crest length: 832.0 m -Dam crest width: 6.0 m -Dam crest elevation: El.235.0 m -Dam volume: 4.915 MCM
1.3	Spillway	-Type: Ogee crest gated spillway -Dam design flood: PMF (8,000 m^3/s) -Overflow crest elevation: El. 220.0 m -Effective overflow width of spillway: 57 m -Release water capacity of spillway: 4,890 m^3/s (excl. the emergency spillway)
1.4	Waterway to power station	-Type: Tunnel -Section: Circular section -Inside diameter: 8.8 m / 7.5 m -Length: 570 m -Max. discharge capacity: 226.8 m^3/s
1.5	Powerhouse	-Type: Above ground type

2.	**Hydro-mechanical Equipment**	
2.1	Spillway gates and hoists	- Gate type: Radial gate - Quantities: 4 sets - Clear span: 14.25 m - Clear height: 11.96 m - Gate radius: 13.00 m - Type of hoist: Hydraulic
2.2	Spillway stoplogs	- Gate type: Slide gate - Quantities: Stoplog 1 set, Guide frame 4 sets - Clear span: 15.18 m - Clear height: 2.831 m @ 4 - Type of hoist: Gantry crane
2.3	Intake trash racks (Screen)	- Type: Removable - Quantities: 2 sets - Clear span: 7.515 m - Clear height: 3.275 m @ 6
2.4	Mechanical Trash racks	- Type: Gantry type - Quantities: 1 set - Rake width: 7.5 m
2.5	Intake gates and hoists	- Gate type: Fixed wheel gate - Quantities: 2 sets - Clear span: 5.00 m - Clear height: 9.00 m - Type of hoist: Hydraulic
2.6	Steel penstocks	- Quantities: 2 lanes - Diameter: 5.20 m to 3.41 m - Length: 1,800 m / 1,700 m
2.7	Draft tube gates and hoists	- Gate type: Slide gate - Quantities: 4 sets - Clear span: 3.832 m - Clear height: 3.610 m - Type of hoist: Gantry crane
2.8	Drawdown culvert (DDC) intake gate	- Gate type: Slide gate - Quantities: 1 set - Clear span: 7.00 m - Clear height: 3.59 m @ 5 + 3.45 m @ 1 - Type of hoist: Gantry crane
2.9	Drawdown culvert (DDC) gates and hoists	- Gate type: High-pressure slide gate - Quantities: 4 sets for 2 lanes - Clear span: 1.70 m - Clear height: 2.65 m - Type of hoist: Hydraulic

3.	Generating Equipment	
3.1	Water turbine	- Number of units: 3 units - Turbine output: 61,500 kW - Type of turbine: Vertical Francis type - Net head: 88.5 m - Water discharge: 74 m^3/s - Speed: 230.8 r.p.m. - Manufacturer: Boving
3.2	Generator	- Number of units: 3 units - Output: 67,010kVA - Type of generator: Umbrella type - Voltage : 13.8 kV - Power factor: 0.9 - Frequency: 50 Hz. - Manufacturer: ASEA
3.3	Main transformer	- Number of units: 3units - Output: 70,000kVA - Voltage : 13.8/154 kV - Manufacturer: ASEA

APPENDIX B4 PRINCIPAL FEATURE OF SAGULING HYDROPOWER STATION

Project Name	Saguling Hydropower Station
Project Location	West Java Province
Installed Capacity	700 MW (175 MW x 4 units)

Layout Outline

General Layout of Saguling Dam

Saguling Power Station

Table B-5 Principal Features of Saguling Hydropower Station

No.	Structures	Description
1.	**Civil Works**	
1.1	Reservoir	-Catchment's area: 2,283 km2 -Max. flood water level: El. 645.00 m(correspond. 5,343 ha of reservoir area) -HWL: El.643.00 m (correspond. 4,869 ha of reservoir area) -LWL: El.623.00 m -Gross reservoir capacity: 970 MCM (correspond. Max. Flood water level) and 875 MCM (correspond. HWL) -Effective reservoir capacity: 611MCM -Dead reservoir capacity: 264 MCM
1.2	Dam	-Type: Rock fill dam with center core -Dam height: 97.5 m -Dam crest length: 301.4 m -Dam crest width: 10.0 m -Dam crest elevation: El.650.5 m -Dam volume: 2.79 MCM
1.3	Spillway	-Type: Side spillway + Ogee crest gated spillway -Dam design flood: 10,000 year probability flood (6,600 m3/s) -Release water capacity of spillway; 6,600 m3/s <u>Side spillway</u> -Overflow crest elevation: El. 643.0 m -Effective overflow width of spillway: 62 m <u>Ogee crest gated spillway</u> -Gate: Slide gates, 3 nos -Effective overflow width: 10 m x 8.3 m x 3 nos. -Overflow crest elevation: El.634.70 m
1.4	Waterway to power station	<u>Headrace tunnel</u> -Type: Pressure flow tunnel -Section: Circular section -Inside diameter: 5.8 m x 2 lanes -Length: 4,667.7 m / 4,668.2 m -Entrance gate: Slide gate -Max. discharge capacity: 224 m^3/s <u>Surge tank</u> -Section: Circular section, 2 nos -Inner diameter:12.0 m -Height:103.2 m / 98.2 m <u>Steel penstock</u> -Type: Steel pipe -Length: 1,868 m / 1,768 m, 2 lines -Inner diameter: 4.30 m / 2.83 m
1.5	Powerhouse	-Type: Semi-underground type -Size: 32.5 m (W) x 104.4 m (L)x 42.5 m(H)

2.	**Hydro-mechanical Equipment**	
2.1	Spillway gates and hoists	- Gate type: Fixed wheel gate - Quantities: 3 sets - Clear span: 10.0 m - Clear height: 8.3 m - Type of hoist: 1 Motor – 2 Drum
2.2	Spillway stoplogs	- Gate type: Slide gate - Quantities: Stop log 1 set Guide frame 3 sets - Clear span: 10.0 m - Clear height: 8.3 m - Type of hoist: Monorail hoist
2.3	Intake trash racks (Screen)	- Type: Fixed - Quantities: 4 sets - Clear span: 9.0 m - Clear height: 32.00 m
2.4	Mechanical trash rakes	- Type: Trash car - Quantities: 1 set - Rake width: 3.0 m
2.5	Intake gates and hoists	- Gate type: Fixed wheel gate - Quantities: 2 sets - Clear span: 5.80 m - Clear height: 5.80 m - Type of hoist: 1 Motor – 2 Drum
2.6	Steel penstocks	- Quantities: 2 lane - Diameter: 4.3 m to 2.83 m - Length: (No.1 /2) 1,868 m / 1,768 m
2.7	Draft tube gates and hoists	- Gate type: Fixed wheel gate - Quantities: 1 set - Clear span: 3.825 m - Clear height: 3.200 m - Type of hoist: Gantry crane

3.	Generating Equipment	
3.1	Water turbine	- Number of units: 4 units - Turbine output: 178,800 kW - Type of turbine: Vertical Francis type - Net head: 355.7 m - Water discharge: 56 m^3/s - Speed: 333.3 r.p.m. - Manufacturer: Toshiba, Japan
3.2	Generator	- Number of units: 4 units - Output: 206,100 kVA - Type of generator: Umbrella type - Voltage : 16.5 kV - Power factor: 0.85 - Frequency: 50 Hz. - Manufacturer: Mitsubishi, Japan
3.3	Main transformer	- Number of units: 2 units - Output: 412,200kVA for 2 units - Voltage : 16.5/500 kV - Manufacturer: Mitsubishi, Japan

APPENDIX C

Result of Site Investigation

Table C1-1 Summary of Investigation for Hydro-Mechanical Equipment at SUTAMI Hydropower Station

Name of Hydropower Station:	Sutami (Karang Kates)	
Constructed (Year)	1972/75	
Fabricator (Contractor)	Sakai Iron Works	
Equipment & Specifications	**Data**	**Observation**
Intake Trash Racks (Screen) - Type - Quantities - Clear Span - Clear Height	 Fixed 3 sets 8.00 m 13.90 m	These screens are submerged and not observed. O & M staff reported no trouble about choking trash racks.
Intake Gates and Hoists - Gate Type - Quantities - Clear Span - Clear Height - Type of Hoist	 Fixed Wheel Gate 3 sets 3.40 m 3.40 m 1Motor-2Drum	O & M staff reported that no trouble about operation. It is observed that, (1) Whole system have been well maintained, and (2) Control cabinets have been superannuated.
Steel Penstocks and Surgetank - Quantities - Penstock Diameter x Length - Surgetank Diameter x Length	 3 lanes 3.4-3.2 m x 229/224/192m 7.0 m x 52.2 m	Observation was made by visual inspection from outside. Well maintained, and Good
Draft Tube Gates and Hoists - Gate Type - Quantities - Clear Span - Clear Height - Type of Hoist	 Slide Gate 1 lot 3.80 m 3.17 m Gantry Crane	Observation was made by visual inspection. Well maintained, and Good

Table C1-2 Detailed Investigation for Hydro-Mechanical Equipment at SUTAMI Hydropower Station

Name of Hydropower Station:	Sutami (Karang Kates)	
Check Points	**Conditions of Equipment**	**Remarks**
Intake Gates and Hoist Unit No. 1		
- Water leakage	A little leakage	Scheduled to replace seals at next maintenance period.
- Function of gate wheels	OK	
- Function of gate hoists	OK	
- Mechanical damage of structures	OK	
- Damage of protective coating	OK	

Other Observations:

1. Visual inspection was made for hoist. Conditions of intake gate leaves were monitored by interview to operation and maintenance staffs.
2. Gate leaves are sound and no need to be rehabilitated.
3. Hoists are sound and no need to be rehabilitated.
4. Local control cabinets have been deteriorated and most of the cover glasses with colors on the control cabinet have been broken. It is necessary to clean inside of the panel by a vacuum cleaner.
5. There is no problem about spare parts supply other than the above covers.
6. Model of the control cabinet has been old and it is recommended to replace with the new ones conforming to the latest codes of electric appliances.

Table C1-3 Summary of Investigation for Generating Equipment at SUTAMI Hydropower Station

Name of Hydropower Station:	Sutami (Karang Kates)	
Constructed (Year)	Unit 1 1973 / Unit 2 1976 / Unit 3 1976	
Fabricator (Contractor)	Toshiba	
Equipment & Specifications	**Data**	**Observation**
Water Turbine		
- Type	Vertical Francis	Well maintained
- Quantities	3 sets	
- Manufacturer	Toshiba	
- Rated head	85.4 m	
- Rated output	36 MW	
- Material runner	Cast steel	Composition :18% Cr, 8% Ni
Inlet Valve		
- Type	Butterfly	Water leakage from was continuously occurred. The tray is added to drain ditch.
- Quantities	3 sets	
- Manufacturer	Toshiba	
- Diameter	3.75 m	
- Operating method	Hydraulic	
Governor		
- Type	Mechanical Governor	With Pendulum motor & PMG
- Quantities	3 sets	Mechanical unloader valve replacement for Unit 2 in 2009 and for Unit 3 in 2010.
- Manufacturer	Toshiba	Change with Electronic type is planned
Generator		
- Type	Semi Umbrella	Well maintained
- Manufacturer	Toshiba	
- Voltage	11 kV	
- Rated capacity	39 MVA	
- Power factor	0.9	
Supervisory and Control System		
- Type	Analog type control	All protection relays and meters are analog type and not more produced.
- Manufacturer	Toshiba	
- Type of protection relay	Mechanical Relay	
- Unit Control	Relay sequence	
- Synchronization	Common synchro for 3 units	5 minutes max and 3 minute normal

Table C1-4 Detailed Investigation for Generating Equipment at SUTAMI Hydropower Station

Name of Hydropower Station:	Sutami (Karang Kates)	
Check Points	**Conditions of Equipment**	**Remarks**
Water Turbine No.1		
- Runner cavitations	Average depth 3 mm	At major overhaul in 2004
- Temperature of bearing	Average 58°C	Alarm 60°C, Trip 65°C If 59°C, cleaning cooler.
- Wear and corrosion of bearing	Normal	Re-babbit after 8 year (base on condition)
- Function of guide vane operating system	Normal	Replaced U packing (leather material) annually (8 ea)
- Function of governor	Normal	Hunting at 35MW sometimes, Drain oil on dashpot, clean pilot valve bushing
Water Turbine No.2		
- Runner cavitations	Average depth 3 mm	At major overhaul in 2006
- Temperature of bearing	Average 58°C	Alarm 60°C, Trip 65°C If 59°C, cleaning cooler
- Wear and corrosion of bearing	Normal	Rebabbit after 8 year (base on condition)
- Function of guide vane operating system	Normal	Replaced U packing, annually (8 ea) and L packing. Replaced servo motor in 2009
- Function of governor	Normal	Hunting at 35MW, sometimes Drain oil on dashpot, clean pilot valve bushing
Water Turbine No.3		
- Runner cavitations	Average depth 3mm	At major overhaul in 2008
- Temperature of bearing	Average 58°C	Alarm 60°C, Trip 65°C If 59°C, cleaning cooler
- Wear and corrosion of bearing	Normal	Rebabbit after 8 year (base on condition)
- Function of guide vane operating system	Normal	Replaced U packing annually (8 ea) and L packing. Planned servo motor replace in 2010.
- Function of governor	Normal	Hunting at 35 MW, sometime. Drain oil on dashpot, clean pilot valve bushing.
Inlet Valve No.1		
- Function of inlet valve	Normal	
- Water leakage	Leakage	Gland packing degradation
- Wear condition of seal, valve body and valve bearing	Normal	Visual inspection
Inlet Valve No.2		
- Function of inlet valve	Normal	
- Water leakage	Leakage	Gland packing degradation
- Wear condition of seal, valve body and valve bearing	Normal	Visual inspection
Inlet Valve No.3		

- Function of inlet valve	Normal	
- Water leakage	Leakage	Gland packing degradation
- Wear condition of seal, valve body and valve bearing	Normal	Visual inspection
Generator No.1		
- Insulation of stator coil - Insulation of rotor coil	Normal Normal	Megger, polarity index and winding resistance at major overhaul in 2004.
- Function of exciter system	Normal	
- Temperature of bearings	Average 58°C	Within the allowable value
- Vibration of shaft	Normal	
Generator No.2		
- Insulation of stator coil - Insulation of rotor coil	Normal	Megger, polarity index, winding resistance at major overhaul in 2006.
- Function of exciter system	Normal	
- Temperature of bearings	Average 58°C	Within the allowable value
- Vibration of shaft	Normal	
Generator No.3		
- Insulation of stator coil - Insulation of rotor coil	Normal	Megger, polarity index, winding resistance at major overhaul in 2008.
- Function of exciter system	Normal	
- Temperature of bearings	Normal	Within the allowable value
- Vibration of shaft	Normal	
Supervisory and Control System		
- Function of protection relay	Normal	All relays are analog type.
- Function of control system - Function of supervisory system	Normal Normal	
Switchgear		
- Function of 11kV switchgear	Normal	
- Function of low voltage switchgear	Normal	
Transformer		
- Oil leakage	Leakage	Small leakage was found in 2009.
- Temperature of coil and oil	Average 85°C	Within the allowable value
- Damage of HT and LT bushings	Normal	

Other problems to be solved:

Non-availability of spare parts for (a) Motor 65, 77, 90, (b) Loader and un-loader valve for governor sump tank, and (c) Governor dashpot

Table C1-5 Summary of Visual Inspection for Civil Structures at SUTAMI Hydropower Station

Name of Hydropower Station:	Sutami (Karang Kates)	
Constructed (Year)	Sutami Dam : 1972, Lahor Dam :1977, Power Station :1973.	
Inspection date	05 to 07 April 2010	
Structures / Inspection Items	**Conditions of Structures**	**Remarks**
1. Sutami Dam		
1.1 Main Dam		According to the JASA TILTA I, no serious problem has not been observed at the Sutami main dam through their visual inspection and measuring results by the monitoring apparatus
- Foundation Settlement	Not observed	
- Deformation of Dam Body	Not observed	
- Water Leakage	Acceptable Range	
- Open Crack	Not observed	
- Slope sliding	Not observed	
- Others	-	
1.2 Spillway		Energy dissipater of the spillway had been repaired in 2007 by the financial assistance of Japan ODA Loan.
- Deformation	Not observed	
- Water Leakage	Acceptable Range	
- Open Crack	Acceptable Range	
- Abrasion / Scouring	Repaid	
- Others	-	
2. Lahor Dam		
2.1 Main Dam		According to the JASA TILTA I, no serious problem has not been observed at the Lahor main dam through their visual inspection and measuring results by the monitoring apparatus
- Foundation Settlement	Not observed	
- Deformation of Dam Body	Not observed	
- Water Leakage	Acceptable Range	
- Open Crack	Not observed	
- Slope sliding	Not observed	
- Others	-	
2.2 Spillway		
- Deformation	Not observed	
- Water Leakage	Acceptable Range	
- Open Crack	Acceptable Range	
- Abrasion / Scouring	Not observed	
- Others	-	

Structures / Inspection Items	Conditions of Structures	Remarks
3. Waterway		Headrace tunnel has not been inspected due to filling water. According to the PJB, no significant problem has been observed in the headrace tunnel.
3.1 Intake Tower		
- Foundation Settlement	Not observed	
- Deformation	Not observed	
- Open Crack	Acceptable Range	
- Others	-	
3.2 Penstock Anchor Block		
- Foundation Settlement	Not observed	
- Deformation	Not observed	
- Open Crack	Acceptable Range	
- Others	-	
4. Powerhouse		Well maintained
- Foundation Settlement	Not observed	According to the PJB, periodical inspection for the powerhouse civil structure has not been performed. However, no serious problem has been observed at the powerhouse civil structure.
- Deformation	Not observed	
- Water Leakage	Not observed	
- Open Crack	Acceptable Range	
- Others	-	

Table C2-1 Summary of Investigation for Hydro-Mechanical Equipment at WLINGI Hydropower Station

Name of Hydropower Station:	Wlingi	
Constructed (Year)	1978	
Fabricator (Contractor)	Marushima Hydraulic Gate Works	
Name of Equipment & Specifications	**Data**	**Observation**
Intake Trash Racks (Screen) - Type - Quantities - Clear Span - Clear Height	 Fixed 4 sets 10.50 m 10.00 m	The screens are submerged and not observed. O & M staff reported no trouble about choking trashracks. Trash cleaning operation has been done whenever required without trouble.
Mechanical Rakes - Type - Quantities	 Trash car 2 sets	The mechanical rakes had been relocated from Sengguruh dam and have been replaced with the new ones. Well maintained
Intake Gates - Gate Type - Quantities - Clear Span - Clear Height - Type of Hoist	 Fixed wheel gate 4 sets 9.50 m 8.50 m 1 Motor – 2 Drum	Observation was made by visual inspection. O & M staff reported no trouble about operation and maintenance. Well maintained.
Draft Tube Gates and Hoists - Gate Type - Quantities - Clear Span - Clear Height - Type of Hoist	 Slide gate with gantry crane 4 set 6.20 m 6.54 m Gantry Crane	Observation was made by visual inspection. O & M staff reported no trouble about operation and maintenance. Well maintained, and Good

Other Observations:

1. Visual inspection was made for intake gate and its hoists.
2. Conditions of intake gate leaves were good.
3. Conditions of hoists with control system were good.
4. There is no problem about spare parts supply.

Table C2-2 Summary of Investigation for Generating Equipment at WLINGI Hydropower Station

Name of Hydropower Station:	Wlingi	
Constructed (Year)	Unit 1 in 1978, Unit 2 in 1980	
Fabricator (Contractor)	Sumitomo Corpration	
Equipment & Specifications	**Data**	**Observation**
Water Turbine		
- Type	Vertical Kaplan	Well maintained.
- Quantities	2 sets	
- Manufacturer	Toshiba	
- Rated head	22 m	
- Rated output	27.8 MW	
- Material runner		Stainless steel
Governor		
- Type	Mechanical Governor	With Pendulum & PMG
- Quantities	2 sets	
- Manufacturer	Toshiba	
Generator		
- Type	Umbrella	Well maintained.
- Manufacturer	Meidensha	1 AVR failed.
- Voltage	11kV	
- Rated capacity	30MVA	
- Power factor	0.9	
Supervisory and Control System		
- Type	Analog type control	
- Manufacturer	Meidensha	
- Type of protection relay	Mechanical Relay	

Table C2-3 Detailed Investigation for Generating Equipment at WLINGI Hydropower Station

Name of Hydropower Station:	Wlingi	
Check Points	**Conditions of Equipment**	**Remarks**
Water Turbine No.1		
- Runner cavitations	90 cm^3 (all pitting volume)	At major overhaul in 2006
- Temperature of bearing	Normal (22°C in average)	Within the allowable value
- Wear and corrosion of bearing	Normal	
- Function of guide vane operating system	Normal	
- Function of governor	Normal	
Water Turbine No.2		
- Runner cavitations	51 cm^3 (total pitting volume)	At major overhaul in 2008
- Temperature of bearing	Normal (22°C in average)	Within the allowable value
- Wear and corrosion of bearing	Normal	
- Function of guide vane operating system	Normal	
- Function of governor	Normal	
Generator No.1		
- Insulation of stator coil - Insulation of rotor coil	Normal	Only megger measurement at overhaul in 2006
- Function of exciter system	Decrease the performance due to obsolete spare parts/materials	In process of the replacement
- Temperature of bearings	Normal	Within the allowable value
- Vibration of shaft	Normal	
Generator No.2		
- Insulation of stator coil	Normal	Only megger measurement at overhaul in 2008
- Function of exciter system	Decrease the performance due to obsolete spare parts/materials	In process of the replacement.
- Temperature of bearings	Normal	Within the allowable value
- Vibration of shaft	Normal	
Supervisory and Control System		
- Function of protection relay	Ground voltage relay for Unit 1 is broken	Planned to be replaced
- Function of control system	Normal	
Switchgear		
- Function of 11kV switchgears	Normal	
- Function of low voltage switchgers	Normal	
Transformer		
- Oil leakage	No leakage	
- Temperature of coil and oil	Normal	Within the allowable value
- Damage of HT and LT bushings	No damage	

Table C2-4 Summary of Visual Inspection
for Civil Structures at WLINGI Hydropower Station

Name of Hydropower Station:	Wlingi	
Constructed (Year)	Wlingi Dam : 1976, Power Station :1979	
Inspection date	07 April 2010	
Structures / Inspection Items	**Conditions of Structures**	**Remarks**
1. Wlingi Dam		
1.1 Main Dam - Foundation Settlement - Deformation of Dam Body - Water Leakage - Open Crack - Slope sliding - Others	 Not observed Not observed Acceptable Range Not observed Not observed -	According to the JASA TILTA I, no serious problem has not been observed at the Wlingi main dam through their visual inspection and measuring results by the monitoring apparatus
1.2 Spillway - Deformation - Water Leakage - Open Crack - Abrasion / Scouring - Others	 Not observed Acceptable Range Acceptable Range Not observed -	
2. Waterway		
2.1 Intake Tower - Foundation Settlement - Deformation - Open Crack - Others	 Not observed Not observed Acceptable Range -	
3. Powerhouse - Foundation Settlement - Deformation - Water Leakage - Open Crack - Others	 Not observed Not observed Not observed Acceptable Range (See Note) -	Well maintained ***Note : newly hair clack has been observed at upstream side wall of the powerhouse. At present the crack is not serous level, however, periodical inspection should be performed.***

Table C3-1 Summary of Investigation for Hydro-Mechanical Equipment at SOEDIRMAN Hydropower Station

Name of Hydropower Station:	Soedirman (Mrica)	
Constructed (Year)	1988	
Fabricator (Contractor)	Boving	
Equipment & Specifications	**Data**	**Observation**
Spillway Gates and Hoists		
- Gate Type	Radial Gate	A little leakage was observed on seal for Gate No. 3.
- Quantities	4 sets	Scheduled to adjust the seal at next maintenance.
- Clear Span	14.25 m	Others are maintained well, and Good.
- Clear Height	11.96m	
- Gate Radius	13.00 m	
- Type of Hoist	Hydraulic	
Spillway Stoplogs		
- Gate Type	Slide Gate	Well maintained, and Good
- Quantities	Stoplogs 1 set Guide Frame 4 sets	
- Clear Span	15.18	
- Clear Height	2.831 m @ 4	
- Type of Hoist	Gantry Crane	
Intake Trash Racks (Screen)		
- Type	Removable	These screens are submerged and not observed.
- Quantities	2 sets	O & M staff reported that no damage has been found during inspection at drying up.
- Clear Span	7.515 m	Well maintained, and Good
- Clear Height	3.275 m @ 6	
Mechanical Trash Rakes		
- Type	Gantry Type	Well maintained, and Good
- Quantities	1 set	
- Rake Width	7.5 m	
Intake Gates and Hoists		
- Gate Type	Fixed wheel gate	Well maintained, and Good
- Quantities	2 sets	
- Clear Span	5.00 m	
- Clear Height	9.00 m	
- Type of Hoist	Hydraulic	
Steel Penstocks		
- Quantities	2 lanes	Well maintained, and Good
- Diameter	5.20 m to 3.41 m	
- Length	1,800/1,700 m	

Equipment & Specifications	Data	Observation
Draft Tube Gates and Hoists		
- Gate Type	Slide gate	Well maintained, and Good
- Quantities	4 sets	
- Clear Span	3.832 m	
- Clear Height	3.610 m	
- Type of Hoist	Gantry crane	
Drawdown Culvert (DDC) Intake Gate		
- Gate Type	Slide gate	Well maintained, and Good.
- Quantities	1 set	
- Clear Span	7.00 m	
- Clear Height	3.59 m @ 5 + 3.45 m @ 1	
- Type of Hoist	Gantry crane	
Drawdown Culvert (DDC) Gates and Hoists		
- Gate Type	High-pressure Slide gate	Well maintained, and Good. A little leakage was observed at the top flange of cylinder for guard gate Lane No. 1. Small seepage was observed between upstream side of gate bonnet of the guard gate for Lane 1. See photo No. 100409-17.
- Quantities	4 sets for 2 lanes	
- Clear Span	1.70 m	
- Clear Height	2.65 m	
- Type of Hoist	Hydraulic	

Table C3-2 Detailed Investigation for Drawdown Culvert Gates and Hoists at SOEDIRMAN Hydropower Station

Name of Hydropower Station:	Soedirman (Mrica)	
Check Points	**Conditions of Equipment**	**Remarks**
Spillway Gate and Hoist No. 3		
- Water leakage	OK	A little leakage at seal
- Function of gate wheels	OK	
- Function of gate hoists	OK	
- Mechanical damage of structures	OK	
- Damage of protective coating	OK	
Drawdown Culvert (DDC) Guard Gate and Hoist for Lane No. 1		
- Water leakage	OK	
- Function of gate wheels	OK	
- Function of gate hoists	OK	A little leakage at operation
- Mechanical damage of structures	OK	
- Damage of protective coating	OK	

Other Observations:

1. Visual inspection was made for gates and hoists. Conditions of gates and hoists were monitored by interview to operation and maintenance staffs.
2. Gate leaves are sound and no need to be rehabilitated.
3. Hoists are sound and no need to be rehabilitated.
4. A little leakage was observed at water seal of Spillway Gate No. 3. This leakage was very little and does not influence the others. The seal is schedule to be replaced at next annual maintenance
5. A little leakage was reported at the top flange of hydraulic cylinder during closing operation of the DDC guard gate of Lane 1. The gasket is scheduled to be replaced at next annual maintenance.
6. A little seepage was observed at the upstream end of DDC guard Gate of Lane 1. The seepage was newly found last year and its quantity has been observed periodically.
7. There is no problem about spare parts supply other than the above covers.
8. No replacement of hydraulic fluid has been done since 1988. We advised the staff to check quality of hydraulic fluid and replace the fluid periodically.

Table C3-3 Summary of Investigation for Generating Equipment at SOEDIRMAN Hydropower Station

Name of Hydropower Station:	Soedirman (Mrica)	
Constructed (Year)	1988	
Fabricator (Contractor)	Boving	
Equipment & Specifications	**Data**	**Observation**
Water Turbine		
- Type	Vertical Francis	Well maintained.
- Quantities	3 sets	
- Manufacturer	Boving	
- Rated head	88.5 m	
- Rated output	60.5 MW	
- Material runner	Stainless steel	
Inlet Valve		
- Type	Butterfly	Water leakage from valve bearing was continuously occurred. IP is planned to replace seal packing in 2010.
- Quantities	3 sets	
- Manufacturer	Boving	
- Diameter	3.41 m	
- Operating method	Hydraulic	
Governor		
- Type	E40M	Electric type governor was introduced and it was well maintained.
- Quantities	3 sets	
- Manufacturer	Boving	
Generator		
- Type	Umbrella	Well maintained
- Manufacturer	ASEA	
- Voltage	13.8kV	
- Rated capacity	67.6MVA	
- Power factor	0.9	
Supervisory and Control System		
- Type	Automatic with PLC	Replacement of control system was done in 2006. The supervisory and control was adopted with computerized system.
- Manufacturer	Schneider	
- Type of protection relay	Digital	

Table C3-4 Detailed Investigation for Generating Equipment at SOEDIRMAN Hydropower Station

Equipment & Specifications	Data	Observation
Water Turbine No.1		
- Runner cavitations	OK	Repair at annual inspection
- Temperature of bearing	OK	Within the allowable value
- Wear and corrosion of bearing	OK	
- Function of guide vane operating system	OK	
- Function of governor	OK	
Water Turbine No.2		
- Runner cavitations	OK	Repair at annual inspection
- Temperature of bearing	OK	Within the allowable value
- Wear and corrosion of bearing	OK	
- Function of guide vane operating system	OK	
- Function of governor	OK	
Water Turbine No.3		
- Runner cavitations	OK	Repair at annual inspection
- Temperature of bearing	OK	Within the allowable value
- Wear and corrosion of bearing	OK	
- Function of guide vane operating system	OK	
- Function of governor	OK	
Inlet Valve No.1		
- Function of inlet valve	OK	
- Water leakage	Leakage from valve bearing	
- Wear condition of seal, valve body and valve bearing	Wear of seal for valve bearing	Plan to repair in Aug.2010
Inlet Valve No.2		
- Function of inlet valve	OK	
- Water leakage	No leakage	
- Wear condition of seal, valve body and valve bearing	Good	
Inlet Valve No.3		
- Function of inlet valve	OK	
- Water leakage	Leakage from valve bearing	
- Wear condition of seal, valve body and valve bearing	Wear of seal for valve bearing	Plan to repair in Aug.2010

Generator No.1		
- Insulation of stator coil	OK	
- Function of exciter system	OK	AVR was replaced with new type in 2006.
- Temperature of bearings	OK	Within the allowable value
- Vibration of shaft	OK	
Generator No.2		
- Insulation of stator coil	OK	
- Function of exciter system	OK	AVR was replaced with new type in 2006.
- Temperature of bearings	OK	Within the allowable value
- Vibration of shaft	OK	
Generator No.3		
- Insulation of stator coil	OK	
- Function of exciter system	OK	AVR was replaced with new type in 2006.
- Temperature of bearings	OK	Within the allowable value
- Vibration of shaft	OK	
Supervisory and Control System		
- Function of protection relay	OK	All relays are digital type. Relay test is done every year and meter calibration every 2 years
- Function of control system	OK	
Switchgear		
- Function of 13kV switchgears	OK	
- Function of low voltage switchgers	OK	
Transformer		
- Oil leakage	OK	Small leakage was found in 2009.
- Temperature of coil and oil	OK	Within the allowable value
- Damage of HT and LT bushings	No damage	
- Function of tap changer	OK	

Table C3-5 Summary of Visual Inspection for Civil Structures at SOEDIRMAN Hydropower Station

Name of Hydropower Station:	Soedirman	
Constructed (Year)	Mrica Dam : 1988, Soedirman Power Station :1989	
Inspection date	09 to 10 April 2010	
Structures / Inspection Items	**Conditions of Structures**	**Remarks**
1. Mrica Dam		
1.1 Main Dam - Foundation Settlement - Deformation of Dam Body - Water Leakage - Open Crack - Slope sliding - Others	 Not observed Not observed Acceptable Range **(See Note)** Not observed Not observed -	According to the IP , no serious problem has not been observed at the Mrica main dam through their visual inspection and measuring results by the monitoring apparatus. ***Note : water leakage at drainage tunnel has been suctioned by the drainage pump adequately. The leakage volume may be reached stable condition, however, the leakage volume shall be observed carefully.***
1.2 Spillway - Deformation - Water Leakage - Open Crack - Abrasion / Scouring - Others	 Not observed Acceptable Range Acceptable Range Not observed -	
1.3 Drawdown Culvert - Deformation - Water Leakage - Open Crack - Abrasion / Scouring - Others	 Not observed Acceptable Range Acceptable Range Not observed	
2. Waterway		
2.1 Intake Tower - Foundation Settlement - Deformation - Open Crack - Others	 Not observed Not observed Acceptable Range -	
3. Powerhouse - Foundation Settlement - Deformation - Water Leakage - Open Crack - Others	 Not observed Not observed Not observed Not observed -	Well maintained According to the IP, periodical inspection for the powerhouse civil structure has not been performed. However, no serious problem has been observed for the powerhouse civil structure.

Table C4-1 Summary of Investigation for Hydro-Mechanical Equipment at SAGULING Hydropower Station

Name of Hydropower Station:	Saguling	
Constructed (Year)	1986	
Fabricator (Contractor)	Marushima Hydraulic Gate Works	
Equipment & Specifications	**Data**	**Observation**
Spillway Gates and Hoists		
- Gate Type	Fixed Wheel Gate	Well maintained, and Good
- Quantities	3 sets	O & M staff reported no trouble about operation.
- Clear Span	10.0 m	
- Clear Height	8.3 m	
- Type of Hoist	1Motor-2Drum	
Spillway Stoplogs		
- Gate Type	Slide Gate	Well maintained, and Good.
- Quantities	Stoplogs 1 set Guide Frame 3 sets	O & M staff reported no trouble about operation.
- Clear Span	10.0 m	
- Clear Height	8.3 m	
- Type of Hoist	Monorail Hoist	
Intake Trash Racks (Screen)		
- Type	Fixed	These screens are submerged and not observed.
- Quantities	4 sets	O & M staff reported no trouble about operation.
- Clear Span	9.00 m	
- Clear Height	32.00 m	
Mechanical Trash Rakes		
- Type	Trash Car	Well maintained, and Good
- Quantities	1 set	O & M staff reported no trouble about operation.
- Rake Width	3.0 m	
Intake Gates and Hoists		
- Gate Type	Fixed Wheel Gate	Well maintained, and Good
- Quantities	2 sets	O & M staff reported no trouble about operation.
- Clear Span	5.80 m	
- Clear Height	5.80 m	
- Type of Hoist	1Motor-2Drum	
Steel Penstocks		
- Quantities	2 lanes	Well maintained, and Good
- Diameter	4.3 m to 2.83 m	O & M staff reported no trouble about operation.
- Length	(No.1/2) 1868m/1768 m	

Equipment & Specifications	Data	Observation
Draft Tube Gates and Hoists		Well maintained, and Good
- Gate Type	Fixed Wheel Gate	O & M staff reported no trouble about operation.
- Quantities	1 set	
- Clear Span	3.825 m	
- Clear Height	3.200 m	
- Type of Hoist	Gantry Crane	

Other Observations:

1. Visual inspection was made for gate leaves and hoists. Conditions of all the gate leaves and hoists were monitored by interview to operation and maintenance staffs.
2. Gate leaves are sound and no need to be rehabilitated.
3. Hoists and controls are sound and no need to be rehabilitated.
4. Penstocks are sound and no need to be rehabilitated.
5. There is no problem about spare parts supply.

Table C4-2 Summary of Investigation for Generating Equipment at SAGULING Hydropower Station

Name of Hydropower Station:	Saguling	
Constructed (Year)	1985	
Fabricator (Contractor)	Sumitomo Corpration	
Equipment & Specifications	**Data**	**Observation**
Water Turbine - Type - Quantities - Manufacturer - Rated head - Rated output - Material runner	 Vertical Francis 4 sets Toshiba 355.7 m 178.8 MW Stainless steel	 Well maintained
Inlet Valve - Type - Quantities - Manufacturer	 Rotary Valve 4 sets Toshiba	
Governor - Type - Quantities - Manufacturer	 Analog PID type 4 sets Toshiba	 In process of the replacement
Generator - Type - Manufacturer - Voltage - Rated capacity - Power factor	 Umbrella Mitsubishi 16.5kV 206.1MVA 0.85	 Well maintained
Supervisory and Control System - Type	 SCADA system using 5 personal computers	Replacement of control system was done in 2002. The supervisory and control was adopted with computerized system.
- Manufacturer - Type of protection relay	Mitsubishi Digital	

Table C4-3 Detailed Investigation for Generating Equipment at SAGULING Hydropower Station

Name of Hydropower Station:	Saguling	
Check Points	**Conditions of Equipment**	**Remarks**
Water Turbine No.1		
- Runner cavitations	OK	Repair at annual inspection
- Temperature of bearing	OK	Within the allowable value
- Wear and corrosion of bearing	OK	
- Function of guide vane operating system	OK	
- Function of governor	No good	
Water Turbine No.2		
- Runner cavitations	OK	Repair at annual inspection
- Temperature of bearing	OK	Within the allowable value
- Wear and corrosion of bearing	OK	
- Function of guide vane operating system	OK	
- Function of governor	No good	
Water Turbine No.3		
- Runner cavitations	OK	Repair at annual inspection
- Temperature of bearing	OK	Within the allowable value
- Wear and corrosion of bearing	OK	
- Function of guide vane operating system	OK	
- Function of governor	No good	
Water Turbine No.4		
- Runner cavitations	OK	Repair at annual inspection
- Temperature of bearing	OK	Within at annual inspection
- Wear and corrosion of bearing	OK	
- Function of guide vane operation	OK	
- Function of governor		
Inlet Valve No.1		
- Function of inlet valve	OK	
- Water leakage	No leakage	
- Wear condition of seal, valve body and valve bearing	OK	
Inlet Valve No.2		
- Function of inlet valve	OK	
- Water leakage	No leakage	
- Wear condition of seal, valve body and valve bearing	Good	

Check Points	Conditions of Equipment	Remarks
Inlet Valve No.3		
- Function of inlet valve	OK	
- Water leakage	Leakage from valve bearing	
- Wear condition of seal, valve body and valve bearing	OK	
Inlet Valve No.4		
- Function of inlet valve	OK	
- Water leakage	OK	
- Wear condition of seal, valve body and valve bearing	OK	
Generator No.1		
- Insulation of stator coil	OK	
- Function of exciter system	OK	
- Temperature of bearings	OK	Within the allowable value
- Vibration of shaft	OK	
Generator No.2		
- Insulation of stator coil	OK	
- Function of exciter system	OK	
- Temperature of bearings	OK	Within the allowable value
- Vibration of shaft	OK	
Generator No.3		
- Insulation of stator coil	OK	
- Function of exciter system	OK	
- Temperature of bearings	OK	Within the allowable value
- Vibration of shaft	OK	
Generator No.4		
- Insulation of stator coil	OK	
- Function of exciter	OK	Within the allowable value
- Temperature of bearing	OK	
- Vibration of shaft	OK	
Supervisory and Control System		
- Function of protection relay	OK	All relays are digital type. Relay test is done every year and meter calibration every 2 years
- Function of control system	OK	
Switchgears		
- Function of 16.5kV switchgears	OK	
- Function of low voltage switchgears	OK	
Transformer		
- Oil leakage	OK	
- Temperature of coil and oil	OK	
- Damage of HT and LT bushings	No damage	
- Function of tap changer	OK	

Table C4-4 Summary of Visual Inspection for Civil Structures at SAGULING I Hydropower Station

Name of Hydropower Station:	Saguling	
Constructed (Year)	Saguling Dam : 1986, Power Station :1989	
Inspection date	13 April 2010	
Structures / Inspection Items	**Conditions of Structures**	**Remarks**
1. Saguling Dam		
1.1 Main Dam		According to the PJB, no serious problem has not been observed at the Saguling main dam through their visual inspection and measuring results by the monitoring apparatus
- Foundation Settlement	Not observed	
- Deformation of Dam Body	Not observed	
- Water Leakage	Acceptable Range	
- Open Crack	Not observed	
- Slope sliding	Not observed	
- Others	-	
1.2 Spillway		
- Deformation	Not observed	
- Water Leakage	Acceptable Range	
- Open Crack	Acceptable Range	
- Abrasion / Scouring	Not observed	
- Others	-	
2. Waterway		
2.1 Intake Tower		
- Foundation Settlement	Not observed	
- Deformation	Not observed	
- Open Crack	Acceptable Range	
- Others	-	
3. Powerhouse		Well maintained
- Foundation Settlement	Not observed	
- Deformation	Not observed	
- Water Leakage	Not observed	
- Open Crack	Not observed	
- Others	-	

APPENDIX D

Site Investigation Report for Sutami(2004)

SITE INVESTIGATION REPORT
FOR
PRESENT STATUS
OF
ELECTRO-MECHANICAL EQUIPMENT
FOR
SUTAMI HYDROPOWER STATION

DECEMBER 2004

NIPPON KOEI CO., LTD.

CONSULTING ENGINEERS
TOKYO JAPAN

SITE INVESTIGATION REPORT
FOR
PRESENT STATUS OF ELECTRO-MECHANICAL EQUIPMENT
FOR
SUTAMI HYDROPOWER STATION

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<u>APPENDICES</u>

1. BACKGROUND OF SITE INVESTIGATION

The Sutami Hydropower Station have been operated for over 30 years since its commissioning in 1973, as shown in Table 1. According to statistic results, averaged life of electromechanical equipment is more or less 30 years. It was therefore concerned that the operating conditions of the electromechanical equipment had been deteriorated as a whole due to aging and corrosion.

Development of Sutami Hydropower Station

	Installation of Units	Output	Completion
First Stage	Units No. 1	35.1 MW x 1	September 30, 1973
Second Stage	Units No. 2 and No. 3	35.1 MW x 2	February 28, 1976

Under such circumstances, Nippon Koei Co., Ltd proposed to carry out the site investigation of the electromechanical equipment, as the original consulting engineer at the construction stage of the Sutami Hydropower Station, in order to figure out their present status and to make assessment of the necessity of their rehabilitation.

It was agreed that the site investigation should be carried out during the major overhaul work of the electromechanical equipment for Unit 1, which was scheduled from September 27 to October 26, 2004.

Principal Features of Electromechanical Equipment

Hydraulic Turbine

- Type of turbine	:	Vertical shaft, Francis
- Rated turbine output	:	36,000 kW
- Maximum gross head	:	93.5 m
- Design head	:	85.4 m
- Rated head	:	78.4 m
- Rotational speed	:	250 rpm

Generator

- Rated generator output	:	39,000 kVA
- Type of generator	:	Semi-umbrella
- Rated generator voltage	:	11 kV
- Number of pole	:	24 poles
- Rated frequency	:	50 Hz
- Rated power factor	:	0.9 lagging

2. SCOPE OF SITE INVESTIGATION

The site investigation was carried out for the following equipment for Unit 1:

(1) Hydraulic Turbine and Auxiliary Equipment

(a) Turbine
(b) Inlet valve
(c) Governor
(d) Pressure oil supply system

(2) Generator and Excitation System

(a) Generator
(b) Excitation system equipment

(3) Control and Relay Boards

(a) Main control boards
(b) Automatic control boards
(c) Relay boards

3. METHODS OF SITE INVESTIGATION

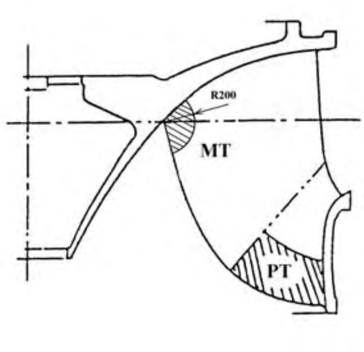
The site investigation of the electromechanical equipment was carried out by the following methods:

(1) Visual Inspection, to see any abnormality such as corrosion, erosion, crack, heavy rust, breakage, leakage, discoloration and deformation

(2) Non-Destructive Tests for Turbine Runner, to diagnose the present status and to make an assessment of its residual life.

(a) Liquid penetrant test (PT), for the parts of stainless surface at the discharge side of the runner.

(b) Magnetic particle test (MT), for the root of the runner crown at the discharge side of the runner. MT is used for detection of new defects, which are caused by material deterioration.



(c) Replica film test (ST), to analyze the characteristics of the defects, which were found by PT and MT. Metal specimens of typical defective parts will be sampled by SUMP method.

(3) Diagnostic Test of Generator Stator Coils, to make an assessment of their residual life.

(a) Polarization index (PI) test, to confirm the present condition of the stator windings prior to AC voltage test. Test voltage is DC 1,000 V for 10 minutes.

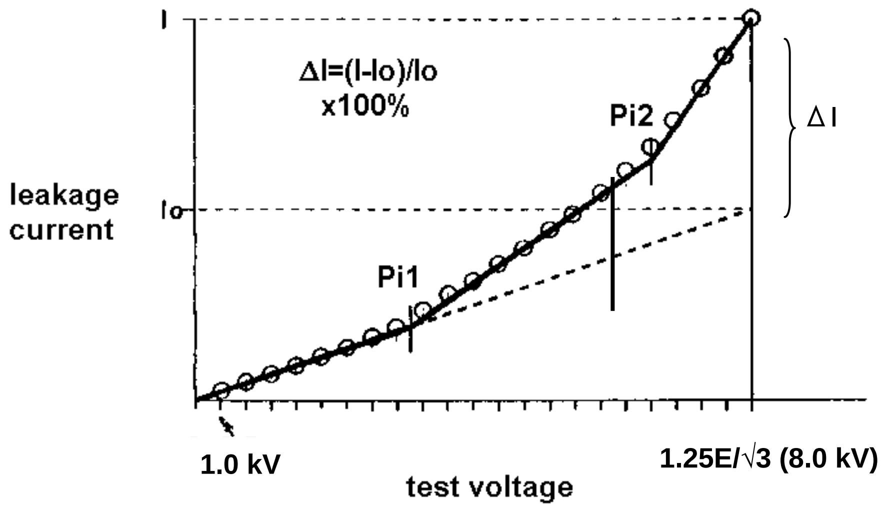
PI = (Insulation resistance at 10 minutes)/(Insulation resistance at 1 minute)

Criteria: PI > 1.5

(b) AC leakage current test

Test voltage is AC 8.0 kV which is equal to 1.25E/√3 (E = 11 kV). Leakage current will be measured at every 1.0 kV step.

The characteristics of leakage current will be indicated as follows:



The result of AC leakage current test will be evaluated by parameters Pi1, Pi2 and Δ I as follows:

Pi1:	Voltage at the first rapid increasing of leakage current
Pi2:	Voltage at the second rapid increasing of leakage current
Δ I:	Rate of leakage current increment

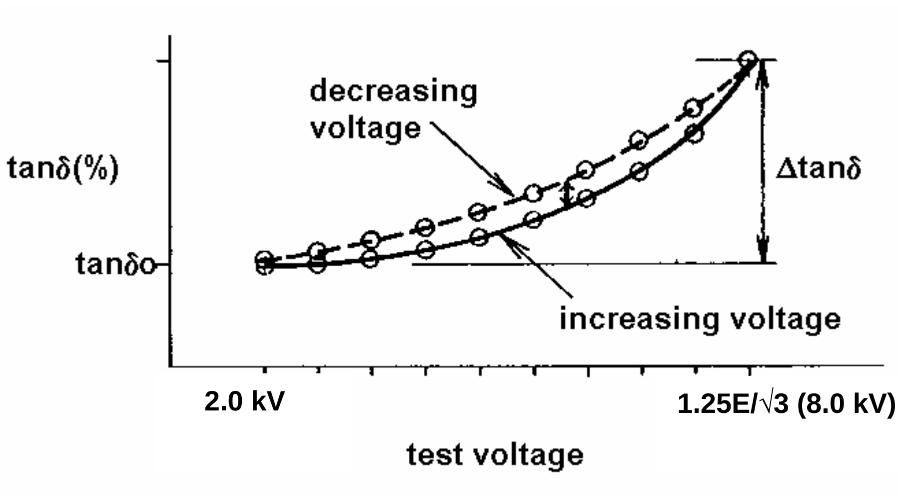
Criteria: Δ I < 5.0 %, at 8.0 kV (= 1.25E/√3)
Δ I < 12.0 %, at 11 kV

(c) Dielectric loss angle (tan δ) test

Test voltage is AC 8.0 kV which is equal to 1.25E/√3 (E = 11 kV).

Loss angle (tan δ) will be measured at every 2.0 kV step.

The characteristics of loss angle (tan δ) will be indicated as follows:



The result of dielectric loss angle test will be evaluated by the parameter $\Delta \tan \delta$:

$\Delta \tan \delta$ = (Maximum test voltage $\tan \delta$) - (Initial test voltage $\tan \delta o$).

Criteria: $\Delta \tan \delta$ at 8.0 kV < 2.5 %
$\Delta \tan \delta o$ at 11.0 kV < 6.5 %

(4) Corona Test (Partial Discharge Test)

Test voltage is AC 8.0 kV, 6.4 kV and 5.1 kV. Partial discharge pulse will be measured at each voltage step in order of 8.0 kV, 6.4 kV and 5.1 kV.

The result of corona test will be evaluated by the parameter Q_{max} at 6.4 kV (= E/√3).

Criteria: Q_{max} at 6.4 kV < 10,000 pc

4. PROGRESS OF SITE INVESTIGATION

Items	October 2004									
	11	12	13	14	15	16	17	18	19	20
Meeting and Preparation	■		■			■			■	
Runner Inspection										
- Visual inspection		■	■	■						
- Removal of paint			■	■	■					
- PT				■						
- MT & ST									■	■
Bearing Inspection								■		
Generator Inspection										
- Visual inspection		■	■							
- Rotor voltage balance test				■						
- Stator coil diagnosis test									■	
Inspection for Other Equipment					■					
Clean-up										■

5. RESULTS OF SITE INVESTIGATION

5.1 Results for Hydraulic Turbine and Auxiliary Equipment

5.1.1 Turbine Runner

(1) General Information

The runner is made of cast steel (SC46) with 18-8 stainless overlay. The runner surface is coated with corrosion protective paint named “Corocoat”.

There is one (1) spare runner. The used runner will be replaced by the spare one on the occasion of the major overhaul work, which is carried out after the unit operation reaches to 40,000 hours. The used runner will be repaired and stored as spare for replacement at the next major overhaul work.

The present runner Unit 1 has been operated for 7 years since the last major overhaul in 1997.

(2) Visual Inspection

Cavitation pitting were seen at the inlet and outlet sides of each runner blade.

At the inlet side, the averaged pitting area on each blade is 122 mm x 47 mm and the averaged pitting depth is 2.5 mm. In particular, the pitting depth of the blade No. 12 is 7.0 mm where the cavitation erosion bursts a hole on the cast steel through the stainless overlay.

At the outlet side, the averaged pitting area is 130 mm x 6.6 mm and the averaged pitting depth is 0.5 mm.

In addition to cavitation erosion, pitting corrosion and cloudy cavitation were also seen at the outlet side of each blade.

The results of visual inspection are detailed in **Appendix-1**.

(3) Liquid Penetrant Test (PT)

No serious defects were detected by the liquid penetrant test (PT).

The results of PT are detailed in **Appendix-2**.

(4) Magnetic Particle Test (MT)

No serious defects were detected by the magnetic particle test (MT).

The results of MT are detailed in **Appendix-3**.

(5) Replica Film Test (ST)

No serious defects were detected by the replica film test (ST).

The results of ST are detailed in **Appendix-4**.

5.1.2 Turbine Guide Bearing

(1) Visual Inspection

The turbine guide bearing is of cylindrical type which can be split into two pieces.

The Babbitt metals have been detached from the bearing support as shown in the results of the liquid penetrant test (PT), even though the metal surface is still in good condition.

It is therefore much concerned that such detachment of the bearing metal would cause more serious trouble such as excessive vibration and overheating, if it is used in the turbine assembly as it is.

(2) Liquid Penetrant Test (PT)

The liquid penetrant test (PT) was applied to the circumference of the Babbitt metal.

The results of PT show that the Babbitt metals have been detached from the bearing support at the portions of almost 100 % on the circumference.

The photographic records of PT are shown in **Appendix-5**.

(3) Temperature Records

As compared with the commissioning test records in 1973, the turbine guide bearing temperatures at full load (35 MW) increase by more than 5 °C. However, the cause of this temperature increase have not been examined so far.

<u>Comparison of Temperatures of Turbine Guide Bearing</u>

Unit 1	Commissioning Test in 1973		Operation Records in 2004	
	Dial Thermometer	RTD	Dial Thermometer	RTD
Turbine guide metal	51 °C	50 °C	56 °C	59 °C
Turbine oil	-	35.5 °C	-	52 °C

(4) Availability of Spare Parts

(a) Turbine guide bearing

There is one (1) spare guide bearing in the Power Station. This spare guide bearing was once used for Unit 1 for about 10 years. As the inner diameter got 0.6 mm bigger than the designed value, this spare guide bearing has not used since 1984.

On the other hand, the liquid penetrant test (PT) shows that the Babbitt metal on the spare guide bearing has also been detached at portions about 40 % on the circumference.

Accordingly, this spare guide bearing cannot be used without reconditioning.

(b) Consumables

The original consumable supplies for the turbine guide bearing; such as packing and O-rings, has been run out. So far necessary consumables for replenishment were procured from local suppliers.

5.1.3 Guide Vanes and Operating Mechanism

(1) Visual Inspection

The guide vanes are made of cast steel (SC46) with 18-8 stainless overlay on the shuttering surfaces. The bearings for the guide vane stems and the guide link connecting rods employ grease lubrication system.

The guide vanes, facing plates and operating mechanisms were well maintained and were still in good conditions.

(2) Availability of Spare Parts

(a) Guide vanes

The original spare guide vanes of 10 pieces still remain unused.

(b) Shear pins

So far fourteen (14) pieces of spare shear pins have been consumed and only six (6) pieces remain as spare.

(c) Upper and lower bushes

The original supplies of spare upper bushes has been run out. However, additional upper bushes were procured from a local supplier.

Concerning the spare lower bushes, so far only one (1) piece of the original supplies has been consumed and the remaining nine (9) pieces still remain as spare.

(d) Consumables

The original consumable supplies for the turbine guide bearing; such as packing and O-rings, has been run out. So far necessary consumables for replenishment were procured from local suppliers.

5.1.4 Other Turbine Parts

(1) Visual Inspection

(a) Main shaft seal

The seal liner surface has been corroded as a whole. Therefore, it is concerned that water leakage from the shaft seal will increase if the corrosion is left as it is.

(b) Head cover and bottom cover

The head cover and the bottom cover were slightly rusted but any specific problem was not observed.

On the other hand, there are scratches on both wearing rings of the head cover and the bottom cover. These scratches may be attributable to imperfect centering of the turbine shaft.

(c) Stay vanes and draft tube

The stay vanes and the draft tubes were already overhauled and painted prior to the commencement of our visual inspection.

Any specific problem was not observed on the overhauled stay vanes and draft tube.

(2) Availability of Spare Parts

(a) Main shaft seal

There is one (1) spare shaft seal in the Power Station. As this spare shaft seal was once used, the seal liner surface has also been corroded.

(b) Head cover and bottom cover

The original supplies of spare wearing rings still remain unused.

(c) Consumables

The original consumable supplies for the turbine parts; such as packing and O-rings, has been run out. So far necessary consumables for replenishment were procured from local suppliers.

5.1.5 Inlet Valve

(1) Visual Inspection

The valve body and the valve disc were slightly rusted but any specific problem was not observed.

(2) Availability of Spare Parts

Almost all the original spare parts and consumable supplies for the inlet valve and bypass valve; such as disc seals, packing and O-rings, has already been run out. So far necessary consumables for replenishment have been procured from local suppliers.

5.1.6 Governor and Turbine Control Equipment

(1) Visual Inspection

The governor was well maintained and all the parts were kept in neat and tidy condition.

However, it was informed that the pilot valve and dashpot did not work well due to deterioration and this has caused degradation of the speed response and overall governor performance.

(2) Availability of Spare Parts

(a) Essential governor parts

Even though the existing pilot valve and dashpot did not work well, there were no spare parts for these items. Spare parts for the speed adjusting motor and pendulum motor were also not available in the Power Station.

A critical problem is that spare parts for mechanical type governor are not available any longer in the original supplier because of obsolescence.

(b) Consumables

Almost all the original consumable supplies for the governor and turbine control equipment; such as springs and washers, have already been run out. So far necessary consumables for replenishment were procured from local suppliers.

5.2 Results for Generator and Excitation System

5.2.1 Stator

(1) Visual Inspection

(a) Stator core

Neither looseness nor waving was observed on the stator core. No abnormality was observed on the clamping finger plates.

(b) Stator coils

The wedges have been loosen as a whole. Movement of some wedges was also observed.

(2) Temperature Records

As compared with the commissioning test records in 1973, the air cooler inlet air temperature at full load (35 MW) increased by more than 10 °C and the air cooler outlet air temperature reached to 45 °C which is too high for cooling air of the generator. (Generally speaking, the temperature of cooling air entering into the generator should not be higher than 40 °C)

As a result, the stator winding temperatures increased by about 10 °C.

However, the cause of this temperature increase have not been examined so far.

Comparison of Temperatures of Stator Winding and Cooling Air

Unit 1	Commissioning Test in 1973		Operation Records in 2004	
	Dial Thermometer	RTD	Dial Thermometer	RTD
Stator winding	-	79 - 82 °C	-	92 °C
Air cooler inlet air	-	45 °C	63 °C	58 °C
Air cooler outlet air	-	41 °C	45 °C	46 °C

(3) Diagnostic Test of Generator Stator Coils

The diagnostic tests were carried out to make an assessment of the residual life of the stator coils.

The test results are shown in **Appendix-7** and are summarized as follows:

(a) Polarization index test

Insulation resistance at 1 minute = 106 M-ohm
Insulation resistance at 10 minute = 180 M-ohm

PI = (Insulation resistance at 10 minutes)/(Insulation resistance at 1 minute)
= 180/106
= 1.70 > 1.5

Criteria: PI > 1.5

(b) AC leakage current test

Pi1: Voltage at the first rapid increasing of leakage current = 6.10 kV
Pi2: Voltage at the second rapid increasing of leakage current = Not Appeared
ΔI: Rate of leakage current increment = 6.29 % > 5.0 %

Criteria: ΔI < 5.0 %, at 8.0 kV (= 1.25E/√3)

(c) Dielectric loss angle (tan δ) test

Dielectric loss angle (tan δ) test was not carried out because of non-availability of the testing instrument.

(d) Corona test (Partial discharge test)

Low Frequency Band (3 kHz to 200 kHz)

Q_{max} at 6.4 kV (= E/√3) = 22,000 pc > 10,000 pc

Criteria: Q_{max} at 6.4 kV < 10,000 pc

Wide Frequency Band (3 kHz to 3 MHz)

Q_{max} at 6.4 kV (= E/√3) = 11,000 pc > 5,000 pc

Criteria: Q_{max} at 6.4 kV < 5,000 pc (Toshiba's Standard, for reference)

(e) Estimate of breakdown voltage of stator coil

Referring to the criteria of the Central Research Institute of Electric Power Industry in Japan, the breakdown voltage of the stator coil is estimated as follows:

$Vbd = E \bullet [12.0 - 2.2 \log Q_{max} - 280 (\tan \delta_0 / R_1 \bullet C_0)^2]$

where,
- E: Nominal voltage of stator coil = 11 kV
- Q_{max}: Maximum corona discharge at 6.4 kV = 22,000 pc
- $\tan \delta_0$: Dielectric loss angle at 2.0 kV (%)
- R_1: Insulation resistance at 1 minute (M-ohm)
- C_0: Capacitance (pF)

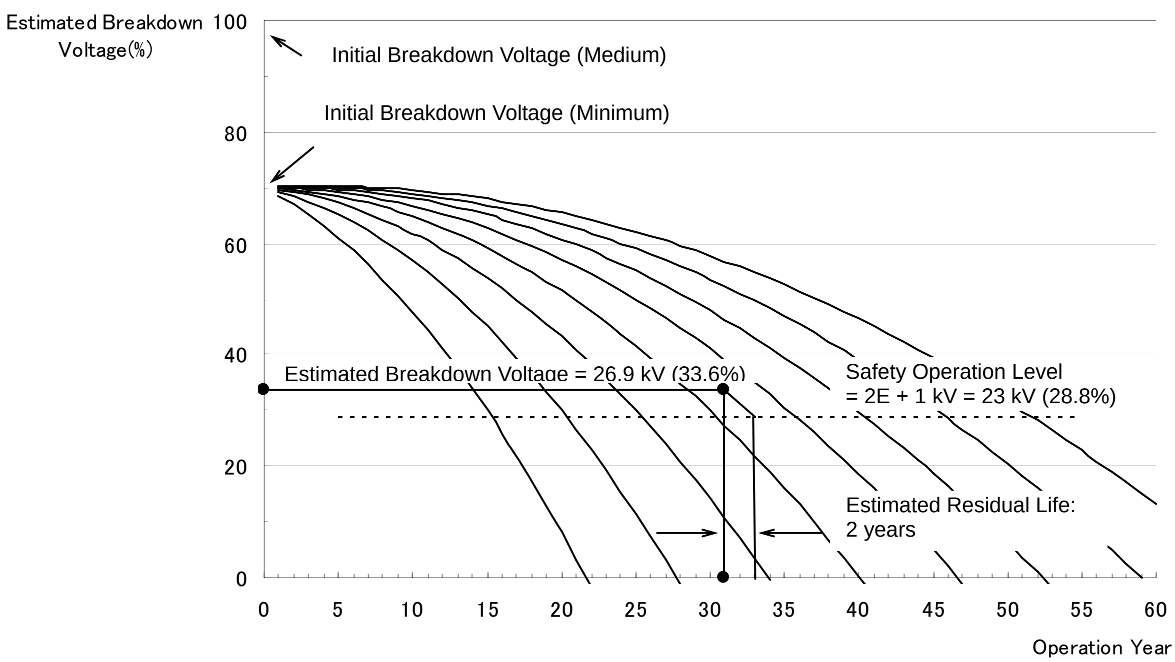
Thus, the breakdown voltage (Vbd) is estimated at 26. 9 kV.

(f) Estimated residual life of stator coil

For safe continuous operation of the generator, it is required that the breakdown voltage of the stator coil should be higher than the safety operational level, which is obtained by a formula; 2E + 1 kV where E is a normal operating voltage. At E = 11 kV, the safety operation level is calculated as 23 kV.

As shown in the graph below, it is estimated that the stator coil breakdown voltage will be dropped to 23 kV in two years.

Relationship between Stator Coil Breakdown Voltage and Operation Year
(Reference: Central Research Institute of Electric Power Industry in Japan)



On the other hand, referring to the report of the Electrical Technology Research Association in Japan, the averaged life of the stator coil is reported as 33.8 years.

Accordingly, the residual life of the stator coil is estimated at two (2) or three (3) years.

(4) Availability of Spare Parts

Almost all the original supplies of spare parts for the stator still remain unused.

5.2.2 Rotor

(1) Visual Inspection

The rotor was well maintained as a whole and no abnormalities were observed on the rotor coils and rims.

To stretch a point, minor high-spot markings, which might be caused by local overheating, were observed on the brake ring surface. However, this will not have any problem at this moment.

(2) Rotor Coil Drop Test (Voltage Balance Test)

The rotor coil drop test had a good result.

The test results are shown in **Appendix-8**.

(3) Availability of Spare Parts

Almost all the original supplies of spare parts for the rotor still remain unused. However, spare thrust bearing runner (rotary pad) was not available.

5.2.3 Generator Bearings

(1) Visual Inspection

(a) Upper guide bearing

The upper guide bearing is of cylindrical type which can be split into two pieces.

Partial cracks were observed on the metal surface and a part of the Babbitt metal was dropped out.

Fretting corrosion was observed on the outer circumference of the bearing metal, similarly to the bearing support.

As a result of the liquid penetrant test (PT), the Babbitt metals have been detached partially from the bearing support.

(b) Thrust bearing

No abnormality was observed on the thrust bearing pad.

Concerning the thrust bearing springs, the design height is 52.0 ± 0.15 mm. However, the measured heights of the thrust bearing springs were ranged between 51.74 mm and 52.36 mm. This variation of the spring height is not acceptable.

(c) Lower guide bearing

The lower guide bearing is of segmental type.

No abnormality was observed on the lower guide bearing.

(2) Temperature Records

Unit 1	Commissioning Test in 1973		Operation Records in 2004	
	Dial Thermometer	RTD	Dial Thermometer	RTD
Upper guide metal	50 °C	48 °C	55 °C	57 °C
Upper oil	-	43 °C	-	54 °C
Thrust metal	52 °C	51 - 52 °C	56 °C	64 °C
Lower guide metal	47 °C	46.5 °C	55 °C	64 °C
Lower oil	-	34.5 °C	-	-

(3) Availability of Spare Parts

The original consumable supplies for the generator bearings; such as packing and O-rings, has been run out. So far necessary consumables for replenishment were procured from local suppliers.

5.2.4 Excitation Cubicles

(1) Visual Inspection

The excitation cubicles were well maintained and all the parts were kept in neat and tidy condition.

The excitation system was old-fashioned and has been deteriorated as a whole.

However, no abnormality was observed on the system equipment and wirings in the excitation cubicles and so far there seems no operation problems on the system equipment.

(2) Availability of Spare Parts

Almost all the original supplies of spare parts and consumables remain unused.

To stretch a point, additional spare parts will not be available any longer in the original supplier because of obsolescence.

5.3 Results for Control and Relay Boards

5.3.1 Main Control Boards and Automatic Control Boards

(1) Visual Inspection

The main control boards and the automatic control boards were well maintained and all the parts were kept in neat and tidy condition.

The main control boards and the automatic control boards have been deteriorated as a whole due to aging with the following problems:

(a) Some control switches, which are frequently used in the customary operation, have become weak in the joints.

(b) All display windows of the group status indicators have faded considerably and cannot give a clear sight to the operator.

(c) The internal wirings of the main control boards and the automatic control boards have become discolored due to aging.

However, such deteriorated conditions have not become serious problems to date and did not affect immediately to further continuous operation.

(b) Availability of Spare Parts

Many items of the original spare parts are still remained.

The original consumable supplies for the main control boards have been run out. However, necessary consumables for replenishment were procured from local suppliers.

5.3.2 Relay Boards

(1) Visual Inspection

The relay boards were also well maintained and all the parts were kept in neat and tidy condition.

All the electrical protective relays are of mechanical type. The electrical protective relays were periodically tested and confirmed that they were still in good condition for proper operations.

(2) Availability of Spare Parts

Spare relays are still available to all kinds of the electrical protective relays.

6. RECOMMENDED REHABILITATION PLAN

Based on the results of the field investigation, the following rehabilitation is recommended for the electromechanical equipment of the Sutami Hydropower Station, to restore the electromechanical equipment in their technical performances, reliability and safety to the original conditions, in order to achieve their further long-term operation.

6.1 Recommended Rehabilitation Plan for Hydraulic Turbine and Auxiliary Equipment

(1) Rehabilitation Urgently Required

The urgent rehabilitation is recommended for the following items:

(a) Replacement of turbine guide bearing

The Babbitt metals have been detached from the bearing support and no spare bearing is available.

Therefore, replacement of the turbine guide bearing or reconditioning of the Babbitt metals is urgently required.

(b) Renewal of governor

The existing pilot valve and dashpot did not work well and this has caused degradation of the speed response and overall governor performance. However, there were no spare parts for these items and speed adjusting motor and pendulum motor.

On the other hand, mechanical type governor will not be available any longer in the original supplier because of obsolescence.

The governor is the most essential equipment for operation of the power station. Therefore, renewal of the governor is urgently required.

(c) Replacement of dial thermometers, embedded temperature detectors and pressure gauges

All the instruments have been used for more than 30 years beyond their standard life time.

Monitoring of the operating temperatures and pressure is the most essential to confirm the turbine operating conditions.

Therefore, all the dial thermometers, embedded temperature detectors and pressure gauges shall be urgently replaced by new ones.

In this connection, it is recommended that all the control cables for their instruments should be replaced by new ones together with them.

(d) Additional supply of spare parts

Additional procurement of the following spare parts are urgently required.

i) Turbine guide bearing
ii) Shear pins
iii) Main shaft seals
iv) Wearing rings
v) Spare parts for new governor

(2) Rehabilitation at Next Overhaul

It is recommended that rehabilitation of the following items should be carried out on the occasion of the next overhaul.

(a) Replacement of main shaft seal

The seal liner surface has been corroded as a whole and it was concerned that water leakage from the shaft seal would increase if the corrosion is left as it is.

Therefore, the main shaft seal shall be replaced by new one as soon as possible.

(b) Replacement of wearing rings

There were scratches on both wearing rings of the head cover and the bottom cover.

Therefore, replacement of the wearing rings is required.

Probably the wearing rings for Unit 1 will be replaced by spare ones. However, those for other units will be replaced by new ones.

(c) Replacement of bearings for guide vanes and their operating mechanism

Grease lubricant has been applied to the bearings of the existing guide vanes and their operating mechanism, which are exposed to the water. Nowadays such grease lubricant system is replaced by grease-less system to avoid water pollution in the downstream and to mitigate the maintenance work as well.

Therefore, it is recommended that the guide vanes and their operating mechanism should be modified with grease-less type bearings.

6.2 Recommended Rehabilitation Plan for Generator and Excitation System

(1) Rehabilitation Urgently Required

The urgent rehabilitation is recommended for the following items:

(a) Replacement of stator coils

As a result of the diagnostic test for the generator stator coils, the residual life of the stator coils is estimated at two (2) or three (3) years.

For safe continuous operation of the generator, the replacement of the stator coils is urgently required.

(b) Replacement of upper guide bearing

Partial cracks on the metal surface, dropping out of a part of the Babbitt metal and fretting corrosion on the outer circumference of the bearing metal were observed. The result of the liquid penetrant test (PT) shows that the Babbitt metals have been detached partially from the bearing support.

Therefore, replacement of the upper guide bearing or reconditioning of the Babbitt metals is urgently required.

(c) Replacement of dial thermometers and embedded temperature detectors

All the instruments have been used for more than 30 years beyond their standard life time.

Monitoring of the operating temperatures is the most essential to confirm the generator operating conditions.

Therefore, all the dial thermometers and embedded temperature detectors shall be urgently replaced by new ones.

In this connection, it is recommended that all the control cables for their instruments should be replaced by new ones together with them.

(d) Additional supply of spare parts

Additional procurement of the following spare parts are urgently required.

i) Thrust bearing runner
ii) Upper guide bearing metal

(2) Rehabilitation at Next Overhaul

It is recommended that rehabilitation of the following items should be carried out on the occasion of the next overhaul.

(a) Replacement of Springs for Thrust Bearing

The measured heights of the thrust bearing springs were ranged between 51.74 mm and 52.36 mm beyond the design height of 52.0 ± 0.15 mm.

Therefore, all the springs that exceed the tolerance of 52.0 ± 0.15 mm are required to be replaced by new ones.

(b) Renewal of Excitation System

The excitation system was old-fashioned and has been deteriorated as a whole.

Although neither abnormality nor operation problem has not reported to date, it is much concerned that the deterioration will be progressed in short time because the excitation system has been used beyond their standard life time of 30 years.

The excitation system is the most essential equipment for operation of the power station. Therefore, it is recommended that the excitation system should be renewed at the next overhaul.

6.3 Recommended Rehabilitation Plan for Control and Relay Boards

(1) Rehabilitation Urgently Required

The urgent rehabilitation is recommended for the following items:

(a) Minor modification of main control board and automatic control board

In connection with renewal of the governor, minor modification of the unit control system will be required for interfacing with the new governor system.

(2) Rehabilitation at Next Overhaul

It is recommended that rehabilitation of the following items should be carried out on the occasion of the next overhaul.

(a) Renewal of Main Control Board and Automatic Control Board

The main control boards and the automatic control boards have been deteriorated as a whole due to aging and some problems were also observed on them.

Although such problems have not became serious yet, it is much concerned that the deterioration will be progressed in short time because the excitation system equipment has been used beyond its standard life time of 30 years.

APPENDIX-1: RESULTS OF VISUAL INSPECTION FOR RUNNER

1. Results of Visual Inspection for Runner

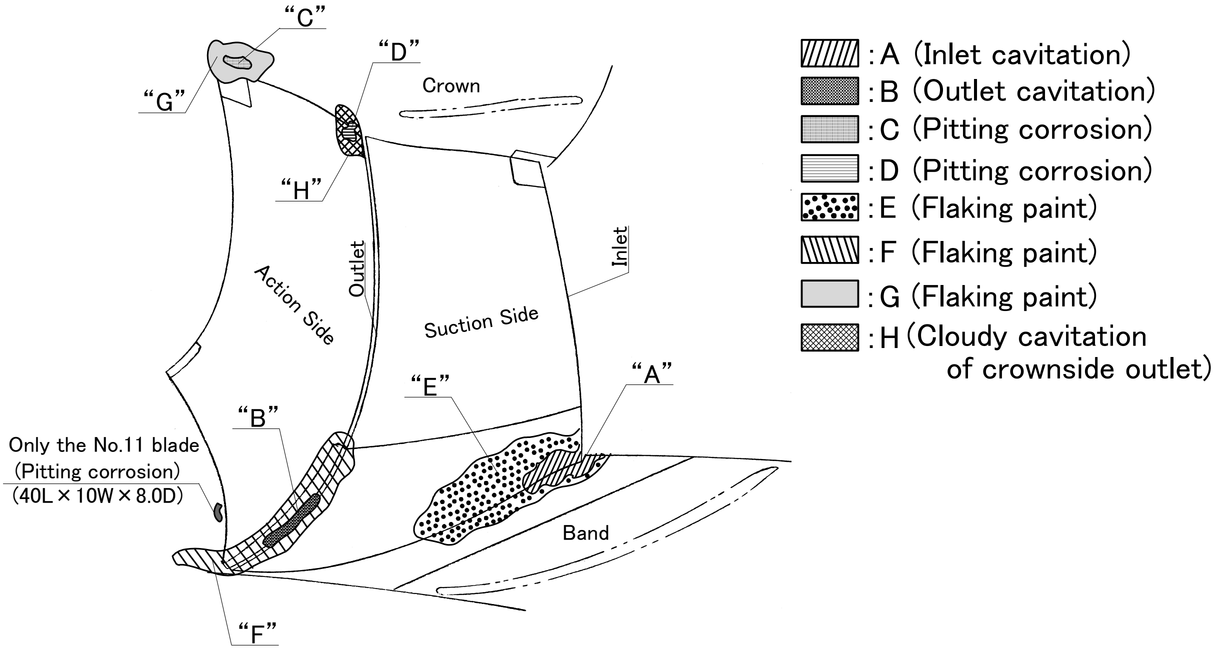


Table 1: Extent of Cavitation Erosion and Pitting Corrosion

Length x Width x Depth [mm]

Blade No.	A (Cavitation Erosion)	B (Cavitation Erosion)	C (Pitting Corrosion)	D (Pitting Corrosion)
1	105 x 32 x 0.5	240 x 12 x 1.0	-	-
2	120 x 45 x 1.0	215 x 05 x 0.5	95 x 30 x 1.0	-
3	110 x 50 x 2.0	180 x 12 x 1.0	-	-
4	140 x 60 x 3.5	120 x 03 x 0.2	-	-
5	120 x 45 x 3.0	150 x 05 x 0.5	190 x 70 x 3.5	-
6	110 x 45 x 2.5	-	-	70 x 30 x 10 70 x 20 x 3.0 50 x 15 x 5.0
7	95 x 40 x 1.5	140 x 05 x 0.2	-	35 x 15 x 7.0 40 x 15 x 3.0
8	130 x 50 x 2.0	80 x 06 x 0.5	-	-
9	130 x 40 x 1.0	-	-	-
10	150 x 50 x 1.5	60 x 12 x 0.5	130 x 45 x 4.0	-
11	130 x 40 x 2.0	60 x 05 x 0.5 85 x 05 x 0.5	-	-
12	140 x 55 x 7.0	60 x 05 x 0.3	-	-
13	140 x 50 x 4.0	175 x 12 x 1.0	-	30 x 10 x 5.0
14	120 x 50 x 1.5	110 x 10 x 0.5	-	-
15	85 x 50 x 1.5	200 x 05 x 0.5	45 x 25 x 2.5	-
16	110 x 50 x 3.0	170 x 03 x 0.2	-	-
17	140 x 45 x 0.5	160 x 07 x 1.0	60 x 30 x 2.0	-

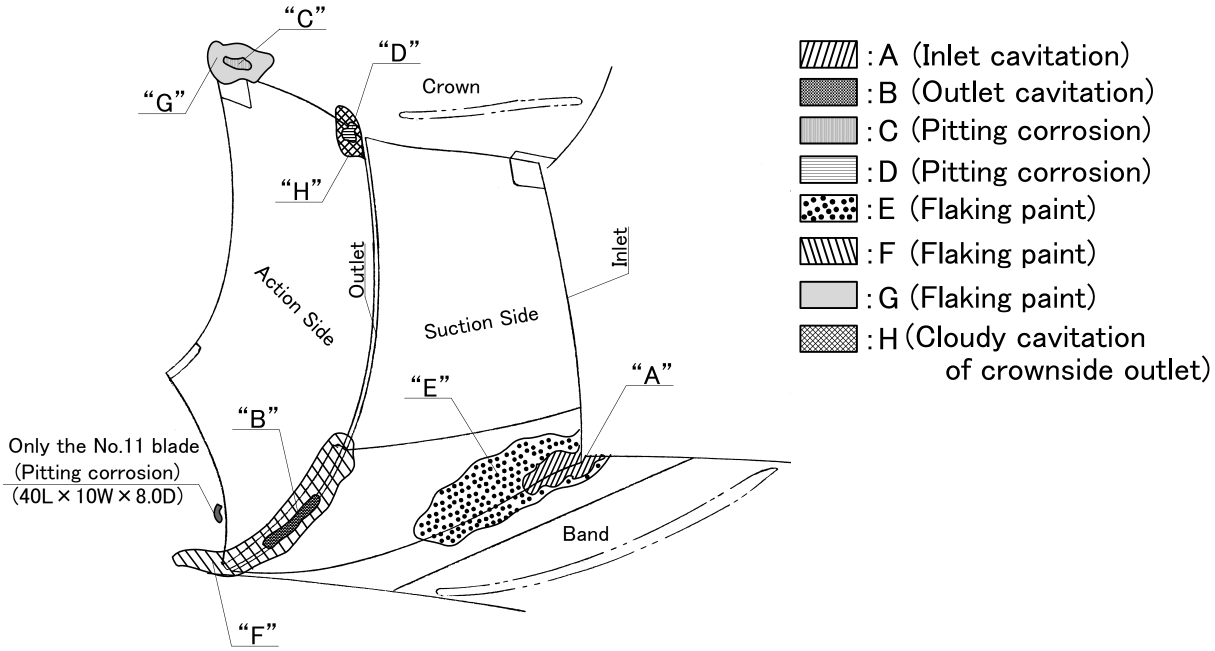
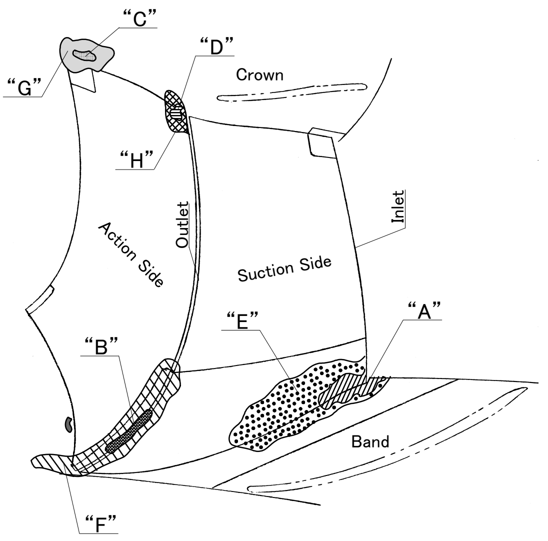


Table 2: Paint Peeled Area and Cloudy Cavitation

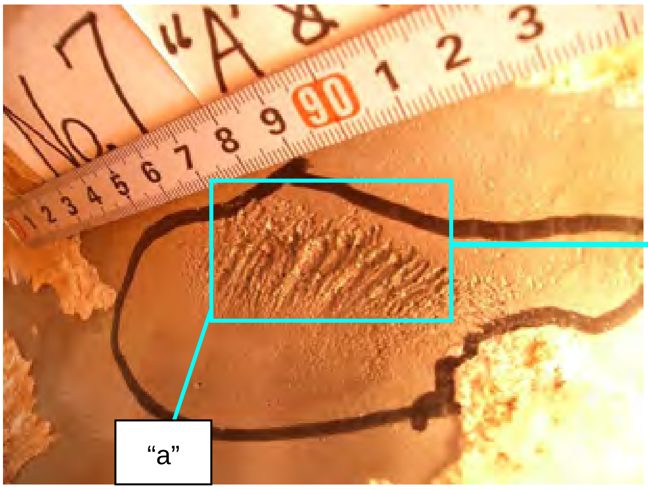
Length x Width x Depth [mm]

Blade No.	E (Paint Peeled Area)	F (Paint Peeled Area)	G (Paint Peeled Area)	H (Cloudy Cavitation)
1	406 x 160	650 x 70	95 x 30	300 x 110
2	580 x 300	600 x 260	-	280 x 60
3	180 x 70	540 x 50	-	350 x 110
4	230 x 100	340 x 125	-	170 x 50 100 x 50
5	310 x 150	335 x 70	280 x 190	190 x 50
6	160 x 80	320 x 100	200 x 100	350 x 150
7	180 x 80	430 x 320	-	320 x 110
8	180 x 80	300 x 60	-	170 x 50 140 x 60
9	300 x 70	320 x 130	170 x 75	330 x 130
10	130 x 100	290 x 75	-	210 x 60
11	280 x 120	540 x 150	-	260 x 80
12	280 x 120	460 x 365	-	290 x 110
13	350 x 110	480 x 350	-	260 x 120
14	800 x 130	700 x 95	-	80 x 50
15	900 x 300	570 x 55	30 x 20	280 x 130
16	500 x 350	790 x 90	-	320 x 98
17	570 x 400	850 x 170	75 x 30	270 x 100

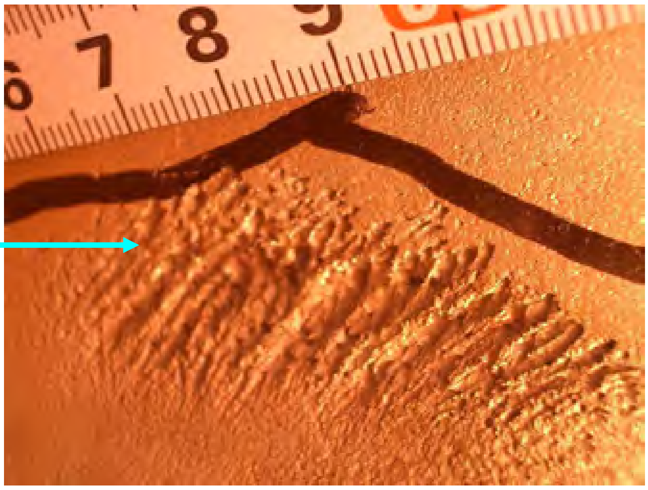
2. Photographic Records of Runner Blades (Blade No. 7)



Cavitation and Paint Peeled Area at Inlet Side



Cavitation at Inlet Side

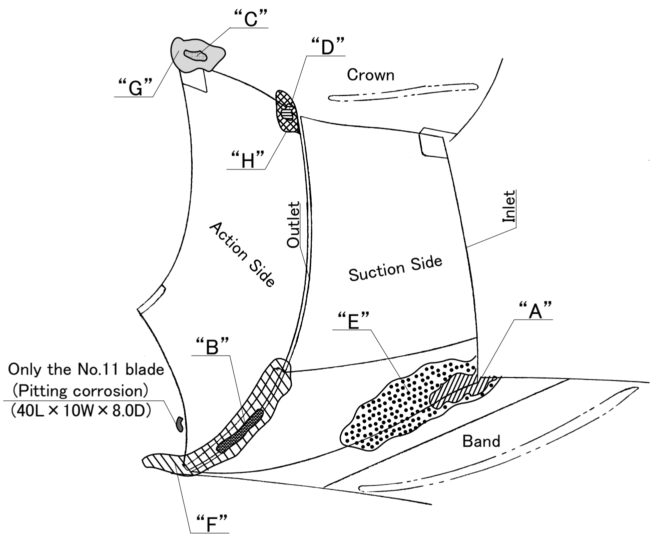


Detail "a"

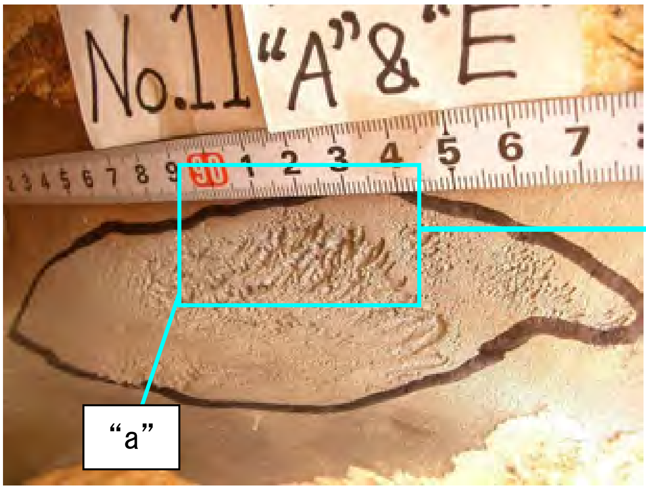
Pitting Corrosion and Cloudy Cavitation at Outlet Side

Pitting Corrosion at Outlet Side

3. Photographic Records of Runner Blades (Blade No. 11)



Cavitation and Paint Peeled Area at Inlet Side



Cavitation at Inlet Side

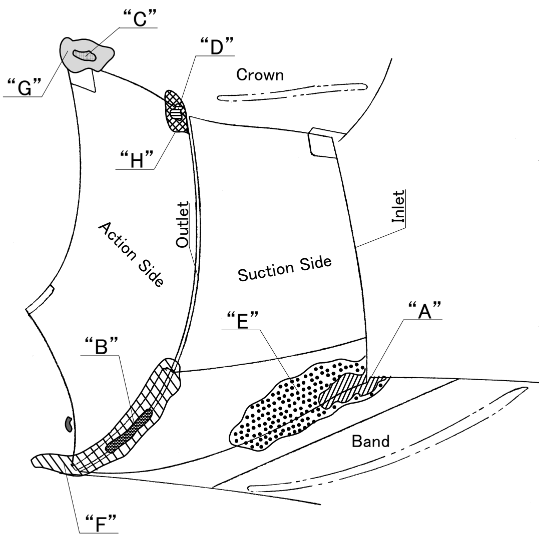
Detail "a"

Pitting Corrosion at Outlet Side (Only on Blade No. 11)

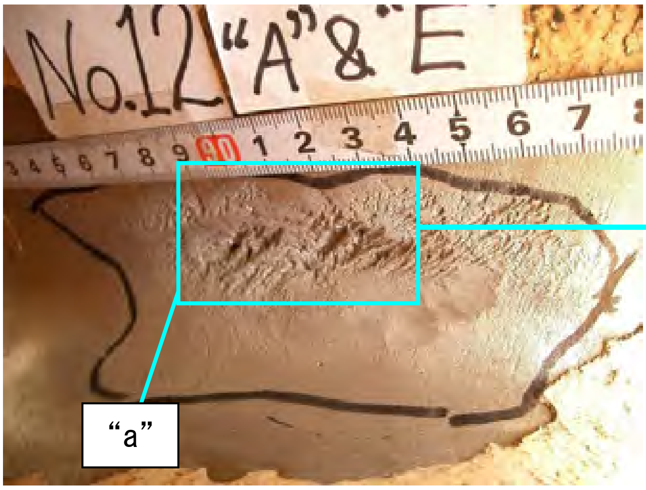
Size of Pitting Corrosion: 40L x 10W x 8.0D mm

Detail of Pitting Corrosion)

4. Photographic Records of Runner Blades (Blade No. 12)



Cavitation and Paint Peeled Area at Inlet Side



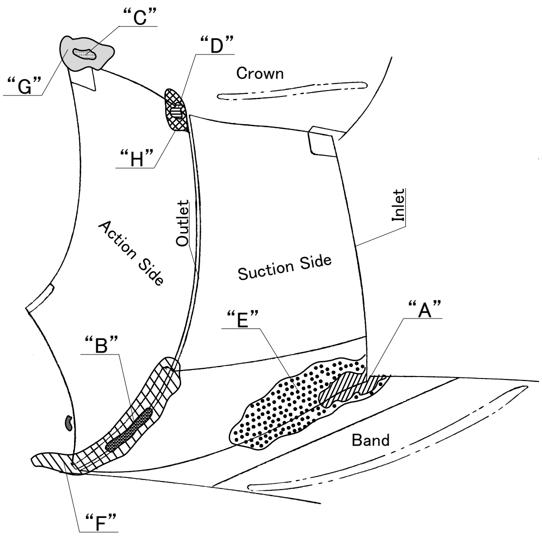
Cavitation at Inlet Side

Detail "a"

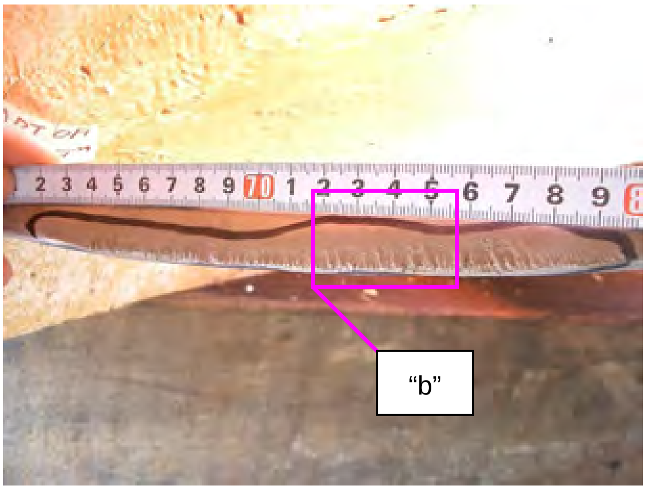
Cavitation and Paint Peeled Area at Outlet Side

Cavitation at Outlet Side

5. Photographic Records of Runner Blades (Blade No. 13)



Cavitation and Paint Peeled Area at Outlet Side



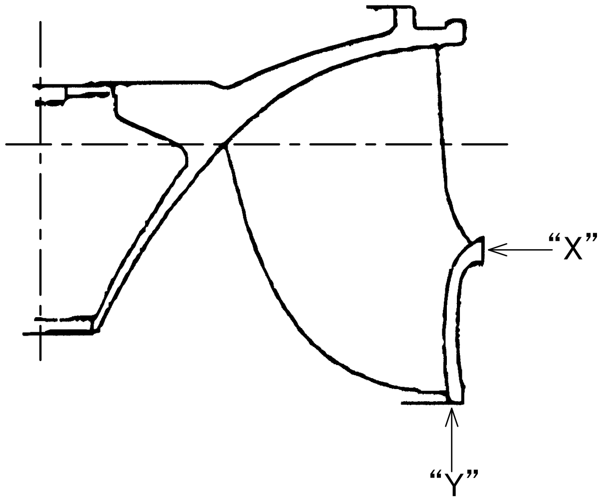
Cavitation at Outlet Side

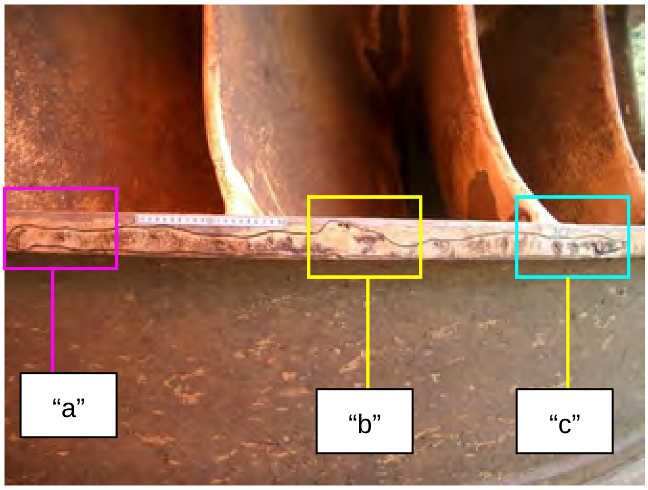
Detail "a"

Pitting Corrosion and Cloudy Cavitation at Outlet Side

Pitting Corrosion at Outlet Side

6. Photographic Records of Runner Circumference (Side View 1/2)

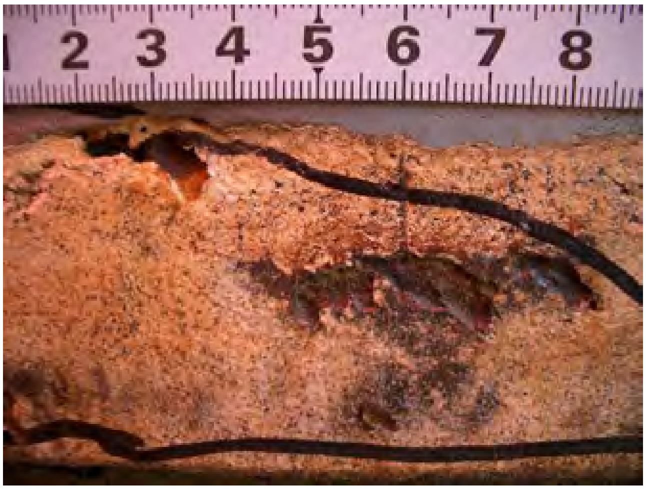




Between Blade No. 1 and No. 17 (Side View “X”)

Pitting Corrosion: 1,000L x 40W x (0.5 - 4.0)D mm

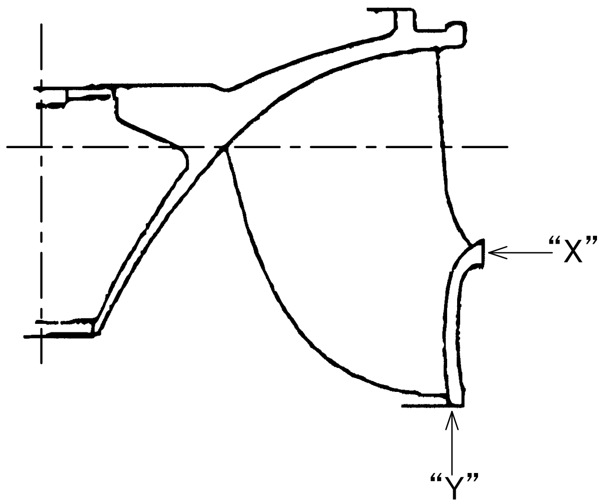
Detail “a”

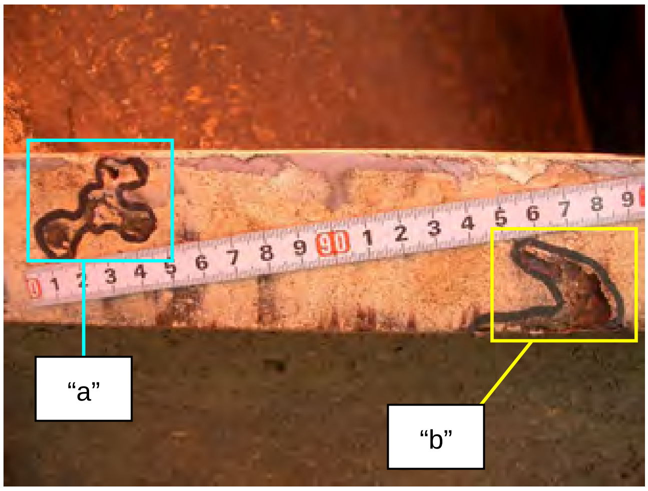


Detail “b”

Detail “c”

7. Photographic Records of Runner Circumference (Side View 2/2)





Blade No. 8 (Side View "X")

Pitting Corrosion: 40L x 15W x 3.0D mm, 45L x 25W x 4.0 mm

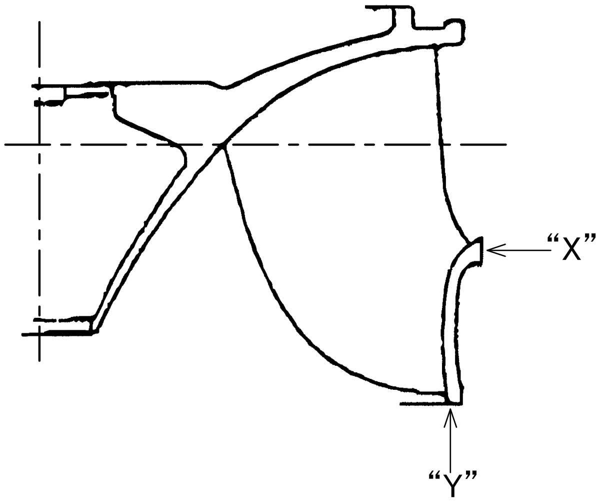
Detail "a"

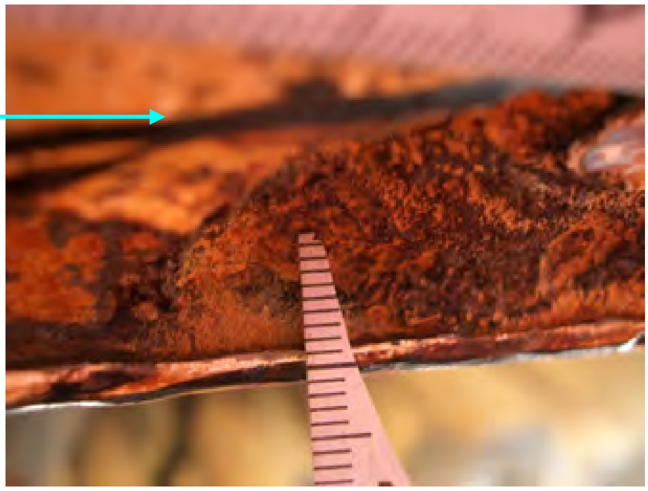
Detail "b"

Blade No. 8 (Side View "X")

Pitting Corrosion: 15L x 6W x 2.0D mm

8. Photographic Records of Runner Circumference (Bottom View)





Between Blade No.1 and No.2 (Bottom View "Y")

Pitting corrosion: 120L x 30W x (3.0 - 8.0)D mm

Blade No. 16 (Bottom View "Y")

Pitting Corrosion: 40L x 12W x 5.0D mm

APPENDIX-2: RESULTS OF PENETRANT TEST (PT) FOR RUNNER

1. Inspection Area

The penetrant test (PT) was applied to the area shown in Figure 2-1.

(1) Area ”A”: Outlet side of blade on runner band (Only blade No.2 , Nos. 13 to 15)
(2) Area “B”: Outlet side of blade on runner crown (Only blade No.6 , 15)

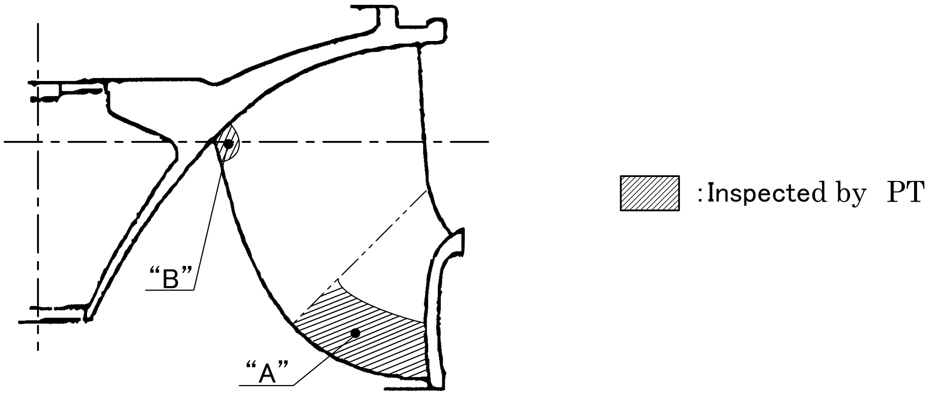


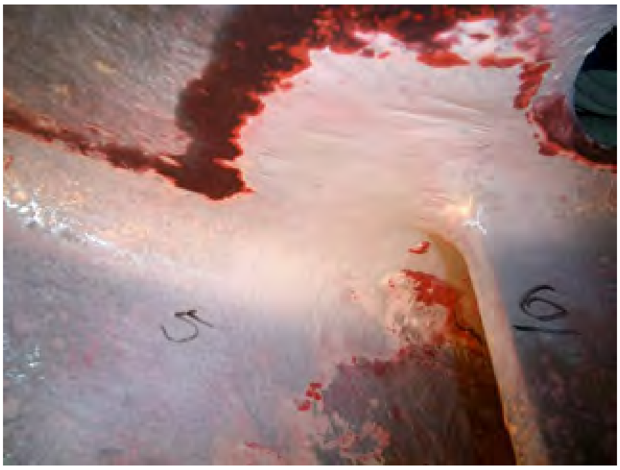
Figure 2-1: Area of Inspection by Penetrant Test (PT)

2. Test Results

No flaw was detected by the penetrant test (PT) on the areas “A” and “B”.

3. Photographic Records

Detail on Area “A” (Blade No. 2)



Detail on Area “B” (Blade No. 5)

APPENDIX-3: RESULTS OF MAGNETIC PARTICLE TEST (MT) FOR RUNNER

1. Inspection Area

The magnetic particle test (MT) was applied to the area shown in Figure 3-1.

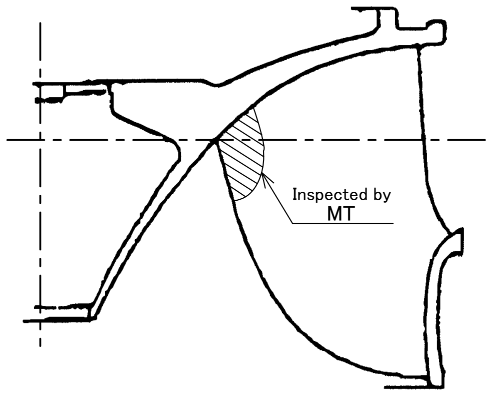


Figure 3-1: Area of Inspection by Magnetic Particle Test (MT)

2. Test Results

(1) The magnetic particle test (MT) detected a flaw of 5 mm on Blade No. 1 as shown in Figure 3-2. This will be an inherent flaw and not a progressive defect.

(2) No other defects were detected on the runner.

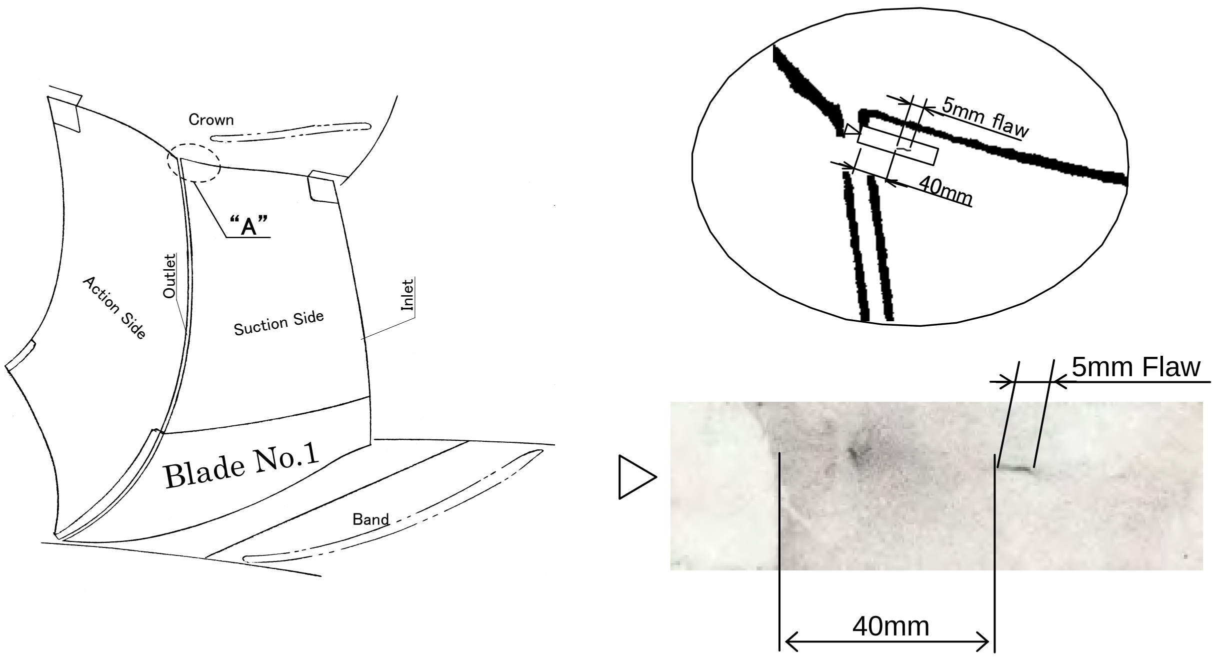


Figure 3-2: Flaw on Blade No. 1

APPENDIX-4: RESULTS OF REPLICA FILM TEST (ST) FOR RUNNER

1. Inspection Area

The replica film test (ST) was applied to the Blades Nos. 9 and 15 for the tips at the outlet side on the runner crown as shown in Figure 4-1.

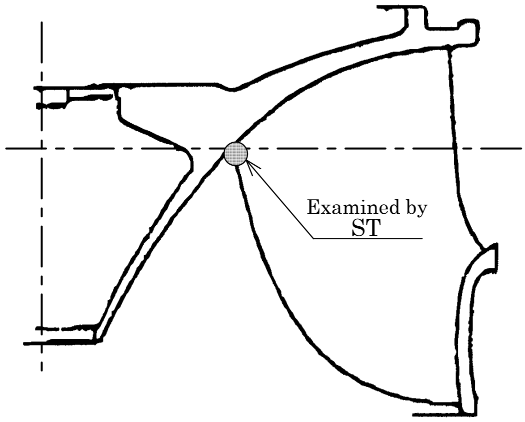
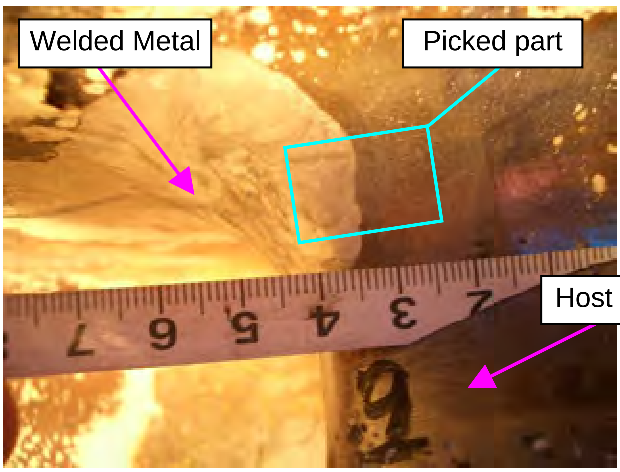
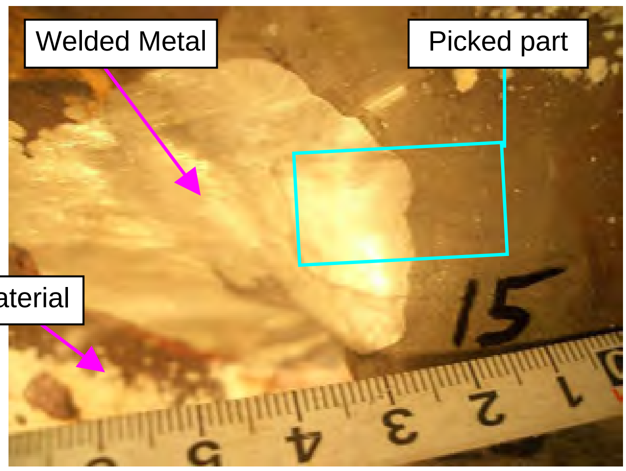


Figure 4-1: Area of Inspection by Replica Film Test (ST)



Detail of Blade No. 9



Detail of Blade No.15

2. Test Results

(1) As a result of the replica film test (ST), it was found that the Blades No. 9 and 15 had been reinforced by welding of two kinds of metals; stainless steel and mild steel, to the host material (SC46) as shown in Figure 4-2.

(2) However, no defects were detected on the Blades No. 9 and 15.

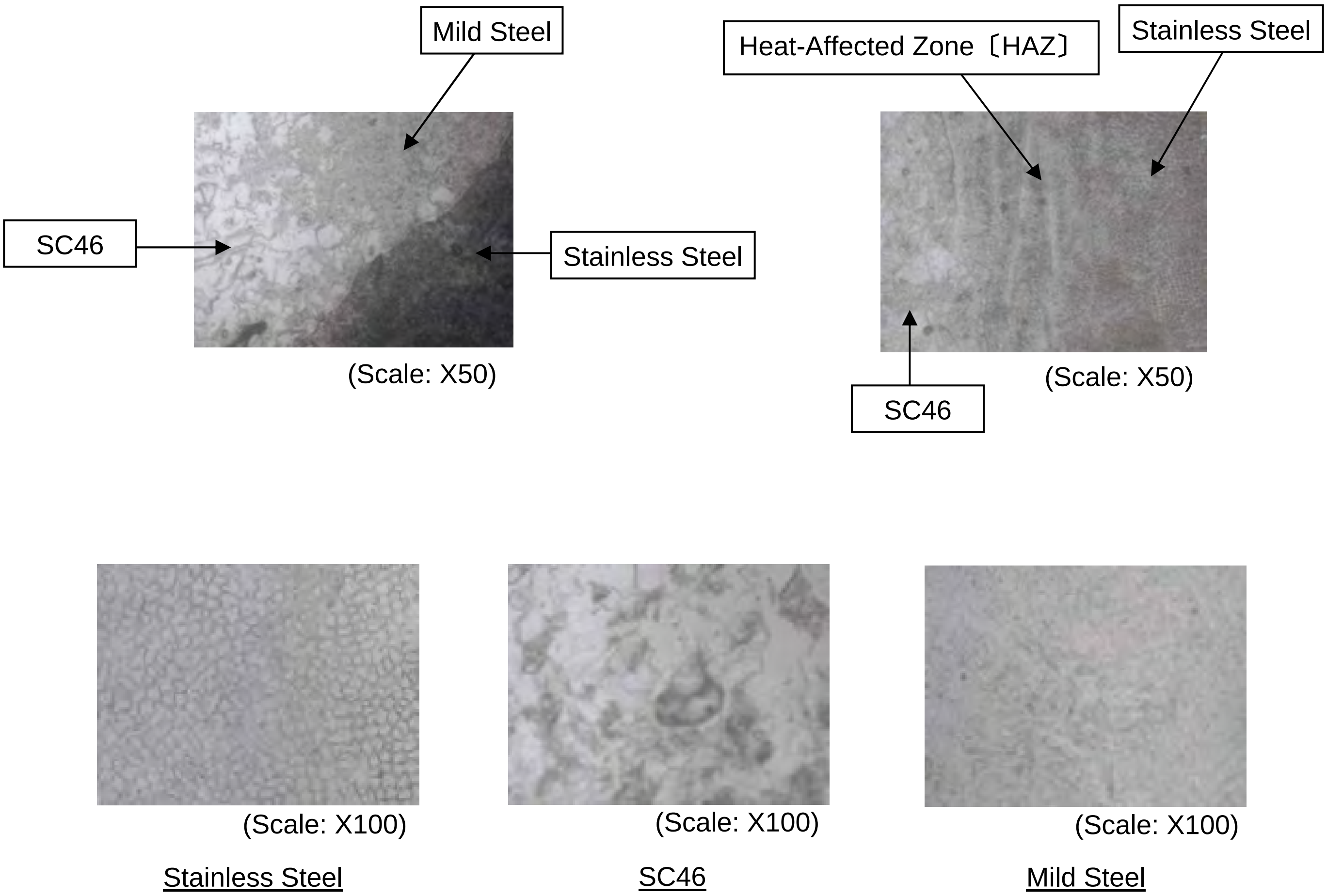


Figure 4-2: Microstructure Photographic Records

APPENDIX-5: RESULTS OF PENETRANT TEST (PT) FOR TURBINE GUIDE BEARING

1. Inspection Area

The penetrant test (PT) was applied to the circumference of the Babbitt metal to check adhesion of the Babbitt metal to the bearing support for the turbine guide bearing.

2. Test Results

The penetrant test (PT) showed that the Babbitt metals have been detached from the bearing support at the portions of almost 100 % on the circumference, as shown on the photographic records below.

3. Photographic Record

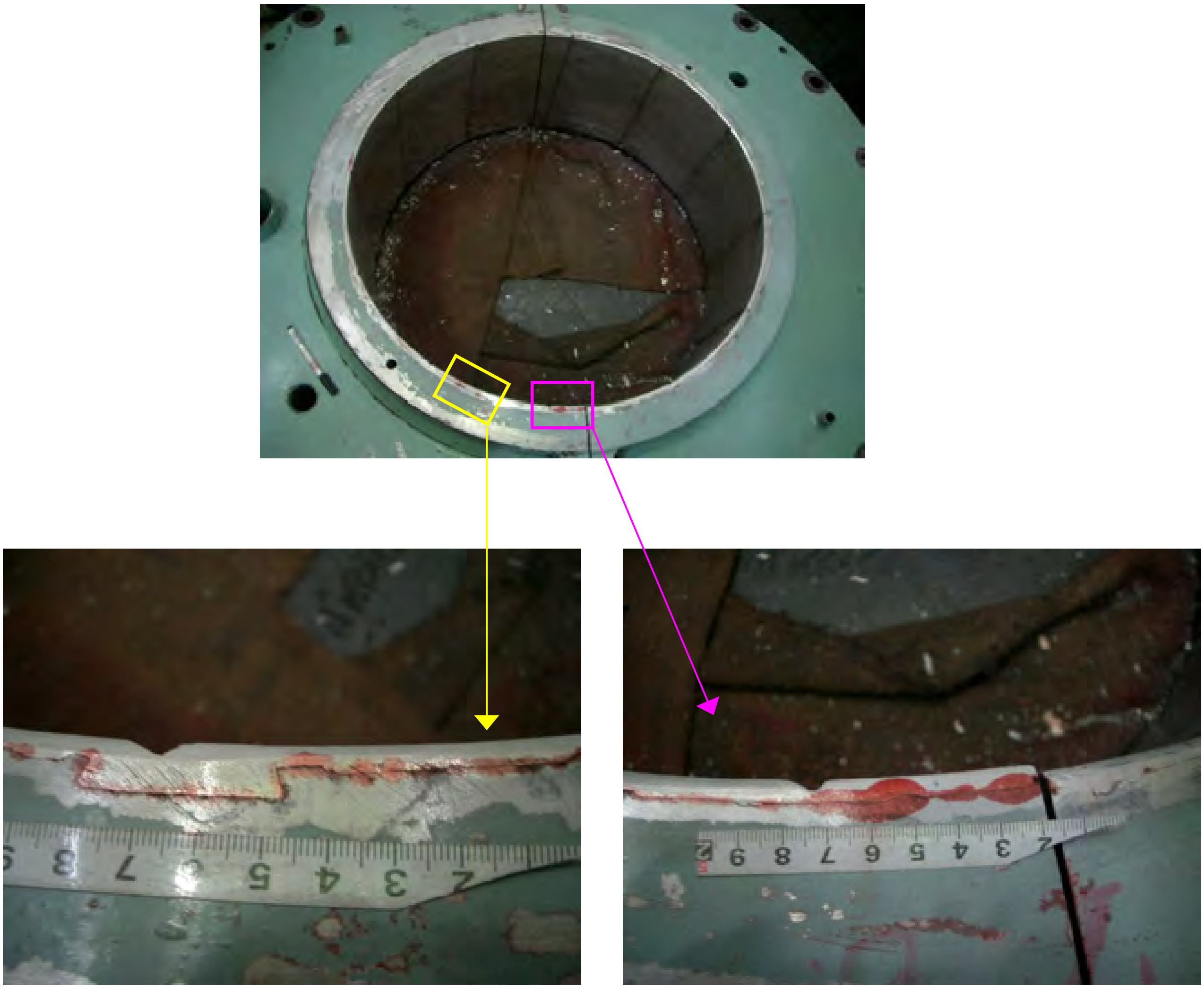
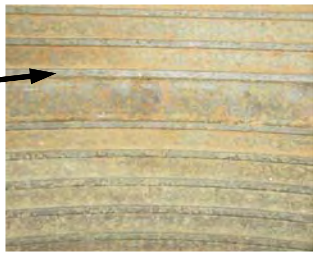


Figure 5-1: Detachment of Babbitt Metal from Bearing Support

APPENDIX-6: PHOTOGRAPHIC RECORDS OF TURBINE INSPECTION

1. Main Shaft Seal

Seal Liner



Corrosion on Seal Liner Surface

Sleeve

2. Turbine Guide Bearing

Overall View

Babbitt Metal has been detached from the Bearing Support

3. Guide Vanes

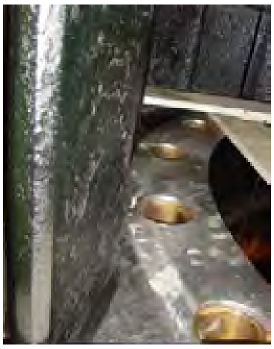
Guide Vanes

Guide Vane Upper Bushing

Guide Vane Arms

Guide Vane Link

4. Sheet Liners (Upper and Lower)

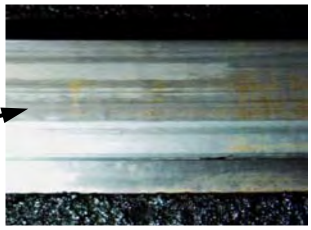


Upper Sheet Liner

Lower Sheet Liner

5. Wearing Rings, Head Cover and Bottom Cover

Bottom Cover



Upper Wearing Ring

Lower Wearing Ring

Scratch on Wearing Ring

6. Wearing Rings, Head Cover and Bottom Cover

Stay Ring after Repair

7. Inlet Valve

Butterfly Valve

Valve Disc

Bypass Valve

8. Draft Tube (After Repair)

Aeration Pipe (Below Runner)

Aeration Pipe (Upper Draft Tube)

APPENDIX-7: RESULTS OF DIAGNOSTIC TEST OF GENERATOR STATOR COILS

1. Method of Diagnostic Test

The diagnostic test of the generator stator coils was carried out for the following tests in accordance with the test methods stated in Clause 3 (3) of the Main Report.

(1) Polarization test
(2) AC leakage current test
(3) Dielectric loss angle (tan δ) test
(4) Corona (partial discharge) test

Concerning the test voltage, the rated generator terminal voltage (E) or 1.25E/√3 is usually applied to the diagnostic tests. Considering 31-year operation of the generator, the applied test voltage was selected at 1.25E/√3 to minimize the risk of damage on the stator coils due to this test.

Therefore, the applied test voltage was 1.25E/√3 = 8.0 kV.

2. Test Results

(1) Polarization Index Test

Polarization index (PI) was measured by applying DC 1,000 V for 10 minutes to three phases of the stator coils, in order to confirm the dry condition of the stator coil before applying AC high voltage.

PI = (Insulation resistance at 10 minutes)/(Insulation resistance at 1 minute)

Criteria: PI > 1.5

The measured results were as tabulated below.

Time (min)	Insulation Resistance (M-ohm)	Time (min)	Insulation Resistance (M-ohm)
0.50	81	5.00	161
1.00	**106**	6.00	166
1.50	118	7.00	177
2.00	129	8.00	173
3.00	143	9.00	178
4.00	155	10.00	**180**
Ambient Temperature = 31.1 °C, Relative Humidity = 74.6 %			

Then, PI is calculated as follows:

PI = 180/106
= 1.70 > 1.5

This test result showed that the stator coils were enough dried for AC high voltage test.

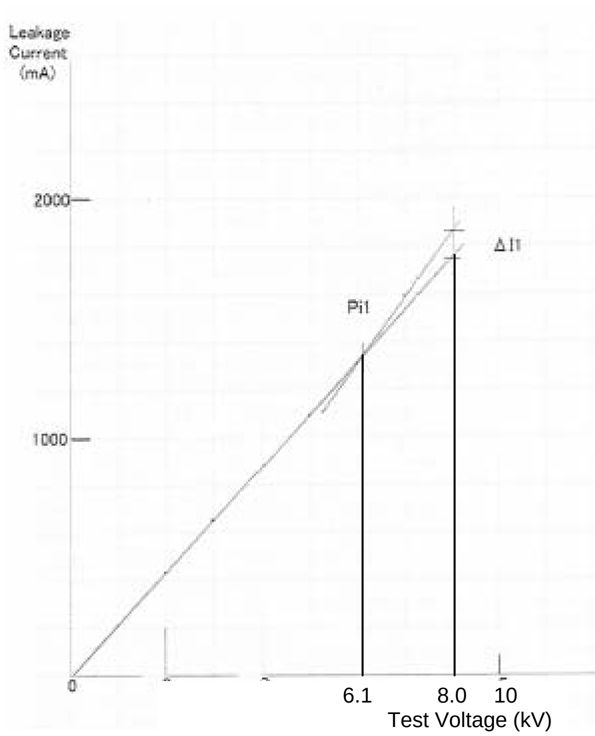
(2) AC Leakage Current Test

Normal power-frequency voltage was applied to three-phase of the stator coils through a high voltage transformer.

The voltage was gradually increased from initial voltage 1.0 kV to 8.0 kV, which is equal to 1.25E/√3 (E = 11 kV), and leakage currents was measured at every 1.0 kV step.

Below is the test results:

Test Voltage (kV)	Leakage Current (mA)
1.0	210
2.0	430
3.0	650
4.0	870
5.0	1090
6.0	1310
7.0	1590
8.0	1860



Pi1 (Voltage at the first rapid increasing of leakage current) was measured at 6.1 kV, which is lower than the acceptance criteria (Pi1 ≥ 7.3 kV). However, Pi2 (Voltage at the second rapid increasing of leakage current) was not appeared.

Rapid increase of leakage current is a factor to indicate that partial discharge is occurred at Pi1 due to voids in the main insulation layers of the stator coils. According to the initial insulation characteristics, Pi1 is higher than the rated terminal voltage E = 11.0 kV.

On the other hand, Δ I (Rate of leakage current increment) at the test voltage 8.0 kV was measured at 6.29 %. This Δ I = 6.29 % does not satisfy the acceptance criteria (Δ I ≤ 5.0 %).

Normally Δ I is 0 % at the rated terminal voltage.

(3) Dielectric Loss Angle (tan δ) Test

Dielectric loss angle (tan δ) test was not carried out because of non-availability of the testing instrument.

(4) Corona Test (Partial Discharge Test)

The test voltage was AC 8.0 kV, 6.4 kV and 5.1 kV. Partial discharge pulse was measured at each voltage step in order of 8.0 kV, 6.4 kV and 5.1 kV.

The partial discharge analyzer has two amplifiers; one for wide frequency band of 3 kHz to 3 MHz, and the other for lower frequency band of 3 kHz to 200 kHz.

The test results are shown on Pages AP7-4 to AP7-7.

According to the test results, the maximum discharge (Q_{max}) at 6.4 kV (= E/√3) was measured as follows:

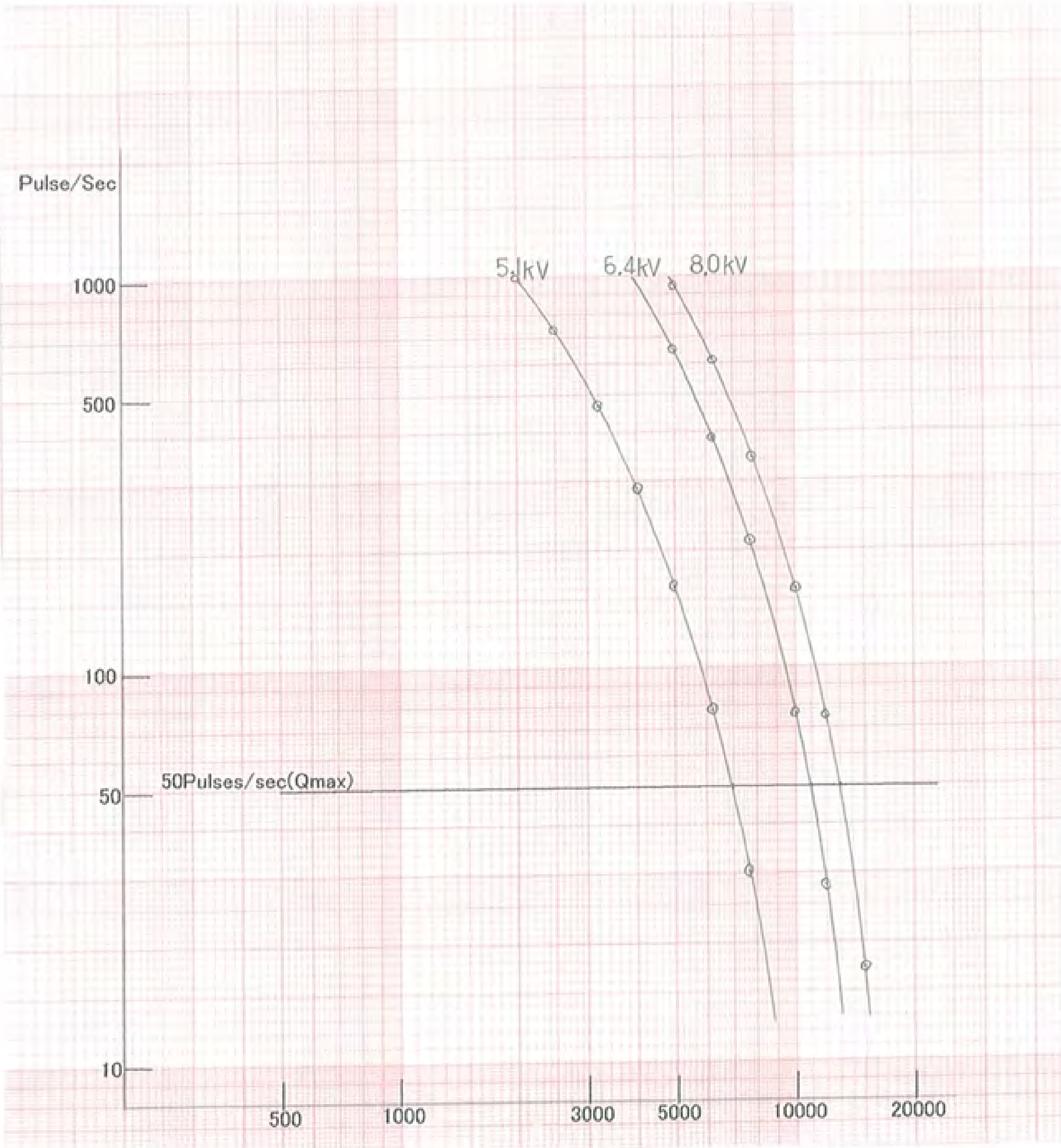
Type of Amplifier	Max Discharge (Q_{max})	Acceptance Criteria
Wide band frequency	11,000 pc	≤ 5,000 pc
Low band frequency	22,000 pc	≤ 10,000 p

This measurement shows that the measured Q_{max} is exceeding the acceptance criteria for both wide and low band frequencies.

Diagnostic Test of Stator Winding on Unit 1

Corona (Partial Discharge) Test

Discharge pulse repetitive rate/sec versus test voltage, <u>Type of amplifier : wide band</u>



Tested by : K.Yasuda

Test condition : Ambient Temp 31.1℃ Relative Humidity 74.6%

Test date: 19. Oct. 2004

Diagnostic Test of Stator Winding on Unit 1

Corona (Partial Discharge) Test

The maximum discharge Qmax versus test voltage, Type of amplifier : wide band

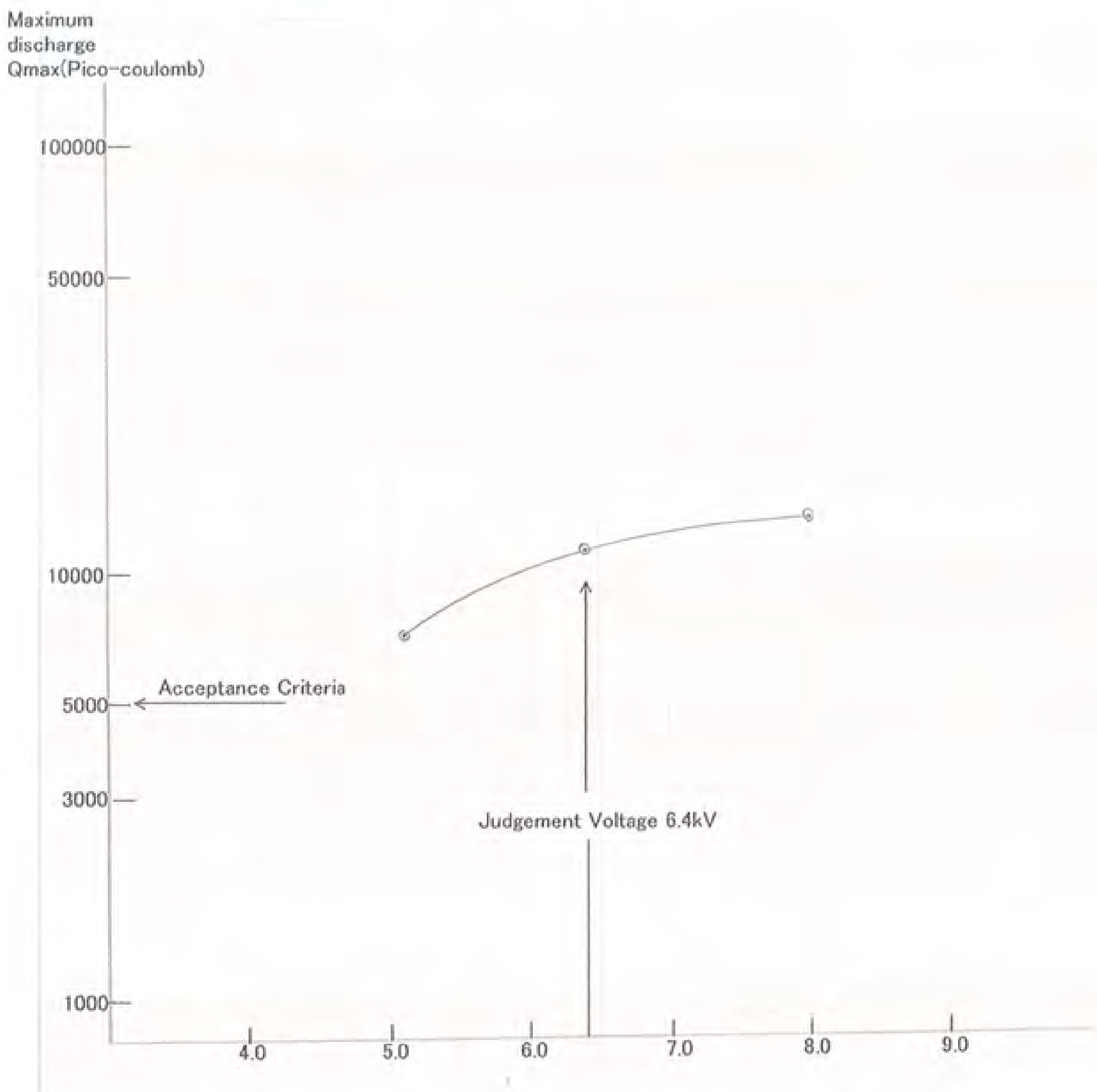
Test result

Qmax(6.4kV) was lager than 5000 pico-coulomb ----- unacceptable

Discount Point ----- 5

Test Voltage(kV)	Qmax (PC)		
8.0	13000		
* 6.4	11000		
5.1	7000		
Phase	Three phase		

※ Judgment Voltage



Tested by : K.Yasuda

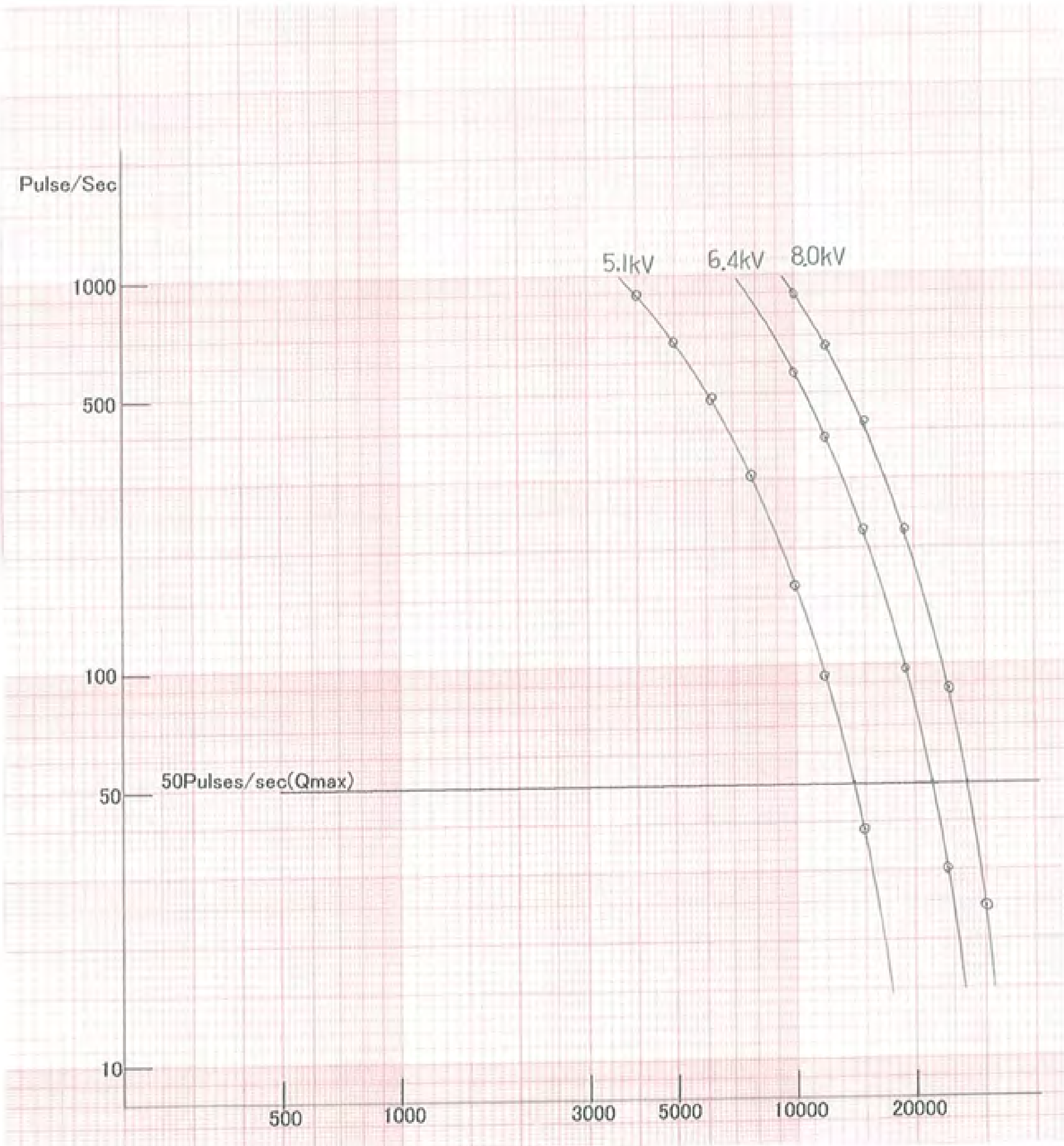
Test condition : Ambient Temp 31.1℃ Relative Humidity 74.6%

Test date: 19. Oct. 2004

Diagnostic Test of Stator Winding on Unit 1

Corona (Partial Discharge) Test

Discharge pulse repetitive rate/sec versus test voltage, Type of amplifier : Low band



Tested by : K.Yasuda

Test condition : Ambient Temp 31.1℃ Relative Humidity 74.6%

Test date: 19. Oct. 2004

Diagnostic Test of Stator Winding on Unit 1

Corona (Partial Discharge) Test

The maximum discharge Qmax versus test voltage, Type of amplifier : Low band

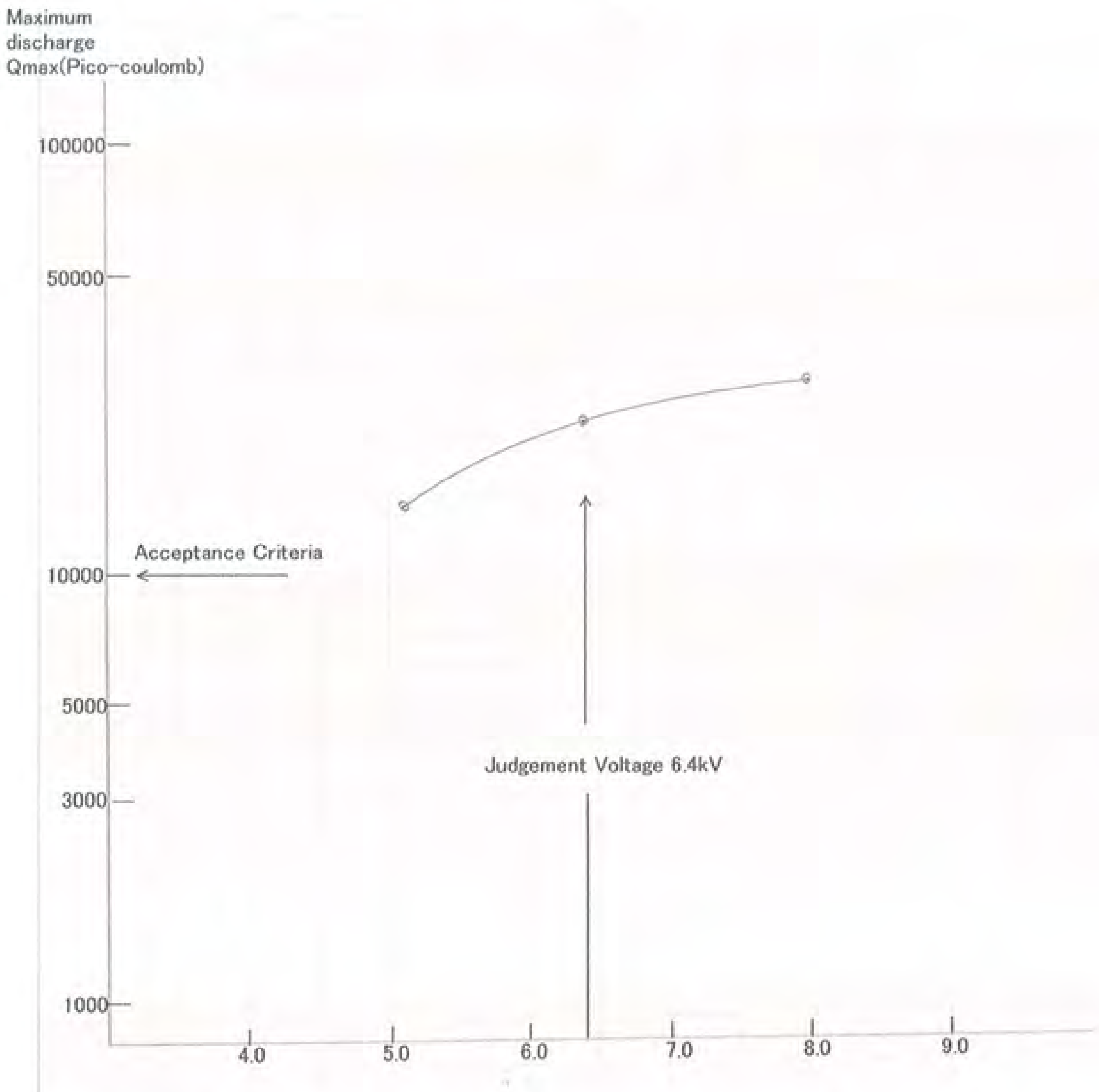
Test result

Qmax(6.4kV) was lager than 10000 pico-coulomb ----- unacceptable

Discount Point ----- 5

Test Voltage(kV)	Qmax (PC)		
8.0	27000		
* 6.4	22000		
5.1	14000		
Phase	Three phase		

※ Judgment Voltage



Tested by : K.Yasuda

Test condition : Ambient Temp 31.1℃ Relative Humidity 74.6%

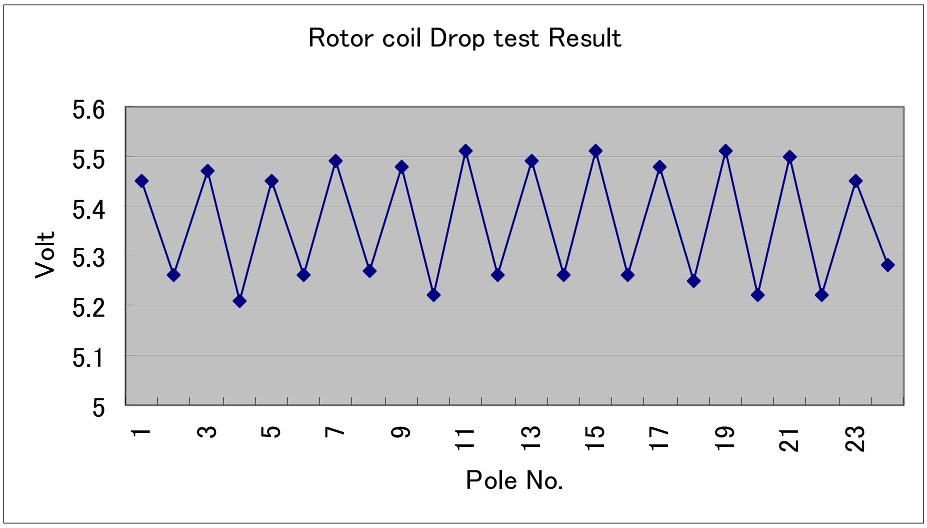
Test date: 19.Oct. 2004

APPENDIX-8: RESULTS OF ROTOR COIL DROP TEST (VOLTAGE BALANCE TEST)

1. Results of Rotor Coil Drop Test (Voltage Balance Test)

Pole No.	Voltage	Pole No.	Voltage	Pole No.	Voltage
1	5.45	9	5.48	17	5.48
2	5.26	10	5.22	18	5.25
3	5.47	11	5.51	19	5.51
4	5.21	12	5.26	20	5.22
5	5.45	13	5.49	21	5.5
6	5.26	14	5.26	22	5.22
7	5.49	15	5.51	23	5.45
8	5.27	16	5.26	24	5.28
Total: 128.76 V			Average: 5.365 V		

Criteria: 5.365 V ± 10 % (4.8 - 5.9 V)



<u>Result: Good</u>

2. Insulation Resistance Test for Rotor

The insulation resistance of the rotor was measured by 500 V megger for one minute.

<u>Result: More than 1,000 M-ohm</u>

APPENDIX E

Power and Energy Calculation

of Sutami and Wlingi

APPENDIX E POWER AND ENERGY ESTIMATION OF SUTAMI AND WLINGI HYDROPOWER STATION

E1. ENERGY ESTIMATION OF SUTAMI I POWER STATION

E1.1 OBJECTIVES OF THE STUDY

Replacement of the turbine and the generator of the Sutami power station and have been proposed by the JICA Study as described in Chapter 4.1 of the main report. By means of the replacement, rest of life period of the generating equipment will be extended and also the efficiency of the generating equipment will be increased. In order to estimate the energy benefit, the energy calculations of with project (with replacement) and without project (without replacement) have been carried out.

E1.2 STUDY CASES

As described Chapter 4.1 of the main report, the combination the number of the operated generating equipment in each study cases are planed as shown in Table E1.1.

Calculation of the generating energy production including dependable power output has been performed based on the operated combinations.

Table E1.1 Combination of Operated Generating Equipment

Year	Without Project				With Project	
	Case 1		Case 2			
	Exist. Eq.	New Eq.	Exist. Eq.	New Eq.	Exist. Eq.	New Eq.
2014	3	-	3	-	2	-
2015	3	-	3	-	1	1
2016	3	-	3	-	-	2
2017	2	-	2	-	-	3
2018	2	-	2	-	-	3
2019	2	-	2	-	-	3
2020	-	-	-	-	-	3
2021	-	-	-	-	-	3
2022	-	-	-	1	-	3
2023	-	-	-	1	-	3
2024	-	-	-	1	-	3
2025	-	-	-	3	-	3
2026	-	-	-	3	-	3
……	-	-	-	3	-	3
2060	-	-	-	3	-	3

Source : Prepared by JICA Study Team

E1.3 CONDITIONS FOR ESTIMATION OF ENERGY PRODUCTION

(1) EFFECTIVE STORAGE VOLUME

According to the JASA TIRTA I, the effective storage volume of the Sutami reservoir is estimated as 141.16MCM in 2009 based on the water depth survey. The effective volumes in each have been estimated in accordance with previous study report "THE BRANTAS RIVER AND THE BENGAWAN SOLO RIVER BASIN", FEBRUARY 2005 (here in after mentioned as "Brantas Project")

Table E.1.2 Effective Storage Volume of Sutami Reservoir

Year	Effective Storage Volume (MCM)
1976	204.98*1)
2009	141.16*1)
2014	137.36
2015	136.60
2016	135.84
2017	135.08
2018	134.32
2019	133.56
2020	132.80
2021	132.04
2022	131.28
2023	130.52
2024	129.76
2025	129.00
2026	128.24
2060	102.20

Source : Prepared by JICA Study Team based on estimation of the JASA TIRTA I and the 'Brantas Project'.

*1) : Estimated by the JASA TIRTA I based on survey record.

(2) RESERVOIR OPEPRATION RULE

Operation rule of the Sutami reservoir has been determined based on priority of the generating pattern of the power station. Fist priority of the Sutami reservoir is the water supply to the downstream river so as to meet the irrigation and the domestic water supply.

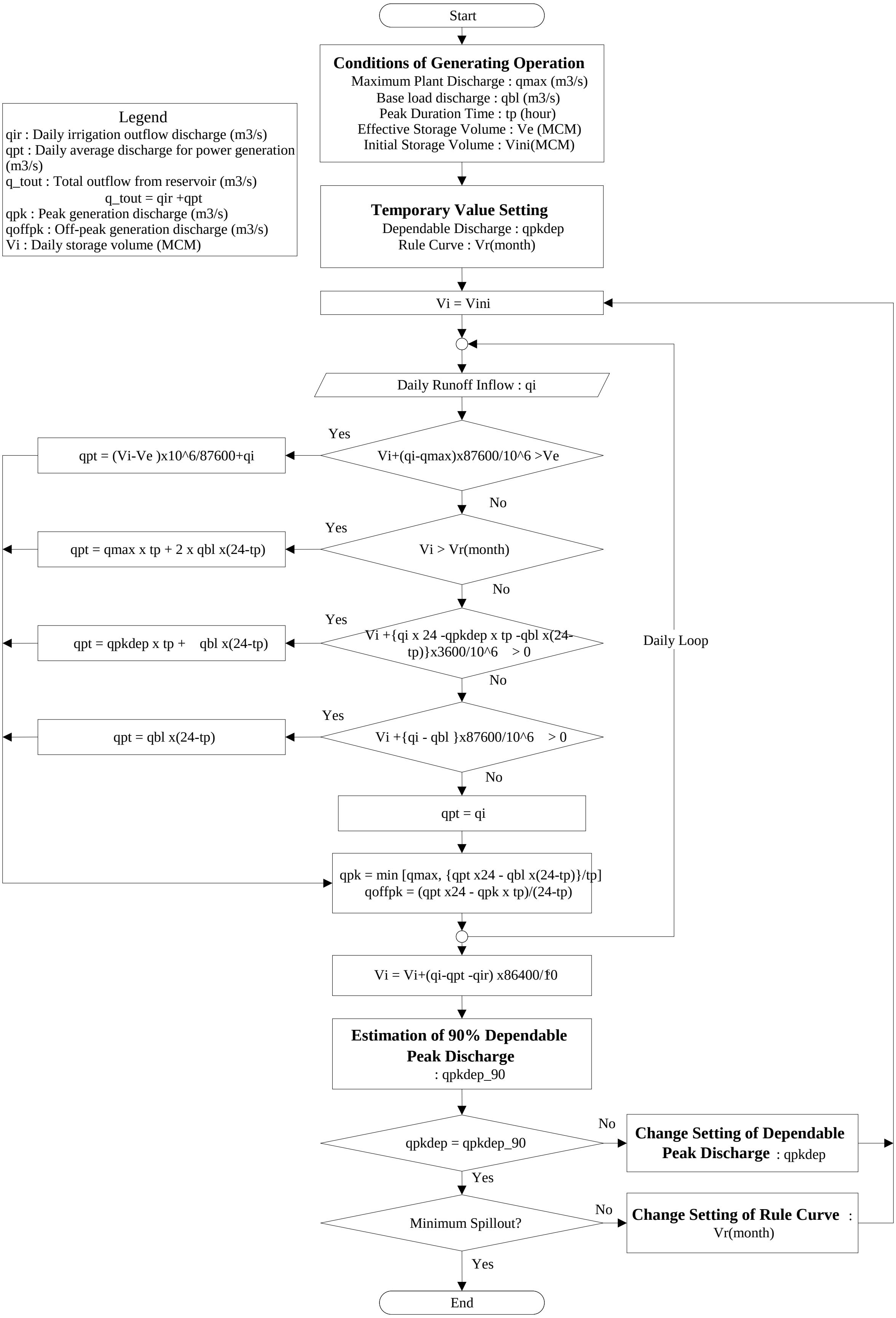
At least, one number of generating equipment is operated with half load capacity throughout the day (24hour) so that the power discharge volume can meet requirements of the water supply. Second priority, which is the main purpose of the power station, is maximum number of the generating equipment is operate with full load capacity for 6 hours so as to meet peak power demand. Third priority is to utilize excess water for the power generation.

Generating pattern for the Sutami Power Station and the operation rule of the Sutami reservoir are as shown in Table E1.3 and Figure E1.1 respectively.

Table E.1.3 Generating Pattern for Sutami Power Station

Priority	Generating Pattern			Purpose
	Number of Unit (Nos.)	Operation Time (hour)	Power Ratio (Operation / Capacity) (%)	
First	1	24	50	Water supply for irrigation and domestic water supply
Second	Maximum number of operational units	6	100	Peak power supply.
Third	Maximum number of operational units	24	100	Excess power supply.

Source : Prepared by JICA Study Team based on the planned and actual generating pattern.

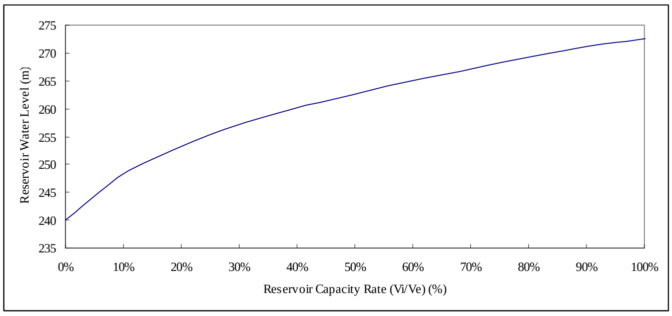


Source : Prepared by JICA Study Team

Figure E.1.1 Reservoir Operation Rule of Sutami Reservoir

(3) RESERVOIR WATER LEVEL

Reservoir water level is estimated by effective capacity ration – reservoir water level relationship as shown in Figure E1.2. The relationship is estimated by the survey results in 1994.



Source : Prepared by JICA Study Team based on water depth survey by the JASA TIRTA I in 1994

Figure E.1.2 Effective Storage Capacity Rate – Water Level Relationship

(4) Tail Water Level, Head Loss and Effective Head

The effective head of the Sutami power station has been estimated by applying following assumption as shown in Table E1.4.

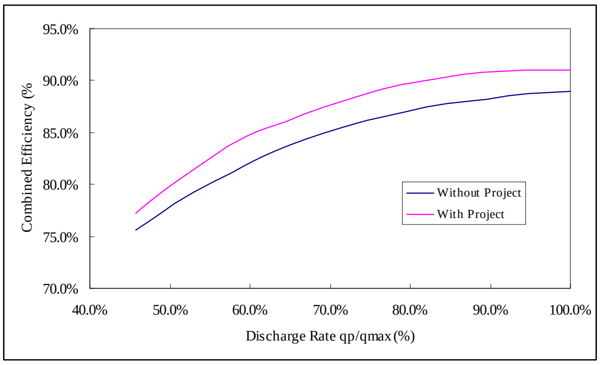
Table E.1.4 Effective Head Calculation Criteria of Sutami Power Station

Item	Value
Tail Water Level	182.50 m
Head Loss	8% of Gross Head
Effective Head	Reservoir Water Level – Tail Water Level – Head Loss

Source : Prepared by JICA Study Team

(5) Combined efficiency of Turbine and Generator

Assumed combined efficiency of turbine and generator is as shown in Figure E1.3.



Source : Prepared by JICA Study Team

Figure E.1.3 Combined Efficiency of Turbine and Generator

E1.4RESULTS OF ENERGY CALCULATION

Based on the runoff inflow data from 2004 to 2009, energy calculation has been carried out. Summary of the energy calculation is as shown in Table E1.5.

Table E1.5 Summary of Energy Estimation (Sutami PS)

Year	Without Project								With Project			
	Case 1				Case 2							
	Dependable Output (MW)	Energy (GWh)			Dep. Op. (MW)	Energy (GWh)			Dep. Op. (MW)	Energy (GWh)		
		Primary	Secondary	Total		Prm.	Sec.	Tot.		Prm.	Sec.	Tot.
1976	**80.0**	**215**	**210**	**425**					-	-	-	-
2014	71,2	202	225	427	71,2	202	225	427	67.9	159	255	414
2015	71.1	202	225	427	71.1	202	225	427	68.9	161	259	420
2016	71.0	202	225	427	71.0	202	225	427	69.9	164	263	427
2017	67.9	159	255	414	67.9	159	255	414	72.9	208	232	440
2018	67.9	159	255	414	67.9	159	255	414	72.9	207	233	440
2019	67.9	159	255	414	67.9	159	255	414	72.6	207	233	440
2020	-	-	-	-	-	-	-	-	72.5	207	233	440
2021	-	-	-	-	-	-	-	-	72.5	207	233	440
2022	-	-	-	-	37.2	84	223	307	72.3	207	233	440
2023	-	-	-	-	37.2	84	223	307	72.0	206	234	440
2024	-	-	-	-	37.2	84	223	307	72.0	206	234	440
2025	-	-	-	-	71.8	206	234	440	71.8	206	234	440
2026	-	-	-	-	71.7	206	233	439	71.7	206	234	440
……	-	-	-	-	**……**	**……**	**……**	**……**	**……**	**……**	**……**	**……**
2060	-	-	-	-	67.3	201	240	440	67.3	201	240	440

Source : Prepared by JICA Study Team

Summary outputs of the above calculations are as shown in Table E1.6 to E1.10.

Table E1.6 Summary Output of Energy Estimation for Sutami Hydropower Station (Original Case)

A. Conditions

Case : Original

Storage : **Effective Volume=** **204.98** MCM **Year of Storage Estimation=** **1976**

Equipment : **Number of Existing Machine=** **3** Nos. **Number of Replaced Machine=** **0** Nos.

B. Summary Results

90% Dependable Power Output= 80.0 MW

Average Power Output= 94.9 MW

Primary Energy= 215 GWh/year

Secondary Energy= 211 GWh/year

Total Energy= 425 GWh/year

Average Inflow= 73.2 m3/s

Average Power Discharge= 72.9 m3/s

Annual Spill out Discharge = 17.0 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	105.3	105.3	105.3	105.3	105.3	105.3	105.3	101.5	91.1	59.9	57.5	102.1	95.8
2005	105.3	105.3	105.3	105.3	105.3	105.3	105.2	100.8	89.2	76.0	49.1	89.1	95.1
2006	105.3	105.3	105.3	105.3	105.3	105.3	105.3	105.0	99.1	86.7	39.3	57.1	93.7
2007	65.1	79.8	86.7	103.8	105.3	105.3	105.3	103.1	94.4	60.4	74.7	98.8	90.2
2008	105.3	105.3	105.3	105.3	105.3	105.3	105.3	103.9	96.6	84.9	87.4	101.3	100.9
2009	105.3	105.3	105.3	105.3	105.3	105.3	105.3	102.9	94.4	83.7	55.0	54.0	93.9
Average	98.6	101.0	102.2	105.0	105.3	105.3	105.3	102.8	94.1	75.3	60.5	83.7	94.9

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	19.5	20.2	20.8	20.7	20.0	20.1	18.9	16.4	11.1	10.4	19.2	217.5
2005	20.7	18.5	20.8	20.2	20.6	19.4	19.8	18.7	16.1	14.1	8.8	16.6	214.4
2006	20.7	18.8	20.8	20.2	20.8	20.1	20.5	19.8	17.8	16.1	7.1	10.6	213.3
2007	12.1	13.4	16.1	18.9	20.6	20.0	20.2	19.2	17.0	11.2	13.5	18.5	200.6
2008	20.8	19.5	20.9	20.2	20.8	20.0	20.4	19.4	17.4	15.8	15.7	18.9	229.6
2009	20.3	18.9	20.8	20.2	20.8	20.0	20.2	19.1	17.0	15.6	9.9	10.1	212.9
Average	19.1	18.1	19.9	20.1	20.7	19.9	20.2	19.2	16.9	14.0	10.9	15.6	214.7

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	16.6	35.6	52.4	28.8	13.0	11.3	10.0	9.4	8.2	7.5	7.2	13.2	213.0
2005	22.0	22.4	36.9	34.9	11.6	9.6	9.8	9.3	8.0	7.6	7.1	8.3	187.4
2006	33.0	34.9	36.9	44.4	34.2	13.6	10.2	9.8	8.9	8.0	7.1	7.4	248.3
2007	7.4	6.8	8.0	22.3	10.6	12.9	10.0	9.5	8.4	7.6	7.2	9.2	120.0
2008	32.8	31.5	57.2	45.7	26.7	10.9	10.1	9.6	8.6	7.8	7.8	9.4	258.3
2009	21.3	51.2	41.0	32.2	27.1	14.6	10.0	9.5	8.4	7.7	7.1	7.4	237.6
Average	22.2	30.4	38.7	34.7	20.5	12.2	10.0	9.5	8.4	7.7	7.3	9.1	210.8

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	71.9	110.6	140.1	93.8	64.1	61.6	58.9	58.9	58.9	48.6	47.9	65.8	73.4
2005	81.4	87.2	108.6	107.0	61.5	13.6	58.9	58.9	58.9	56.1	44.0	58.7	66.2
2006	101.7	111.7	108.6	124.8	103.6	66.3	58.9	58.9	58.9	58.9	39.5	48.0	78.3
2007	51.7	58.2	58.9	85.9	59.6	64.9	58.9	58.9	58.9	48.5	56.1	58.9	60.0
2008	101.2	102.7	145.5	127.4	90.0	60.9	58.9	58.9	58.9	58.9	58.9	58.9	81.8
2009	80.5	144.5	116.0	101.9	90.7	68.3	58.9	58.9	58.9	58.9	47.0	46.5	77.6
Average	81.4	102.5	112.9	106.8	78.2	55.9	58.9	58.9	58.9	55.0	48.9	56.1	72.9

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	7.2	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.7
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	1.2	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	29.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.3
2009	1.8	32.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.1
Average	0.3	6.6	8.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0

Source: Estimated by JICA Study Team

Table E1.7-1 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case1 &2)

A. Conditions

Case : Without Case 1 & Case 2

Storage : **Effective Volume=** 137.36 MCM **Year of Storage Estimation=** 2014

Equipment : **Number of Existing Machine=** 3 Nos. **Number of Replaced Machine=** 0 Nos.

B. Summary Results

90% Dependable Power Output=	71.2 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	89.8 MW	**Average Power Discharge=**	72.6 m3/s
Primary Energy=	202 GWh/year	**Annual Spill out Discharge =**	18.9 MCM
Secondary Energy=	225 GWh/year		
Total Energy=	427 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	102.6	105.3	105.3	105.3	101.6	100.2	97.3	90.0	77.5	36.8	55.6	101.2	89.9
2005	105.3	105.3	105.3	105.3	100.1	96.9	97.4	91.6	79.0	61.6	54.3	85.2	90.6
2006	105.3	105.3	105.3	105.3	105.0	101.9	99.1	95.8	87.9	63.0	34.2	54.1	88.5
2007	69.6	74.2	86.1	105.3	102.7	101.1	97.9	92.9	82.8	39.8	74.0	97.1	85.3
2008	105.3	105.3	105.3	105.3	104.8	100.8	98.8	93.8	85.2	68.1	80.4	98.4	96.0
2009	105.3	105.3	105.3	105.3	104.8	102.0	97.5	91.9	81.8	60.5	50.2	55.5	88.8
Average	98.9	100.1	102.1	105.3	103.2	100.5	98.0	92.7	82.4	55.0	58.1	81.9	89.8

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.6	19.4	20.1	20.8	19.3	18.1	18.1	16.7	13.9	6.8	10.0	19.5	202.6
2005	20.7	18.3	20.8	20.1	18.7	17.4	18.1	17.0	14.2	11.5	9.8	16.0	202.7
2006	20.8	18.8	20.8	20.2	20.7	18.8	18.4	17.8	15.8	11.7	6.2	10.1	200.0
2007	12.9	12.5	16.0	20.1	19.7	18.6	18.2	17.3	14.9	7.4	13.3	18.7	189.6
2008	20.8	19.5	20.8	20.1	20.6	18.3	18.4	17.4	15.3	12.7	14.5	18.7	217.2
2009	20.8	18.8	20.8	20.1	20.6	18.8	18.1	17.1	14.7	11.3	9.0	10.3	200.5
Average	19.3	17.9	19.9	20.2	19.9	18.3	18.2	17.2	14.8	10.2	10.5	15.5	202.1

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.6	35.5	52.4	28.7	15.0	10.9	10.0	9.3	7.7	7.3	7.2	28.3	232.0
2005	21.9	22.2	36.9	34.8	11.2	9.7	10.0	9.4	7.9	7.6	7.2	11.1	189.9
2006	43.7	34.9	36.9	44.3	33.5	15.0	10.2	9.9	8.7	7.7	7.1	7.4	259.1
2007	7.5	7.0	10.0	34.8	15.6	12.9	10.1	9.6	8.2	7.3	7.4	20.2	150.6
2008	36.8	31.5	58.5	45.7	26.4	11.6	10.2	9.7	8.5	7.5	8.0	14.6	269.0
2009	32.8	51.1	40.9	32.2	26.4	15.3	10.0	9.5	8.1	7.4	7.1	7.4	248.3
Average	27.1	30.4	39.2	36.8	21.4	12.6	10.1	9.5	8.2	7.5	7.3	14.8	224.8

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	76.1	110.6	140.1	93.8	65.1	57.3	54.9	54.9	54.9	38.3	46.7	91.1	73.7
2005	81.4	87.2	108.6	107.0	57.2	15.0	54.9	54.9	54.9	48.9	46.0	59.6	64.6
2006	120.9	111.7	108.6	124.8	102.1	66.3	54.9	54.9	54.9	49.4	37.1	46.4	77.7
2007	53.3	54.5	58.0	107.0	67.3	62.1	54.9	54.9	54.9	39.1	54.9	76.4	61.5
2008	108.6	102.7	148.0	127.4	89.0	58.9	54.9	54.9	54.9	52.5	54.9	65.1	81.0
2009	101.2	144.5	116.0	101.9	89.0	67.1	54.9	54.9	54.9	49.5	44.5	46.9	77.1
Average	90.2	101.9	113.2	110.3	78.3	54.5	54.9	54.9	54.9	46.3	47.4	64.3	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	9.2	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	32.9
2005	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2006	13.6	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.5
2007	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2008	1.1	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.7
2009	0.0	29.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.6
Average	2.4	6.5	8.2	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	18.9

Source: Estimated by JICA Study Team

Table E1.7-2 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case1 &2)

A. Conditions

Case : Without Case 1 & Case 2

Storage : **Effective Volume=** **136.6** MCM **Year of Storage Estimation=** **2015**

Equipment : **Number of Existing Machine=** **3** Nos. **Number of Replaced Machine=** **0** Nos.

B. Summary Results

90% Dependable Power Output=	71.1 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	89.7 MW	**Average Power Discharge=**	72.6 m3/s
Primary Energy=	202 GWh/year	**Annual Spill out Discharge =**	19.6 MCM
Secondary Energy=	225 GWh/year		
Total Energy=	427 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	102.5	105.3	105.3	105.3	101.5	100.0	97.1	89.8	77.3	36.9	55.6	101.1	89.8
2005	105.3	105.3	105.3	105.3	99.9	96.7	97.2	91.5	78.9	61.7	54.4	85.1	90.6
2006	105.3	105.3	105.3	105.3	104.9	101.8	98.9	95.6	87.7	63.0	34.2	54.1	88.4
2007	69.7	74.0	86.1	105.3	102.0	101.1	97.5	92.5	82.4	38.9	73.9	97.1	85.0
2008	105.3	105.3	105.3	105.3	104.8	100.7	98.6	93.6	85.1	68.1	80.3	98.3	95.9
2009	105.3	105.3	105.3	105.3	104.8	101.9	97.3	91.7	81.7	60.5	50.1	55.5	88.7
Average	98.9	100.1	102.1	105.3	103.0	100.4	97.8	92.5	82.2	54.8	58.1	81.9	89.7

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.6	19.4	20.1	20.8	19.3	18.1	18.1	16.7	13.9	6.9	10.0	19.5	202.4
2005	20.7	18.3	20.8	20.1	18.7	17.4	18.1	17.0	14.2	11.5	9.8	15.9	202.6
2006	20.8	18.8	20.8	20.2	20.7	18.7	18.4	17.8	15.8	11.7	6.2	10.1	199.9
2007	13.0	12.4	16.0	20.1	19.5	18.6	18.1	17.2	14.8	7.2	13.3	18.7	188.9
2008	20.8	19.5	20.8	20.1	20.6	18.3	18.3	17.4	15.3	12.7	14.4	18.7	217.0
2009	20.8	18.8	20.8	20.1	20.6	18.8	18.1	17.1	14.7	11.3	9.0	10.3	200.4
Average	19.3	17.9	19.9	20.2	19.9	18.3	18.2	17.2	14.8	10.2	10.5	15.5	201.9

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.6	35.5	52.4	28.7	15.0	10.9	10.0	9.3	7.7	7.3	7.2	28.3	232.0
2005	21.9	22.2	36.9	34.8	11.2	9.7	10.0	9.4	7.9	7.6	7.2	11.1	190.0
2006	43.7	34.9	36.9	44.3	33.5	15.0	10.2	9.9	8.8	7.7	7.1	7.4	259.2
2007	7.5	7.0	10.0	36.1	14.6	13.3	10.1	9.5	8.2	7.3	7.4	20.2	151.2
2008	36.9	31.5	58.5	45.7	26.4	11.6	10.2	9.7	8.5	7.5	8.0	14.7	269.0
2009	32.8	51.2	40.9	32.2	26.4	15.3	10.0	9.5	8.1	7.4	7.1	7.4	248.3
Average	27.1	30.4	39.3	37.0	21.2	12.6	10.1	9.5	8.2	7.5	7.4	14.8	224.9

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	76.1	110.6	140.1	93.8	65.1	57.3	54.8	54.8	54.8	38.3	46.7	91.0	73.6
2005	81.4	87.2	108.6	107.0	57.2	15.0	54.8	54.8	54.8	49.0	46.1	59.6	64.6
2006	120.9	111.7	108.6	124.8	102.1	66.2	54.8	54.8	54.8	49.4	37.1	46.4	77.6
2007	53.3	54.5	58.0	109.5	65.0	62.9	54.8	54.8	54.8	38.7	54.8	76.4	61.5
2008	108.6	102.7	148.0	127.4	89.0	58.9	54.8	54.8	54.8	52.4	54.8	65.1	80.9
2009	101.2	144.5	116.0	101.9	89.0	67.0	54.8	54.8	54.8	49.5	44.5	46.9	77.1
Average	90.2	101.9	113.2	110.7	77.9	54.5	54.8	54.8	54.8	46.2	47.3	64.2	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	9.4	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	34.0
2005	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2006	14.5	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.4
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	2.1	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7
2009	0.0	30.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.7
Average	2.8	6.7	8.2	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	19.6

Source: Estimated by JICA Study Team

Table E1.7-3 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case1 &2)

A. Conditions

Case : **Without Case 1 & Case 2**

Storage : **Effective Volume=** **135.84** MCM **Year of Storage Estimation=** **2016**

Equipment : **Number of Existing Machine=** **3** Nos. **Number of Replaced Machine=** **0** Nos.

B. Summary Results

90% Dependable Power Output= 71.0 MW
Average Power Output= 89.7 MW
Primary Energy= 202 GWh/year
Secondary Energy= 225 GWh/year
Total Energy= 427 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 72.6 m3/s
Annual Spill out Discharge = 19.4 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	102.8	105.3	105.3	105.3	101.4	100.0	97.0	89.7	77.2	36.5	55.6	101.2	89.8
2005	105.3	104.9	105.3	105.3	99.4	96.7	97.2	91.5	78.9	61.8	54.4	85.1	90.5
2006	105.3	105.3	105.3	105.3	104.9	101.7	98.8	95.5	87.6	62.5	34.2	54.0	88.4
2007	69.7	74.0	86.4	105.3	102.6	100.9	97.7	92.6	82.5	39.4	73.9	97.1	85.2
2008	105.3	105.3	105.3	105.3	104.8	100.6	98.6	93.5	84.9	67.6	80.3	98.5	95.8
2009	105.3	105.3	105.3	105.3	104.8	101.8	97.2	91.6	81.5	60.1	50.1	55.5	88.6
Average	98.9	100.0	102.1	105.3	103.0	100.3	97.7	92.4	82.1	54.6	58.1	81.9	89.7

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.7	19.4	20.1	20.8	19.2	18.1	18.0	16.7	13.9	6.8	10.0	19.5	202.3
2005	20.7	18.2	20.8	20.1	18.5	17.4	18.1	17.0	14.2	11.5	9.8	15.9	202.3
2006	20.8	18.8	20.8	20.2	20.7	18.7	18.4	17.8	15.8	11.6	6.2	10.1	199.8
2007	13.0	12.4	16.1	20.0	19.7	18.5	18.2	17.2	14.9	7.3	13.3	18.7	189.2
2008	20.8	19.5	20.8	20.1	20.6	18.3	18.3	17.4	15.3	12.6	14.4	18.8	216.9
2009	20.8	18.8	20.8	20.1	20.6	18.8	18.1	17.0	14.7	11.2	9.0	10.3	200.2
Average	19.3	17.9	19.9	20.2	19.9	18.3	18.2	17.2	14.8	10.2	10.5	15.5	201.8

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	18.6	36.9	52.4	28.7	15.0	10.9	10.0	9.3	7.7	7.3	7.2	28.3	232.3
2005	21.9	21.9	38.2	34.8	10.6	9.7	10.0	9.4	7.9	7.6	7.2	11.1	190.4
2006	43.7	34.9	36.9	44.3	33.5	15.0	10.2	9.9	8.7	7.6	7.1	7.4	259.1
2007	7.5	7.0	11.5	33.4	15.6	12.9	10.1	9.6	8.2	7.3	7.4	20.2	150.7
2008	36.9	31.5	58.5	45.7	26.4	11.6	10.2	9.7	8.5	7.5	8.0	15.0	269.4
2009	32.8	51.1	40.9	32.2	26.4	15.3	10.0	9.5	8.1	7.4	7.1	7.4	248.2
Average	26.9	30.5	39.7	36.5	21.2	12.6	10.1	9.5	8.2	7.5	7.4	14.9	225.0

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.4	113.2	140.1	93.8	65.1	57.2	54.8	54.8	54.8	38.2	46.6	91.0	73.7
2005	81.4	86.3	111.0	107.0	55.6	15.0	54.8	54.8	54.8	49.0	46.1	59.6	64.6
2006	120.9	111.7	108.6	124.8	102.1	66.2	54.8	54.8	54.8	49.2	37.1	46.3	77.6
2007	53.3	54.4	61.2	104.5	67.3	62.1	54.8	54.8	54.8	39.0	54.8	76.4	61.4
2008	108.6	102.7	148.0	127.4	89.0	58.8	54.8	54.8	54.8	52.3	54.8	65.9	81.0
2009	101.2	144.5	116.0	101.9	89.0	67.0	54.8	54.8	54.8	49.3	44.5	46.9	77.1
Average	90.0	102.1	114.1	109.9	78.0	54.4	54.8	54.8	54.8	46.2	47.3	64.3	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	7.5	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	32.9
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	15.3	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2
2007	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2008	3.0	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.6
2009	0.0	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.5
Average	3.1	6.2	8.1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	19.4

Source: Estimated by JICA Study Team

Table E1.7-4 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case1 &2)

A. Conditions

Case : **Without Case 1 & Case 2**

Storage : **Effective Volume=** **135.08** MCM **Year of Storage Estimation=** **2017**

Equipment : **Number of Existing Machine=** **2** Nos. **Number of Replaced Machine=** **0** Nos.

B. Summary Results

90% Dependable Power Output=	67.9 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	69.6 MW	**Average Power Discharge=**	66.6 m3/s
Primary Energy=	159 GWh/year	**Annual Spill out Discharge =**	195.4 MCM
Secondary Energy=	255 GWh/year		
Total Energy=	414 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.2	66.7	64.9	70.2	69.4
2005	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.5	68.8	69.8	70.0	70.0
2006	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	68.5	65.1	62.3	69.0
2007	66.1	68.9	69.9	70.2	70.2	70.2	70.2	70.2	70.0	66.4	67.3	70.1	69.1
2008	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	68.6	70.0	70.2	70.1
2009	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.0	67.9	69.0	69.8
Average	69.5	70.0	70.1	70.2	70.2	70.2	70.2	70.2	69.9	68.0	67.5	68.6	69.6

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	13.6	13.0	13.5	13.9	13.9	13.4	13.8	13.5	12.5	12.4	11.7	13.9	159.0
2005	13.9	12.5	13.9	13.5	13.8	13.3	13.8	13.6	12.6	12.9	12.6	13.6	160.0
2006	13.9	12.6	13.9	13.5	13.9	13.4	13.8	13.8	13.0	12.7	11.7	11.6	157.8
2007	12.3	11.6	13.2	13.5	13.9	13.4	13.8	13.7	12.7	12.4	12.1	13.8	156.3
2008	13.9	13.0	13.9	13.5	13.9	13.4	13.8	13.7	12.9	12.8	13.1	13.9	161.7
2009	13.9	12.6	13.9	13.5	13.9	13.4	13.8	13.7	12.8	12.8	12.2	12.8	159.3
Average	13.6	12.6	13.7	13.5	13.9	13.4	13.8	13.6	12.7	12.7	12.2	13.3	159.0

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	24.6	34.5	40.4	30.6	22.3	15.1	11.3	10.4	9.6	9.6	9.0	35.8	253.1
2005	26.6	29.7	38.5	34.5	15.5	13.4	13.4	10.5	9.7	9.9	9.7	28.5	239.8
2006	39.8	35.7	37.8	39.1	37.2	20.2	12.3	11.0	10.0	9.8	9.0	8.9	270.9
2007	9.5	13.1	26.0	39.1	21.0	17.5	12.7	10.5	9.8	9.5	9.3	35.7	213.7
2008	37.2	32.5	41.8	39.8	30.6	17.9	11.7	10.5	9.9	9.8	20.5	29.2	291.4
2009	34.5	37.7	39.1	36.5	33.2	20.2	10.6	10.5	9.8	9.9	9.4	9.9	261.5
Average	28.7	30.6	37.3	36.6	26.6	17.4	12.0	10.6	9.8	9.8	11.2	24.7	255.1

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	72.5	94.5	103.6	83.0	67.8	55.3	47.3	46.0	46.0	46.0	46.0	92.6	66.7
2005	75.7	87.5	97.5	92.3	55.0	20.2	51.1	46.0	46.0	46.0	46.0	79.4	61.9
2006	100.0	99.6	96.3	101.1	95.1	65.2	49.2	46.6	46.0	46.0	46.0	46.0	69.7
2007	46.0	55.1	76.9	101.1	65.3	59.8	49.8	46.0	46.0	46.0	46.0	92.5	60.9
2008	95.1	90.6	103.6	102.3	83.0	60.7	47.9	46.0	46.0	46.0	65.9	80.6	72.3
2009	90.3	103.6	98.8	96.1	87.8	65.1	46.0	46.0	46.0	46.0	46.0	46.0	68.1
Average	79.9	88.5	96.1	96.0	75.7	54.4	48.6	46.1	46.0	46.0	49.3	72.8	66.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	4.1	54.0	117.8	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.6	245.4
2005	3.6	11.7	33.4	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9	111.6
2006	67.4	32.5	34.4	72.1	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	225.1
2007	0.0	0.0	0.0	33.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	63.1
2008	40.6	26.7	146.4	66.2	10.4	0.0	0.0	0.0	0.0	0.0	0.0	14.1	304.3
2009	27.4	131.2	41.6	16.3	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	222.8
Average	23.9	42.7	62.3	39.8	5.9	0.0	0.0	0.0	0.0	0.0	0.0	21.0	195.4

Source: Estimated by JICA Study Team

Table E1.7-5 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case1 &2)

A. Conditions

Case : Without Case 1 & Case 2
Storage : **Effective Volume=** 134.32 MCM **Year of Storage Estimation=** 2018
Equipment : **Number of Existing Machine=** 2 Nos. **Number of Replaced Machine=** 0 Nos.

B. Summary Results

90% Dependable Power Output= 67.9 MW
Average Power Output= 69.5 MW
Primary Energy= 159 GWh/year
Secondary Energy= 255 GWh/year
Total Energy= 414 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 66.6 m3/s
Annual Spill out Discharge = 195.4 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.2	66.7	64.8	70.2	69.4
2005	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.5	68.8	69.8	70.0	70.0
2006	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	68.4	65.1	62.1	69.0
2007	66.1	68.9	69.8	70.2	70.2	70.2	70.2	70.2	70.0	66.4	67.2	70.1	69.1
2008	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	68.6	70.0	70.2	70.0
2009	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.1	69.0	67.9	68.9	69.8
Average	69.5	70.0	70.1	70.2	70.2	70.2	70.2	70.2	69.9	68.0	67.5	68.6	69.5

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	13.6	13.0	13.5	13.9	13.9	13.4	13.8	13.5	12.4	12.4	11.7	13.9	158.9
2005	13.9	12.5	13.9	13.5	13.8	13.4	13.8	13.6	12.6	12.9	12.6	13.6	160.0
2006	13.9	12.6	13.9	13.5	13.9	13.4	13.8	13.8	13.0	12.7	11.7	11.6	157.8
2007	12.3	11.6	13.2	13.5	13.9	13.4	13.8	13.7	12.7	12.3	12.1	13.8	156.2
2008	13.9	13.0	13.9	13.5	13.9	13.4	13.8	13.7	12.9	12.8	13.1	13.9	161.7
2009	13.9	12.6	13.9	13.5	13.9	13.4	13.8	13.7	12.8	12.8	12.2	12.8	159.3
Average	13.6	12.5	13.7	13.5	13.9	13.4	13.8	13.6	12.7	12.7	12.2	13.3	159.0

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	24.6	34.5	40.4	30.6	22.3	15.1	11.3	10.4	9.6	9.6	9.0	35.8	253.1
2005	26.6	29.7	38.5	34.5	15.1	14.0	13.0	10.5	9.7	9.9	9.7	28.5	239.8
2006	39.8	35.7	37.8	39.1	37.2	20.2	12.3	11.0	10.0	9.8	9.0	8.9	270.9
2007	9.5	13.1	26.0	39.1	21.0	17.5	12.7	10.5	9.8	9.5	9.3	35.7	213.7
2008	37.2	32.5	41.8	39.8	30.6	17.9	11.7	10.5	9.9	9.8	20.5	29.2	291.3
2009	34.5	37.7	39.1	36.5	33.2	20.2	10.6	10.5	9.8	9.9	9.4	9.9	261.5
Average	28.7	30.6	37.3	36.6	26.6	17.5	11.9	10.6	9.8	9.7	11.2	24.7	255.1

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	72.5	94.5	103.6	83.0	67.8	55.3	47.3	46.0	46.0	46.0	46.0	92.6	66.7
2005	75.7	87.5	97.5	92.3	54.4	20.2	50.5	46.0	46.0	46.0	46.0	79.4	61.8
2006	100.0	99.6	96.3	101.1	95.1	65.2	49.2	46.6	46.0	46.0	46.0	46.0	69.7
2007	46.0	55.1	76.9	101.1	65.3	59.8	49.8	46.0	46.0	46.0	46.0	92.5	60.9
2008	95.1	90.6	103.6	102.3	83.0	60.7	47.9	46.0	46.0	46.0	65.9	80.6	72.3
2009	90.3	103.6	98.8	96.1	87.8	65.1	46.0	46.0	46.0	46.0	46.0	46.0	68.1
Average	79.9	88.5	96.1	96.0	75.6	54.4	48.4	46.1	46.0	46.0	49.3	72.8	66.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	4.3	54.0	117.8	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.6	245.5
2005	3.6	11.7	33.4	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.2	111.9
2006	67.4	32.5	34.4	72.1	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	225.1
2007	0.0	0.0	0.0	33.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	63.1
2008	40.6	26.7	146.4	66.2	10.4	0.0	0.0	0.0	0.0	0.0	0.0	14.1	304.3
2009	27.4	131.2	41.6	16.3	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	222.8
Average	23.9	42.7	62.3	39.8	5.9	0.0	0.0	0.0	0.0	0.0	0.0	21.0	195.4

Source: Estimated by JICA Study Team

Table E1.7-6 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case1 &2)

A. Conditions

Case : **Without Case 1 & Case 2**

Storage : **Effective Volume=** **133.56** MCM **Year of Storage Estimation=** **2019**

Equipment : **Number of Existing Machine=** **2** Nos. **Number of Replaced Machine=** **0** Nos.

B. Summary Results

90% Dependable Power Output= 67.9 MW
Average Power Output= 69.5 MW
Primary Energy= 159 GWh/year
Secondary Energy= 255 GWh/year
Total Energy= 414 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 66.6 m3/s
Annual Spill out Discharge = 195.5 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.1	66.6	64.7	70.2	69.4
2005	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.5	68.8	69.8	70.0	70.0
2006	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	68.4	65.0	62.0	68.9
2007	66.0	68.8	69.8	70.2	70.2	70.2	70.2	70.2	70.0	66.3	67.1	70.1	69.1
2008	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.1	68.6	70.0	70.2	70.0
2009	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.1	68.9	67.8	68.9	69.8
Average	69.5	70.0	70.1	70.2	70.2	70.2	70.2	70.2	69.8	67.9	67.4	68.6	69.5

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	13.6	13.0	13.5	13.9	13.9	13.4	13.8	13.5	12.4	12.4	11.6	13.9	158.9
2005	13.9	12.5	13.9	13.5	13.8	13.4	13.8	13.6	12.5	12.8	12.6	13.6	160.0
2006	13.9	12.6	13.9	13.5	13.9	13.4	13.8	13.8	13.0	12.7	11.7	11.5	157.7
2007	12.3	11.6	13.2	13.5	13.9	13.4	13.8	13.7	12.7	12.3	12.1	13.8	156.2
2008	13.9	13.0	13.9	13.5	13.9	13.4	13.8	13.7	12.9	12.8	13.1	13.9	161.7
2009	13.9	12.6	13.9	13.5	13.9	13.4	13.8	13.7	12.8	12.8	12.2	12.8	159.2
Average	13.6	12.5	13.7	13.5	13.9	13.4	13.8	13.6	12.7	12.6	12.2	13.2	159.0

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	24.6	34.5	40.4	30.6	22.3	15.1	11.3	10.4	9.6	9.5	9.0	35.8	253.1
2005	26.6	29.7	38.5	34.5	15.1	14.0	13.0	10.5	9.7	9.9	9.7	28.5	239.8
2006	39.8	35.7	37.8	39.1	37.2	20.2	12.3	11.0	10.0	9.8	9.0	8.9	270.9
2007	9.5	13.1	26.0	39.1	21.0	17.5	12.7	10.5	9.8	9.5	9.3	35.7	213.6
2008	37.2	32.5	41.8	39.8	30.6	17.9	11.7	10.5	9.9	9.8	20.5	29.2	291.3
2009	34.5	37.7	39.1	36.5	33.2	20.2	10.6	10.5	9.8	9.9	9.4	9.9	261.5
Average	28.7	30.6	37.3	36.6	26.6	17.5	11.9	10.6	9.8	9.7	11.2	24.6	255.0

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	72.5	94.5	103.6	83.0	67.8	55.3	47.3	46.0	46.0	46.0	46.0	92.6	66.7
2005	75.7	87.5	97.5	92.3	54.4	20.2	50.5	46.0	46.0	46.0	46.0	79.4	61.8
2006	100.0	99.6	96.3	101.1	95.1	65.2	49.2	46.6	46.0	46.0	46.0	46.0	69.7
2007	46.0	55.1	76.9	101.1	65.3	59.8	49.8	46.0	46.0	46.0	46.0	92.5	60.9
2008	95.1	90.6	103.6	102.3	83.0	60.7	47.9	46.0	46.0	46.0	65.9	80.6	72.3
2009	90.3	103.6	98.8	96.1	87.8	65.1	46.0	46.0	46.0	46.0	46.0	46.0	68.1
Average	79.9	88.5	96.1	96.0	75.6	54.4	48.4	46.1	46.0	46.0	49.3	72.8	66.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	4.4	54.0	117.8	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.6	245.7
2005	3.6	11.7	33.4	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.2	111.9
2006	67.4	32.5	34.4	72.1	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	225.1
2007	0.0	0.0	0.0	33.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	63.1
2008	40.6	26.7	146.4	66.2	10.4	0.0	0.0	0.0	0.0	0.0	0.0	14.1	304.3
2009	27.4	131.2	41.6	16.3	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	222.8
Average	23.9	42.7	62.3	39.8	5.9	0.0	0.0	0.0	0.0	0.0	0.0	21.0	195.5

Source: Estimated by JICA Study Team

Table E1.8-1 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case 2)

A. Conditions

Case : Without Case 2

Storage : **Effective Volume=** 131.28 MCM **Year of Storage Estimation=** 2022

Equipment : **Number of Existing Machine=** 0 Nos. **Number of Replaced Machine=** 1 Nos.

B. Summary Results

90% Dependable Power Output=	37.2 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	37.2 MW	**Average Power Discharge=**	46.9 m3/s
Primary Energy=	84 GWh/year	**Annual Spill out Discharge =**	809.7 MCM
Secondary Energy=	223 GWh/year		
Total Energy=	307 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2005	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2006	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2007	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2008	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2009	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
Average	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	7.1	6.7	6.9	7.2	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.2
2005	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.1
2006	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.1	84.1
2007	7.1	6.4	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.0	6.9	7.2	84.0
2008	7.2	6.7	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.4
2009	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.1	84.1
Average	7.1	6.5	7.1	7.0	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.1

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.6	20.1	20.8	21.5	21.5	20.8	17.3	12.6	14.6	13.5	15.6	21.5	220.7
2005	21.5	19.4	21.5	20.8	20.5	18.0	20.4	13.3	13.3	17.7	14.0	21.2	221.6
2006	21.5	19.4	21.5	20.8	21.5	20.8	20.4	17.3	11.6	14.2	11.2	17.4	217.8
2007	21.2	19.3	21.5	20.8	21.5	20.1	20.4	14.3	12.6	12.2	17.4	21.5	222.9
2008	21.5	20.1	21.5	20.8	21.5	20.8	19.7	15.3	12.3	17.2	20.1	21.5	232.5
2009	21.5	19.4	21.5	20.8	21.5	20.8	18.0	15.0	12.9	17.9	14.3	17.0	220.8
Average	21.3	19.6	21.4	20.9	21.3	20.2	19.4	14.6	12.9	15.4	15.4	20.0	222.7

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	50.6	51.8	51.8	51.8	51.8	51.8	44.5	36.0	40.5	37.9	42.4	51.8	46.9
2005	51.8	51.8	51.8	51.8	50.0	20.8	50.0	37.3	38.0	45.1	39.3	51.2	44.9
2006	51.8	51.8	51.8	51.8	51.8	51.8	50.0	44.5	34.9	39.1	34.3	44.5	46.5
2007	51.8	51.8	51.8	51.8	51.8	50.5	50.0	39.1	36.8	35.4	45.5	51.8	47.3
2008	51.8	51.8	51.8	51.8	51.8	51.8	48.8	40.9	36.1	44.5	50.5	51.8	48.6
2009	51.8	51.8	51.8	51.8	51.8	51.8	45.7	40.3	37.4	45.7	39.9	43.9	47.0
Average	51.6	51.8	51.8	51.8	51.5	46.4	48.2	39.7	37.3	41.3	42.0	49.2	46.9

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	63.2	161.4	252.0	100.4	40.0	11.0	2.0	0.6	1.1	0.9	45.9	191.4	869.9
2005	64.3	101.3	156.0	135.2	12.3	16.2	3.0	0.8	0.9	16.2	1.1	151.1	658.5
2006	196.7	145.5	156.2	196.9	135.6	29.4	3.0	2.0	0.3	1.1	0.2	13.7	880.7
2007	5.6	27.5	91.7	165.7	37.6	21.0	2.2	1.1	0.7	0.4	18.8	190.3	562.6
2008	156.6	124.0	285.1	195.9	93.2	18.7	2.5	1.4	0.6	1.8	78.5	89.7	1,047.9
2009	133.9	256.5	167.4	130.1	102.1	31.4	2.1	1.3	0.8	2.2	8.7	2.1	838.5
Average	103.4	136.0	184.7	154.0	70.1	21.3	2.5	1.2	0.7	3.8	25.5	106.4	809.7

Source: Estimated by JICA Study Team

Table E1.8-2 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case 2)

A. Conditions

Case : Without Case 2

Storage : **Effective Volume=** 130.52 MCM   **Year of Storage Estimation=** 2023

Equipment : **Number of Existing Machine=** 0 Nos.   **Number of Replaced Machine=** 1 Nos.

B. Summary Results

90% Dependable Power Output= 37.2 MW
Average Power Output= 37.2 MW
Primary Energy= 84 GWh/year
Secondary Energy= 223 GWh/year
Total Energy= 307 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 46.9 m3/s
Annual Spill out Discharge = 809.7 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2005	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2006	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2007	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2008	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2009	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
Average	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	7.1	6.7	6.9	7.2	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.2
2005	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.1
2006	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.1	84.1
2007	7.1	6.4	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.0	6.9	7.2	84.0
2008	7.2	6.7	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.4
2009	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.1	84.1
Average	7.1	6.5	7.1	7.0	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.1

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.6	20.1	20.8	21.5	21.5	20.8	17.3	12.6	14.6	13.5	15.6	21.5	220.7
2005	21.5	19.4	21.5	20.8	20.5	18.0	20.4	13.3	13.3	17.7	14.0	21.2	221.6
2006	21.5	19.4	21.5	20.8	21.5	20.8	20.4	17.3	11.6	14.2	11.2	17.4	217.8
2007	21.2	19.3	21.5	20.8	21.5	20.1	20.4	14.3	12.6	12.2	17.4	21.5	222.9
2008	21.5	20.1	21.5	20.8	21.5	20.8	19.7	15.3	12.3	17.2	20.1	21.5	232.5
2009	21.5	19.4	21.5	20.8	21.5	20.8	18.0	15.0	12.9	17.9	14.3	17.0	220.8
Average	21.3	19.6	21.4	20.9	21.3	20.2	19.4	14.6	12.9	15.4	15.4	20.0	222.7

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	50.6	51.8	51.8	51.8	51.8	51.8	44.5	36.0	40.5	37.9	42.4	51.8	46.9
2005	51.8	51.8	51.8	51.8	50.0	20.8	50.0	37.3	38.0	45.1	39.3	51.2	44.9
2006	51.8	51.8	51.8	51.8	51.8	51.8	50.0	44.5	34.9	39.1	34.3	44.5	46.5
2007	51.8	51.8	51.8	51.8	51.8	50.5	50.0	39.1	36.8	35.4	45.5	51.8	47.3
2008	51.8	51.8	51.8	51.8	51.8	51.8	48.8	40.9	36.1	44.5	50.5	51.8	48.6
2009	51.8	51.8	51.8	51.8	51.8	51.8	45.7	40.3	37.4	45.7	39.9	43.9	47.0
Average	51.6	51.8	51.8	51.8	51.5	46.4	48.2	39.7	37.3	41.3	42.0	49.2	46.9

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	63.4	161.4	252.0	100.4	40.0	11.0	2.0	0.6	1.1	0.9	45.9	191.4	870.0
2005	64.3	101.3	156.0	135.2	12.3	16.2	3.0	0.8	0.9	16.2	1.1	151.1	658.5
2006	196.7	145.5	156.2	196.9	135.6	29.4	3.0	2.0	0.3	1.1	0.2	13.7	880.7
2007	5.6	27.5	91.7	165.7	37.6	21.0	2.2	1.1	0.7	0.4	18.8	190.3	562.6
2008	156.6	124.0	285.1	195.9	93.2	18.7	2.5	1.4	0.6	1.8	78.5	89.7	1,047.9
2009	133.9	256.5	167.4	130.1	102.1	31.4	2.1	1.3	0.8	2.1	8.8	2.1	838.5
Average	103.4	136.0	184.7	154.0	70.1	21.3	2.5	1.2	0.7	3.7	25.5	106.4	809.7

Source: Estimated by JICA Study Team

Table E1.8-3 Summary Output of Energy Estimation for Sutami Hydropower Station (Without Project Case 2)

A. Conditions

Case : **Without Case 2**

Storage : **Effective Volume=** **129.76** MCM **Year of Storage Estimation=** **2024**

Equipment : **Number of Existing Machine=** **0** Nos. **Number of Replaced Machine=** **1** Nos.

B. Summary Results

90% Dependable Power Output= 37.2 MW
Average Power Output= 37.2 MW
Primary Energy= 84 GWh/year
Secondary Energy= 223 GWh/year
Total Energy= 307 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 46.9 m3/s
Annual Spill out Discharge = 810.0 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2005	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2006	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2007	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2008	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
2009	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
Average	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	7.1	6.7	6.9	7.2	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.2
2005	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.1
2006	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.1	84.1
2007	7.1	6.4	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.0	6.9	7.2	83.9
2008	7.2	6.7	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.4
2009	7.2	6.5	7.2	6.9	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.1	84.1
Average	7.1	6.5	7.1	7.0	7.2	6.9	7.1	7.1	6.9	7.1	6.9	7.2	84.1

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.6	20.1	20.8	21.5	21.5	20.8	17.3	12.6	14.6	13.5	15.6	21.5	220.7
2005	21.5	19.4	21.5	20.8	20.5	18.0	20.4	13.3	13.3	17.7	14.0	21.2	221.6
2006	21.5	19.4	21.5	20.8	21.5	20.8	20.4	17.3	11.6	14.2	11.2	17.4	217.8
2007	21.2	19.3	21.5	20.8	21.5	20.1	20.4	14.3	12.6	12.2	17.4	21.5	222.9
2008	21.5	20.1	21.5	20.8	21.5	20.8	19.7	15.3	12.3	16.9	20.1	21.5	232.2
2009	21.5	19.4	21.5	20.8	21.5	20.8	18.0	15.0	12.9	17.9	14.3	17.0	220.8
Average	21.3	19.6	21.4	20.9	21.3	20.2	19.4	14.6	12.9	15.4	15.4	20.0	222.7

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	50.6	51.8	51.8	51.8	51.8	51.8	44.5	36.0	40.5	37.9	42.4	51.8	46.9
2005	51.8	51.8	51.8	51.8	50.0	20.8	50.0	37.3	38.0	45.1	39.3	51.2	44.9
2006	51.8	51.8	51.8	51.8	51.8	51.8	50.0	44.5	34.9	39.1	34.3	44.5	46.5
2007	51.8	51.8	51.8	51.8	51.8	50.5	50.0	39.1	36.8	35.4	45.5	51.8	47.3
2008	51.8	51.8	51.8	51.8	51.8	51.8	48.8	40.9	36.1	43.9	50.5	51.8	48.6
2009	51.8	51.8	51.8	51.8	51.8	51.8	45.7	40.3	37.4	45.7	39.9	43.9	47.0
Average	51.6	51.8	51.8	51.8	51.5	46.4	48.2	39.7	37.3	41.2	42.0	49.2	46.9

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	63.5	161.4	252.0	100.4	40.0	11.0	2.0	0.6	1.1	0.9	45.9	191.4	870.2
2005	64.3	101.3	156.0	135.2	12.3	16.2	3.0	0.8	0.9	16.2	1.1	151.1	658.5
2006	196.7	145.5	156.2	196.9	135.6	29.4	3.0	2.0	0.3	1.1	0.2	13.7	880.7
2007	5.6	27.5	91.7	165.7	37.6	21.0	2.2	1.1	0.7	0.4	18.8	190.3	562.6
2008	156.6	124.0	285.1	195.9	93.2	18.7	2.5	1.4	0.6	1.8	80.1	89.7	1,049.6
2009	133.9	256.5	167.4	130.1	102.1	31.4	2.1	1.3	0.8	2.1	8.8	2.1	838.5
Average	103.4	136.0	184.7	154.0	70.1	21.3	2.5	1.2	0.7	3.7	25.8	106.4	810.0

Source: Estimated by JICA Study Team

Table E1.9-1 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : **With Project**

Storage : **Effective Volume=** **137.36** MCM **Year of Storage Estimation=** **2014**

Equipment : **Number of Existing Machine=** **2** Nos. **Number of Replaced Machine=** **0** Nos.

B. Summary Results

90% Dependable Power Output=	67.9 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	69.6 MW	**Average Power Discharge=**	66.6 m3/s
Primary Energy=	159 GWh/year	**Annual Spill out Discharge =**	195.3 MCM
Secondary Energy=	255 GWh/year		
Total Energy=	414 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.3	66.9	65.1	70.2	69.4
2005	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.6	68.9	69.9	70.0	70.0
2006	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	68.6	65.3	62.6	69.0
2007	66.3	69.0	69.9	70.2	70.2	70.2	70.2	70.2	70.1	66.6	67.4	70.1	69.2
2008	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	68.8	70.1	70.2	70.1
2009	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	69.1	68.0	69.1	69.8
Average	69.6	70.0	70.2	70.2	70.2	70.2	70.2	70.2	69.9	68.1	67.6	68.7	69.6

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	13.6	13.0	13.5	13.9	13.9	13.4	13.8	13.5	12.5	12.4	11.7	13.9	159.1
2005	13.9	12.5	13.9	13.5	13.8	13.3	13.8	13.6	12.6	12.9	12.7	13.6	160.1
2006	13.9	12.6	13.9	13.5	13.9	13.4	13.8	13.8	13.0	12.8	11.8	11.6	158.0
2007	12.3	11.6	13.2	13.5	13.9	13.4	13.8	13.7	12.8	12.4	12.1	13.8	156.4
2008	13.9	13.0	13.9	13.5	13.9	13.4	13.8	13.7	12.9	12.8	13.1	13.9	161.8
2009	13.9	12.6	13.9	13.5	13.9	13.4	13.8	13.7	12.8	12.9	12.2	12.9	159.4
Average	13.6	12.6	13.7	13.5	13.9	13.4	13.8	13.7	12.7	12.7	12.3	13.3	159.1

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	24.6	34.5	40.4	30.6	22.3	15.1	11.3	10.4	9.6	9.6	9.0	35.8	253.2
2005	26.6	29.7	38.5	34.5	15.5	13.4	13.4	10.5	9.7	9.9	9.8	28.5	239.9
2006	39.8	35.7	37.8	39.1	37.2	20.3	12.3	11.0	10.0	9.8	9.1	9.0	271.1
2007	9.5	13.2	26.0	39.1	21.0	17.5	12.7	10.5	9.8	9.5	9.3	35.7	213.8
2008	37.2	32.5	41.8	39.8	30.6	17.9	11.7	10.5	9.9	9.9	20.5	29.2	291.4
2009	34.5	37.7	39.1	36.5	33.2	20.2	10.6	10.5	9.9	9.9	9.4	9.9	261.6
Average	28.7	30.6	37.3	36.6	26.6	17.4	12.0	10.6	9.8	9.8	11.2	24.7	255.2

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	72.5	94.5	103.6	83.0	67.8	55.3	47.3	46.0	46.0	46.0	46.0	92.6	66.7
2005	75.7	87.5	97.5	92.3	55.0	20.3	51.1	46.0	46.0	46.0	46.0	79.4	61.9
2006	100.0	99.6	96.3	101.1	95.1	65.2	49.2	46.6	46.0	46.0	46.0	46.0	69.7
2007	46.0	55.1	76.9	101.1	65.3	59.8	49.8	46.0	46.0	46.0	46.0	92.5	60.9
2008	95.1	90.6	103.6	102.3	83.0	60.7	47.9	46.0	46.0	46.0	65.9	80.6	72.3
2009	90.3	103.6	98.8	96.1	87.8	65.1	46.0	46.0	46.0	46.0	46.0	46.0	68.1
Average	79.9	88.5	96.1	96.0	75.7	54.4	48.6	46.1	46.0	46.0	49.3	72.8	66.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	3.7	54.0	117.8	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.6	244.9
2005	3.6	11.7	33.4	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9	111.6
2006	67.4	32.5	34.4	72.1	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	225.1
2007	0.0	0.0	0.0	33.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	63.1
2008	40.6	26.7	146.4	66.2	10.4	0.0	0.0	0.0	0.0	0.0	0.0	14.1	304.3
2009	27.4	131.2	41.6	16.3	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	222.8
Average	23.8	42.7	62.3	39.8	5.9	0.0	0.0	0.0	0.0	0.0	0.0	21.0	195.3

Source: Estimated by JICA Study Team

Table E1.9-2 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : With Project

Storage : **Effective Volume=** **136.6** MCM **Year of Storage Estimation=** **2015**

Equipment : **Number of Existing Machine=** **1** Nos. **Number of Replaced Machine=** **1** Nos.

B. Summary Results

90% Dependable Power Output= 68.9 MW
Average Power Output= 71.4 MW
Primary Energy= 161 GWh/year
Secondary Energy= 259 GWh/year
Total Energy= 420 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 66.6 m3/s
Annual Spill out Discharge = 195.3 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	70.3	67.8	66.0	72.3	71.3
2005	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	70.8	70.2	71.3	72.0	71.9
2006	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.2	69.6	66.3	63.4	70.8
2007	67.2	70.3	71.5	72.3	72.3	72.3	72.3	72.3	71.7	67.5	68.4	72.1	70.9
2008	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.0	69.8	71.9	72.3	72.0
2009	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	71.9	70.1	69.0	70.1	71.6
Average	71.5	72.0	72.2	72.3	72.3	72.3	72.3	72.3	71.5	69.2	68.8	70.4	71.4

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	13.8	13.2	13.7	14.1	14.1	13.6	14.0	13.7	12.7	12.6	11.9	14.1	161.4
2005	14.1	12.7	14.1	13.7	14.0	13.5	14.0	13.8	12.8	13.1	12.8	13.8	162.5
2006	14.1	12.8	14.1	13.7	14.1	13.6	14.0	14.0	13.2	12.9	11.9	11.8	160.3
2007	12.5	11.8	13.4	13.7	14.1	13.6	14.0	13.9	12.9	12.6	12.3	14.0	158.7
2008	14.1	13.2	14.1	13.7	14.1	13.6	14.0	13.9	13.1	13.0	13.3	14.1	164.2
2009	14.1	12.8	14.1	13.7	14.1	13.6	14.0	13.9	13.0	13.0	12.4	13.0	161.8
Average	13.8	12.7	13.9	13.7	14.1	13.6	14.0	13.9	12.9	12.9	12.4	13.5	161.5

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	24.9	35.0	41.0	31.1	22.7	15.3	11.5	10.5	9.7	9.7	9.2	36.3	257.0
2005	27.0	30.2	39.0	35.0	15.7	13.6	13.6	10.7	9.8	10.1	9.9	28.9	243.5
2006	40.4	36.3	38.4	39.7	37.7	20.6	12.5	11.1	10.2	10.0	9.2	9.1	275.1
2007	9.6	13.4	26.4	39.7	21.3	17.7	12.9	10.7	10.0	9.7	9.5	36.2	217.0
2008	37.7	33.0	42.4	40.4	31.1	18.2	11.8	10.7	10.1	10.0	20.8	29.6	295.7
2009	35.0	38.3	39.7	37.0	33.7	20.5	10.8	10.7	10.0	10.0	9.6	10.0	265.5
Average	29.1	31.0	37.8	37.1	27.0	17.6	12.2	10.7	10.0	9.9	11.3	25.0	259.0

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	72.5	94.5	103.6	83.0	67.8	55.3	47.3	46.0	46.0	46.0	46.0	92.6	66.7
2005	75.7	87.5	97.5	92.3	55.0	20.6	51.1	46.0	46.0	46.0	46.0	79.4	61.9
2006	100.0	99.6	96.3	101.1	95.1	65.2	49.2	46.6	46.0	46.0	46.0	46.0	69.7
2007	46.0	55.1	76.9	101.1	65.3	59.8	49.8	46.0	46.0	46.0	46.0	92.5	60.9
2008	95.1	90.6	103.6	102.3	83.0	60.7	47.9	46.0	46.0	46.0	65.9	80.6	72.3
2009	90.3	103.6	98.8	96.1	87.8	65.1	46.0	46.0	46.0	46.0	46.0	46.0	68.1
Average	79.9	88.5	96.1	96.0	75.7	54.4	48.6	46.1	46.0	46.0	49.3	72.8	66.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	3.8	54.0	117.8	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.6	245.1
2005	3.6	11.7	33.4	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9	111.6
2006	67.4	32.5	34.4	72.1	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	225.1
2007	0.0	0.0	0.0	33.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	63.1
2008	40.6	26.7	146.4	66.2	10.4	0.0	0.0	0.0	0.0	0.0	0.0	14.1	304.3
2009	27.4	131.2	41.6	16.3	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	222.8
Average	23.8	42.7	62.3	39.8	5.9	0.0	0.0	0.0	0.0	0.0	0.0	21.0	195.3

Source: Estimated by JICA Study Team

Table E1.9-3 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : **With Project**

Storage : **Effective Volume=** **135.84** MCM **Year of Storage Estimation=** **2016**

Equipment : **Number of Existing Machine=** **0** Nos. **Number of Replaced Machine=** **2** Nos.

B. Summary Results

90% Dependable Power Output= 69.9 MW
Average Power Output= 73.2 MW
Primary Energy= 164 GWh/year
Secondary Energy= 263 GWh/year
Total Energy= 427 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 66.6 m3/s
Annual Spill out Discharge = 195.4 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.4	74.4	74.4	74.4	74.4	74.4	74.4	74.1	71.3	68.8	66.9	74.4	73.0
2005	74.4	74.4	74.4	74.4	74.4	74.4	74.4	74.4	71.9	71.2	72.4	73.8	73.7
2006	74.4	74.4	74.4	74.4	74.4	74.4	74.4	74.4	73.9	70.6	67.2	64.3	72.6
2007	68.2	71.3	72.8	74.4	74.4	74.4	74.4	74.4	72.9	68.5	69.3	74.2	72.4
2008	74.4	74.4	74.4	74.4	74.4	74.4	74.4	74.4	73.5	70.7	73.7	74.4	74.0
2009	74.4	74.4	74.4	74.4	74.4	74.4	74.4	74.4	73.1	71.1	70.0	71.1	73.4
Average	73.4	73.9	74.2	74.4	74.4	74.4	74.4	74.4	72.8	70.2	69.9	72.0	73.2

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	14.0	13.4	13.9	14.3	14.3	13.8	14.2	13.9	12.8	12.8	12.0	14.3	163.8
2005	14.3	12.9	14.3	13.9	14.2	13.7	14.2	14.0	12.9	13.2	13.0	14.0	164.8
2006	14.3	12.9	14.3	13.9	14.3	13.8	14.2	14.2	13.4	13.1	12.1	12.0	162.6
2007	12.7	12.0	13.6	13.9	14.3	13.8	14.2	14.1	13.1	12.7	12.5	14.2	161.0
2008	14.3	13.4	14.3	13.9	14.3	13.8	14.2	14.1	13.3	13.2	13.5	14.3	166.6
2009	14.3	13.0	14.3	13.9	14.3	13.8	14.2	14.1	13.2	13.2	12.6	13.2	164.1
Average	14.0	12.9	14.1	13.9	14.3	13.8	14.2	14.1	13.1	13.0	12.6	13.7	163.8

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	25.3	35.5	41.7	31.5	23.0	15.6	11.6	10.7	9.9	9.9	9.3	36.9	260.8
2005	27.4	30.6	39.6	35.5	15.9	13.8	13.8	10.8	10.0	10.2	10.0	29.3	247.1
2006	41.0	36.8	38.9	40.3	38.3	20.9	12.7	11.3	10.3	10.1	9.3	9.2	279.1
2007	9.8	13.5	26.8	40.3	21.6	18.0	13.1	10.8	10.1	9.8	9.6	36.8	220.2
2008	38.3	33.5	43.0	41.0	31.5	18.4	12.0	10.9	10.2	10.1	21.1	30.1	300.1
2009	35.6	38.9	40.3	37.6	34.2	20.8	10.9	10.8	10.1	10.2	9.7	10.2	269.4
Average	29.6	31.5	38.4	37.7	27.4	17.9	12.4	10.9	10.1	10.1	11.5	25.4	262.8

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	72.5	94.5	103.6	83.0	67.8	55.3	47.3	46.0	46.0	46.0	46.0	92.6	66.7
2005	75.7	87.5	97.5	92.3	55.0	20.9	51.1	46.0	46.0	46.0	46.0	79.4	61.9
2006	100.0	99.6	96.3	101.1	95.1	65.2	49.2	46.6	46.0	46.0	46.0	46.0	69.7
2007	46.0	55.1	76.9	101.1	65.3	59.8	49.8	46.0	46.0	46.0	46.0	92.5	60.9
2008	95.1	90.6	103.6	102.3	83.0	60.7	47.9	46.0	46.0	46.0	65.9	80.6	72.3
2009	90.3	103.6	98.8	96.1	87.8	65.1	46.0	46.0	46.0	46.0	46.0	46.0	68.1
Average	79.9	88.5	96.1	96.0	75.7	54.5	48.6	46.1	46.0	46.0	49.3	72.8	66.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	4.0	54.0	117.8	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.6	245.2
2005	3.6	11.7	33.4	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9	111.6
2006	67.4	32.5	34.4	72.1	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	225.1
2007	0.0	0.0	0.0	33.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	63.1
2008	40.6	26.7	146.4	66.2	10.4	0.0	0.0	0.0	0.0	0.0	0.0	14.1	304.3
2009	27.4	131.2	41.6	16.3	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	222.8
Average	23.8	42.7	62.3	39.8	5.9	0.0	0.0	0.0	0.0	0.0	0.0	21.0	195.4

Source: Estimated by JICA Study Team

Table E1.9-3 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : **With Project**

Storage : **Effective Volume=** **135.08** MCM **Year of Storage Estimation=** **2017**

Equipment : **Number of Existing Machine=** **0** Nos. **Number of Replaced Machine=** **3** Nos.

B. Summary Results

90% Dependable Power Output= 72.9 MW

Average Power Output= 93.5 MW

Primary Energy= 208 GWh/year

Secondary Energy= 232 GWh/year

Total Energy= 440 GWh/year

Average Inflow= 73.2 m3/s

Average Power Discharge= 72.6 m3/s

Annual Spill out Discharge = 18.7 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	108.0	111.7	111.7	111.7	105.3	103.0	99.7	92.2	79.4	38.0	57.2	106.3	93.7
2005	111.7	110.5	111.7	111.7	102.4	99.0	99.6	93.7	80.6	62.2	56.2	87.8	93.9
2006	111.7	111.7	111.7	111.7	111.1	105.8	101.5	98.2	90.0	64.6	35.3	55.6	92.4
2007	71.9	76.1	89.0	111.6	106.2	104.9	100.1	95.0	84.6	39.9	75.9	101.5	88.1
2008	111.7	111.7	111.7	111.7	110.8	103.9	101.2	96.1	87.3	69.9	82.5	102.5	100.1
2009	111.7	111.7	111.7	111.7	110.8	106.0	99.8	94.2	83.8	62.1	51.5	57.2	92.7
Average	104.4	105.5	107.9	111.7	107.7	103.8	100.3	94.9	84.3	56.1	59.8	85.2	93.5

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.8	18.6	18.5	17.2	14.3	7.1	10.3	20.2	208.3
2005	21.3	18.8	21.4	20.7	19.1	17.8	18.5	17.4	14.5	11.6	10.1	16.4	207.7
2006	21.5	19.4	21.4	20.8	21.3	19.3	18.9	18.3	16.2	12.0	6.3	10.3	205.6
2007	13.4	12.8	16.5	20.6	20.0	19.1	18.6	17.7	15.2	7.4	13.7	19.2	194.2
2008	21.4	20.0	21.5	20.8	21.2	18.8	18.8	17.9	15.7	13.0	14.9	19.3	223.3
2009	21.4	19.4	21.4	20.7	21.2	19.3	18.6	17.5	15.1	11.5	9.3	10.6	206.1
Average	19.9	18.4	20.5	20.8	20.4	18.8	18.7	17.6	15.2	10.4	10.8	16.0	207.5

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.2	38.0	53.9	29.6	15.4	11.3	10.3	9.5	8.0	7.6	7.5	29.5	239.7
2005	22.6	22.5	39.4	35.9	11.2	9.9	10.3	9.7	8.1	7.8	7.5	12.8	197.7
2006	45.0	35.9	38.0	45.7	34.5	15.4	10.5	10.2	9.0	7.9	7.3	7.6	266.9
2007	7.7	7.2	11.9	35.8	15.1	13.7	10.4	9.8	8.5	7.5	7.6	20.8	155.9
2008	39.4	32.4	58.9	47.0	27.2	12.0	10.5	10.0	8.7	7.8	8.3	15.5	277.5
2009	33.8	52.7	42.1	33.1	27.2	15.8	10.3	9.7	8.4	7.6	7.4	7.6	255.7
Average	27.9	31.4	40.7	37.8	21.8	13.0	10.4	9.8	8.4	7.7	7.6	15.6	232.2

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.4	113.2	140.1	93.8	65.0	57.1	54.7	54.7	54.7	38.3	46.6	91.8	73.7
2005	81.4	86.3	111.0	107.0	56.3	15.4	54.7	54.7	54.7	48.4	46.1	61.9	64.8
2006	120.9	111.7	108.6	124.8	102.1	66.2	54.7	54.7	54.7	49.3	37.1	46.3	77.6
2007	53.4	54.3	61.1	107.0	64.9	62.8	54.7	54.7	54.7	38.7	54.7	76.3	61.4
2008	111.0	102.7	145.5	127.4	89.0	58.8	54.7	54.7	54.7	52.3	54.7	65.8	80.9
2009	101.2	144.5	116.0	101.9	89.0	67.0	54.7	54.7	54.7	49.4	44.5	47.0	77.0
Average	90.4	102.1	113.7	110.3	77.7	54.5	54.7	54.7	54.7	46.1	47.3	64.8	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	7.7	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	32.0
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	9.7	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.6
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.1	0.0	29.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.8
2009	0.0	30.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.8
Average	1.6	6.4	8.8	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	18.7

Source: Estimated by JICA Study Team

Table E1.9-4 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : **With Project**

Storage : **Effective Volume=** **134.32** MCM **Year of Storage Estimation=** **2018**

Equipment : **Number of Existing Machine=** **0** Nos. **Number of Replaced Machine=** **3** Nos.

B. Summary Results

90% Dependable Power Output=	72.9 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	93.4 MW	**Average Power Discharge=**	72.6 m3/s
Primary Energy=	207 GWh/year	**Annual Spill out Discharge =**	18.9 MCM
Secondary Energy=	232 GWh/year		
Total Energy=	440 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	108.0	111.7	111.7	111.7	105.2	103.0	99.6	92.1	79.2	37.6	57.2	106.3	93.6
2005	111.7	110.5	111.7	111.7	102.3	98.9	99.5	93.6	80.4	61.8	56.3	87.8	93.8
2006	111.7	111.7	111.7	111.7	111.1	105.7	101.4	98.1	89.9	64.1	35.3	55.6	92.3
2007	72.0	76.1	89.0	111.6	106.2	104.0	100.2	95.0	84.6	40.0	75.9	101.5	88.0
2008	111.7	111.7	111.7	111.7	110.8	103.8	101.2	96.0	87.2	69.4	82.5	101.9	100.0
2009	111.7	111.7	111.7	111.7	110.8	105.9	99.7	94.0	83.6	61.6	51.5	57.3	92.6
Average	104.4	105.5	107.9	111.7	107.7	103.5	100.3	94.8	84.2	55.8	59.8	85.0	93.4

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.8	18.6	18.5	17.1	14.3	7.0	10.3	20.2	208.2
2005	21.3	18.8	21.4	20.7	19.1	17.8	18.5	17.4	14.5	11.5	10.1	16.4	207.5
2006	21.5	19.4	21.4	20.8	21.3	19.2	18.9	18.2	16.2	11.9	6.3	10.3	205.4
2007	13.4	12.8	16.6	20.6	20.0	18.9	18.6	17.7	15.2	7.4	13.7	19.2	194.0
2008	21.4	20.0	21.5	20.8	21.2	18.8	18.8	17.9	15.7	12.9	14.9	19.1	222.9
2009	21.4	19.4	21.4	20.7	21.2	19.3	18.6	17.5	15.0	11.5	9.3	10.6	205.9
Average	19.9	18.4	20.5	20.8	20.4	18.8	18.7	17.6	15.1	10.4	10.8	16.0	207.3

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.2	38.0	53.9	29.6	15.4	11.3	10.3	9.5	7.9	7.6	7.5	29.5	239.7
2005	22.6	22.5	39.4	35.9	11.2	9.9	10.3	9.7	8.1	7.8	7.5	12.8	197.7
2006	45.0	35.9	38.0	45.7	34.5	15.4	10.5	10.2	9.0	7.9	7.3	7.6	266.9
2007	7.7	7.2	11.9	35.7	15.1	14.0	10.4	9.8	8.5	7.6	7.6	22.2	157.7
2008	38.0	32.4	58.8	47.0	27.2	12.0	10.5	9.9	8.7	7.8	8.3	16.2	276.7
2009	33.7	52.7	42.1	33.1	27.2	15.8	10.3	9.7	8.4	7.6	7.4	7.6	255.7
Average	27.7	31.4	40.7	37.8	21.8	13.1	10.4	9.8	8.4	7.7	7.6	16.0	232.4

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.4	113.2	140.1	93.8	65.0	57.1	54.7	54.7	54.7	38.2	46.6	91.8	73.7
2005	81.4	86.3	111.0	107.0	56.3	15.4	54.7	54.7	54.7	48.2	46.1	61.9	64.8
2006	120.9	111.7	108.6	124.8	102.1	66.1	54.7	54.7	54.7	49.1	37.1	46.3	77.6
2007	53.4	54.3	61.1	107.0	64.9	62.9	54.7	54.7	54.7	38.7	54.7	78.8	61.6
2008	108.6	102.7	145.5	127.4	89.0	58.7	54.7	54.7	54.7	52.2	54.7	66.7	80.8
2009	101.2	144.5	116.0	101.9	89.0	67.0	54.7	54.7	54.7	49.2	44.5	47.0	77.0
Average	90.0	102.1	113.7	110.3	77.7	54.5	54.7	54.7	54.7	45.9	47.3	65.4	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	7.9	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	33.0
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	10.6	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	30.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.6
2009	0.0	29.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2
Average	1.8	6.2	8.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	18.9

Source: Estimated by JICA Study Team

Table E1.9-5 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : With Project

Storage : **Effective Volume=** 133.56 MCM **Year of Storage Estimation=** 2019

Equipment : **Number of Existing Machine=** 0 Nos. **Number of Replaced Machine=** 3 Nos.

B. Summary Results

90% Dependable Power Output= 72.6 MW
Average Power Output= 93.3 MW
Primary Energy= 207 GWh/year
Secondary Energy= 233 GWh/year
Total Energy= 440 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 72.6 m3/s
Annual Spill out Discharge = 18.2 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	107.9	111.7	111.7	111.7	105.0	102.7	99.4	91.9	79.1	38.0	57.1	106.5	93.6
2005	111.7	110.5	111.7	111.7	102.0	98.6	99.3	93.4	80.4	62.2	56.4	87.6	93.8
2006	111.7	111.7	111.7	111.7	111.0	105.5	101.2	97.9	89.8	64.3	35.3	55.5	92.3
2007	72.1	75.9	89.0	111.7	106.3	104.7	99.8	94.7	84.3	39.8	75.7	101.4	87.9
2008	111.7	111.7	111.7	111.7	110.7	103.6	100.9	95.8	87.0	69.6	82.4	102.7	100.0
2009	111.7	111.7	111.7	111.7	110.7	105.7	99.5	93.8	83.4	61.8	51.4	57.3	92.5
Average	104.4	105.5	107.9	111.7	107.6	103.5	100.0	94.6	84.0	56.0	59.7	85.2	93.3

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.7	18.5	18.5	17.1	14.2	7.1	10.3	20.2	208.1
2005	21.3	18.8	21.4	20.7	19.0	17.8	18.5	17.4	14.5	11.6	10.1	16.4	207.4
2006	21.5	19.4	21.4	20.8	21.3	19.2	18.8	18.2	16.2	12.0	6.3	10.3	205.3
2007	13.4	12.8	16.5	20.6	20.0	19.1	18.6	17.6	15.2	7.4	13.6	19.2	194.0
2008	21.4	20.1	21.5	20.8	21.2	18.7	18.8	17.8	15.7	13.0	14.8	19.4	223.0
2009	21.4	19.4	21.4	20.7	21.2	19.3	18.5	17.4	15.0	11.5	9.3	10.7	205.8
Average	19.9	18.4	20.5	20.8	20.4	18.8	18.6	17.6	15.1	10.4	10.7	16.0	207.3

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.2	38.0	53.9	29.6	15.4	11.3	10.3	9.6	8.0	7.6	7.5	29.8	240.0
2005	22.6	22.5	39.4	35.9	11.2	9.9	10.3	9.7	8.1	7.8	7.5	12.8	197.7
2006	45.0	35.9	38.0	45.7	34.5	15.4	10.5	10.2	9.0	7.9	7.3	7.6	266.9
2007	7.8	7.2	11.9	35.8	15.4	13.7	10.4	9.8	8.5	7.5	7.6	22.2	157.7
2008	37.9	32.4	60.2	47.0	27.2	12.0	10.5	10.0	8.8	7.8	8.3	15.8	277.8
2009	33.8	52.7	42.1	33.1	27.2	15.8	10.3	9.7	8.4	7.6	7.4	7.6	255.7
Average	27.7	31.4	40.9	37.8	21.8	13.0	10.4	9.8	8.4	7.7	7.6	16.0	232.7

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.4	113.2	140.1	93.8	64.9	57.0	54.6	54.6	54.6	38.3	46.6	92.5	73.7
2005	81.4	86.3	111.0	107.0	56.2	15.4	54.6	54.6	54.6	48.4	46.2	61.8	64.8
2006	120.9	111.7	108.6	124.8	102.1	66.1	54.6	54.6	54.6	49.2	37.1	46.2	77.5
2007	53.4	54.2	61.0	107.0	65.6	62.7	54.6	54.6	54.6	38.6	54.6	78.7	61.6
2008	108.6	102.7	148.0	127.4	88.9	58.7	54.6	54.6	54.6	52.2	54.6	66.5	80.9
2009	101.2	144.5	116.0	101.9	88.9	66.9	54.6	54.6	54.6	49.2	44.4	47.0	77.0
Average	90.0	102.1	114.1	110.3	77.8	54.5	54.6	54.6	54.6	46.0	47.2	65.5	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	8.1	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	32.0
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	11.5	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	25.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2
2009	0.0	30.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.8
Average	1.9	6.5	8.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	18.2

Source: Estimated by JICA Study Team

Table E1.9-6 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : With Project

Storage : **Effective Volume=** **132.8** MCM **Year of Storage Estimation=** **2020**

Equipment : **Number of Existing Machine=** **0** Nos. **Number of Replaced Machine=** **3** Nos.

B. Summary Results

90% Dependable Power Output=	72.5 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	93.3 MW	**Average Power Discharge=**	72.6 m3/s
Primary Energy=	207 GWh/year	**Annual Spill out Discharge =**	19.2 MCM
Secondary Energy=	233 GWh/year		
Total Energy=	440 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	107.9	111.7	111.7	111.7	104.9	102.6	99.2	91.8	79.0	37.9	57.1	106.5	93.5
2005	111.7	110.5	111.7	111.7	101.9	98.5	99.2	93.3	80.3	62.1	56.4	87.6	93.7
2006	111.7	111.7	111.7	111.7	111.0	105.4	101.0	97.7	89.6	64.1	35.3	55.4	92.2
2007	72.2	75.8	89.0	111.7	106.6	104.3	99.8	94.7	84.4	40.5	75.6	101.7	88.0
2008	111.7	111.7	111.7	111.7	110.7	103.5	100.8	95.7	86.9	69.4	82.3	102.0	99.8
2009	111.7	111.7	111.7	111.7	110.7	105.6	99.3	93.7	83.3	61.6	51.4	57.3	92.5
Average	104.4	105.5	107.9	111.7	107.6	103.3	99.9	94.5	83.9	55.9	59.7	85.1	93.3

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.7	18.5	18.5	17.1	14.2	7.0	10.3	20.2	207.9
2005	21.3	18.8	21.4	20.7	19.0	17.7	18.4	17.4	14.4	11.6	10.2	16.4	207.3
2006	21.5	19.4	21.4	20.8	21.3	19.2	18.8	18.2	16.1	11.9	6.3	10.3	205.2
2007	13.4	12.7	16.6	20.6	20.1	19.0	18.6	17.6	15.2	7.5	13.6	19.2	194.2
2008	21.4	20.0	21.5	20.8	21.2	18.7	18.7	17.8	15.6	12.9	14.8	19.2	222.7
2009	21.4	19.4	21.4	20.7	21.2	19.3	18.5	17.4	15.0	11.5	9.3	10.7	205.6
Average	19.9	18.4	20.5	20.8	20.4	18.7	18.6	17.6	15.1	10.4	10.7	16.0	207.1

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.2	38.0	53.9	29.6	15.4	11.3	10.3	9.6	8.0	7.6	7.5	29.9	240.1
2005	22.6	22.5	39.4	35.9	11.2	9.9	10.3	9.7	8.1	7.8	7.5	12.8	197.7
2006	45.0	35.9	38.0	45.7	34.5	15.4	10.5	10.2	9.0	7.9	7.3	7.6	267.0
2007	7.8	7.2	12.0	35.8	15.7	13.3	10.4	9.9	8.5	7.6	7.6	22.5	158.2
2008	38.0	32.4	58.8	47.0	27.2	12.0	10.5	10.0	8.8	7.8	8.3	16.5	277.1
2009	33.7	52.7	42.1	33.1	27.2	15.8	10.3	9.7	8.4	7.6	7.4	7.6	255.7
Average	27.7	31.4	40.7	37.8	21.9	12.9	10.4	9.8	8.4	7.7	7.6	16.2	232.6

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.3	113.2	140.1	93.8	64.9	57.0	54.5	54.5	54.5	38.3	46.6	92.5	73.7
2005	81.4	86.3	111.0	107.0	56.1	15.4	54.5	54.5	54.5	48.3	46.2	61.8	64.8
2006	120.9	111.7	108.6	124.8	102.1	66.0	54.5	54.5	54.5	49.1	37.1	46.2	77.5
2007	53.4	54.2	60.9	107.0	66.4	61.9	54.5	54.5	54.5	38.9	54.5	79.5	61.7
2008	108.6	102.7	145.5	127.4	88.9	58.6	54.5	54.5	54.5	52.1	54.5	67.4	80.8
2009	101.2	144.5	116.0	101.9	88.9	66.9	54.5	54.5	54.5	49.1	44.4	47.0	77.0
Average	90.0	102.1	113.7	110.3	77.9	54.3	54.5	54.5	54.5	46.0	47.2	65.7	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	8.3	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	33.1
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	12.4	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.3
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	30.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.6
2009	0.0	29.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.4
Average	2.1	6.3	8.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	19.2

Source: Estimated by JICA Study Team

Table E1.9-7 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : With Project
Storage : **Effective Volume=** **132.04** MCM **Year of Storage Estimation=** 2021
Equipment : **Number of Existing Machine=** 0 Nos. **Number of Replaced Machine=** 3 Nos.

B. Summary Results

90% Dependable Power Output= 72.5 MW
Average Power Output= 93.2 MW
Primary Energy= 207 GWh/year
Secondary Energy= 233 GWh/year
Total Energy= 440 GWh/year

Average Inflow= 73.2 m3/s
Average Power Discharge= 72.6 m3/s
Annual Spill out Discharge = 18.4 MCM

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	107.9	111.7	111.7	111.7	104.9	102.5	99.2	91.7	78.8	37.5	57.1	106.5	93.4
2005	111.7	110.4	111.7	111.7	101.8	98.4	99.1	93.2	80.1	61.7	56.5	87.9	93.7
2006	111.7	111.7	111.7	111.7	111.0	105.4	100.9	97.7	89.5	63.6	35.3	55.4	92.1
2007	72.2	75.8	89.1	111.7	106.5	104.5	99.6	94.4	83.9	39.0	75.6	101.7	87.8
2008	111.7	111.7	111.7	111.7	110.7	103.4	100.7	95.6	86.8	68.9	82.3	102.1	99.8
2009	111.7	111.7	111.7	111.7	110.7	105.6	99.2	93.6	83.1	61.1	51.4	57.3	92.4
Average	104.5	105.5	107.9	111.7	107.6	103.3	99.8	94.4	83.7	55.3	59.7	85.2	93.2

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.7	18.5	18.4	17.1	14.2	7.0	10.3	20.3	207.8
2005	21.3	18.8	21.4	20.7	19.0	17.7	18.4	17.3	14.4	11.5	10.2	16.4	207.2
2006	21.5	19.4	21.4	20.8	21.3	19.2	18.8	18.2	16.1	11.8	6.3	10.3	205.0
2007	13.4	12.7	16.6	20.6	20.1	19.0	18.5	17.6	15.1	7.3	13.6	19.3	193.8
2008	21.4	20.0	21.4	20.8	21.2	18.7	18.7	17.8	15.6	12.8	14.8	19.2	222.5
2009	21.4	19.4	21.4	20.7	21.2	19.2	18.5	17.4	15.0	11.4	9.3	10.7	205.5
Average	19.9	18.4	20.5	20.8	20.4	18.7	18.6	17.6	15.1	10.3	10.7	16.0	207.0

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.2	38.0	53.9	29.6	15.4	11.3	10.3	9.5	7.9	7.6	7.5	29.9	240.1
2005	22.6	22.5	39.4	35.9	11.2	9.9	10.3	9.7	8.1	7.8	7.5	13.2	198.0
2006	45.0	35.9	38.0	45.7	34.5	15.4	10.5	10.2	9.0	7.9	7.3	7.6	266.9
2007	7.8	7.2	12.0	35.8	15.7	13.7	10.4	9.8	8.5	7.5	7.6	22.5	158.5
2008	38.0	32.4	60.2	47.0	27.2	12.0	10.5	10.0	8.7	7.7	8.3	16.5	278.5
2009	33.7	52.7	42.1	33.1	27.2	15.8	10.3	9.7	8.4	7.6	7.4	7.6	255.7
Average	27.7	31.4	40.9	37.8	21.9	13.0	10.4	9.8	8.4	7.7	7.6	16.2	232.9

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.3	113.2	140.1	93.8	64.9	57.0	54.5	54.5	54.5	38.1	46.6	92.5	73.7
2005	81.4	86.3	111.0	107.0	56.1	15.4	54.5	54.5	54.5	48.1	46.2	62.5	64.8
2006	120.9	111.7	108.6	124.8	102.1	66.0	54.5	54.5	54.5	48.9	37.1	46.2	77.5
2007	53.5	54.2	60.9	107.0	66.3	62.7	54.5	54.5	54.5	38.3	54.5	79.5	61.7
2008	108.6	102.7	148.0	127.4	88.9	58.6	54.5	54.5	54.5	52.0	54.5	67.3	81.0
2009	101.2	144.5	116.0	101.9	88.9	66.8	54.5	54.5	54.5	49.0	44.4	47.0	76.9
Average	90.0	102.1	114.1	110.3	77.9	54.4	54.5	54.5	54.5	45.7	47.2	65.8	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	8.5	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	34.0
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	11.1	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	24.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.9
2009	0.0	30.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.3
Average	1.9	6.5	8.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	18.4

Source: Estimated by JICA Study Team

Table E1.9-8 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : With Project

Storage : **Effective Volume=** **131.28** MCM **Year of Storage Estimation=** **2022**

Equipment : **Number of Existing Machine=** **0** Nos. **Number of Replaced Machine=** **3** Nos.

B. Summary Results

90% Dependable Power Output=	72.3 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	93.1 MW	**Average Power Discharge=**	72.6 m3/s
Primary Energy=	207 GWh/year	**Annual Spill out Discharge =**	18.4 MCM
Secondary Energy=	233 GWh/year		
Total Energy=	440 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	107.8	111.7	111.7	111.7	104.7	102.3	99.0	91.5	78.7	37.6	57.0	106.8	93.4
2005	111.7	110.4	111.7	111.7	101.6	98.2	98.9	93.1	80.0	61.9	56.6	87.8	93.6
2006	111.7	111.7	111.7	111.7	111.0	105.2	100.7	97.5	89.3	63.6	35.3	55.4	92.1
2007	72.3	75.7	89.1	111.7	106.7	104.1	99.6	94.5	84.1	40.0	75.5	101.7	87.9
2008	111.7	111.7	111.7	111.7	110.7	103.5	100.2	95.0	86.0	66.9	82.2	102.3	99.5
2009	111.7	111.7	111.7	111.7	110.7	105.5	99.0	93.4	82.9	61.1	51.3	57.3	92.3
Average	104.5	105.5	107.9	111.7	107.6	103.1	99.6	94.2	83.5	55.2	59.7	85.2	93.1

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.7	18.5	18.4	17.0	14.2	7.0	10.3	20.3	207.7
2005	21.3	18.8	21.4	20.7	18.9	17.7	18.4	17.3	14.4	11.5	10.2	16.4	207.1
2006	21.5	19.4	21.4	20.8	21.3	19.2	18.7	18.1	16.1	11.8	6.3	10.3	204.9
2007	13.4	12.7	16.6	20.7	20.2	18.9	18.5	17.6	15.1	7.4	13.6	19.3	194.0
2008	21.4	20.1	21.5	20.8	21.2	18.8	18.6	17.7	15.5	12.4	14.8	19.2	221.9
2009	21.4	19.4	21.4	20.7	21.2	19.2	18.4	17.4	14.9	11.4	9.2	10.7	205.3
Average	19.9	18.4	20.5	20.8	20.4	18.7	18.5	17.5	15.0	10.3	10.7	16.0	206.8

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.2	38.0	53.9	29.6	15.4	11.3	10.3	9.6	7.9	7.6	7.5	30.2	240.4
2005	22.6	22.5	39.4	35.9	11.2	9.9	10.3	9.7	8.1	7.9	7.5	13.2	198.1
2006	45.0	35.9	38.0	45.7	34.5	15.4	10.5	10.2	9.0	7.9	7.3	7.6	266.9
2007	7.8	7.2	12.0	35.8	16.1	13.3	10.4	9.9	8.5	7.6	7.6	22.6	158.7
2008	37.9	32.4	60.2	47.0	27.2	12.3	10.5	9.9	8.7	7.7	8.3	16.9	279.0
2009	33.7	52.7	42.1	33.1	27.2	15.8	10.3	9.7	8.4	7.6	7.4	7.6	255.7
Average	27.7	31.4	40.9	37.8	21.9	13.0	10.4	9.8	8.4	7.7	7.6	16.3	233.1

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.3	113.2	140.1	93.8	64.8	56.9	54.4	54.4	54.4	38.2	46.5	93.2	73.7
2005	81.4	86.3	111.0	107.0	56.0	15.4	54.4	54.4	54.4	48.2	46.3	62.5	64.8
2006	120.9	111.7	108.6	124.8	102.0	66.0	54.4	54.4	54.4	48.9	37.1	46.2	77.5
2007	53.5	54.1	60.9	107.0	67.1	61.8	54.4	54.4	54.4	38.7	54.4	79.4	61.7
2008	108.6	102.7	148.0	127.4	88.9	59.3	54.4	54.4	54.4	51.2	54.4	68.1	81.0
2009	101.2	144.5	116.0	101.9	88.9	66.8	54.4	54.4	54.4	48.9	44.4	47.0	76.9
Average	90.0	102.1	114.1	110.3	78.0	54.4	54.4	54.4	54.4	45.7	47.2	66.1	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	8.7	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	33.0
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	12.1	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.9
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.3	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.9
2009	0.0	29.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.3
Average	2.1	6.3	8.1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	18.4

Source: Estimated by JICA Study Team

Table E1.9-9 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : With Project
Storage : **Effective Volume=** 130.52 MCM — **Year of Storage Estimation=** 2023
Equipment : **Number of Existing Machine=** 0 Nos. — **Number of Replaced Machine=** 3 Nos.

B. Summary Results

90% Dependable Power Output=	72.0 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	92.9 MW	**Average Power Discharge=**	72.5 m3/s
Primary Energy=	206 GWh/year	**Annual Spill out Discharge =**	19.2 MCM
Secondary Energy=	233 GWh/year		
Total Energy=	440 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	107.7	111.7	111.7	111.7	105.0	102.0	98.7	91.4	78.7	38.4	57.0	106.7	93.4
2005	111.7	110.4	111.7	111.7	101.6	96.6	97.5	91.6	78.0	57.2	56.8	87.6	92.7
2006	111.7	111.7	111.7	111.7	111.7	105.3	100.4	97.3	89.2	64.3	35.3	55.2	92.1
2007	72.4	75.5	89.3	111.7	106.8	103.1	99.1	94.1	83.7	39.9	75.3	101.6	87.7
2008	111.7	111.7	111.7	111.7	111.7	101.9	99.9	94.8	85.9	67.4	82.0	102.1	99.3
2009	111.7	111.7	111.7	111.7	111.7	105.2	98.7	93.1	82.8	61.7	51.3	57.4	92.4
Average	104.5	105.4	107.9	111.7	108.1	102.3	99.1	93.7	83.1	54.8	59.6	85.1	92.9

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.7	18.4	18.4	17.0	14.2	7.2	10.3	20.3	207.7
2005	21.3	18.8	21.4	20.7	19.0	17.4	18.1	17.0	14.0	10.6	10.2	16.4	205.0
2006	21.5	19.4	21.4	20.8	21.4	19.2	18.7	18.1	16.1	12.0	6.3	10.3	205.0
2007	13.5	12.7	16.6	20.6	20.2	18.7	18.4	17.5	15.1	7.4	13.5	19.2	193.5
2008	21.4	20.1	21.5	20.8	21.3	18.4	18.6	17.6	15.5	12.5	14.8	19.2	221.6
2009	21.4	19.4	21.4	20.7	21.4	19.2	18.4	17.3	14.9	11.5	9.2	10.7	205.5
Average	19.9	18.4	20.5	20.8	20.5	18.5	18.4	17.4	14.9	10.2	10.7	16.0	206.4

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.2	38.0	53.9	29.6	14.9	11.3	10.3	9.6	8.0	7.6	7.5	30.2	240.0
2005	22.6	22.5	39.4	35.9	12.1	9.8	10.2	9.6	7.9	7.8	7.5	13.2	198.5
2006	45.0	35.9	38.0	45.7	35.2	14.4	10.5	10.2	9.0	7.9	7.3	7.6	266.6
2007	7.8	7.2	12.3	35.8	16.7	12.6	10.4	9.9	8.5	7.6	7.6	22.5	158.8
2008	38.0	32.4	60.2	47.0	28.2	11.3	10.5	9.9	8.7	7.7	8.3	16.9	279.1
2009	33.8	52.7	42.1	33.1	26.8	15.8	10.3	9.8	8.4	7.6	7.4	7.6	255.4
Average	27.7	31.4	41.0	37.8	22.3	12.5	10.4	9.8	8.4	7.7	7.6	16.4	233.1

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	74.3	113.2	140.1	93.8	64.7	56.8	54.3	54.3	54.3	38.5	46.5	93.2	73.7
2005	81.4	86.3	111.0	107.0	58.3	14.4	54.3	54.3	54.3	46.0	46.3	62.4	64.7
2006	120.9	111.7	108.6	124.8	103.6	64.2	54.3	54.3	54.3	49.1	37.1	46.1	77.4
2007	53.5	54.0	61.6	107.0	68.6	60.1	54.3	54.3	54.3	38.7	54.3	79.4	61.7
2008	108.6	102.7	148.0	127.4	91.3	56.8	54.3	54.3	54.3	51.3	54.3	68.0	80.9
2009	101.2	144.5	116.0	101.9	88.8	66.7	54.3	54.3	54.3	49.2	44.3	47.0	76.9
Average	90.0	102.1	114.2	110.3	79.2	53.2	54.3	54.3	54.3	45.5	47.2	66.0	72.5

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	9.0	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	34.2
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	13.1	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	1.5	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.2
2009	0.0	30.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.6
Average	2.4	6.6	8.1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	19.2

Source: Estimated by JICA Study Team

Table E1.9-10 Summary Output of Energy Estimation for Sutami Hydropower Station (With Project)

A. Conditions

Case : With Project

Storage : **Effective Volume=** 129.76 MCM **Year of Storage Estimation=** 2024

Equipment : **Number of Existing Machine=** 0 Nos. **Number of Replaced Machine=** 3 Nos.

B. Summary Results

90% Dependable Power Output=	72.0 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	92.9 MW	**Average Power Discharge=**	72.6 m3/s
Primary Energy=	206 GWh/year	**Annual Spill out Discharge =**	18.6 MCM
Secondary Energy=	233 GWh/year		
Total Energy=	440 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	107.7	111.7	111.7	111.7	105.0	101.9	98.7	91.3	78.5	38.0	57.0	105.3	93.2
2005	111.7	110.3	111.7	111.7	101.5	96.5	97.4	91.5	77.8	56.7	56.8	87.6	92.6
2006	111.7	111.7	111.7	111.7	111.7	105.3	100.3	97.2	89.1	63.8	35.3	55.2	92.0
2007	72.5	75.5	89.4	111.7	107.2	102.7	99.2	94.1	83.8	40.2	75.2	101.6	87.8
2008	111.7	111.7	111.7	111.7	111.7	101.8	99.8	94.7	85.7	66.9	82.0	102.5	99.3
2009	111.7	111.7	111.7	111.7	111.7	105.2	98.6	93.0	82.7	61.2	51.2	57.4	92.3
Average	104.5	105.4	107.9	111.7	108.1	102.2	99.0	93.6	82.9	54.5	59.6	84.9	92.9

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.7	18.4	18.4	17.0	14.1	7.1	10.3	20.0	207.2
2005	21.3	18.8	21.4	20.7	18.9	17.4	18.1	17.0	14.0	10.5	10.2	16.4	204.8
2006	21.5	19.4	21.4	20.8	21.4	19.2	18.7	18.1	16.0	11.9	6.3	10.3	204.9
2007	13.5	12.7	16.6	20.7	20.3	18.6	18.4	17.5	15.1	7.5	13.5	19.2	193.6
2008	21.4	20.1	21.5	20.7	21.3	18.4	18.6	17.6	15.4	12.4	14.8	19.3	221.5
2009	21.4	19.4	21.4	20.7	21.4	19.2	18.3	17.3	14.9	11.4	9.2	10.7	205.3
Average	19.9	18.4	20.5	20.8	20.5	18.5	18.4	17.4	14.9	10.1	10.7	16.0	206.2

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.6	36.6	53.9	29.6	14.9	11.3	10.3	9.6	8.0	7.6	7.5	31.6	241.3
2005	22.6	22.5	39.4	35.9	12.1	9.8	10.2	9.6	7.9	7.8	7.5	13.2	198.4
2006	45.0	35.9	38.0	45.7	35.2	14.4	10.5	10.2	9.0	7.9	7.3	7.6	266.6
2007	7.8	7.2	12.3	35.8	17.0	12.3	10.4	9.9	8.5	7.6	7.6	22.6	159.0
2008	38.0	32.4	60.2	47.0	28.2	11.3	10.5	9.9	8.7	7.7	8.3	17.2	279.4
2009	33.7	52.7	42.1	33.1	26.8	15.8	10.3	9.8	8.4	7.6	7.4	7.6	255.3
Average	27.9	31.2	41.0	37.8	22.4	12.5	10.4	9.8	8.4	7.7	7.6	16.6	233.3

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	76.7	110.6	140.1	93.8	64.6	56.8	54.3	54.3	54.3	38.4	46.5	94.9	73.8
2005	81.4	86.3	111.0	107.0	58.3	14.4	54.3	54.3	54.3	45.8	46.3	62.4	64.6
2006	120.9	111.7	108.6	124.8	103.6	64.2	54.3	54.3	54.3	48.9	37.1	46.1	77.4
2007	53.5	53.9	61.5	107.0	69.4	59.2	54.3	54.3	54.3	38.8	54.3	79.4	61.7
2008	108.6	102.7	148.0	127.4	91.3	56.8	54.3	54.3	54.3	51.1	54.3	68.8	81.0
2009	101.2	144.5	116.0	101.9	88.8	66.7	54.3	54.3	54.3	49.0	44.3	47.0	76.9
Average	90.4	101.6	114.2	110.3	79.3	53.0	54.3	54.3	54.3	45.3	47.1	66.4	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	9.1	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.7
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	13.9	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.8
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	2.4	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.0
2009	0.0	29.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.4
Average	2.7	6.4	8.1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.6

Source: Estimated by JICA Study Team

Table E1.10-1 Summary Output of Energy Estimation for Sutami Hydropower Station (With & Without Pr.Case2)

A. Conditions

Case : With & Without Case2

Storage : **Effective Volume=** 129 MCM **Year of Storage Estimation=** 2025

Equipment : **Number of Existing Machine=** 0 Nos. **Number of Replaced Machine=** 3 Nos.

B. Summary Results

90% Dependable Power Output=	71.8 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	92.8 MW	**Average Power Discharge=**	72.6 m3/s
Primary Energy=	206 GWh/year	**Annual Spill out Discharge =**	18.0 MCM
Secondary Energy=	233 GWh/year		
Total Energy=	440 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	107.6	111.7	111.7	111.7	104.8	101.9	98.1	90.6	77.7	36.6	56.9	107.4	93.0
2005	111.7	110.3	111.7	111.7	101.2	96.3	97.2	91.3	77.8	57.1	57.0	88.2	92.6
2006	111.7	111.7	111.7	111.7	111.7	105.1	100.1	96.9	88.9	64.0	35.3	55.1	92.0
2007	72.6	75.3	89.4	111.7	107.1	102.8	98.8	93.7	83.4	39.7	75.1	102.3	87.6
2008	111.7	111.7	111.7	111.7	111.7	101.5	99.5	94.5	85.6	67.1	81.8	103.4	99.3
2009	111.7	111.7	111.7	111.7	111.7	105.0	98.4	92.8	82.5	61.4	51.2	57.4	92.2
Average	104.5	105.4	107.9	111.7	108.0	102.1	98.7	93.3	82.7	54.3	59.5	85.6	92.8

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.7	18.4	18.2	16.9	14.0	6.8	10.2	20.4	207.0
2005	21.3	18.8	21.4	20.7	18.9	17.3	18.1	17.0	14.0	10.6	10.3	16.5	204.9
2006	21.5	19.4	21.4	20.8	21.4	19.2	18.6	18.0	16.0	11.9	6.3	10.3	204.7
2007	13.5	12.7	16.6	20.7	20.2	18.6	18.4	17.4	15.0	7.4	13.5	19.4	193.5
2008	21.4	20.0	21.4	20.7	21.3	18.3	18.5	17.6	15.4	12.5	14.7	19.5	221.6
2009	21.3	19.4	21.4	20.7	21.4	19.1	18.3	17.3	14.9	11.4	9.2	10.7	205.1
Average	19.9	18.4	20.5	20.8	20.5	18.5	18.4	17.4	14.9	10.1	10.7	16.1	206.1

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.6	36.6	53.9	29.6	14.9	11.6	10.3	9.5	7.9	7.6	7.5	30.9	240.8
2005	22.6	22.5	39.3	35.9	12.1	9.8	10.2	9.6	7.9	7.8	7.5	13.9	199.2
2006	45.0	35.9	38.0	45.7	35.2	14.4	10.5	10.2	9.1	7.9	7.3	7.6	266.6
2007	7.8	7.2	12.4	35.8	17.0	12.6	10.4	9.9	8.5	7.6	7.6	23.2	160.0
2008	38.0	32.4	60.2	47.0	28.2	11.3	10.5	9.9	8.7	7.7	8.3	18.2	280.4
2009	32.3	52.7	42.1	33.1	26.8	15.8	10.3	9.8	8.4	7.6	7.4	7.6	253.9
Average	27.7	31.2	41.0	37.8	22.4	12.6	10.4	9.8	8.4	7.7	7.6	16.9	233.5

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	76.7	110.6	140.1	93.8	64.6	57.5	54.2	54.2	54.2	37.7	46.5	94.8	73.7
2005	81.4	86.3	111.0	107.0	58.2	14.4	54.2	54.2	54.2	46.0	46.4	63.9	64.8
2006	120.9	111.7	108.6	124.8	103.6	64.1	54.2	54.2	54.2	49.0	37.1	46.1	77.4
2007	53.6	53.8	61.5	107.0	69.4	60.0	54.2	54.2	54.2	38.6	54.2	80.9	61.8
2008	108.6	102.7	148.0	127.4	91.3	56.7	54.2	54.2	54.2	51.2	54.2	71.1	81.1
2009	98.7	144.5	116.0	101.9	88.8	66.7	54.2	54.2	54.2	49.1	44.3	47.0	76.6
Average	90.0	101.6	114.2	110.3	79.3	53.2	54.2	54.2	54.2	45.3	47.1	67.3	72.6

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	9.4	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	32.1
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	10.6	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	24.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.9
2009	0.0	30.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.8
Average	1.8	6.7	8.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	18.0

Source: Estimated by JICA Study Team

Table E1.10-2 Summary Output of Energy Estimation for Sutami Hydropower Station (With & Without Pr.Case2)

A. Conditions

Case : With & Without Case2

Storage : **Effective Volume=** 128.24 MCM **Year of Storage Estimation=** 2026

Equipment : **Number of Existing Machine=** 0 Nos. **Number of Replaced Machine=** 3 Nos.

B. Summary Results

90% Dependable Power Output=	71.7 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	92.7 MW	**Average Power Discharge=**	72.5 m3/s
Primary Energy=	206 GWh/year	**Annual Spill out Discharge =**	19.0 MCM
Secondary Energy=	233 GWh/year		
Total Energy=	440 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	107.6	111.7	111.7	111.7	104.8	101.8	98.0	90.5	77.5	36.2	56.9	107.7	93.0
2005	111.7	109.9	111.7	111.7	101.2	96.2	97.1	91.3	77.6	56.9	57.0	88.2	92.5
2006	111.7	111.7	111.7	111.7	111.7	105.0	100.0	96.9	88.8	63.5	35.3	55.1	91.9
2007	72.7	75.3	89.4	111.7	106.3	102.4	98.8	93.8	83.5	39.9	75.0	102.6	87.6
2008	111.7	111.7	111.7	111.7	111.7	101.4	99.4	94.4	85.4	66.7	81.8	103.8	99.3
2009	111.7	111.7	111.7	111.7	111.7	105.0	98.3	92.7	82.3	61.0	51.1	57.4	92.2
Average	104.5	105.3	108.0	111.7	107.9	102.0	98.6	93.2	82.5	54.0	59.5	85.8	92.7

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.2	20.0	20.7	21.4	19.7	18.4	18.2	16.8	14.0	6.7	10.2	20.5	206.9
2005	21.3	18.7	21.4	20.7	18.9	17.3	18.1	17.0	14.0	10.6	10.3	16.5	204.7
2006	21.5	19.4	21.4	20.8	21.4	19.1	18.6	18.0	16.0	11.8	6.3	10.3	204.6
2007	13.5	12.6	16.6	20.7	20.0	18.6	18.4	17.4	15.0	7.4	13.5	19.5	193.3
2008	21.4	20.0	21.5	20.7	21.3	18.3	18.5	17.6	15.4	12.4	14.7	19.6	221.5
2009	21.3	19.4	21.4	20.7	21.4	19.1	18.3	17.2	14.8	11.3	9.2	10.7	205.0
Average	19.9	18.4	20.5	20.8	20.5	18.5	18.3	17.3	14.9	10.0	10.7	16.2	206.0

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	20.6	36.6	53.9	29.6	14.9	11.6	10.3	9.5	7.9	7.6	7.5	31.2	241.1
2005	22.6	23.6	37.9	35.9	12.1	9.8	10.2	9.6	7.9	7.8	7.5	13.9	198.9
2006	45.0	35.9	38.0	45.7	35.2	14.4	10.5	10.2	9.0	7.9	7.3	7.6	266.6
2007	7.8	7.2	12.4	37.2	16.3	12.3	10.4	9.9	8.5	7.6	7.6	23.6	160.7
2008	38.0	32.4	58.8	47.0	28.2	11.2	10.5	9.9	8.7	7.7	8.3	18.6	279.3
2009	32.3	52.7	42.1	33.1	26.8	15.8	10.3	9.8	8.4	7.6	7.4	7.6	253.8
Average	27.7	31.4	40.5	38.1	22.3	12.5	10.4	9.8	8.4	7.7	7.6	17.1	233.4

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	76.7	110.6	140.1	93.8	64.6	57.5	54.2	54.2	54.2	37.5	46.5	95.6	73.8
2005	81.4	88.1	108.6	107.0	58.2	14.4	54.2	54.2	54.2	45.9	46.4	63.9	64.7
2006	120.9	111.7	108.6	124.8	103.6	64.1	54.2	54.2	54.2	48.8	37.1	46.1	77.4
2007	53.6	53.8	61.4	109.5	67.8	59.1	54.2	54.2	54.2	38.7	54.2	81.7	61.9
2008	108.6	102.7	145.5	127.4	91.3	56.6	54.2	54.2	54.2	51.0	54.2	71.9	81.0
2009	98.7	144.5	116.0	101.9	88.8	66.6	54.2	54.2	54.2	48.9	44.3	47.0	76.6
Average	90.0	101.9	113.4	110.7	79.0	53.1	54.2	54.2	54.2	45.1	47.1	67.7	72.5

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	9.5	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.1
2005	0.0	0.0	1.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
2006	11.4	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	30.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.2
2009	0.0	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.5
Average	1.9	6.5	9.1	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0

Source: Estimated by JICA Study Team

Table E1.10-3 Summary Output of Energy Estimation for Sutami Hydropower Station (With & Without Pr.Case2)

A. Conditions

Case : **With & Without Case2**

Storage : **Effective Volume=** **102.2** MCM **Year of Storage Estimation=** **2060**

Equipment : **Number of Existing Machine=** **0** Nos. **Number of Replaced Machine=** **3** Nos.

B. Summary Results

90% Dependable Power Output=	67.3 MW	**Average Inflow=**	73.2 m3/s
Average Power Output=	90.5 MW	**Average Power Discharge=**	72.4 m3/s
Primary Energy=	201 GWh/year	**Annual Spill out Discharge =**	19.7 MCM
Secondary Energy=	239 GWh/year		
Total Energy=	440 GWh/year		

C. Monthly Output of Energy Calculation

1. Monthly Average of Primary Power Output (MW)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	105.9	111.7	111.7	111.7	101.2	97.2	92.6	85.1	71.6	32.2	56.0	109.3	90.5
2005	111.7	107.1	111.7	111.7	96.2	91.0	93.1	87.7	74.2	57.4	60.4	87.8	90.8
2006	111.7	111.7	111.7	111.7	111.7	101.9	94.0	91.5	83.2	54.8	35.3	53.5	89.4
2007	71.5	75.1	92.4	111.7	103.5	98.1	93.4	88.8	78.3	35.3	72.3	104.3	85.4
2008	111.7	111.7	111.7	111.7	110.5	97.9	93.6	88.9	79.7	58.9	79.9	106.7	96.9
2009	111.7	111.7	111.7	111.7	111.1	101.9	92.5	87.2	76.3	55.0	49.9	58.4	89.9
Average	104.0	104.8	108.5	111.7	105.7	98.0	93.2	88.2	77.2	49.0	58.9	86.7	90.5

Source: Estimated by JICA Study Team

2. Monthly Production of Primary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.9	20.0	20.7	21.4	19.0	17.6	17.2	15.8	12.9	6.0	10.1	20.9	201.4
2005	21.2	18.2	21.4	20.7	18.0	16.4	17.3	16.3	13.4	10.7	10.9	16.5	200.9
2006	21.4	19.3	21.4	20.8	21.4	18.6	17.5	17.0	15.0	10.2	6.3	10.0	198.9
2007	13.3	12.6	17.2	20.7	19.5	17.8	17.4	16.5	14.1	6.6	13.0	19.9	188.6
2008	21.4	20.0	21.4	20.7	21.1	17.7	17.4	16.5	14.4	11.0	14.4	20.2	216.3
2009	21.2	19.4	21.4	20.7	21.3	18.6	17.2	16.2	13.7	10.2	9.0	10.9	199.8
Average	19.7	18.3	20.6	20.8	20.0	17.8	17.3	16.4	13.9	9.1	10.6	16.4	201.0

Source: Estimated by JICA Study Team

3. Monthly Production of Secondary Energy (GWh)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	22.0	36.5	53.9	29.6	14.9	12.0	10.4	9.5	7.8	7.5	7.5	35.4	247.0
2005	22.5	24.0	37.9	35.8	12.2	9.9	10.4	9.8	8.1	8.0	7.7	19.3	205.5
2006	45.0	35.9	37.9	45.6	35.1	14.7	10.5	10.3	9.0	7.8	7.3	7.6	266.8
2007	8.0	7.6	16.8	41.4	16.3	12.6	10.5	10.0	8.5	7.5	7.8	29.2	176.2
2008	37.9	32.4	60.2	47.0	27.4	12.3	10.5	10.0	8.7	7.6	8.7	25.3	288.0
2009	32.2	52.7	42.1	33.1	27.9	14.7	10.4	9.8	8.3	7.6	7.4	7.7	253.7
Average	27.9	31.5	41.5	38.7	22.3	12.7	10.4	9.9	8.4	7.7	7.7	20.8	239.5

Source: Estimated by JICA Study Team

4. Monthly Average Inflow in the Reservoir (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	84.0	116.2	149.0	89.3	66.7	53.5	45.4	35.9	40.8	35.7	65.6	123.2	75.5
2005	75.8	93.7	110.1	104.0	52.2	55.5	49.0	37.2	38.4	53.6	37.1	110.2	68.1
2006	125.3	112.0	110.1	127.7	102.4	63.1	49.0	44.8	34.6	37.0	37.1	52.4	74.6
2007	47.3	70.5	86.1	115.7	65.8	58.1	48.9	39.1	36.9	32.9	56.1	125.3	65.2
2008	110.3	101.3	158.2	127.4	86.6	58.9	47.2	41.4	36.0	44.0	85.1	85.3	81.8
2009	101.8	157.8	114.3	102.0	89.9	62.8	45.2	40.3	37.9	43.8	48.9	44.7	74.1
Average	90.7	108.6	121.3	111.0	77.3	58.7	47.5	39.8	37.4	41.2	55.0	90.2	73.2

Source: Estimated by JICA Study Team

5. Monthly Average of Power Generation Discharge (m3/s)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2004	78.6	110.6	140.1	93.8	63.4	56.6	52.2	52.2	52.2	35.7	45.9	103.5	73.7
2005	81.4	87.8	108.6	107.0	56.5	14.7	52.2	52.2	52.2	45.8	47.4	72.3	64.8
2006	120.9	111.7	108.6	124.8	103.6	63.8	52.2	52.2	52.2	45.3	37.1	45.2	76.5
2007	52.2	52.2	67.3	117.2	66.9	58.4	52.2	52.2	52.2	36.7	52.2	91.8	62.6
2008	108.6	102.7	148.0	127.4	89.6	57.5	52.2	52.2	52.2	47.8	52.2	84.4	81.2
2009	98.7	144.5	116.0	101.9	90.4	63.8	52.2	52.2	52.2	46.3	43.6	47.2	75.7
Average	90.1	101.6	114.8	112.0	78.4	52.5	52.2	52.2	52.2	42.9	46.4	74.1	72.4

Source: Estimated by JICA Study Team

6. Monthly Spill out Volume (MCM)

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.0	9.7	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	37.4
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	14.9	0.0	1.3	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	2.2	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.8
2009	0.0	28.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.2
Average	2.9	6.3	8.1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	19.7

Source: Estimated by JICA Study Team

E2. ENERGY CALCULATION OF WLINGI POWER STATION

E2.1 GENERAL

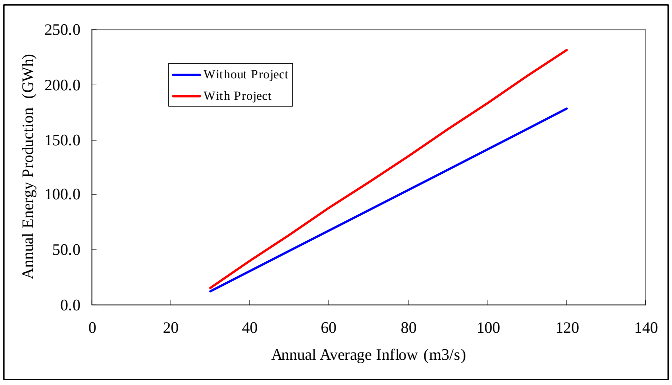
Wlingi reservoir has not seasonal storage function the reservoir utilized for re-regulating pond of the Sutami reservoir. Therefore, the Wlingi power station is categorized the runoff river type with daily peak generation.

E2.2 CONDITIONS FOR CALCULATION OF ENERGY PRODUCTION

No detailed data for the estimation of the daily power output, such as the water level in the downstream river channel, and the head loss relating with the power discharge, has been obtained by the site investigation and previous study report due to lack of the design information.

Therefore, only total energy of the Wlingi power station has been estimated by means of utilizing the relationship between the annual inflow discharge and the annual total energy. The correlation for existing generating equipment, described as "Without Project" is estimated based on actual operating record provided by the PJB. Since combined efficiency of newly installed generating equipment is estimated as 3% higher than existing, the energy production created by newly installed generating equipment, called "With Project", is assumed to be 3% higher than "Without Project".

Relationship between annual average inflow and annual energy production of the Wlingi hydropower station is as shown in Figure E2.1.



Source : Prepared by JICA Study Team estimated by the operation record provided by the PJB

Figure E2.1 Relationship between Annual Average Inflow and Annual Energy Production

E2.3 RESULTS OF ENERGY ESTIMATION

Based on the runoff inflow data from 2006 to 2009, energy estimation has been carried out. Summary of the energy production is as shown in Table E2.1.

Table E2.1 Summary of Energy Estimation (Wlingi PS)

	Total Energy (GWh)
Without Project	140
With Project	144

Source : Prepared by JICA Study Team

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APPENDIX F

Cash Flow for Rehabilitation Works for Sutami and Wlingi

Table F-1 Capacity Value and Energy Value of Alternative Thermal Plant (1/2) (High Speed Diesel Gas Turbine)

1.Unit Construction Cost (US$/kW)	350
2. Unit Construction Cost (UCC) Including Interest during Construction (IDC) (US$/kW)	350 = 350 x 1.0000 = 350
3. Annual O&M Cost (% of UCC)	3.0
4. Life Time (Year)	20
5. Discount Rate (%)	12
6. Capital Recovery Factor (CRF)	0.133879
7. Efficiency Component for Adjustment Factor	Efficiency Component on Hydro and Gas Turbine (%) Hydro / Gas Turbine Station Use: 0.3 / 1 Transmission Line Loss: 5.48 / 1 Forced Outage: 0.5 / 7 Scheduled Outage: 3.15 / 10
8. kW Value Adjustment Factor (KWVAF)	$\frac{(1-0.003) \times (1-0.0548) \times (1-0.005) \times (1-0.0315)}{(1-0.01) \times (1-0.01) \times (1-0.07) \times (1-0.10)}$ $= \frac{0.997 \times 0.9452 \times 0.995 \times 0.9685}{0.99 \times 0.99 \times 0.93 \times 0.90} = 1.107$
9. Capacity Value	Unit Construction Cost x (CRF + O&M) x KWVAF = 350 x (0.133879 + 0.03) x 1.107 = **63.49US$/kW/Year**
10. Fuel Cost (US$/Barrel)	54.11
11. Heat Content of Fuel (kcal/Barrel)	1,467,994
12. Heat Rate (Kcal/kWh)	2,963
13. Fuel Consumption (Barrel/kWh)	2,963 / 1,467,994 = 0.002018
14. Fuel Cost (US$/kWh)	0.002018 x 54.11 = 0.1092
15. O&M Cost for Energy (US$/kWh)	0.001022
16. kWh Value Adjustment Factor (KWhVAF)	$\frac{(1-0.003) \times (1-0.0548)}{(1-0.01) \times (1-0.01)}$ $= \frac{0.997 \times 0.9452}{0.99 \times 0.99} = 0.9615$
17. Energy Value	(Unit Cost of Fuel per kWh + O&M) x KWhVAF = (0.1092 + 0.001022) x 0.9615 = **0.106US$/kWh**

(Prepared by JICA Study Team)

Table F-2 Capacity Value and Energy Value of Alternative Thermal Plant (2/2) (Coal steam Turbine)

1.Unit Construction Cost (US$/kW)	1,000
2. Unit Construction Cost (UCC) Including Interest during Construction (IDC) (US$/kW)	1,000 = 1,000 x 1.0000 = 1,000
3. Annual O&M Cost (% of UCC)	5.0
4. Life Time (Year)	30
5. Discount Rate (%)	12
6. Capital Recovery Factor (CRF)	0.1241
7. Efficiency Component for Adjustment Factor	Efficiency Component on Hydro and Coal Steam (%) Hydro / Coal Steam Station Use: 0.3 / 7 Transmission Line Loss: 5.48 / 1.06 Forced Outage: 0.5 / 10 Scheduled Outage: 3.15 / 12
8. kW Value Adjustment Factor (KWVAF)	$\frac{(1-0.003) \times (1-0.0548) \times (1-0.005) \times (1-0.0315)}{(1-0.07) \times (1-0.0106) \times (1-0.10) \times (1-0.12)}$ $= \frac{0.997 \times 0.9452 \times 0.995 \times 0.9685}{0.93 \times 0.9894 \times 0.9 \times 0.88} = 1.2461$
9. Capacity Value	Unit Construction Cost x (CRF + O&M) x KWVAF = 1,000 x (0.1241 + 0.05) x 1.2461 = **216.95US$/kW/Year**
10. Fuel Cost (Coal Price in 2013; US$/ton)	37.81
11. Heat Rate (Kcal/kWh)	2,324
12. Heat Content of Fuel (Kcal/kg)	5,662
13. Fuel Consumption (kg/kWh)	2,324 / 5,662 = 0.41045
14. Fuel Cost (US$/kWh)	0.41045 x 37.81 / 1,000 = 0.01552
15. O&M Cost for Energy (US$/kWh)	0.00428
16. kWh Value Adjustment Factor (KWhVAF)	$\frac{(1-0.003) \times (1-0.0548)}{(1-0.07) \times (1-0.0106)}$ $= \frac{0.997 \times 0.9452}{0.93 \times 0.9894} = 1.02415$
17. Energy Value	(Unit Cost of Fuel per kWh + O&M) x KWhVAF = (0.01552 + 0.00428) x 1.02415 = **0.02028US$/kWh**

(Prepared by JICA Study Team)

Economic Internal Rate of Return (Ignoring Benefit of CO2 Reduction)

Sutami -case1(1)

(unit: million Rp)

Year		Capital Cost		O&M Cost	Total Cost	Benefit				Net Economic Benefit
		Construction Cost	Indirect Cost			Power Benefit	Reduction of CO2	O&M Cost Cut	Total	
1	2011	-	3,305	-	3,305	-	-	-	0	-3,305
2	12	-	3,305	-	3,305	-	-	-	0	-3,305
3	13	-	3,305	-	3,305	-	-	-	0	-3,305
4	14	82,628	16,691	-	99,319	-31,407	-	-	-31,407	-130,726
5	15	82,628	16,691	-	99,319	-27,935	-	-	-27,935	-127,254
6	16	82,628	16,691	-	99,319	-25,247	-	-	-25,247	-124,566
7	17	-	-	-	-	37,366	-	82	37,448	37,448
8	18	-	-	-	-	37,366	-	82	37,448	37,448
9	19	-	-	-	-	37,366	-	82	37,448	37,448
10	2020	-	-	327	327	232,363	-	-	232,363	232,036
11	21	-	-	327	327	232,363	-	-	232,363	232,036
12	22	-	-	327	327	232,363	-	-	232,363	232,036
13	23	-	-	327	327	232,363	-	-	232,363	232,036
14	24	-	-	327	327	232,363	-	-	232,363	232,036
15	25	-	-	327	327	232,363	-	-	232,363	232,036
16	26	-	-	327	327	232,363	-	-	232,363	232,036
17	27	-	-	327	327	232,363	-	-	232,363	232,036
18	28	-	-	327	327	232,363	-	-	232,363	232,036
19	29	-	-	327	327	232,363	-	-	232,363	232,036
20	2030	-	-	327	327	232,363	-	-	232,363	232,036
21	31	-	-	327	327	232,363	-	-	232,363	232,036
22	32	-	-	327	327	232,363	-	-	232,363	232,036
23	33	-	-	327	327	232,363	-	-	232,363	232,036
24	34	-	-	327	327	232,363	-	-	232,363	232,036
25	35	-	-	327	327	232,363	-	-	232,363	232,036
26	36	-	-	327	327	232,363	-	-	232,363	232,036
27	37	-	-	327	327	232,363	-	-	232,363	232,036
28	38	-	-	327	327	232,363	-	-	232,363	232,036
29	39	-	-	327	327	232,363	-	-	232,363	232,036
30	2040	-	-	327	327	232,363	-	-	232,363	232,036
31	41	-	-	327	327	232,363	-	-	232,363	232,036
32	42	-	-	327	327	232,363	-	-	232,363	232,036
33	43	-	-	327	327	232,363	-	-	232,363	232,036
34	44	-	-	327	327	232,363	-	-	232,363	232,036
35	45	-	-	327	327	232,363	-	-	232,363	232,036
36	46	-	-	327	327	232,363	-	-	232,363	232,036
37	47	-	-	327	327	232,363	-	-	232,363	232,036
38	48	-	-	327	327	232,363	-	-	232,363	232,036
39	49	-	-	327	327	232,363	-	-	232,363	232,036
40	2050	-	-	327	327	232,363	-	-	232,363	232,036
41	51	-	-	327	327	232,363	-	-	232,363	232,036
42	52	-	-	327	327	232,363	-	-	232,363	232,036
43	53	-	-	327	327	232,363	-	-	232,363	232,036
44	54	-	-	327	327	232,363	-	-	232,363	232,036
45	55	-	-	327	327	232,363	-	-	232,363	232,036
46	56	-	-	327	327	232,363	-	-	232,363	232,036

EIRR=	26%
ENPV(Rp)=	760,852
PV(Cost)=	195,134
PV(Benefit)=	955,986
B/C=	4.9

Economic Internal Rate of Return (Ignoring Benefit of CO2 Reduction)

Wlingi -case1(1)

(unit: million Rp)

Year		Capital Cost		O&M Cost	Total Cost	Benefit				Net Economic Benefit
		Construction Cost	Indirect Cost			Power Benefit	Reduction of CO2	O&M Cost Cut	Total	
1	2011	-	2,535	-	2,535	-	-	-	-	-2,535
2	12	-	2,535	-	2,535	-	-	-	-	-2,535
3	13	-	2,535	-	2,535	-	-	-	-	-2,535
4	14	63,384	12,804	-	76,188	-	-	-	-	-76,188
5	15	63,384	12,804	-	76,188	-	-	-	-	-76,188
6	16	63,384	12,804	-	76,188	-	-	-	-	-76,188
7	17	-	-	-	-	1,870	-	32	1,902	1,902
8	18	-	-	-	-	1,870	-	32	1,902	1,902
9	19	-	-	-	-	1,870	-	32	1,902	1,902
10	2020	-	-	-	-	1,870	-	32	1,902	1,902
11	21	-	-	-	-	1,870	-	32	1,902	1,902
12	22	-	-	128	128	67,320	-	-	67,320	67,192
13	23	-	-	128	128	67,320	-	-	67,320	67,192
14	24	-	-	128	128	67,320	-	-	67,320	67,192
15	25	-	-	128	128	67,320	-	-	67,320	67,192
16	26	-	-	128	128	67,320	-	-	67,320	67,192
17	27	-	-	128	128	67,320	-	-	67,320	67,192
18	28	-	-	128	128	67,320	-	-	67,320	67,192
19	29	-	-	128	128	67,320	-	-	67,320	67,192
20	2030	-	-	128	128	67,320	-	-	67,320	67,192
21	31	-	-	128	128	67,320	-	-	67,320	67,192
22	32	-	-	128	128	67,320	-	-	67,320	67,192
23	33	-	-	128	128	67,320	-	-	67,320	67,192
24	34	-	-	128	128	67,320	-	-	67,320	67,192
25	35	-	-	128	128	67,320	-	-	67,320	67,192
26	36	-	-	128	128	67,320	-	-	67,320	67,192
27	37	-	-	128	128	67,320	-	-	67,320	67,192
28	38	-	-	128	128	67,320	-	-	67,320	67,192
29	39	-	-	128	128	67,320	-	-	67,320	67,192
30	2040	-	-	128	128	67,320	-	-	67,320	67,192
31	41	-	-	128	128	67,320	-	-	67,320	67,192
32	42	-	-	128	128	67,320	-	-	67,320	67,192
33	43	-	-	128	128	67,320	-	-	67,320	67,192
34	44	-	-	128	128	67,320	-	-	67,320	67,192
35	45	-	-	128	128	67,320	-	-	67,320	67,192
36	46	-	-	128	128	67,320	-	-	67,320	67,192
37	47	-	-	128	128	67,320	-	-	67,320	67,192
38	48	-	-	128	128	67,320	-	-	67,320	67,192
39	49	-	-	128	128	67,320	-	-	67,320	67,192
40	2050	-	-	128	128	67,320	-	-	67,320	67,192
41	51	-	-	128	128	67,320	-	-	67,320	67,192
42	52	-	-	128	128	67,320	-	-	67,320	67,192
43	53	-	-	128	128	67,320	-	-	67,320	67,192
44	54	-	-	128	128	67,320	-	-	67,320	67,192
45	55	-	-	128	128	67,320	-	-	67,320	67,192
46	56	-	-	128	128	67,320	-	-	67,320	67,192

EIRR=	13%
ENPV(Rp)=	82,539
PV(Cost)=	149,087
PV(Benefit)=	231,626
B/C=	1.6

Economic Internal Rate of Return (Ignoring Benefit of CO2 Reduction) Sutami & Wlingi Case 1(1)

(unit: million Rp)

Year		Capital Cost		O&M Cost	Total Cost	Benefit				Net Economic Benefit
		Construction Cost	Indirect Cost			Power Benefit	Reduction of CO2	O&M Cost Cut	Total	
1	2011	-	5,840	-	5,840	-	-	-	-	-5,840
2	12	-	5,840	-	5,840	-	-	-	-	-5,840
3	13	-	5,840	-	5,840	-	-	-	-	-5,840
4	14	146,012	29,495	-	175,507	-31,407	-	-	-31,407	-206,914
5	15	146,012	29,495	-	175,507	-27,935	-	-	-27,935	-203,442
6	16	146,012	29,495	-	175,507	-25,247	-	-	-25,247	-200,754
7	17	-	-	-	-	39,236	-	114	39,350	39,350
8	18	-	-	-	-	39,236	-	114	39,350	39,350
9	19	-	-	-	-	39,236	-	114	39,350	39,350
10	2020	-	-	327	327	234,233	-	32	234,265	233,938
11	21	-	-	327	327	234,233	-	32	234,265	233,938
12	22	-	-	455	455	299,683	-	-	299,683	299,228
13	23	-	-	455	455	299,683	-	-	299,683	299,228
14	24	-	-	455	455	299,683	-	-	299,683	299,228
15	25	-	-	455	455	299,683	-	-	299,683	299,228
16	26	-	-	455	455	299,683	-	-	299,683	299,228
17	27	-	-	455	455	299,683	-	-	299,683	299,228
18	28	-	-	455	455	299,683	-	-	299,683	299,228
19	29	-	-	455	455	299,683	-	-	299,683	299,228
20	2030	-	-	455	455	299,683	-	-	299,683	299,228
21	31	-	-	455	455	299,683	-	-	299,683	299,228
22	32	-	-	455	455	299,683	-	-	299,683	299,228
23	33	-	-	455	455	299,683	-	-	299,683	299,228
24	34	-	-	455	455	299,683	-	-	299,683	299,228
25	35	-	-	455	455	299,683	-	-	299,683	299,228
26	36	-	-	455	455	299,683	-	-	299,683	299,228
27	37	-	-	455	455	299,683	-	-	299,683	299,228
28	38	-	-	455	455	299,683	-	-	299,683	299,228
29	39	-	-	455	455	299,683	-	-	299,683	299,228
30	2040	-	-	455	455	299,683	-	-	299,683	299,228
31	41	-	-	455	455	299,683	-	-	299,683	299,228
32	42	-	-	455	455	299,683	-	-	299,683	299,228
33	43	-	-	455	455	299,683	-	-	299,683	299,228
34	44	-	-	455	455	299,683	-	-	299,683	299,228
35	45	-	-	455	455	299,683	-	-	299,683	299,228
36	46	-	-	455	455	299,683	-	-	299,683	299,228
37	47	-	-	455	455	299,683	-	-	299,683	299,228
38	48	-	-	455	455	299,683	-	-	299,683	299,228
39	49	-	-	455	455	299,683	-	-	299,683	299,228
40	2050	-	-	455	455	299,683	-	-	299,683	299,228
41	51	-	-	455	455	299,683	-	-	299,683	299,228
42	52	-	-	455	455	299,683	-	-	299,683	299,228
43	53	-	-	455	455	299,683	-	-	299,683	299,228
44	54	-	-	455	455	299,683	-	-	299,683	299,228
45	55	-	-	455	455	299,683	-	-	299,683	299,228
46	56	-	-	455	455	299,683	-	-	299,683	299,228

EIRR=	22%
ENPV(Rp)=	843,391
PV(Cost)=	344,221
PV(Benefit)=	1,187,612
B/C=	3.5

APPENDIX G

Photo

PJB Office at Karangkates

Dam and Power Intake

Dam Reservoir

Spillway – Chute Way

Power Station - Outdoor Switch-yard

Power Station, - Tailrace Channel

Site	**Sutami Dam and Sutami Hydropower Station in East Java**	
Study for Rehabilitation of Hydropower Station in Indonesia		**JICA** **NIPPON KOEI**

Sutami Hydropower Station

Sutami Hydropower Station

Control Panel

Control Desk for Operation

General View of Power House

Generator

Site	**Sutami Hydropower Station**	
Study for Rehabilitation of Hydropower Stations in Indonesia		**JICA** **NIPPON KOEI**

Inlet Valve Floor

Inlet Valve

Governor (Mechanical Type)

Outdoor Switchyard

154kV Disconnecting Switch

Main Transformer

Site	**Sutami Hydropower Station**	
Study for Rehabilitation of Hydropower Stations in Indonesia		**JICA** **NIPPON KOEI**


Dam


Reservoir - Floating Log Boom


Power Intake - Trashrack


Reservoir - Dredging Works


By-pass Channel Located Upstream of Wlingi Dam


Existing Spoil Bank for Reservoir Dredging

Site	**Wlingi Dam**	
Study for Rehabilitation of Hydropower Station in Indonesia		**JICA**
		NIPPON KOEI

Wlingi Hydropower Station

Spillway Gates

Generator

Control Desk for Operation

Inlet Valve

Drainage Pump

Site	**Wlingi Hydropower Station**	
Study for Rehabilitation of Hydropower Stations in Indonesia		**JICA** **NIPPON KOEI**

Governor (Mechanical Type)

Storage Battery

Outdoor Switchyard

Main Transformer

154kV Disconnecting Switch
Air drive

Site	**Wlingi Hydropower Station**	
Study for Rehabilitation of Hydropower Stations in Indonesia		**JICA** **NIPPON KOEI**

Main Dam

Hydropower Station

Dam Reservoir

Power Intake

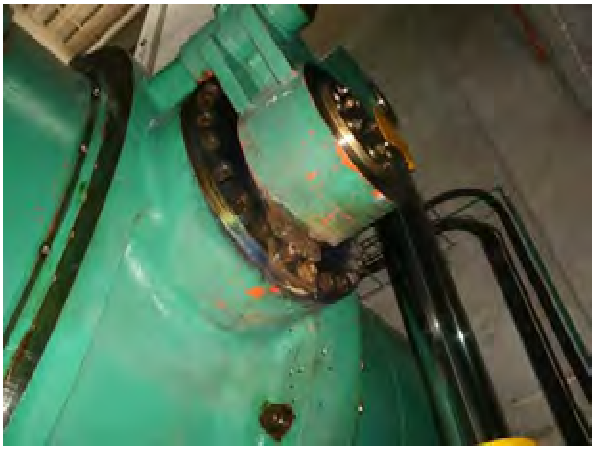
Main Dam Crest

Saddle Dam and Green Belt

Site	**Soedirman (Mrica) Dam and Soedirman Hydropower Station in Central Java**	
Study for Rehabilitation of Hydropower Station in Indonesia		**JICA** **NIPPON KOEI**

Mrica Dam

Soedirman Hydropower Station



Inlet Valve

Water Turbine Pit

Training of Dismantling for Power Station Staff

Strainer for Cooling Water System

Site	**Soedirman Hydropower Station in Central Java** **Generating Equipment**	
Study for Rehabilitation of Hydropower Stations in Indonesia		**JICA** **NIPPON KOEI**

Digital Type AVR
Replaced with new type in 2006

Supervisory and Control System
Replaced with new system in 2006

Storage Battery

Main Transformer

Outdoor Switchyard

Outgoing 154kV Transmission Lines

Site	**Soedirman (Mrica) Hydropower Station in Central Java** **Generating Equipment**	
Study for Rehabilitation of Hydropower Stations in Indonesia		**JICA** **NIPPON KOEI**

Indonesia Power at Saguling

Dam and Reservoir

Spillway

Power Intake

Reservoir

Power Station and Penstock Line

Site	**Saguling Dam and Saguling Hydropower Station in West Java**	
Study for Rehabilitation of Hydropower Station in Indonesia		**JICA** **NIPPON KOEI**

Penstock

Saguling Hydropower Station

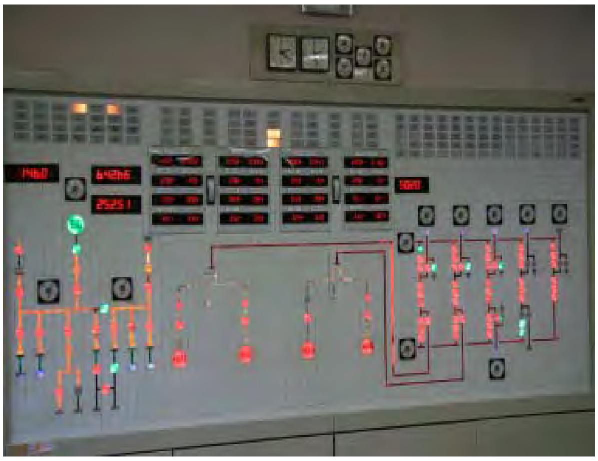
Storage Battery

Generator Floor

Water Turbine Pit

Governor (Mechanical Type)

Site	**Saguling Hydropower Station**	
Study for Rehabilitation of Hydropower Stations in Indonesia		**JICA** **NIPPON KOEI**

	
Control Panel Replaced with new one in 2002	Inlet Valve
	
Main Transformer	Main Transformer
	
Outdoor Switchyard	GIS type Switchgear

Site	**Saguling Hydropower Station**

Study for Rehabilitation of Hydropower Stations in Indonesia	**JICA** **NIPPON KOEI**


Lahor Dam


Lahor Dam Reservoir


Lahor Dam Spillway - Chute Way


Lahor Dam - Side Spillway


Sengguruh Dam - Garbage Removal


Sengguruh Dam Reservoir - Floating Log Boom

Site	**Lahor Dam and Sengguruh Dam in East Java**	
Study for Rehabilitation of Hydropower Station in Indonesia		**JICA**
		NIPPON KOEI