CHAPTER 4

FEASIBILITY STUDY SITE

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The study result of Cutato River site selected to be the FS Site in Chapter 3 is shown below.

4.1 Properties of Prospective Site

Figs.4.1-1(1), (2) shows the location of Cutato HPS Project. The elevation and the catchment area are about 1,400 m and 9,400 m^2, respectively, where the rain, which falls at the plateau over 1,600 m elevation in Huambo and Bie Province, gathers in Cutato River.

Fig.4.1-1(1) Location of the Project : Luanda ~ Cuito ~ Andulo ~ Site

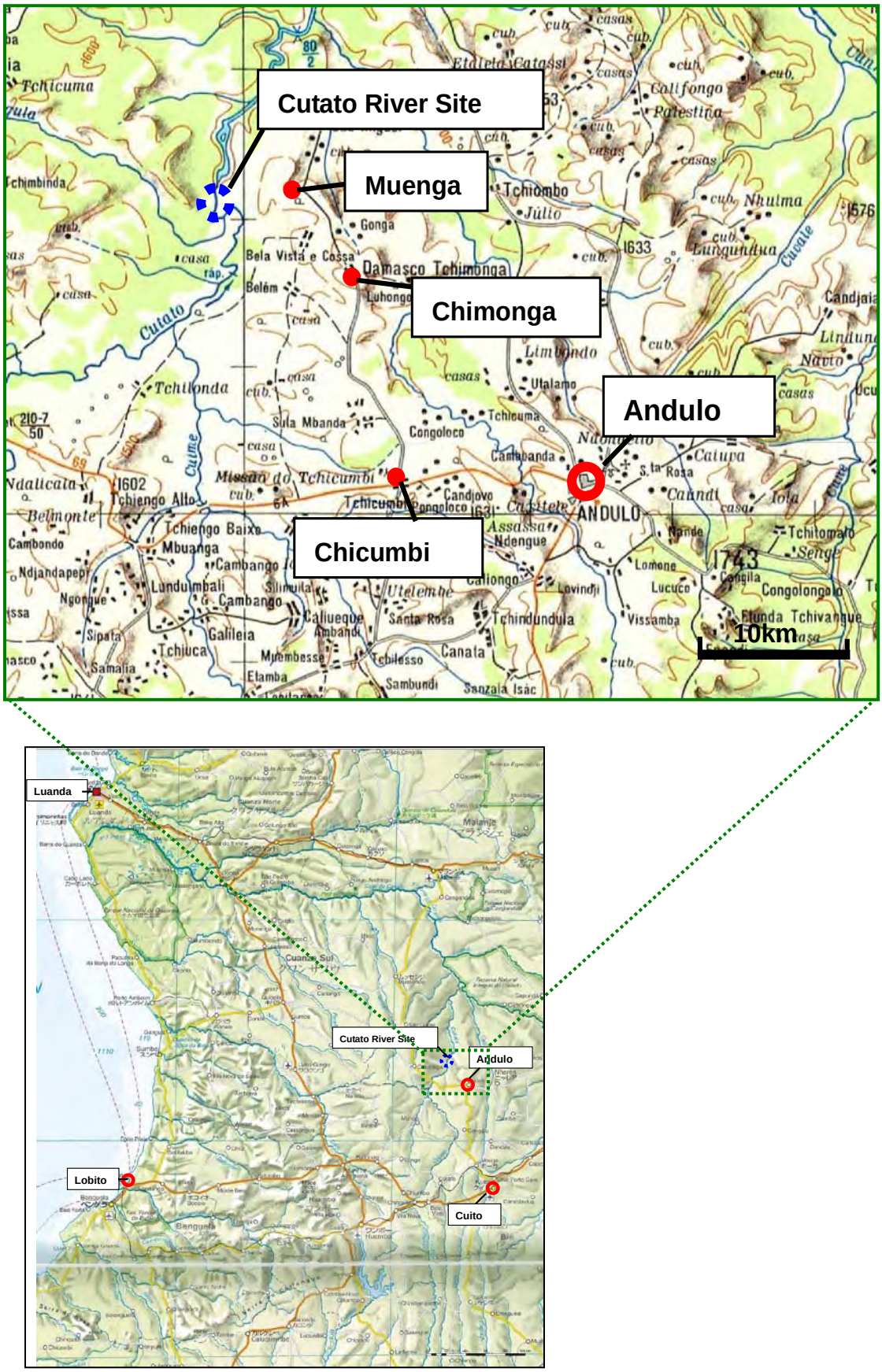


Fig. 4.1-1 (2) Location of the Project : Andulo ~ Site

4.1.1 Topography and Geology

(1) Topographic Features

The project site is located at the gentle sloped hill area at around EL.1,400 m. The Cutato River diverts at the just upstream of the project site, and joins at the downstream through the wide sandbar. The project site is selected at the right river course of the two.

(2) Geological Features

The foundation rocks are composed of the coarse grained granite of Precambrian Period. The hard rocks lie seamlessly along the river. Therefore, each structure can be directly constructed on the rocks well exposed at the riverside. As the explosion for the excavation will not work well because there are few joints in the hard granite, the design of each structure should be considered so as to use the original topography.

(3) Other Items

nil

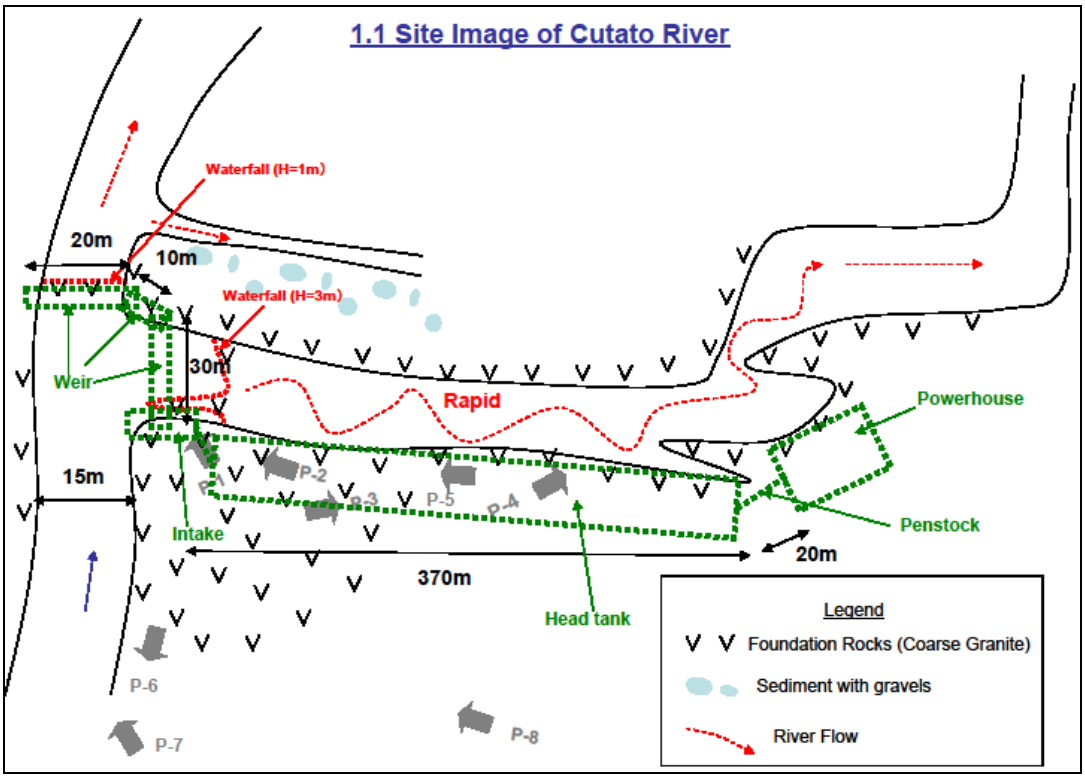


Fig. 4.1-2 Image Map of Cutato River Site

Photo 4.1-1 View of Cutato River Site (Rainy Season: Jan.26, 2011)

4.1.2 Hydrology and Meteorology

4.1.2.1 Overview of Hydrology and Meteorology

(1) Overview of the Site

The Site of Cutato River is located along the Cutato River which is the tributary of the Cuanza River (catchment area: 147,000 km^2). The catchment area of the projected site is 9,400 km^2. Most part of the catchment is located on the highland which is higher than EL. 1,500 m with an exception of the projected powerhouse site from EL. 1,250 to 1,500 m (as already mentioned in Section 2.2.2). This projected site is located in the relatively wet region in Angola with annual rainfall of more than 1,250 mm/yr.

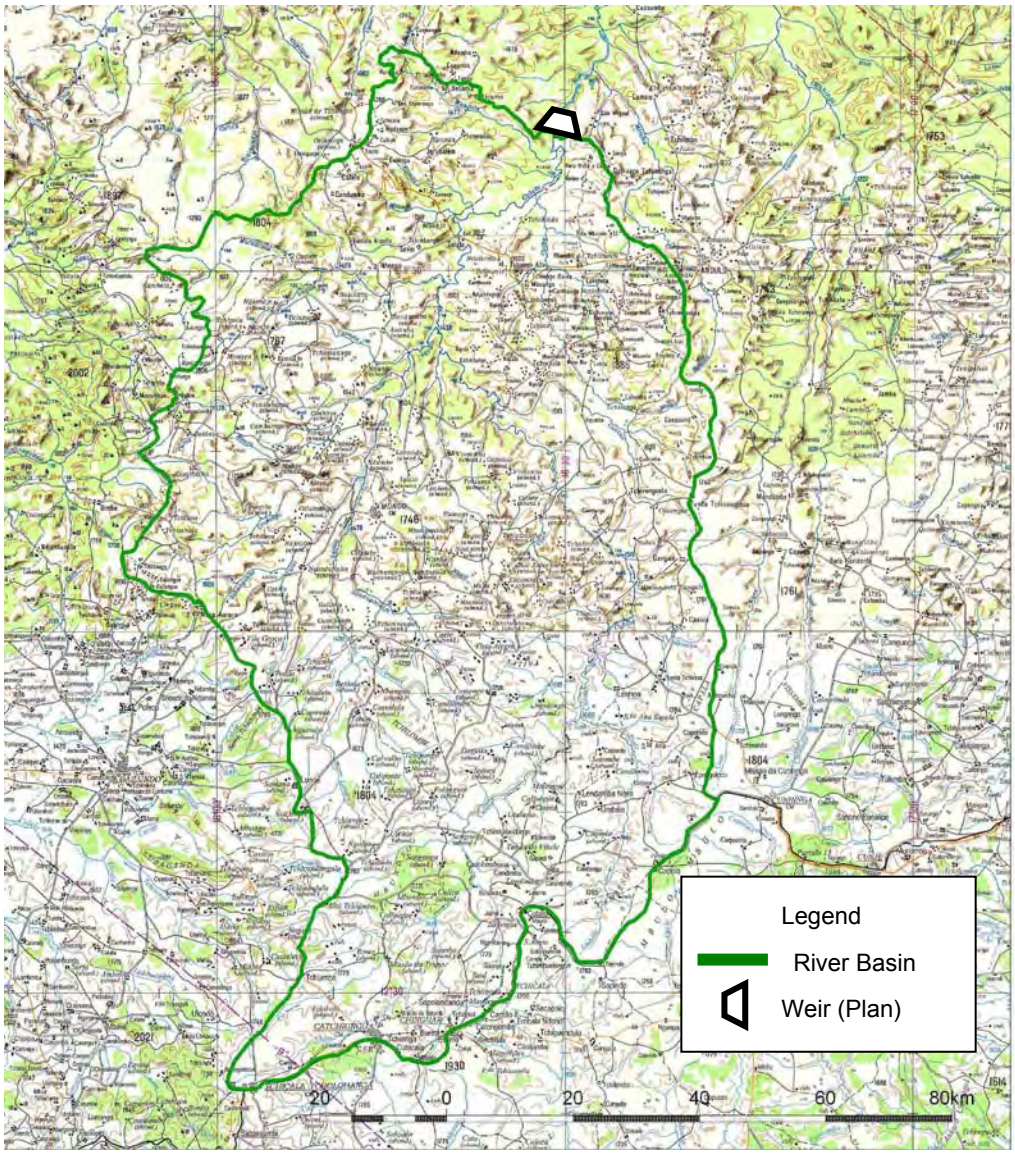


Fig. 4.1-3 Cutato River Basin

(2) Data Collection

Data condition (observation items and period) of meteorological and hydrological data in this study is shown bellow.

Table 4.1-1 Data Condition

Item	Station	1960	1970	1980	1990	2000
Precipitation	Kuito(Bie)*					
	Huambo(Huambo)*					
	Luanda (Luanda)**					
Temperature	Luanda (Luanda)**					
Relative Humidity	Luanda (Luanda)**					
River flow	Cambambe**					

*Source: INAMET: Instituto de Nacianal Meteorologia e Geofísica

**Source: JICA, "Basic design study report on the project for water supply in Luanda Province", 2001

Note: Data existing through a whole year; Some of data is missing

4.1.2.2 Meteorology

The climate of Bie province (the capital: Cuito (=Kuito)) near the projected site of the Cutato River site is cool for its tropical location. The average annual temperature is 18 degree Centigrade, largely due to its high altitude. The coolest period is May to August when almost no rain falls. Heavy rain falls in the main rainy season October to April. Both Bie Province and Huambo Province included in the projected river basin feature almost same climate with averaging nearly 1,500 mm rainfall per annum.

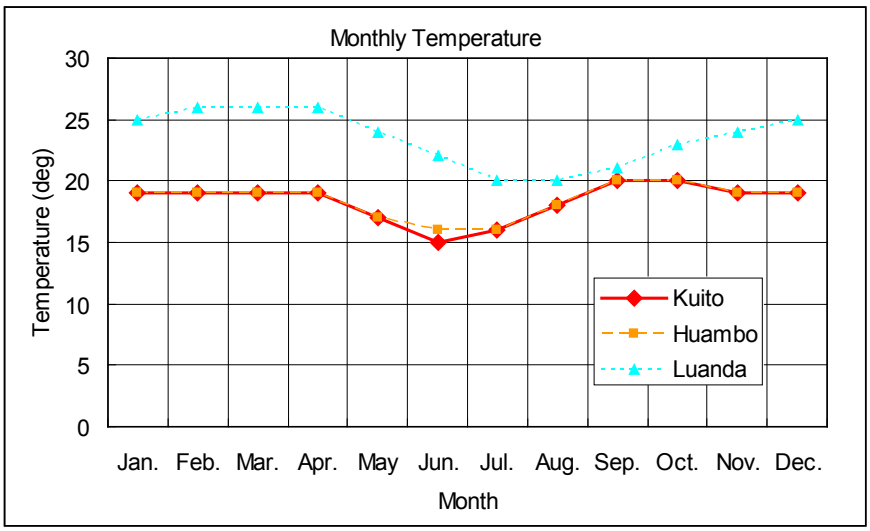


Fig. 4.1-4 Monthly Average Temperature (Cuito (=Kuito), Huambo, Luanda)

Source : Weatherbase - Records and Averages for Angola : http://www.weatherbase.com/

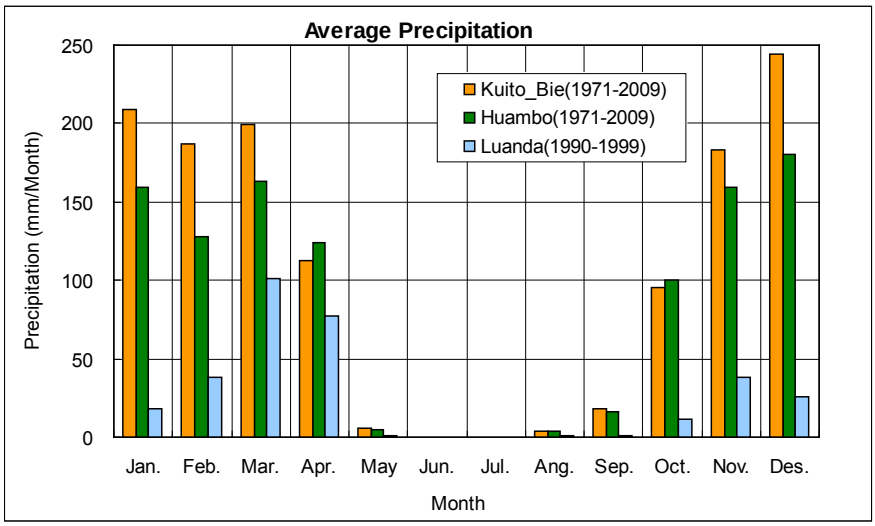


Fig. 4.1-5 Monthly Average Rainfall (Cuito (=Kuito), Huambo, Luanda)

Source: INAMET

Table 4.1-2 (1) Rainfall Data (Cuito (=Kuito), Bie Province)

Kuito_Bie (1971-2009)

Lat 12° 23′ S
Lon 16° 57′ E
Altitude 1711 m
Precipitation

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Ang.	Sep.	Oct.	Nov.	Des.	Total
1971	158.1	128.1	147.0	46.7	1.0	0.2	0.0	0.0	4.2	56.8	122.2	207.0	871.3
1972	142.5	53.8	227.0	128.9	0.0	0.0	0.0	0.0	13.0	150.2	163.2	249.1	1127.7
1973	239.2	170.5	189.4	127.0	18.2	0.0	0.0	0.0	5.4	106.9	203.2	166.0	1225.8
1974	106.5	93.5	138.7	150.3	8.2	0.0	0.0	5.5	11.4	137.6	155.2	300.4	1107.3
1975	219.6	296.5	236.4	101.2	27.5	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	107.6	225.8	-
1977	185.6	160.9	293.3	87.2	0.0	0.0	0.0	0.0	55.9	90.9	188.5	274.0	1336.3
1978	96.4	99.6	280.5	200.7	0.0	0.0	0.0	2.0	14.5	67.1	198.5	147.3	1106.6
1979	322.9	207.5	284.9	48.5	4.7	0.0	5.4	16.6	16.1	75.9	320.3	313.7	1616.5
1980	213.5	83.4	87.1	-	-	-	-	10.9	0.7	31.2	162.7	166.7	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	297.3	154.9	144.1	127.8	11.9	*0.0*	0.0	*0.0*	11.6	77.1	262.7	506.7	1594.1
1985	148.8	150.5	291.7	118.0	28.9	0.0	0.0	0.0	28.7	207.0	125.4	171.1	1270.1
1986	114.3	308.0	123.4	0.3	0.0	0.0	0.0	3.3	18.5	359.6	232.8	178.1	1338.3
1987	-	226.8	209.6	18.6	0.0	0.0	0.2	0.0	-	-	-	-	-
1988	-	-	-	-	0.0	0.0	0.0	4.7	2.5	124.4	125.5	316.4	-
1989	242.7	208.2	236.4	200.5	0.0	0.0	0.0	0.2	7.6	34.5	40.6	103.2	1073.9
1990	290.0	262.7	195.0	201.7	1.5	0.0	0.0	-	0.1	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	273.2	204.2	182.6	36.8	0.0	0.0	0.0	0.8	33.4	79.8	181.8	262.7	1255.3
1999	185.0	203.4	226.3	10.0	12.2	0.0	0.0	0.0	15.6	65.7	-	-	-
2000	-	-	-	-	0.0	0.0	0.0	9.9	45.9	94.5	195.2	-	-
2001	279.8	212.9	217.4	216.4	0.0	0.0	0.0	3.9	35.8	16.5	126.7	166.6	1276.0
2002	230.6	198.4	250.4	84.3	0.0	0.0	0.0	7.9	52.2	81.9	120.3	210.2	1236.2
2003	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	261.3	225.6	184.1	70.5	0.0	0.0	0.0	11.3	26.8	42.9	183.7	260.3	1266.5
2005	251.7	310.2	4.1	200.4	4.1	0.0	0.0	0.0	5.2	74.7	307.0	267.6	1425.0
2006	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-	-	-	-
2009	184.0	142.3	254.5	103.8	13.9	0.5	0.0	0.0	19.7	125.3	329.3	392.5	1565.8
2010	154.3	204.1	173.3	200.4	15.9	0.0	-	-	-	-	-	-	-
Average	209.0	187.2	199.0	112.7	6.2	0.0	0.2	3.3	18.5	95.5	183.4	244.3	1276.0

Source: INAMET

Table 4.1-2 (2) Rainfall Data (Huambo, Huambo Province)

Huambo (1971-2009)

Lat 12° 48′ S
Lon 15° 45′ E
Altitude 1700 m
Precipitation

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Ang.	Sep.	Oct.	Nov.	Des.	Total
1971	144.7	171.4	142.6	71.7	19.5	0.0	0.0	0.0	8.4	135.3	126.6	228.4	1048.6
1972	229.6	36.9	230.1	172.2	8.2	0.0	0.0	0.0	16.0	112.0	134.2	350.2	1289.4
1973	314.7	87.1	191.3	197.5	4.3	0.0	0.0	0.0	4.2	195.2	73.6	194.6	1262.5
1974	50.1	17.5	268.4	197.0	3.4	0.0	0.0	0.2	8.1	143.3	205.0	380.8	1273.8
1975	168.7	269.3	155.0	147.0	48.8	0.0	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	143.4	163.3	244.4	112.0	0.0	0.0	0.0	0.0	32.2	80.5	342.7	90.4	1208.9
1978	25.7	67.3	360.0	228.9	0.0	0.0	0.0	8.0	8.7	122.9	198.8	169.0	1189.3
1979	188.9	314.0	294.2	16.7	0.0	0.0	4.7	11.5	39.6	76.7	294.4	176.4	1417.1
1980	183.6	210.1	73.6	95.0	0.0	0.0	0.0	0.3	11.4	68.7	91.3	72.3	806.3
1981	250.8	192.2	223.9	70.3	0.0	0.0	0.0	14.1	0.0	100.7	179.6	294.5	1326.1
1982	298.7	275.3	192.1	289.2	0.0	0.0	0.0	0.0	1.9	127.4	129.3	-	-
1983	-	110.0	0.0	73.5	2.1	0.0	0.0	0.0	71.0	-	339.2	-	-
1984	530.0	-	190.8	94.4	0.0	0.0	0.0	-	2.4	62.1	210.6	-	-
1985	47.6	138.4	201.7	237.8	0.0	0.0	0.0	-	-	78.0	141.8	89.3	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	41.0	115.6	135.4	46.3	-
1988	115.6	14.8	171.2		0.0	0.0	0.0	0.0	0.0	18.5	148.9	267.9	-
1989	155.4	44.0	152.7	253.6	0.0	0.0	0.0	-	-	-	-	-	-
1990	59.9	37.5	41.2	140.4	0.0	0.0	0.0	-	-	-	82.4	64.5	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	220.6	67.7	126.6	44.3	0.0	0.0	0.0	14.8	6.6	96.4	113.0	127.6	817.6
1999	146.7	148.1	140.1	78.9	0.0	0.0	0.0	-	9.8	90.4	101.9	200.3	-
2000	81.2	60.0	114.9	147.5	0.0	0.0	0.0	-	42.0	56.7	130.2	115.3	-
2001	81.5	208.4	132.4	161.7	0.0	0.0	0.0	7.0	12.7	19.2	47.8	158.6	829.3
2002	136.9	135.4	161.8	94.3	0.0	0.0	0.0	-	20.2	31.8	77.6	142.6	-
2003	157.5	174.9	102.9	69.0	0.0	0.0	0.0	-	12.1	78.2	251.3	316.4	-
2004	220.9	69.9	40.3	28.5	0.0	0.0	0.0	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	1.2	0.0	206.9	124.7	119.3	-
2006	68.6	75.9	202.0	-	0.0	0.0	0.0	-	16.0	180.1	238.7	210.5	-
2007	156.1	103.0	122.9	45.1	0.0	0.0	0.0	-	14.2	74.1	122.5	92.3	-
2008	74.5	121.3	165.0	88.0	42.7	0.0	0.0	-	0.5	130.3	149.1	-	-
2009	87.0	126.7	123.0	74.7	10.2	0.0	0.0	-	-	95.7	113.0	234.0	-
2010	124.8	140.0	-	-	-	-	-	-	-	-	-	-	-
Average	159.4	127.9	163.0	124.2	5.0	0.0	0.2	3.8	15.8	99.9	159.4	180.1	1133.5

Source: INAMET

4.1.2.3 Hydrology

Discharge duration curve of the Cuanza River generated from river-flow data described in Section 2.2.2 is shown bellow (Fig.4.1-6). The Fig.4.1-7 in the next page shows the averaged discharge duration curve with the table of 25% flow (95-day flow), 50% flow (183-day flow), 75 % flow (274-day flow), and 95 % flow (346-day flow). This discharge duration curve shows that monthly maximum discharge of the Cuanza River is about 2.0 $m^3/s/100km^2$.

Table 4.1-3 River-flow of the Cuanza River (at Cambambe, 1962 - 1972）

Monthly Discharge

Cuanza river Basin Area: 121,470 km2 Station: Cambambe

Observation Period: 1962-72 E:14:29:00 S:9:45:00 Elevation: 187 m (m^3/s)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Ang.	Sep.	Oct.	Nov.	Des.	Total*
1962										318	424	787	882.5
1963	1044	1491	1577	1913	1204	692	477	369	294	281	474	636	663.5
1964	799	1168	1496	1327	660	373	293	244	211	187	290	455	608.0
1965	919	1090	1188	1276	739	416	293	239	204	219	213	459	809.6
1966	794	1466	2120	2022	983	549	365	284	241	300	396	421	639.8
1967	550	798	1030	1286	1299	634	385	313	265	265	592	1017	1114.7
1968	1561	2129	2606	2092	1248	698	485	376	307	286	472	734	1044.3
1969	1478	1588	2469	2554	1163	658	455	380	295	377	569	1123	969.0
1970	1347	1604	2412	1581	961	563	430	361	300	327	489	687	649.4
1971	1034	805	900	1317	832	465	355	307	275	216	268	337	349.8
1972	522	417	397	715	501	269	222	182	151				
Average(m^3/s)	1004.8	1255.6	1619.5	1608.3	959.0	531.7	376.0	305.5	254.3	277.6	418.7	665.6	773.1

* : Average of Oct.-Sep.

Source: JICA, "Basic Design Study Report on the Project for Water Supply in Luanda Province", 2001

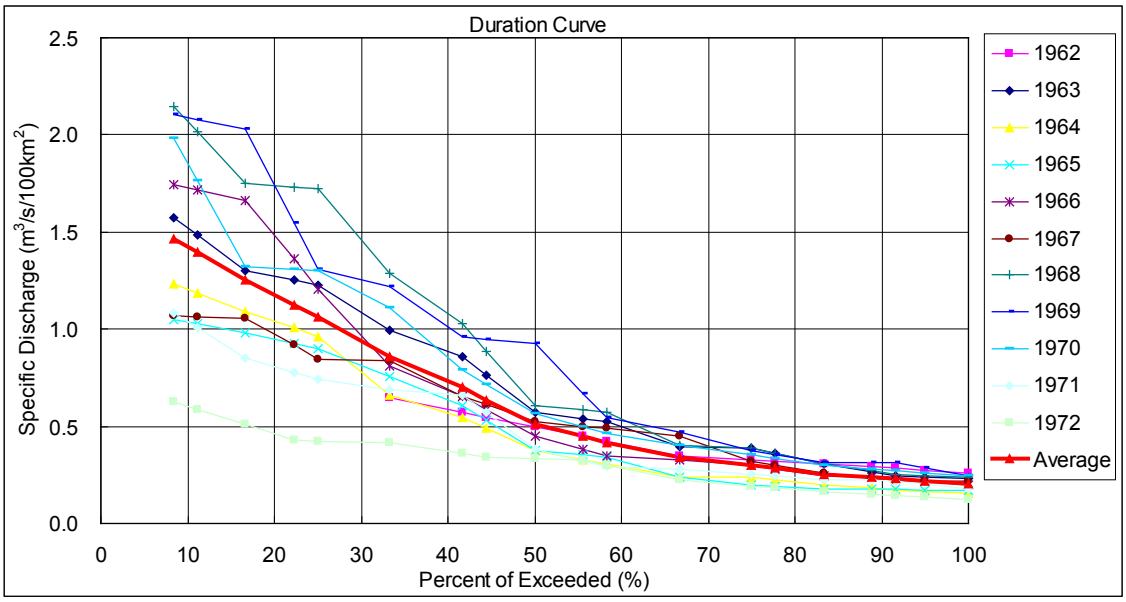
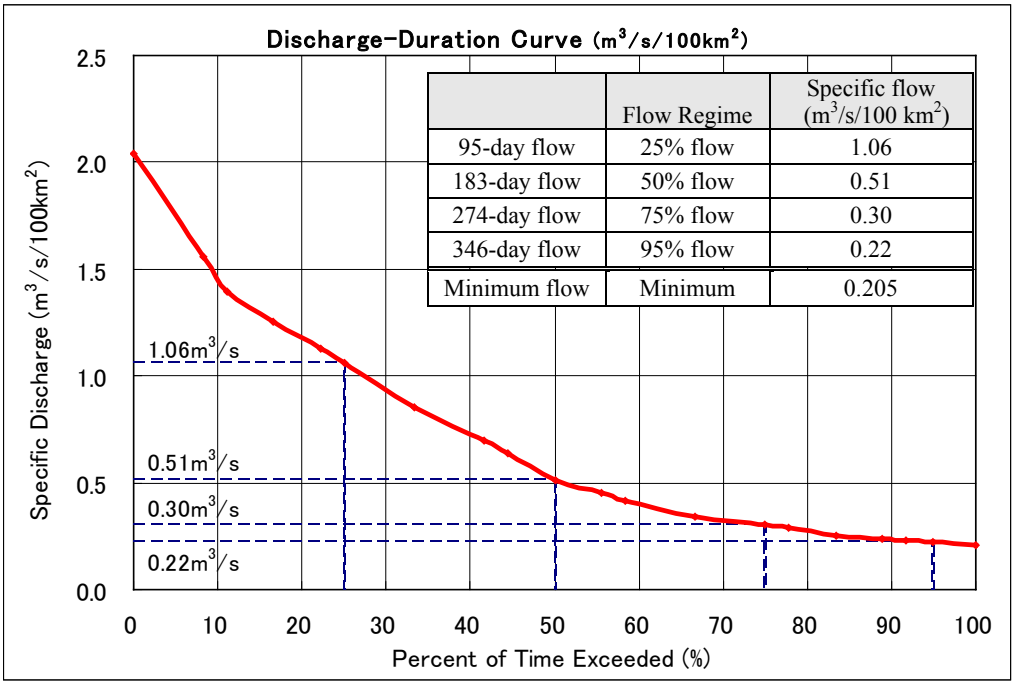


Fig. 4.1-6 Discharge Duration Curve of the Cuanza River (1962 – 1972)



	Flow Regime	Specific flow ($m^3/s/100\ km^2$)
95-day flow	25% flow	1.06
183-day flow	50% flow	0.51
274-day flow	75% flow	0.30
346-day flow	95% flow	0.22
Minimum flow	Minimum	0.205

Fig. 4.1-7 Discharge Duration Curve of the Cuanza River *(Specific Discharge, $m^3/s/100\ km^2$)*

The Discharge duration curve for the Cutato River is obtained as below from the data above and catchment area of the Cutato River (9,400km^2). From the graph below, the maximum monthly discharge is estimated to be 188m^3/s.

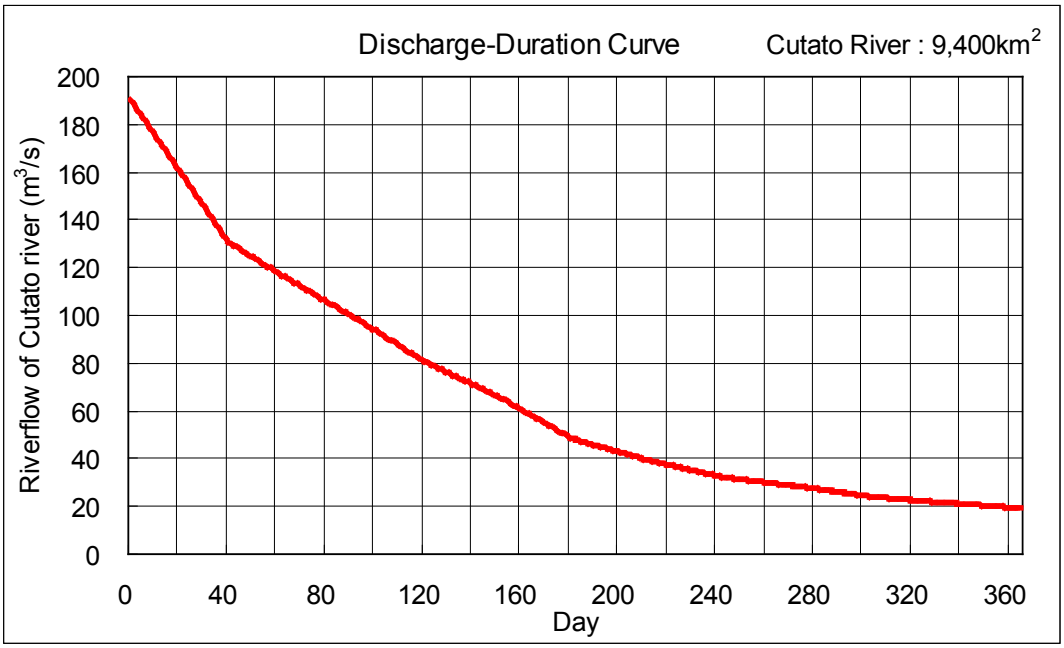


Fig. 4.1-8 Discharge Duration Curve of the Cutato River

※ Discharge of Cutato River is obtained from the data of the Cuanza River by multiplying catchment area ratio (Area of Cutato / Area of Cuanza = 9,400 km^2 / 121,470 km^2)

4.2 Plan of Generation and Distribution

4.2.1 Powerhouse Location

Changing river-flow work for drying river is very important when structures in river like dam and weir are constructed. There are 2 types of changing river-flow work, one is temporally diversion work and the other is divided river work. Temporally diversion work is suitable for narrow, steep and a little discharge river in mountain and dividing river work is suitable for wide, mild and much discharge river in plain field. Dividing river work is especially suitable for Cutato site. The site which is considered most suitable has sandbar (in the river), so the changing river-flow work at construction stage can be easily executed thanks to its natural topography. In addition, river slope becomes steep at just downstream of branch, gross head can be gotten by short water channel. This site is just suitable for hydro power plant.

Cutato Powerhouse location was decided to be the right bank of the right branch (Cutato River has a branch at downstream of the weir). Because the above location is superior to other locations from many viewpoints of, for example, distribution line, access road, temporary facilities site and easiness of operation, maintenance and construction (refer to Fig.4.2-1).

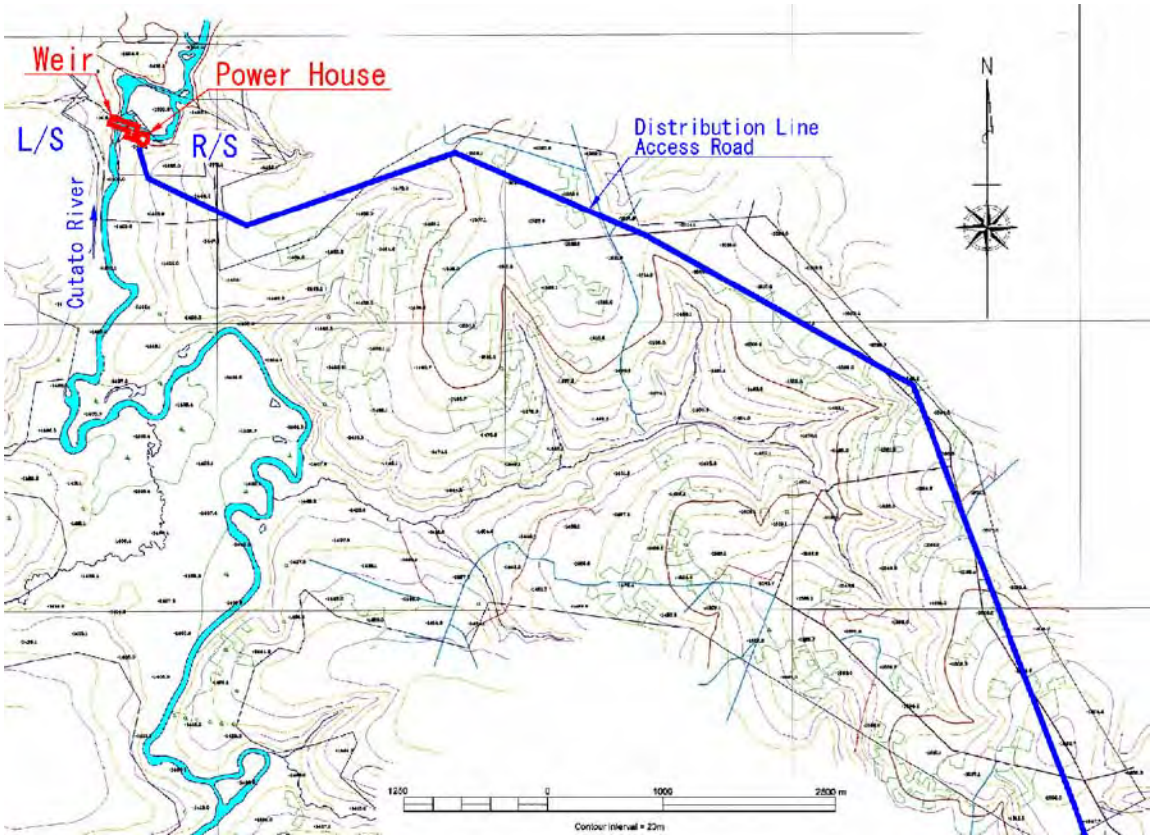


Fig.4.2-1 Location of Powerhouse

There are 2 candidate sites of the powerhouse location at the right bank of the right branch. One is the place of just downstream of the weir (Weir Type) and another is the place of about 400 m downstream of the weir with water way (Water Way Type).

At first, Water Way Type was mainly considered which was shown at Section 3.2.1 "Cutato Site".

Because there is a lot of hard bedrock of Precambrian granite around the river, the powerhouse location was selected to become a few excavations. This time we compared the 2 types. Excavation volume of Weir Type is more than one of Water Way Type, but concrete volume of Weir Type is less than one of Water Way Type. As a result, the construction cost of Weir Type is less than one of Water Way Type (refer to Table 4.2-1, Figs.4.2-2, Fig.4.2-3). The location of powerhouse is decided at just downstream of the weir at right bank of right side river.

Table 4.2-1 Comparison of Construction Cost (by only main items)

Item	Description	Unit	Quantity	Rate(Yen)	Amount (Yen)	
					Waterway Type Fig 4.2-2(1)	Weir Type Fig 4.2-2(2)
Concrete Work	Reinforced concrete 0.1 t/m^3	m^3	8,000	51,800	414,400,000	
Framework	Reinforced Structure	m^2	10,400	2,770	28,808,000	
Excavation Work	Hard Rock II	m^3	17,920	7,690		137,804.800
Total					443,208,000 ≒440,000,000	137,804,800 ≒140,000,000

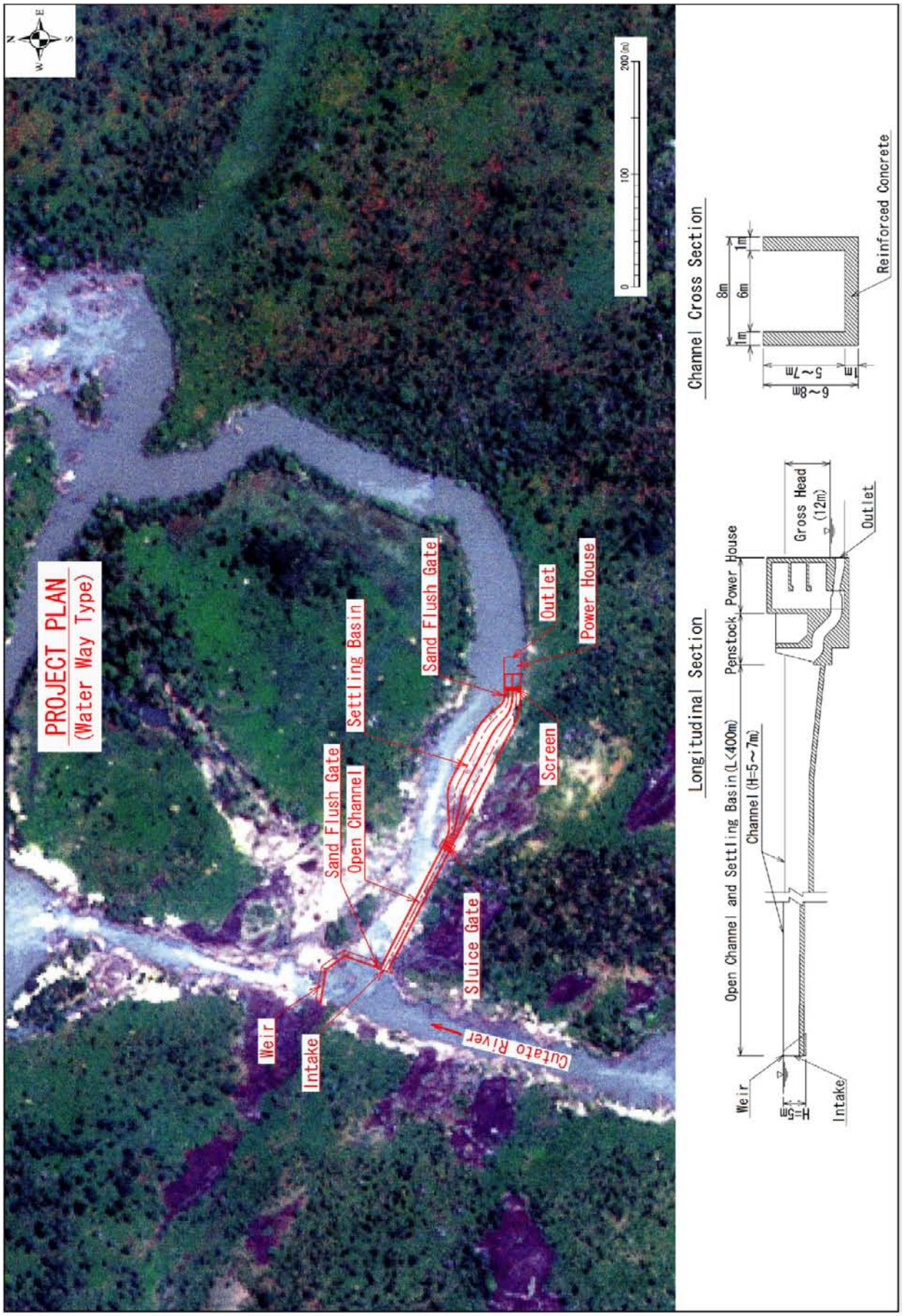


Fig. 4.2-2 Water Way Type Project Plan

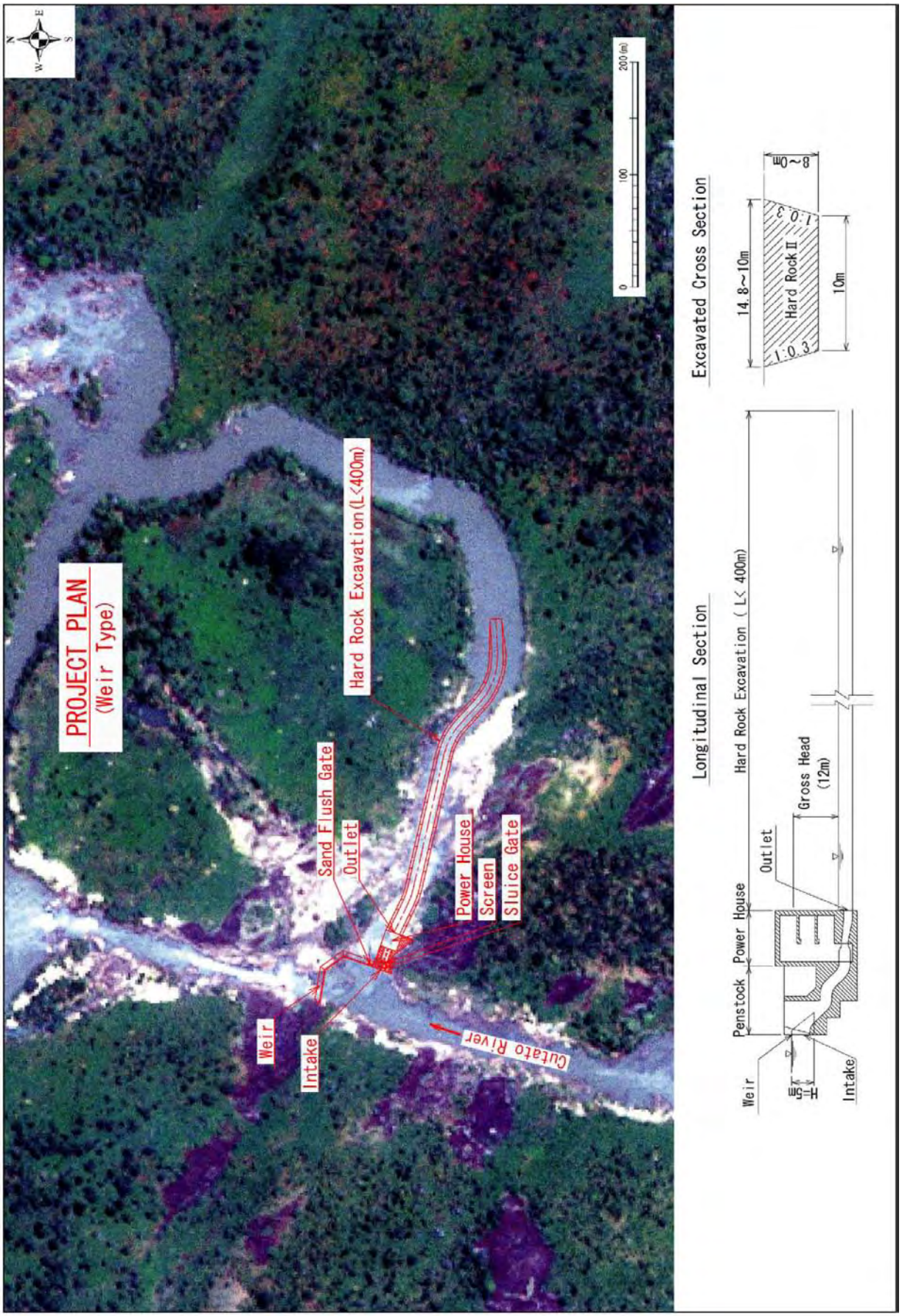


Fig. 4.2-3 Weir Type Project Plan

4.2.2 Weir Height and Maximum Discharge

Optimum weir height and optimum maximum discharge are checked up in condition that Cutato powerhouse location is at right bank of right branch.

It is necessary that the weir has flap crest gates which height is about 3 m and length is 70 m in order not to raise water revel and influence natural and social environment even at design flood discharge (560 m^3/s).
So height of weir is checked up over 3 m.

Maximum discharge were checked up each 10 m^3/s from 20 m^3/s, which was minimum river-flow that was usually adopted as maximum discharge in Angola, to 90m^3/s, 25% river-flow (95-day flow) that was frequently adopted as maximum discharge at end-stage hydro-development time in Japan.

It is requested to get CDM credit in this project that the ratio of installed capacity to water reservoir area is more than 4 W/m^2 to meet CDM criteria.
Table 4.2-2 shows weir height and maximum discharge combination which can become the above ratio over 4 W/m^2. Table 4.2-3 shows the optimum combination in various cases after checking up power generation, construction cost, benefit in a year and cost in a year. Fig.4.2-4 shows various water reservoir areas in each weir height.

Table 4.2-2 Checking up Combinations of Weir Height and Maximum Discharge

Weir height (m)	Submerged area (km^2)	Required power output (4 W/m^2) (kW)	Effective head (m)	Combined efficiency (%)	Required water discharge (m^3/s)	Maximum discharge (m^3/s)
3	0.48	1,920	6.5	82	36.8	40, 50, 60, 70, 80, 90
4	0.72	2,880	7.5	82	47.2	50, 60, 70, 80, 90
5	1.20	4,800	8.5	82	70.3	80, 90
6	2.72	10,880	9.5	82	142.5	-

Fig.4.2-5 and Fig.4.2-6 shows the result. In the case of 3 m weir height, the ratio of benefit to cost (B/C) becomes the most one at 40 m^3/s maximum discharge. In the case of 4 m weir height, the ratio becomes the most one at 50 m^3/s maximum discharge. In the case of 5 m weir height, the ratio becomes the most one at 80 m^3/s maximum discharge.

In all cases of Table 4.2-2, the optimum combination is 4 m weir height and 50 m^3/s maximum discharge. The combination lead to the maximum ratio of benefit to cost.

So it is concluded that the weir height is 4 m and the maximum discharge is 50 m^3/s.

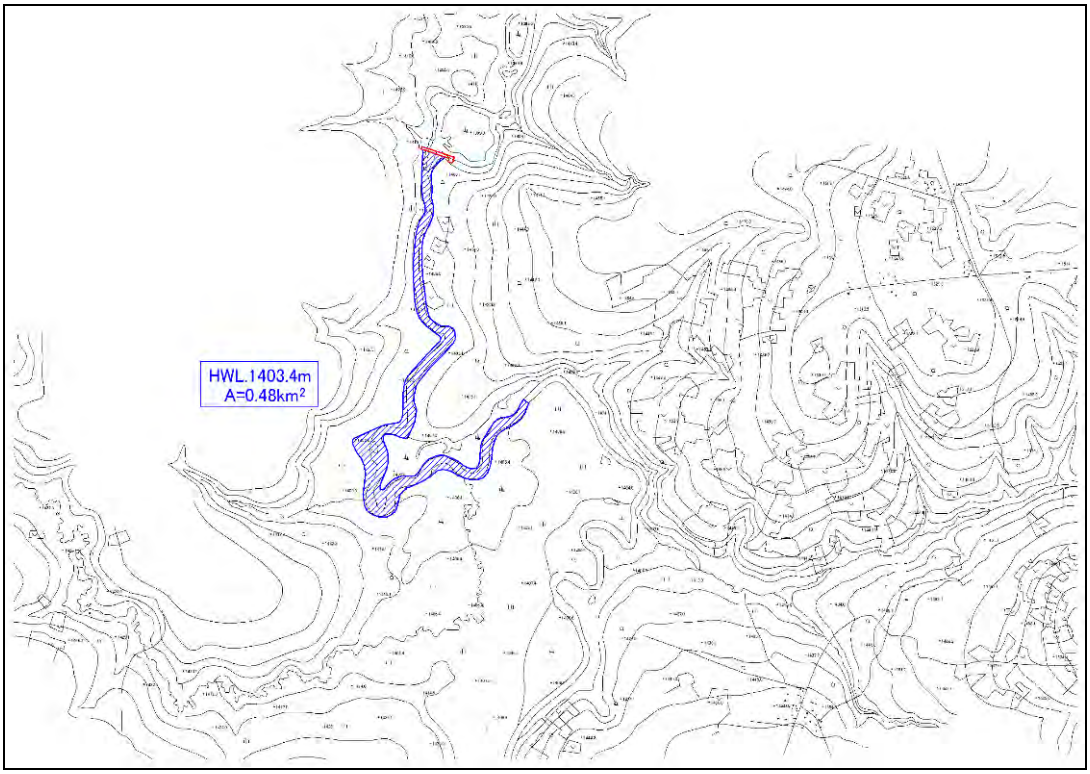
Table 4.2-3 Study Result of Optimum Weir Height and Maximum Discharge

Plan : S-Type Tubular : 2 units

Weir Height	Q	P	H	E	Construction Cost in Japan	Construction Cost in Angola	Kz/kWh	Annual B	Annual C	B-C	B/C
m	m^3/s	kW	m	MWh	M¥ *	MKz*		MKz/y	MKz/y	MKz/y	
3.0	40	2,100	6.5	15,847	3,080	3,403	214.7	259.891	165.355	94.536	1.572
	50	2,600	6.5	18,231	3,576	3,951	216.7	298.988	191.984	107.004	1.557
	60	3,100	6.5	20,145	4,069	4,496	223.2	330.378	218.452	111.926	1.512
	70	3,700	6.5	21,730	4,567	5,046	232.2	356.372	245.188	111.184	1.453
	80	4,200	6.5	23,089	5,071	5,603	242.7	378.660	272.246	106.414	1.391
	90	4,700	6.5	24,258	5,585	6,171	254.4	397.831	299.841	97.991	1.327
4.0	50	3,000	7.5	21,113	3,757	4,151	196.6	346.253	201.701	144.552	1.717
	60	3,600	7.5	23,359	4,285	4,734	202.7	383.088	230.048	153.040	1.665
	70	4,200	7.5	25,195	4,820	5,325	211.4	413.198	258.770	154.428	1.597
	80	4,800	7.5	26,771	5,365	5,928	221.4	439.044	288.030	151.015	1.524
	90	5,400	7.5	28,122	5,924	6,545	232.7	461.201	318.040	143.160	1.450
5.0	80	5,500	8.5	30,447	5,658	6,251	205.3	499.331	303.760	195.571	1.644
	90	6,100	8.5	31,985	6,263	6,920	216.3	524.554	336.240	188.314	1.560

* Both Construction cost in Japan (Million JPY) and Construction Cost in Angola (Million Kz); Construction cost of the Main Body (excluding cost for removal of mines)

Submerged area in case of weir height 3.0 m



Submerged area in case of weir height 4.0 m

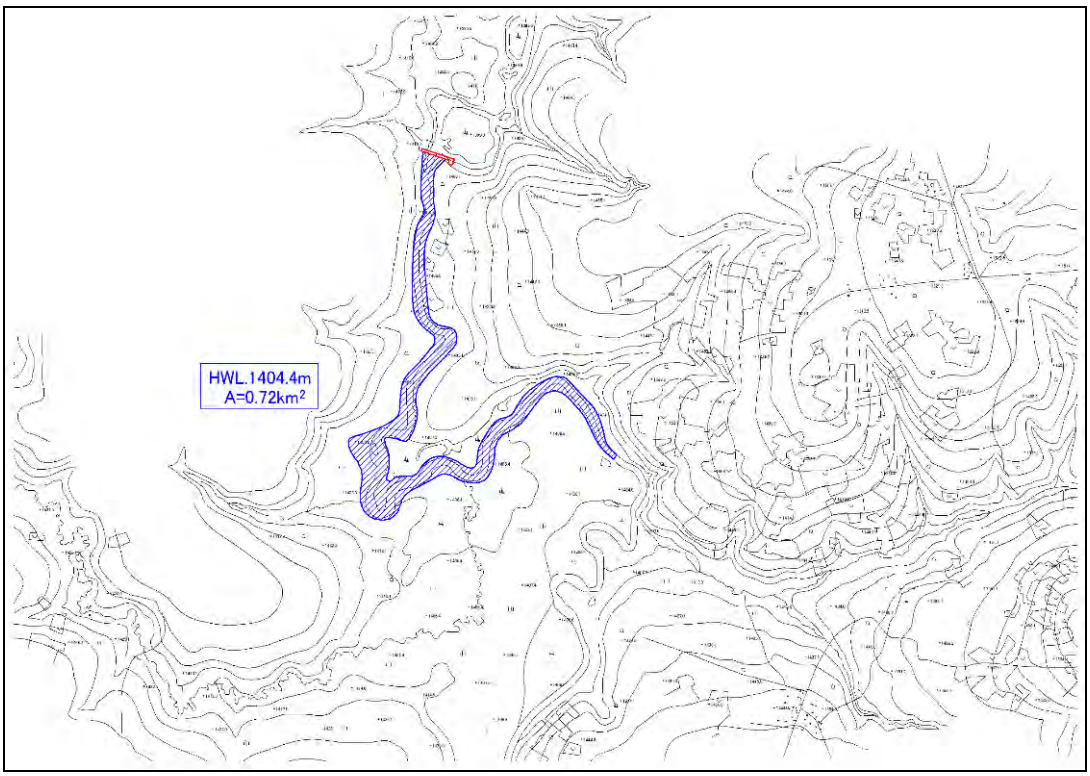
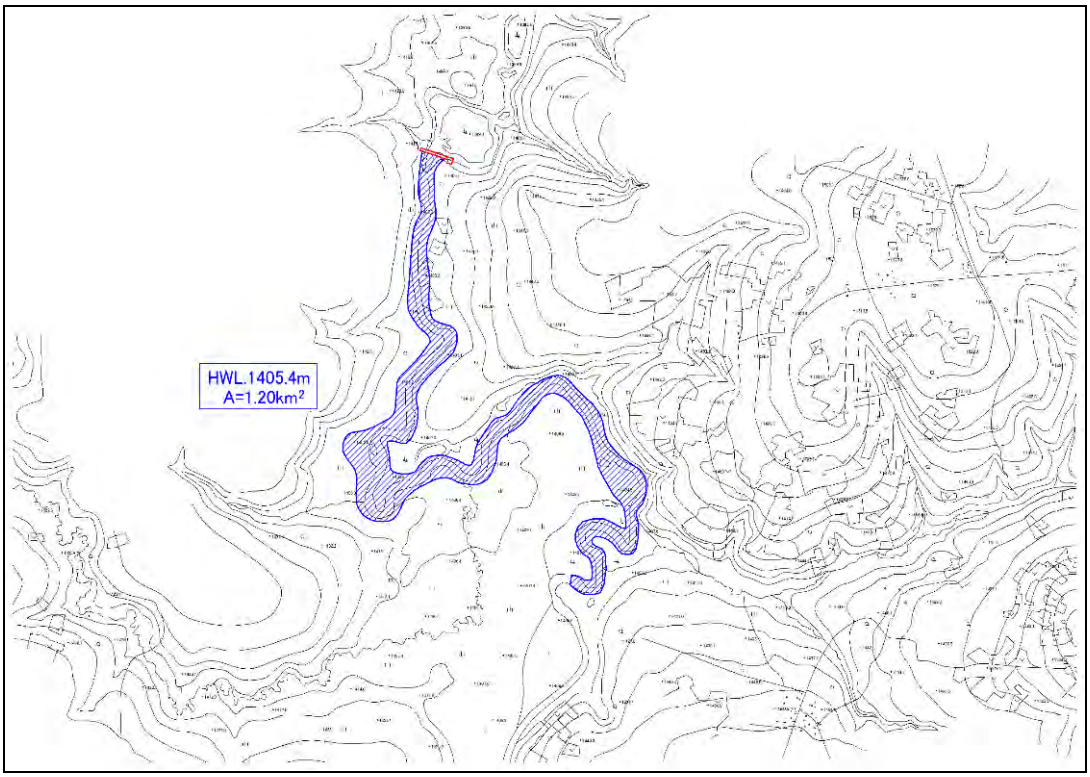


Fig. 4.2-4(1) Submerged Area for Each Cases of Weir Height

Submerged area in case of weir height 5.0 m



Submerged area in case of weir height 6.0 m

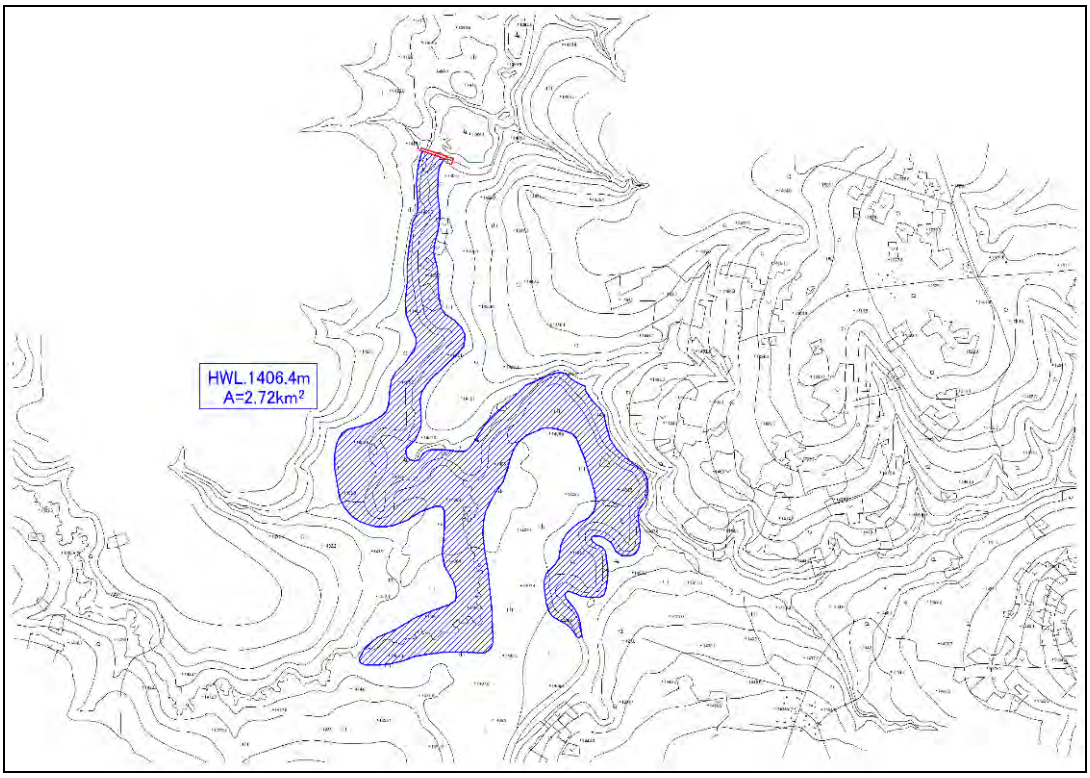


Fig. 4.2-4(2) Submerged Area for Each Cases of Weir Height

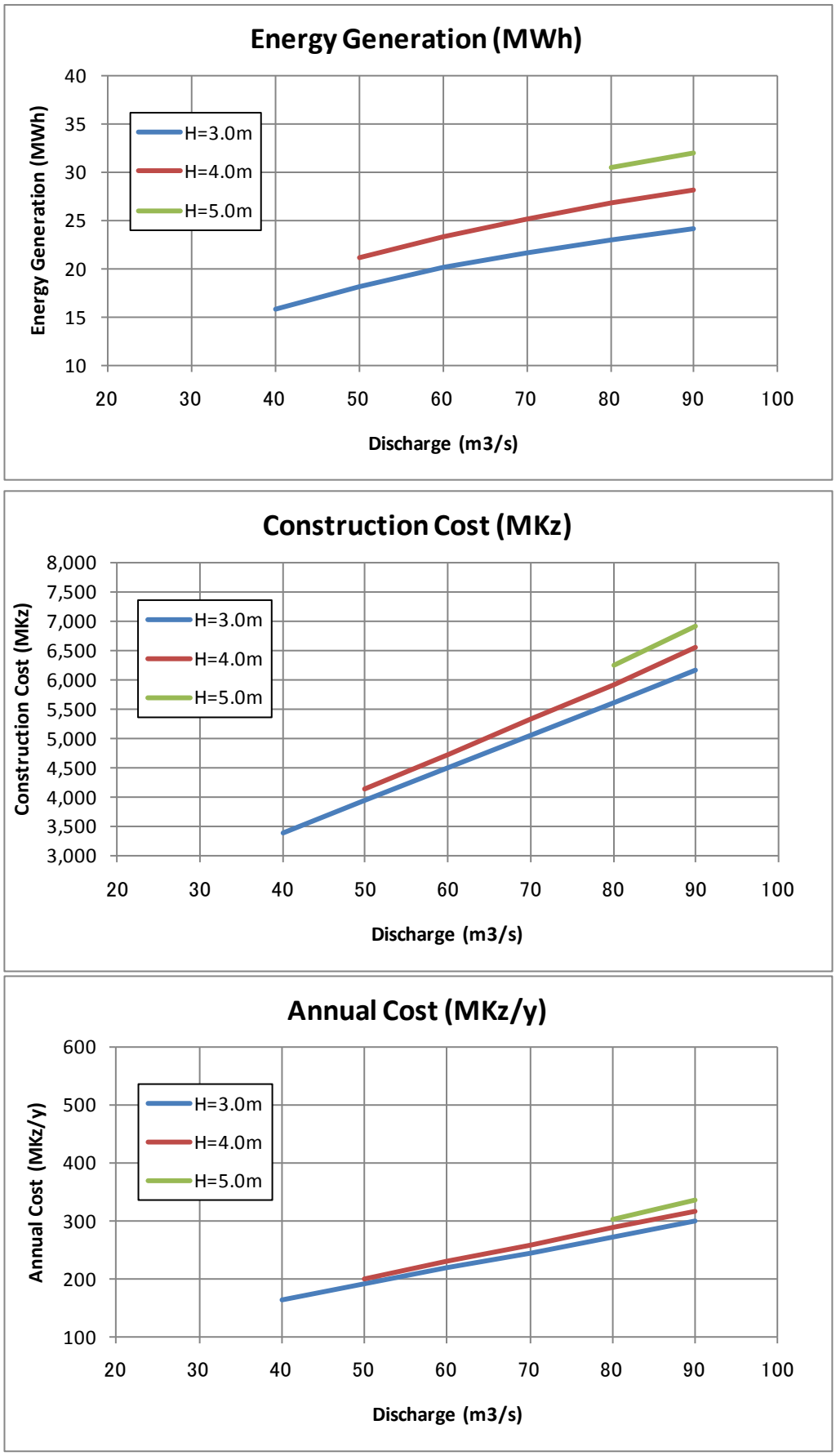


Fig. 4.2-5(1) Optimization of Weir Height

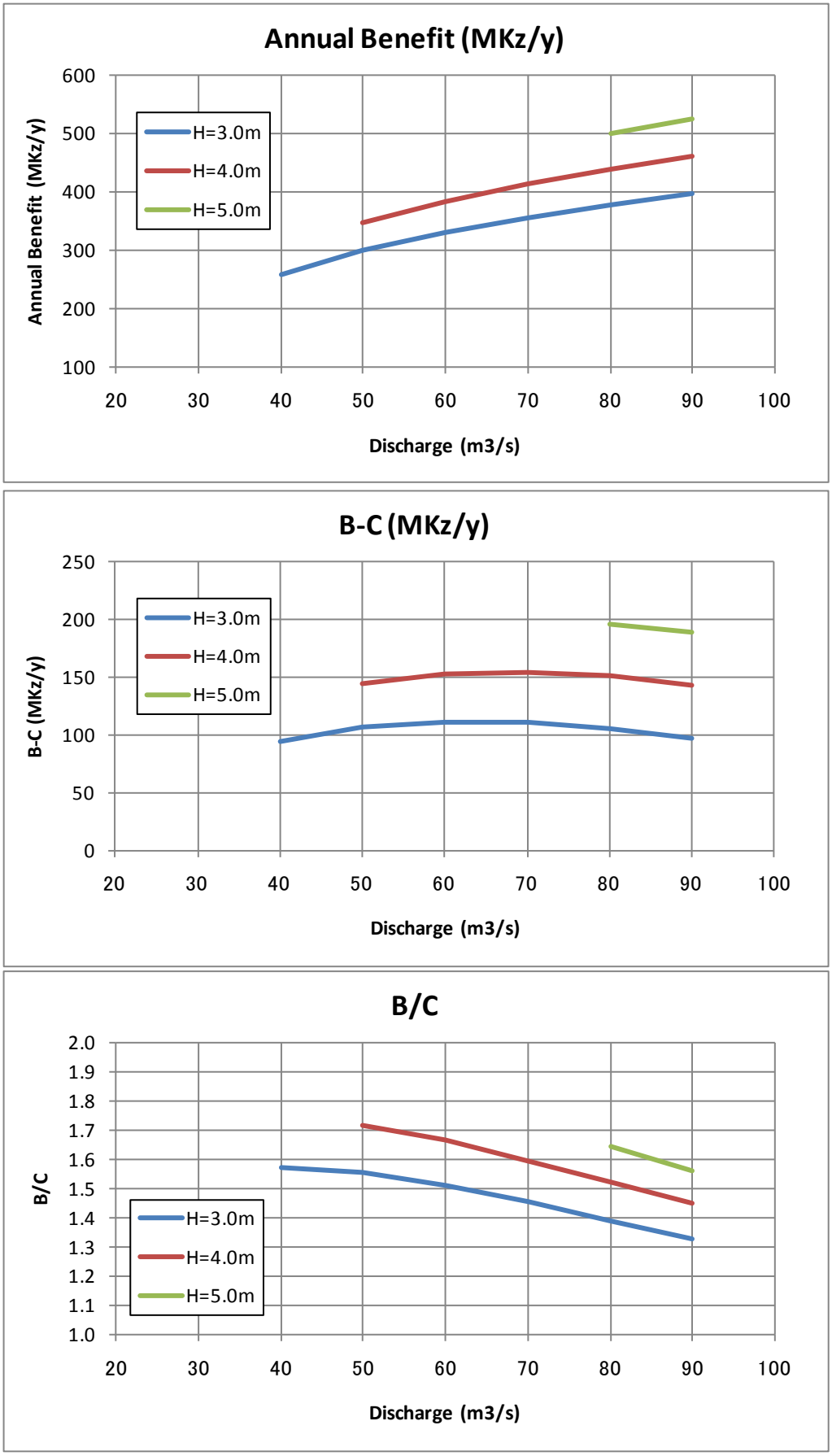
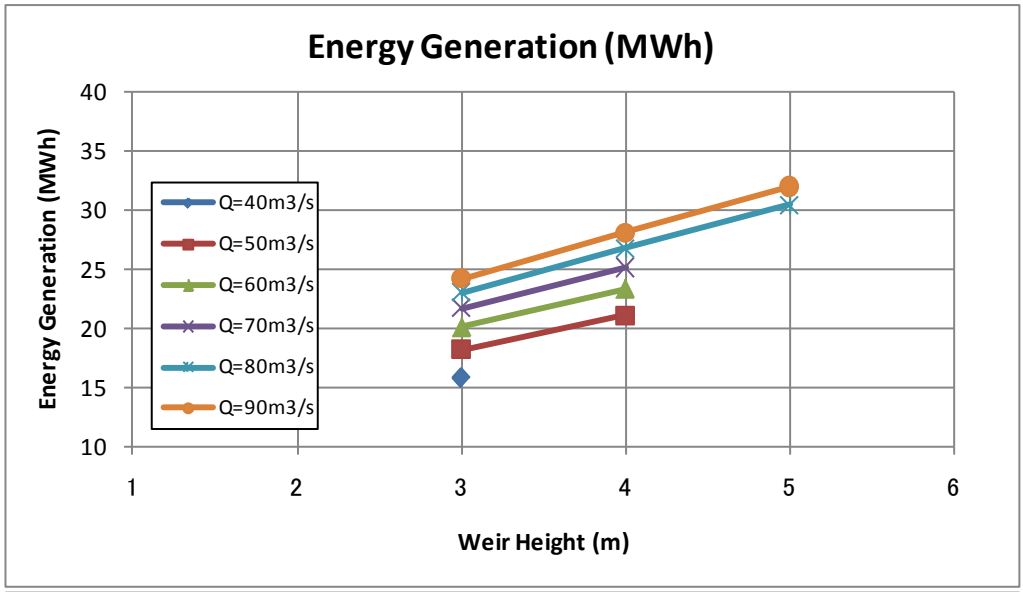
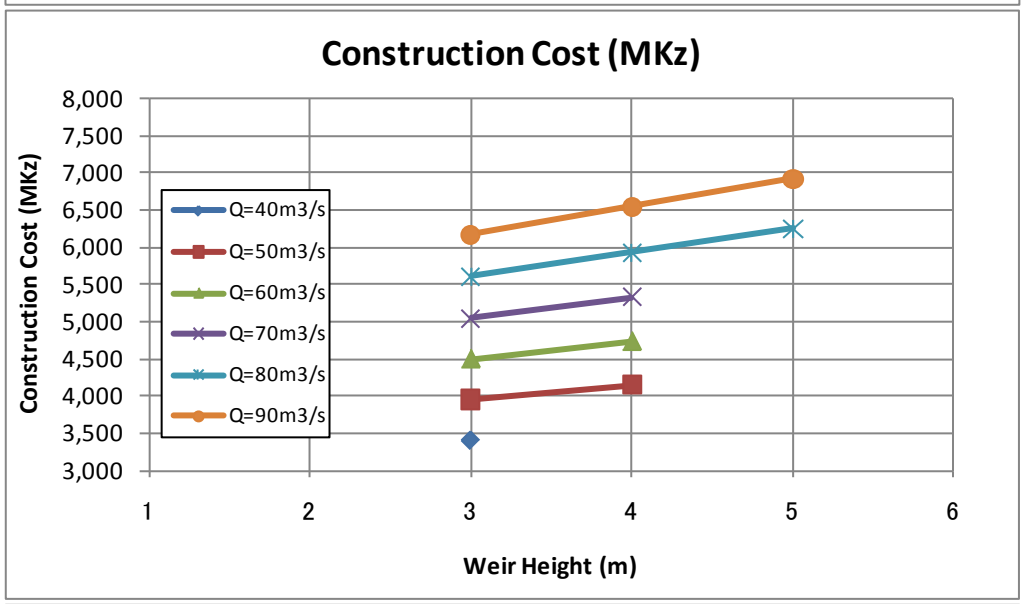


Fig. 4.2-5(2) Optimization of Weir Height





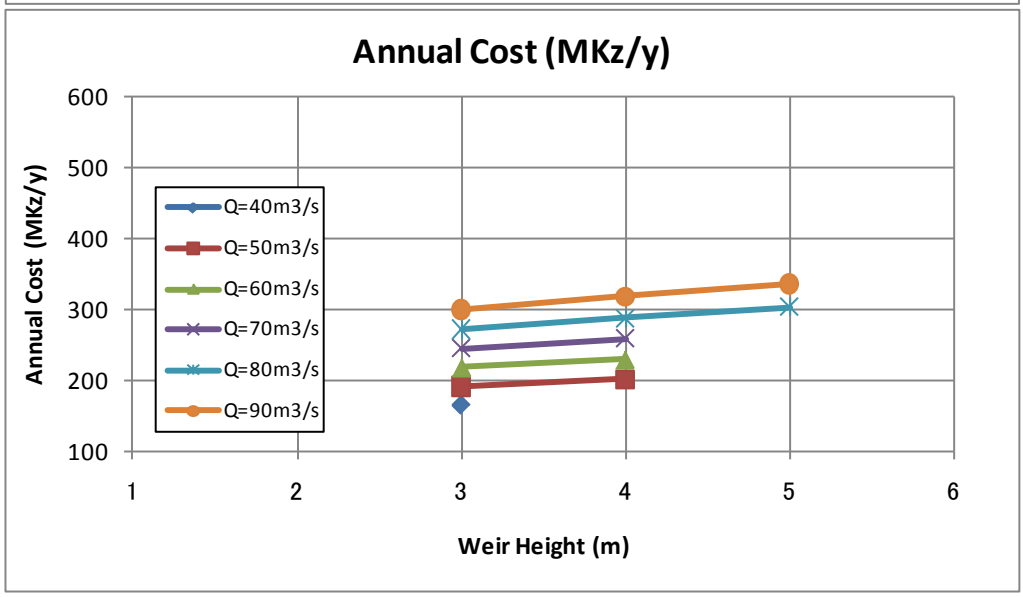
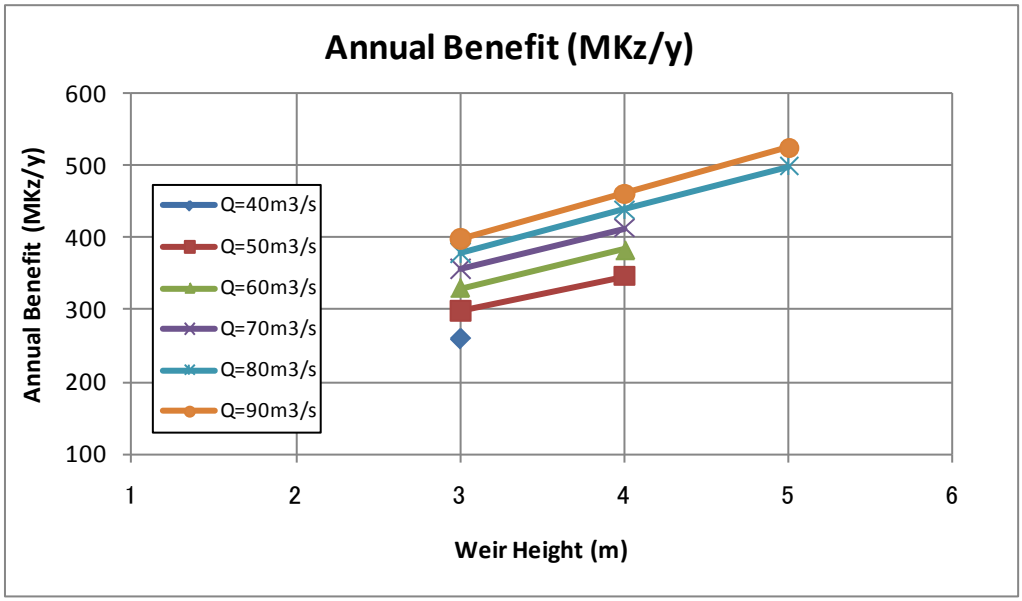
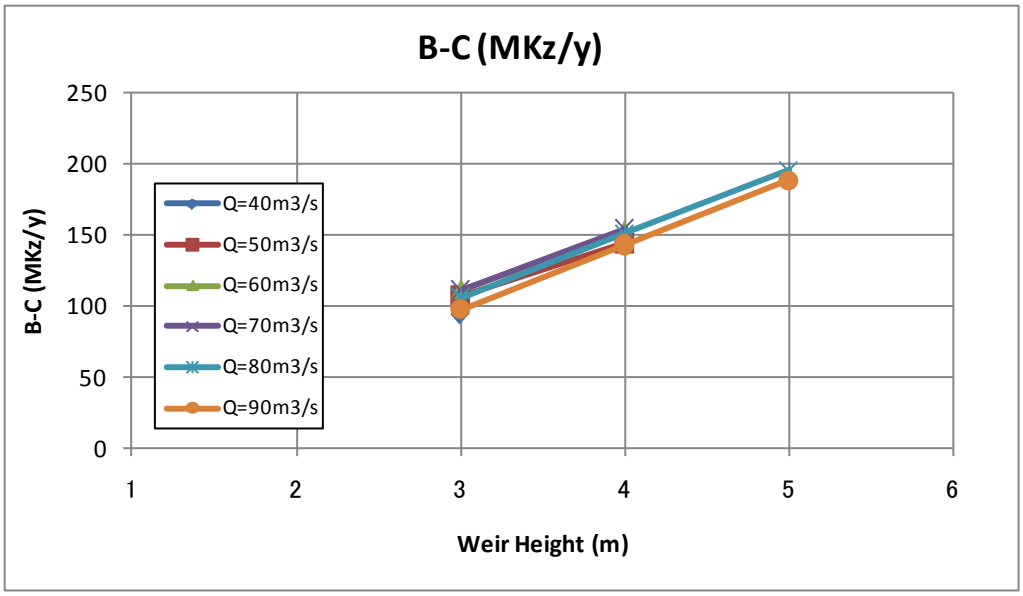


Fig. 4.2-6(1) Optimization of Maximum Discharge





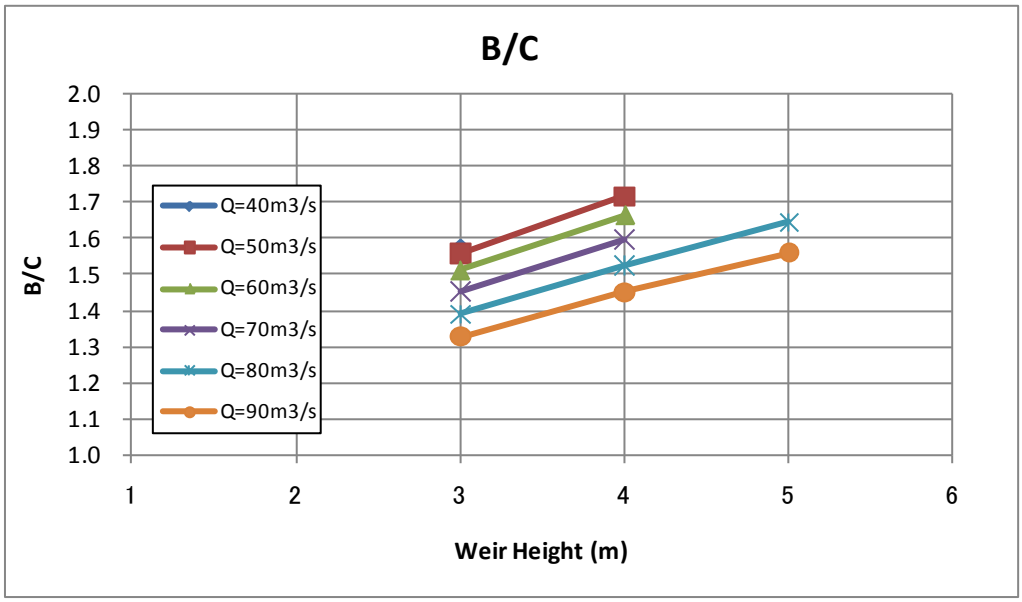


Fig. 4.2-6(2) Optimization of Maximum Discharge

4.2.3 Decision of Water Turbine Type and Number

There is no firm electric power grid near the proposed power station and electricity is supplied to all surrounding customers from this power station which has only electric power generators for them through the single power grid.

It is considered better to install an electric power generator as small number as possible and only one unit is the best.

On the other hand, when the periodical maintenance and troubles happened at the power station which is connected with the independent power grid, electricity supply is would be stopped and all customers would be able not to use electricity. It is a very big issue for the important customer like a hospital which takes care of serious patients. Then it is necessary to secure power supply reliability to avoid the issue mentioned before.

From the reason mentioned above, it is necessary to set two water turbines and generators to secure both reliability of electric power supply and economy.

To set two water turbines and generators keeps stabilizing operation of the power station even if the capacity of electric generation is small, expecting to reduce partial operation of the power station with water turbine efficiency up.

Then, it is not necessary to duplicate the distribution line which will be recovered from an accident on it and, the main transformer and other equipment of the power station which have the very rare failure rate.

Table 4.2-4 Comparison Table of Two Sets and One Set of Turbine & Generator (T&G)

condition	Case of Two sets of Turbine & Generator	Case of One set of Turbine & Generator
Operation	Operation along with water quantity is possible. In the rainy season two sets are in operation and in the dry season one set is in operation. In both case load factor is big and high generation efficiency is high, and then kWh generated in a year becomes large.	In the rainy season water quantity is large and load factor is expected high. But in the dry season water quantity is small and load factor is expected low and low generation efficiency is expected. Then kWh generated by one set in a year becomes smaller than two sets.
Operation and maintenance	- In case of an accident and/or a fault in one unit, the rest set is still in operation and generation continues. Therefore there is seldom case to stop two sets of T&G. - A periodical inspection for T&G is necessary. Since it is able to do one by one, the inspection is possible without stoppage of generation. - When an accident occurred at two sets of T&G and both T&Gs stopped, parts of one set of T&G is used for repair of the other T&G. Therefore one of T&G can be repaired and it is possible to supply partial electricity to the customer. - When the driftwood is flown into the turbine part and caught at the turbine and the T&G is stepped, it is necessary to take off the driftwood from the turbine. However the rest of T&G can generate electricity and supply electricity to the customer.	- When one set of T&G met an accident and /or a fault, generation is stopped completely. Then electricity supply to all customers is stopped completely. - When every periodical inspection per a year is held, generation is completely stopped and electric supply to the customer is stopped. ・ Therefore, as the result of the inspection, the periodical inspection is not done actually. - When an accident occurred at T&G and if there is luck of spare parts at the power station, it will take a long time to arrange spare parts. Then recovery from the accident will be delayed. - When the driftwood is flown into the turbine part and caught at the turbine and the T&G is stopped, it is necessary to take off the driftwood from the turbine. But the T&G is only one set and it is impossible to generate electricity and supply electricity to the customer. - In case of stoppage of running of T&G, the customer gets forced to depend on diesel generation during out of order
Construction	Comparing the weight and size per unit, the unit of two set composition of T&G is lighter than that of one set composition. It means that in the construction work it is easy to transport from the firm to the site (reduction or without the burden to the transportation road and bridge) and it is easier to construct the T&G.	Comparing the weight and size per unit, f the size is bigger and the weight is heavier than one set out of two sets of T&G system. This means transportation and construction of one set is difficult and needs more efforts than one set out of two sets.
Construction Cost	Output of one set T&G out of two sets is 1/2 and its construction cost is cheaper than that of only one set, but the number of T&G set is two, and those the equipment and electric work cost is only 20 to 30% higher than only one set T&G system, but not double	Base

According the data shown former page, in case of the maximum water volume for generation, Qmax = 50 m^3/sec and effective head, H = 7.50 m and considering two water turbines and generators, maximum water flow for the turbine Qt becomes 25.0 m^3/sec.
In this condition, type of most suitable water turbine is shown on Fig.4.2-7 and it is Vertical Axis Kaplan and S-type Tubular.

The Vertical Axis Kaplan type water turbine is designed to be controlled smoothly by adjusting degree of opening the guide vane following water flow, and by adjusting appropriate degree of opening the runner vane to keep smooth water flow against fluctuation of water flow and head.

It makes high efficiency of electric power generation.

The mechanism of the Vertical Axis Kaplan is that water flow goes into right angle to the water turbine axis and goes out along the water turbine angle.

Generally, the casing of the water turbine is whirlpool shape or half whirlpool shape and the outlet pipe of it is shaped into elbow form.
The S-type Tubular is basically transformation of the Vertical Axis Kaplan water turbine.
The horizontal axis or angle parking axis of the water turbine with the cylindrical casing of the water turbine and the outlet pipe is shaped into trumpet form.
Whole shape is S-type with a guide vane and a runner vane of flexible divergence angle.

As the ground of the hydropower station is hard bedrock and the two units of the water turbine and generator are to be installed, it is essential to take into less excavation volume of the ground and simple electric equipment arrangement of the hydropower station.

Consequently, it recommended to select the S-type Tubular.

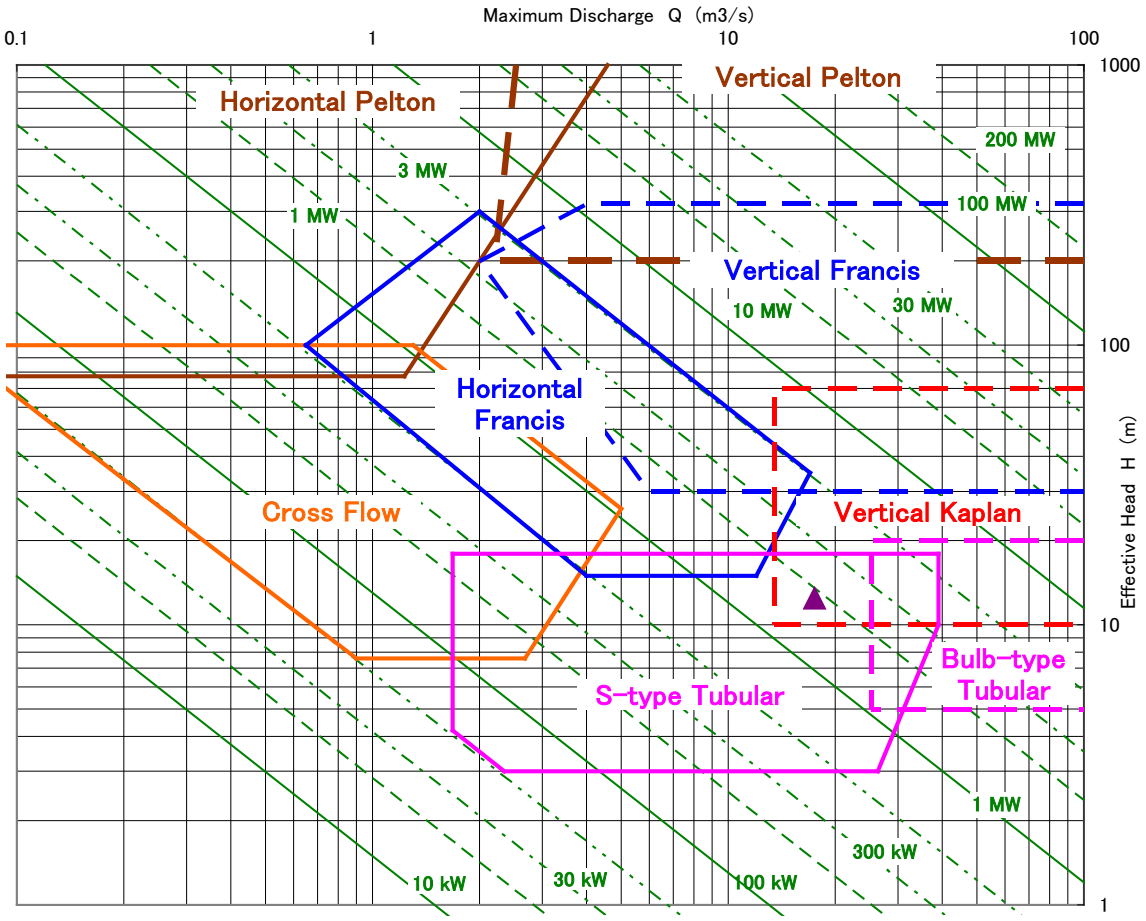


Fig. 4.2-7 Selection of Water Turbine Type

4.2.4 Area of Plan and Impact

The generation and distribution facilities of this project consist of civil facilities, electrical-mechanical facilities and distribution facilities (shown in Table 4.3-1). The area of plan and impact of each facility are shown below.

(1) Civil Facilities

The most upstream civil facility is the weir (4 m height). This weir has an influence on about 6 km upstream of the river. The influence is that the water surface level at design flood discharge (560 m^3/s) is WL. 1,404.4 m about as same as that is WL. 1,404.0 m at maximum discharge (50 m^3/s). Area of the river is 0.72 km^2 at design flood discharge which is same number before and after project, and at maximum discharge, area of the river becomes from 0.06 km^2 before project to 0.72 km^2 after project. Because flap gates settled on the weir (height is 3 m, length is 35 m × 2 units) reduce raising the design flood water level, the project plan becomes to reduce the impact to natural-social environment at upstream of the river.

Fig. 4.2-8 shows water level increasing which is about 0.6 ~ 1.1 m at design flood discharge and is 0.9 ~ 2.9 m at maximum discharge.

River has a branch at the downstream of the weir and there is the intake (width: 21m, height: 18m, length: 14.5m) at right tributary. From here the maximum discharge (50 m^3/s) is taken to the powerhouse, generates maximum power about 3 MW and goes out to the river again from the outlet (width: 21 m, height: 15 m, length: 2 m). The outlet is the most downstream civil facility but the most downstream civil work is river open cut excavation work which length is maximum 200 m from the outlet to downstream, so that the water head for generating can be much obtained.

As Section 4.2.6, (1) "Water Operation" says that the Cutato River stream regime in future from the outlet to the confluence of river which is about 1 km downstream of the powerhouse, is a little different (maximum difference of water level is about 0.4 m) compared with the one of current situation when the river-flow is less than twice the maximum discharge. When the river-flow is more than twice the maximum discharge, the river stream regime in future at downstream of the confluence of river, is completely same as the one of current situation at any river-flow. Then it is considered that water reducing area which is about from the weir to the confluence doesn't need extra water for river environment because the water level difference (between now and future) impacts little influence to natural-social environment.

In addition to above river area, the project needs access road (along the distribution line, it's about 5 m wide and 28 km long) from Chicumbi to the site, and temporary facilities site (area is about 7,000 m^2 including disposal area of waste soil) near the power station.

For the reasons stated above, area of plan and area of being impacted by the civil work is follows.

- River area from about 6 km upstream of the Weir to about 1 km downstream of the Powerhouse
- The Access Road 28 km long
- The Temporary Facilities Ground Area of 7,000 m^2

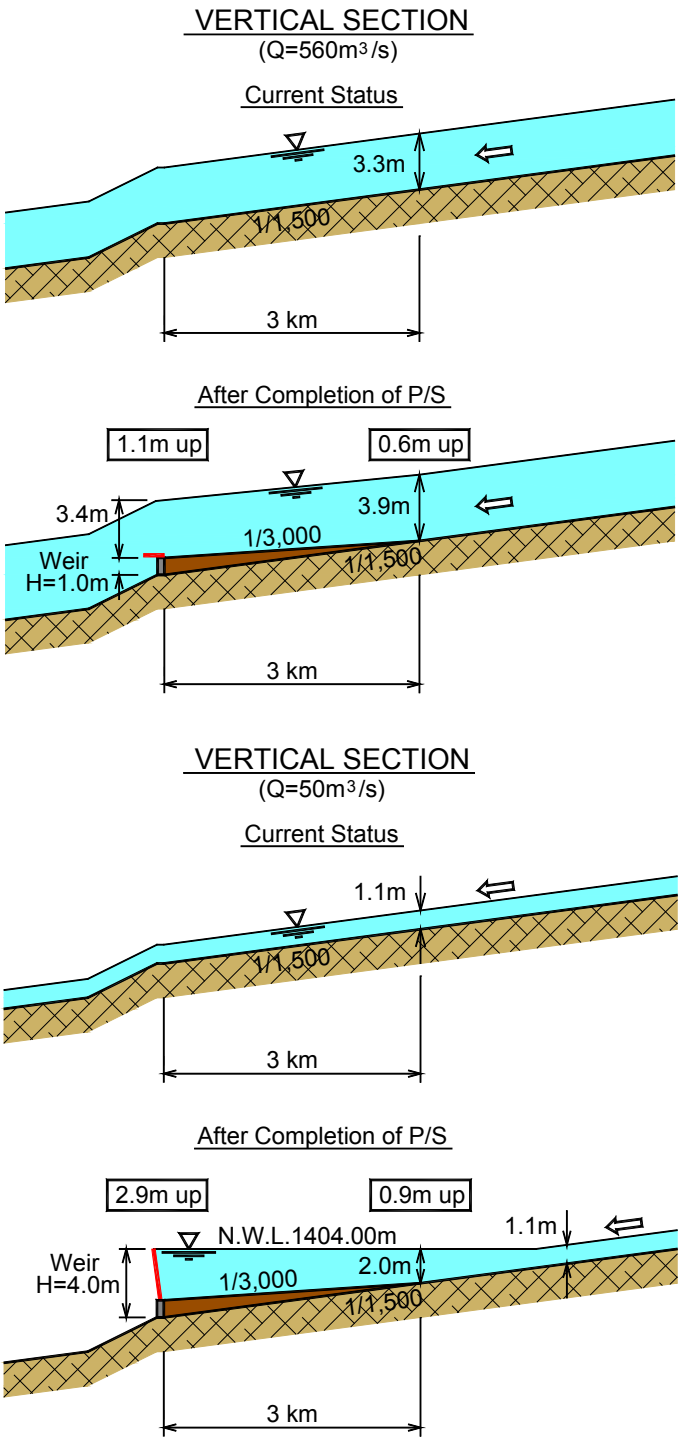


Fig. 4.2-8 Influence Area of Civil Facilities

(2) Electro-Mechanical Facilities

Electric mechanical facilities are organized of the equipment attached from the upper edge of the water turbine to the end edge of the outlet tube. Potential energy, water pressure and velocity at the upper edge of the water turbine are efficiently converted into mechanical energy. The powerhouse is constructed on the river and riverbed and its superstructure is 21 m wide, 15 m high and 30 m long.

Then, electricity goes into the main transformer, switch gear and until distribution facilities.

The specification and protection relay of the main transformer, switchgear and outlet facilities need to be coordinated with distribution facilities.

All auxiliary equipment, control protection facilities belong to the electric mechanical facilities.

(3) Distribution Facility (Line Route for Demand Area)

30 kV distribution line shall be planed from Cutato Power Station through Muenga Village, Chicumbi Village to Andulo City in the main road paralleling. Above main demand site is as shown in Fig. 4.2-9. Outline of this plan is as follows.

- A part of distribution line from Cutato Power Station through Muenga to Chicumbi Village shall be planned near access road for Cutato Power Station.
- After supplying Chicumbi Village, this line shall be extended and finally reached for Andulo City in the existing road paralleling.
- Target demand side shall be Muenga Village, Chicumbi Village and Andulo City
- Only for Chicumbi Village, church, school and hospital under reconstruction after war shall be supplied by low voltage distribution (400-230V)
- For Andulo City's inside all distribution network, and low voltage distribution network for Muenga Village is out of scope on this FS.

According to these road paralleling planning, it can be not only contribute for electricity power demand growth by new house hold and/or new factory constructing near future, but also contribute for the reduction of landmine investigation area and easy obtaining the safety construction work and investigation space, so more safer than the investigation by new straight route selecting with getting across the huge unknown safety area. Distribution plan and the scope of study are shown in Fig. 4.2-10.

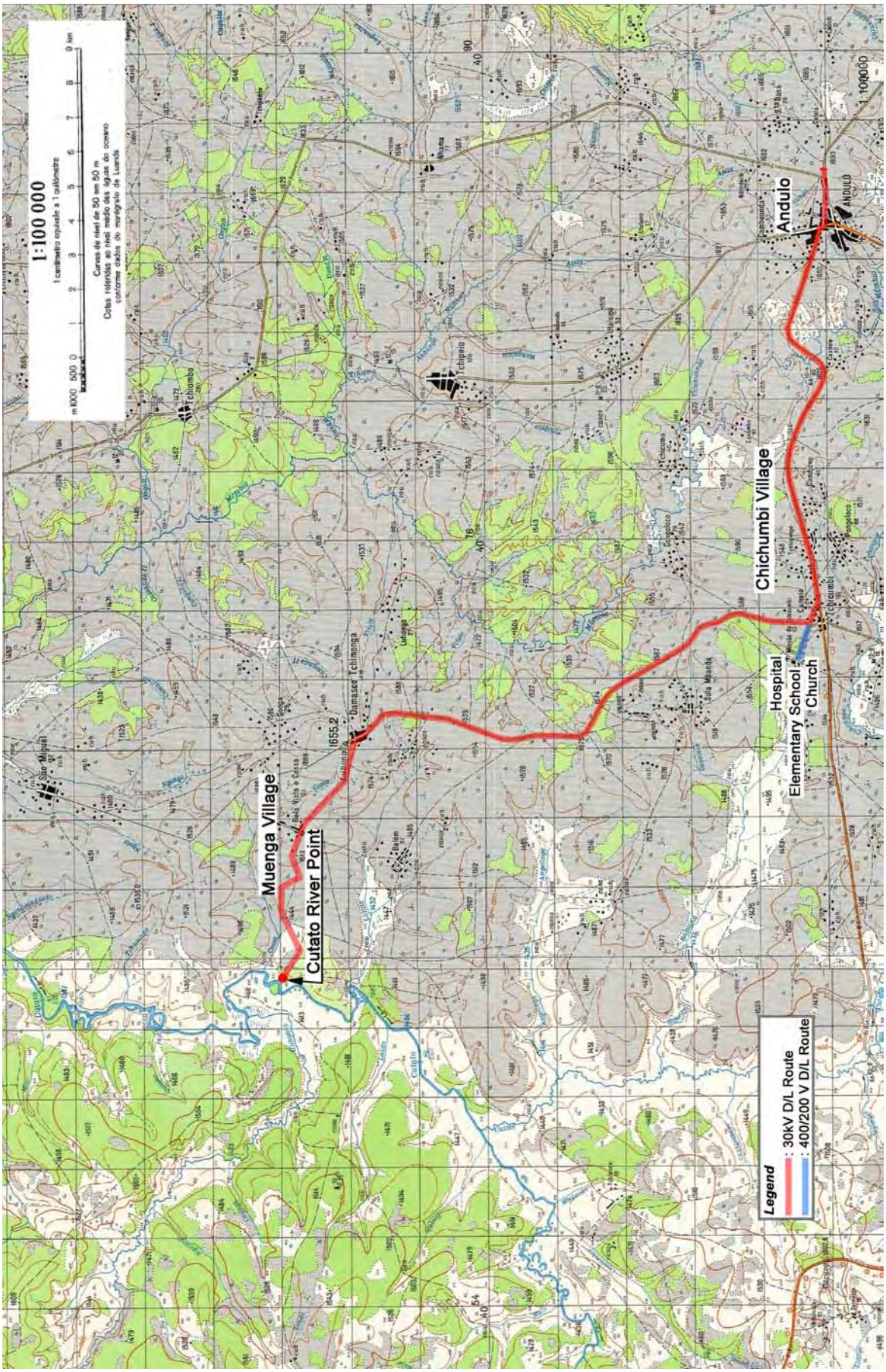


Fig. 4.2-9 Distribution Line Route

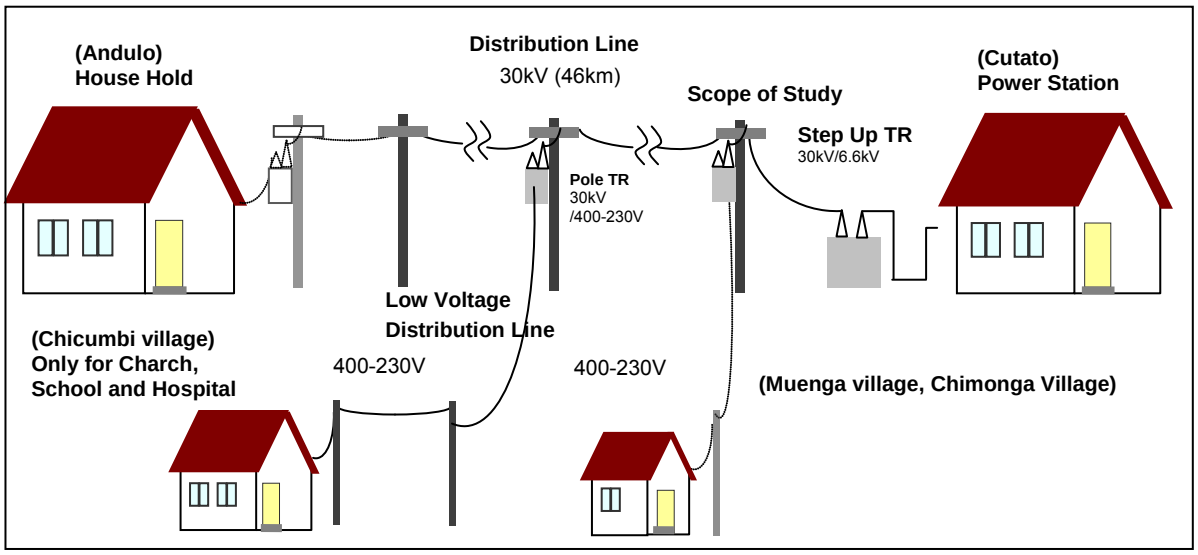


Fig. 4.2-10 Distribution Plan and the Scope of Study

P1: Road to Muenga Village on the distribution line route

P2: Muenga Village (where transformer for distribution will be installed)

P3:Chicumbi Village Church (Low voltage distribution: 400-230V)

P4: Streetlights in Andulo city (230V)

Photo 4.2-1 Site Photographs on the Distribution Line Route

4.2.5 Current Situation and Forecast of Power Demand

(1) Current Situation of Power Demand

- Public power supply in Andulo relies on two (2) diesel power generators of 600 kW in total (400 kW and 200 kW) installed in Andulo City, the county of Andulo. Additionally, 40 kW diesel generator is installed for a church, a school, and a hospital in Chicumbi Village.
- It seems that not a few households with sufficient funds possess small diesel generators of 2 - 3 kW, but the number of such households is unknown.
- As a result of hearing, it was discovered that total power demand must be larger (especially for street lighting) than estimated demand. At present, street lighting is maintained by rolling blackout (power is supplied to regions in turn).

(2) Power Demand Forecast

- The current capacity of diesel power stations is only 640 kW. Total capacity will be increased to 3,640 kW by the installation of Cutato HPS for this project.
- Power generation of 3,640 kW will meet the demands of 7,300 households (3,640 kW, 0.5 kW/household) and it is equivalent to one third of the power demand of approximately 23,000 households (140 thousand people, 6 people/household) in Andulo City where is the target area of power transmission and distribution in this project. That is, if GOA provides the distribution network by completion of the Cutato HPS, all generated power will be distributed for consumption.
- The population of Andulo is approximately 300 thousand, and among them 140 thousand in Andulo City. It is valid estimation that power consumption per household in Andulo City is about 500W because of the forecast of increasing power demand (3 times of 150W, initial power demand) based on the site survey and information from the Ministry of Economic Coordination (initial power demand will increase into 2 ~ 3 times in a few years after electrification). It is expected that Andulo will face the power supply shortage in the near future due to rapid growth of power demand as progress of the arrangement of distribution network. Therefore, also a new power station site for the Cutato River will be necessary to be developed in addition to the investigation site this time.

Table 4.2-5 Result of Hearing in Andulo

Item	Result of Hearing
Population	Electrification area for this project is Andulo in Bie. Population of Andulo is approximately 300 thousand and among them 142 thousand in Andulo City. At the time the civil war was over 10 years ago, the population was 20 thousand, and it has been rapidly increasing. There are three (3) main villages (Muenga, Chimonga, Chicumbi) along the transmission route to Andulo, and approximately 15 thousand people live in those villages.
Desire to purchase of electric products	Electric products the consumers in those villages desire to purchase after electrification, are electric lights (60W × 3 =180 W or such electricity), electric pot (about 500W), refrigerator (about 100W), electric kettle (about 500W), television (about 40W), acoustic equipment (such as radio and component stereo, several tens of kW), etc.
Industry	Main industry of Andulo is agriculture and a coffee bean peeling factory is under construction. People extremely expect the power supply from the small hydropower station.
Current capacity of power supply and power demand	There are diesel power stations near the airport in the suburb of Andulo. The power of 600 kW (400 kW and 200 kW) from those stations is supplied to about 230 consumers including street lights, major public facilities, and general consumers, but rolling blackout (power is supplied to the consumers in turn) is still inevitable because of shortage of power supply against the demand.
Request for power supply	There was a request for 200 kW in total of power supply for public facilities such as a church, a hospital, and a school (in Chicumbi), which are located on the way from the Cutato HPS to Andulo City and have been requested for electrification by the director of the power sector in Bie.
Power supply from a new power station	Generation by the power station designed in this project is 3,000 kW and cannot meet the total demand of whole Andulo. Therefore, it is expected that the power is limitedly supplied to inhabitants of Muenga (100 kW), church, hospital, and school in Chicumbi (250 kW), and new consumers in Andulo City along the transmission route.

4.2.6 Policy of Facilities Operation

(1) Water Operation (Civil Facilities)

The type of Cutato Power Station is called “Weir Type” power station from a viewpoint of getting head. The type of Cutato Power Station is called also “run-of-river type” power station from a viewpoint of water operation. The reservoir of this power station has a very little water volume for controlling generation, but it has no water volume for regulating river-flow.

Concrete water operation will be designed and operated as follows. The river-flow of the right branch and the left branch is almost same as it is now, but it changes after the completion of this power station. In case the river-flow is smaller than the maximum discharge (50 m^3/s), all of the flow will go to the right branch through the power station. In case the river-flow is bigger than the maximum discharge and smaller than twice (100 m^3/s) as much as the maximum discharge, the rest river-flow after being taken by the power station will fully go to the left branch. When the river-flow is more than twice volume of the maximum discharge, the river-flow of the right branch and the left branch will be almost same as it is now (refer to Fig. 4.2-11).

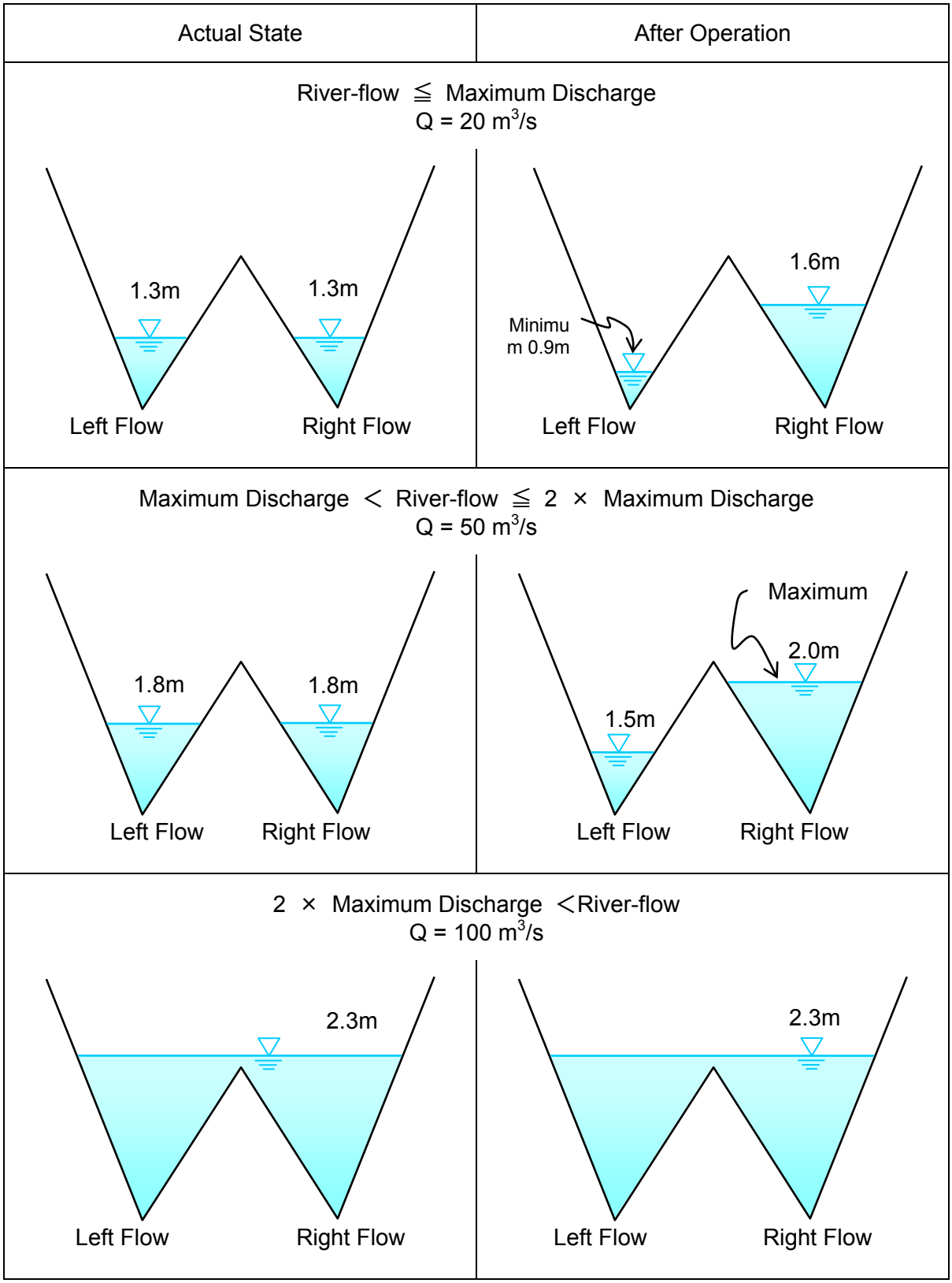


Fig. 4.2-11 Water Operation

(Downstream View from the Weir)

(2) Operation of the Facilities

After completion of installation,

- This power station can generate 3,000 kW with 2 units of turbine and generator if the river-flow of the Cutato River is bigger than 50m^3/s. It can generate power 180 days/year.
- Even in case the river-flow is smaller than 19 m^3/s, it can generate 1,200 kW with 1 unit of turbine and generator. It can generate power 365 days/year.
- It can generate 1,200 kW – 3,000 kW during 180 – 365 days/year with 1 unit or 2 units.

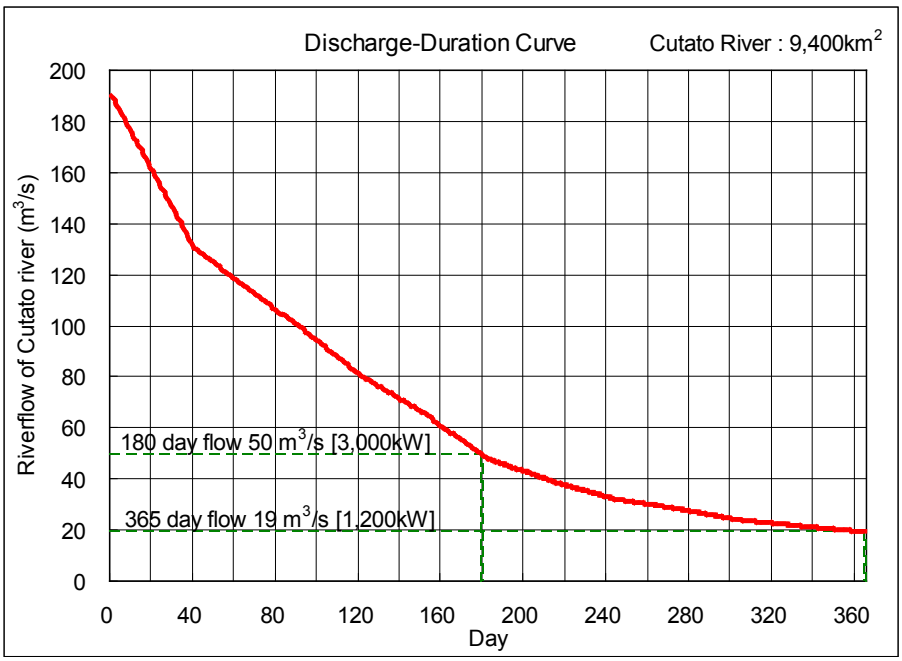


Fig. 4.2-12 Discharge Duration Curve of the Cutato River

※ Discharge of Cutato river is obtained from the data of the Cuanza river by multiplying catchment area ratio (Area of Cutato / Area of Cuanza = 9,400 km^2 / 121,470 km^2)

Observation and control system of the hydropower station is to be patrolled time to time as routine work.

The engineer of the hydropower station will patrol at the starting time of the work every morning, when the peak period of electricity demand and others. Patrolling shall be done one or more times a day for necessary observation and control of the hydropower station.

The facilities of the hydropower station to be patrolled and observed are not only the electro mechanical facilities but also the civil facilities, and whole facilities of the hydropower station is to be secured in a good operating condition.

The facilities of the hydropower station can be operated and controlled by one engineer called

"one person operation and a control".
The structure of operation and maintenance consists of one director and three engineers.

The director of the hydropower station shall choose the three engineers who have the knowledge of the hydropower station and supervise those engineers operating the hydropower station well.

In case something trouble/accidents happen at the hydropower station or the engineers have some questions, the director gives advice to them.

A pair of engineer works in turn under the normal working condition, patrolling for the electric facilities and civil facilities more than one time a day and record the data of the hydropower station. And also they operate and check the hydropower facilities, keeping a daily report for the log.

In emergency case like an accident and/or a trouble, off duty engineer shall be called to the office and all members including the director tackle those events.

For the operation mentioned above, the facilities of the hydropower station are designed below;

- Two generators for electricity generation are necessary to avoid the black out of the whole system
- To respond the recovery from the whole system down, emergency electric power source must be secured by the battery all the time.
- The diesel generator must be prepared in case of the whole system down for the emergency electric power source to be used, the electric power source of the communication equipment and operation of the gate of the intake weir.
- A part of the lighting facilities of the hydropower station must be prepared for the emergency lighting.

After the whole system down of the hydropower station, starting up the electric power generation by the first start up generator, synchronize circuit breaker is forced to turn on but to avoid working the protection relays by frequency separation on frequency drop, the circuit breakers connected to the demands must be cut off or restricted demand must be cut off besides limited important demands.

The circuit breaker of the second generation must be turned on enter the electric power system for parallel operation of the generator by the automatic synchronizer.

(3) Operation of Distribution Facility

Power station's chief manager holds an additional post as chief manager of distribution

facilities. Also power station's three chief engineers hold additional post as same position of distribution facilities, so they have responsibility about distribution facilities management, operation and maintenance work too. As for the safety patrol and facilities inspection shall be done at one time per day with two person's work shift system. Sometime it shall be done about the operation and measurement work if needed. These works result shall be recorded as daily reports. When the trouble and/or obstacle occur, one off duty person shall be called to deal with it. All of three responsible engineers shall cooperate for settlement.

4.2.7 Landmine Survey

(1) Demining Landmine Organization of Angola

Demining landmine organization is organized by GOA under direct National Institution of cabinet so called "CNIDAH (The National Commission for Demining and Humanitarian Assistance)". It clears landmines, and plans and carries out victim assistance support. In Angola, there are 2 independent demining landmine organizations, "INAD (National Institute for Demining)" which is main national operator and "GRN (Angola's National Reconstruction Office)". In addition, the Army of GOA is involved. There is a commission to control above these three organizations called "CED (The Executive Commission for Demining)" which consist of members of Minister of Assistance and Social Reintegration, delegation from INAD, Angolan Armed Forces and Ministry of Transportation. The parties which involve survey and clearance for local power industry construction will be CNIDAH and INAD. The organization chart for clearance of Angola shows as Fig.4.2-13.

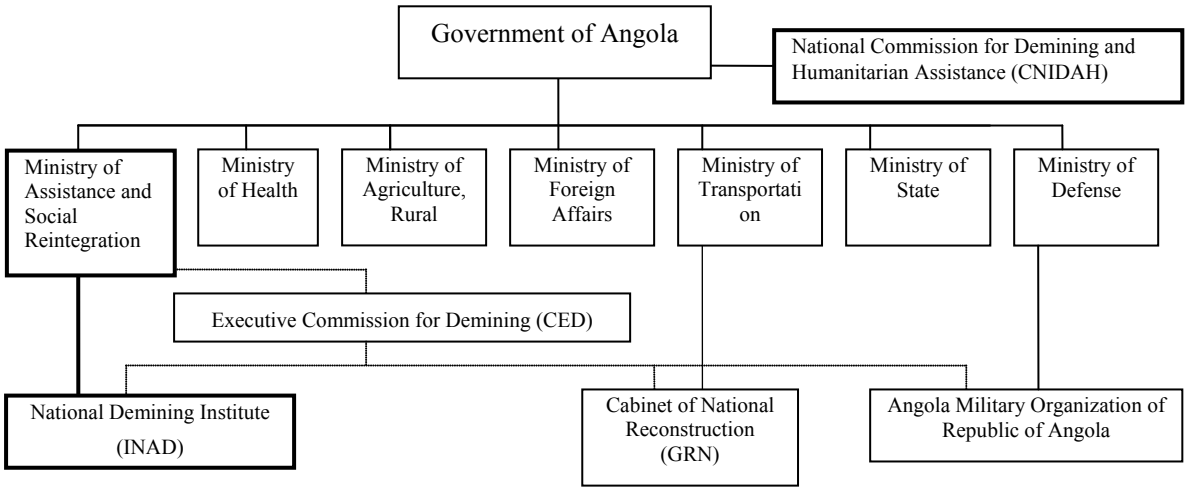


Fig.4.2-13 Organization Chart for Landmine Clearance of Angola

(3) State of Contamination by Landmine in Bie Province

Table 4.2-6 shows province polluted by landmine. The Bie Province ranked the second heaviest mine laying province.

Table 4.2-6 Province Polluted by Landmines

Name of province	Number of contaminated	Very severe	Severe	Less severe
Moxico	290	15	107	168
Bie	282	1	60	221
Cuando Cudango	171	1	33	137
Uige	171	0	29	142
Cuwanza Sul	169	6	33	130
Huambo	153	2	35	116
Benguela	127	4	17	106
Cunene	126	0	7	119
Malanje	88	4	38	46
Bengo	74	0	15	59
Lunda Sul	73	1	31	41
Huila	72	1	9	62
Other 6 provinces	192	5	41	146
TOTAL	**1988**	**40**	**455**	**1493**

Source: United Nations Certification Committee

In addition, Fig. 4.2-14 a map of provides mine contamination in Bie province. It shows whole area of Bie province has been heavily affected by landmines.

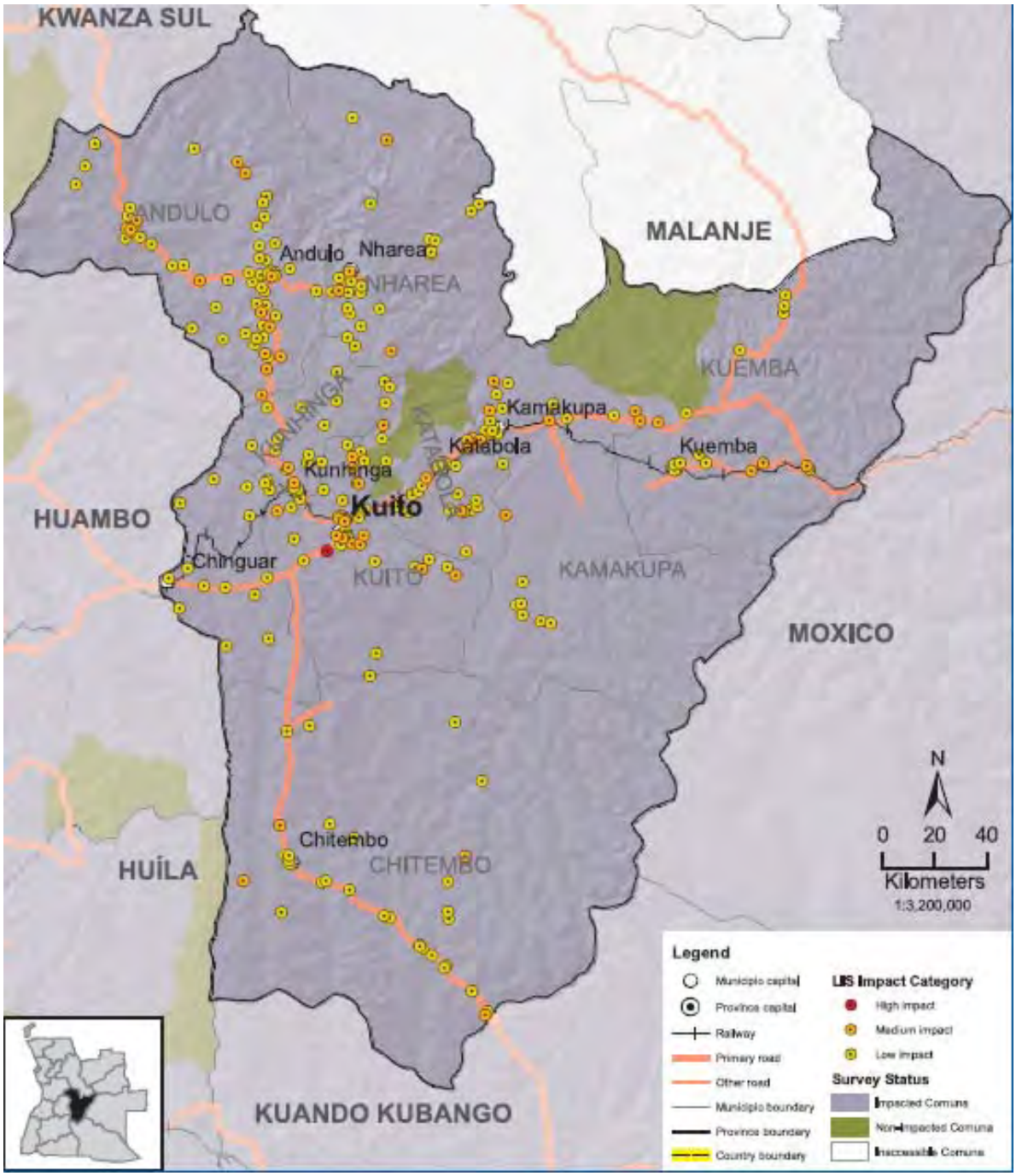


Fig. 4.2-14 Mine Contaminations in Bie Province

Source : United Nations Certification Committee

Number of casualties for each province is shown Table 4.2-7. The Bie Province ranked top 5. It has serious number of causalities.

Table 4.2-7 Causalities affected by Province

Name of province	Total number of killed /casualties	Number of killed/casualties		Total number of accidents
		Number of casualties	Number of killed	
Malanje	770	399	371	258
Moxico	567	285	282	338
Uige	463	262	201	157
Huambo	318	177	141	169
Bie	272	119	153	188
Cuando Cubango	234	90	144	251
Benguela	192	113	79	299
Lunda Sul	146	79	67	115
Cuanza Sul	125	70	55	65
Huila	106	53	53	97
Cunene	76	31	45	48
Cuanza Norte	68	33	35	36
Bengo	29	20	9	42
Lunda Norte	16	4	12	15
Londa	3	2	1	2
Total	3,385	1,737	1,648	2,080

Source: United Nations Certification Committee

(4) Landmine Condition related to Hydroelectric Power Construction Area

The material transportation and power transmission route of Chicumbi Village, Chimonga Village and Muenga Village hearing investigations are:

1. During the civil war from 1975 to 2002, these regions had ongoing combat. Their war potential had 630 of guards. In addition to this,
2. Mortar, howitzer and tank were used as main weapons.
3. Elders testified that there were no accidents by unexploded ordnances or landmines, however, one Anti Personnel Mine was found between Chicumbi and Chimonga area in 2007.

Since they do not have a contamination map (Landmine/UXO) of planned hydroelectric power construction area (including the material transportation and transmit electricity route), it is difficult to identify where they exist.

In addition to above, the material transportation of transmission power road may use Lobito - Alto Hama - Cuito - Andulo - Chicumbi. In some area, they need to rehabilitate or strengthen some bridges. In that case, they may have landmines since these areas had not been previously identified landmine. For example, mine contamination of Andulo district area shows Fig. 4.2-15.

Fig. 4.2-15 Contained Landmines around Andulo District Area

Source : Halo Trust, British NGO (Nongovernmental Organization)

Photo 4.2-2(1) Destroyed Tank in Bie Province

Photo 4.2-2(2) Destroyed Tank in Bie Province

Photo 4.2-2(3) Ruined Bullet Trace in Chimonga Village

4.2.8 CDM Project Support

(1) Applicability as CDM Project

According to UNFCCC (United Nations Framework Convention on Climate Change), Kyoto Protocol and other related guidance, there are some requirements need to be met as CDM project.

As for "Cutato River HPS Project in Angola," there should be considered following 5 requirements:

> ***Requirement 1****: "Recalling Article 12 of the Kyoto Protocol which provides that the purpose of the clean development mechanism shall be to assist Parties not included in Annex I to the Convention in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3 of the Kyoto Protocol"*[1]
> *"Affirming that it is the host Party's prerogative to confirm whether a clean development mechanism project activity assists it in achieving sustainable development"*[2]

Republic of Angola is clearly one of the non-Annex I parties signed Kyoto Protocol on June 14th 1992, that is confirmed on UNFCCC website.[3] Angola has already set up DNA (Designated National Authority), and been ready for approving those projects contribute to the Angola's sustainable development.

The project aims to generate electricity through renewable energy and transmit it to the non-electrified rural area and the city area of Andulo County with no connection to the national grid of Angola; therefore the project is a very feasible and supposed to be approved by Angola's DNA.

As stated above, the project is supposed to satisfy Requirement 1.

> ***Requirement 2:*** *"A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity."*[4]

The project will generate electricity through hydropower, one of the renewable energy, with newly constructing the electricity generating station. As a result, the part of electricity generated from the existing diesel generator will be replaced; therefore the anthropogenic GHG emission would be reduced additionally.
As stated above, the project satisfies Requirement 2.

[1] "Kyoto Protocol to the United Nations Framework Convention on Climate Change" Art.12 para2
[2] FCCC/CP/2001/13/Ad2, page 20
[3] "List of Non-Annex I Parties to the Convention" http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php

> ***Requirement 3:*** *"Recognizing that Parties included in Annex I are to refrain from using certified emission reductions generated from nuclear facilities to meet their commitments under Article 3, paragraph 1"*[5]

The project is not a nuclear power generation project; this requirement is not applicable.

> ***Requirement 4:*** *"That the eligibility of land use, land-use change and forestry project activities under the clean development mechanism is limited to afforestation and reforestation"*[6]

The project is a kind of emission reduction project, not a land use, land-use change and forestry project; this requirement is not applicable.

> ***Requirement 5:*** *"Emphasizing that public funding for clean development mechanism projects from Parties in Annex I is not to result in the diversion of official development assistance and is to be separate from and not counted towards the financial obligations of Parties included in Annex I"*[7]

The financial plan of the project involves public funding from Japan; therefore it is necessary to be proven by the Japanese Government that the public financing is neither an appropriation of ODA (Official Development Assistance) nor any financial obligations of Japan.

Following to the above considerations, the project meets each of the requirements 2 to 4, on the other hand, as for Requirements 1 and 5, both of letters need to be acquired: LoA (Letter of Approval) from Angola's DNA and the confirmation letter that proves the public funding is neither an appropriation of ODA nor any financial obligations of Japan from Japanese Government.

(2) CDM Approval Scheme and Implementation Status in Angola

Angola's DNA has been established based on "Decreto 2/10-13 de Janeiro", the decree approved by the minister on November 27th 2009 and issued on January 13th 2010. The decree provides the guidance over the DNA function and organization, project evaluation, procedures for approval and others as following;

1) DNA Function

a) Approve and validate the eligibility of project activities in the context of CDM according to the principles of Kyoto Protocol and UNFCCC;
b) Harmonize the CDM projects with the different sectoral policies concerning the

[4] FCCC/KP/CMP/2005/8/Ad1, page16
[5] FCCC/CP/2001/13/Ad2, page 20
[6] FCCC/CP/2001/13/Ad2, page 22
[7] FCCC/CP/2001/13/Ad2, page 20

exploration, protection, management and sustainable use of natural resources;

c) Define additional eligibility criteria referring to Kyoto Protocol and UNFCCC at the internal level in coordination with other sectors;
d) Verify and certify greenhouse gas emission reductions and carbon dioxide removal;
e) Keeping the list of activities of CDM updated;
f) Keeping the information about CDM projects available and updated;
g) Sending the Annual Report to UNFCCC EB.

2) DNA organization

DNA consists of following units;

a) Coordinator (appointed by MINAMB (Ministério da Energia e Águas))
b) Technical Evaluation Commission
c) Secretariat

3) Project evaluation

The CDM projects are evaluated by a Technical Evaluation Commission chaired by the Coordinator and formed by a vice coordinator appointed by the Minister of the Environment among specialists, as well as one representative from each related ministries.

Technical Evaluation Commission is held monthly and has extraordinary sessions called by the Coordinator. Invitations for its meetings must be sent within a minimum of five days in advance.

The decisions of the Technical Evaluation Commission are made by a simple majority; in case of tie in votes, the Coordinator shall effect on the decision.

The Technical Evaluation Commission may request the participation to representatives from other ministries or other relevant entities for specific tasks.

4) Procedures for Approval

(a) Submission

The applicant shall make and submit the project outline and following documents in Portuguese:

i) Copy of environmental license and declaration of the environmental impact
ii) Project Concept Note (PCN)
iii) Project Information Note (PIN)

(b) Provisional approval

DNA gives provisional approval after reviewing the submitted documents whether

the project meets each of the environmental, social and economical requirements. The provisional approval could be given before the submission of environmental license.

Technical Evaluation Commission shall report the technical comments to the DNA coordinator in 15 working days after the submission of the proposal.

DNA secretariat notifies the applicant with the acceptance of the submission in 5 working days. DNA would request the additional information to the applicant as needed.

(c) Final decision

Technical Evaluation Commission makes decision whether the project meets each of the environmental, social and economical requirements, and related laws and regulations then reports the technical comments or summary in 15 working days.

DNA Coordinator makes final decision over the project approval after accepting the technical comments from Technical Evaluation Commission in 10 working days.

Once the project is approved, the applicant is formally notified and the LoA is issued.

In case the project is rejected, the applicant is formally notified the rejection and its reasons; modification shall be requested as required. It is permitted to request for reviewing the rejected project.

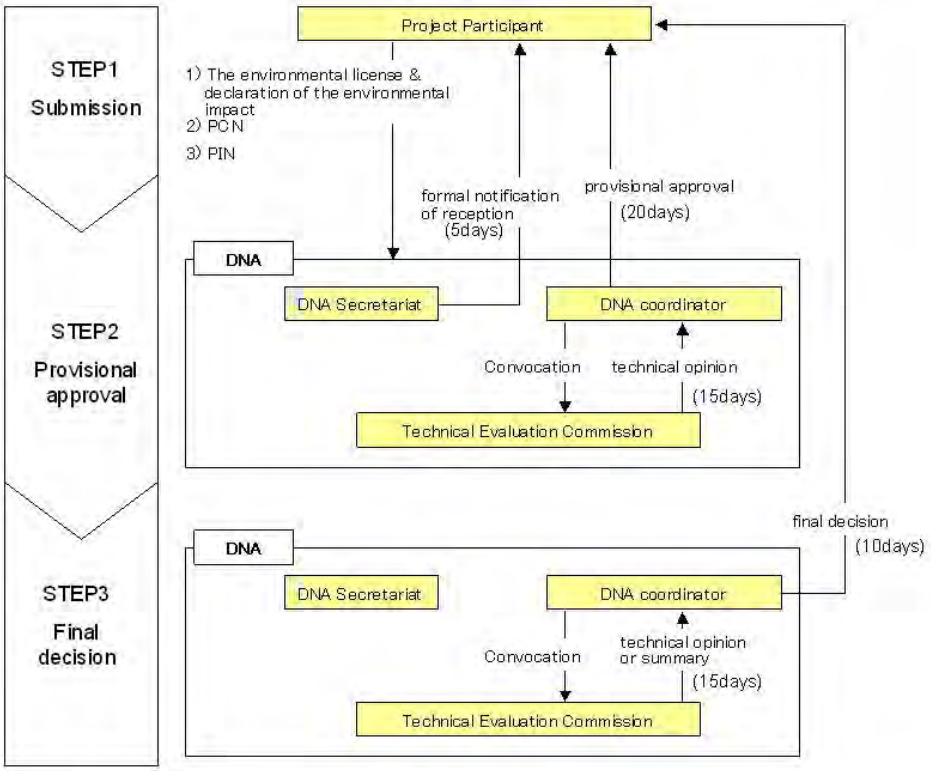


Fig. 4.2-16 Project Approval Cycle in Angola

Photo 4.2-3 DNA Coordinator Office in Angola

According to the Angola's DNA coordinator, there has been neither approved project nor submission to the DNA as of January 2011 in Angola; as of 29th March 2011, no project is in sight that has been notified the Prior Consideration to UNFCCC, opened for public comment, requested for registration nor registered in Angola. The project would probably be the first CDM project in Angola.

The PCN, PIN and PDD shall be completed cooperating with Angola's DNA coordinator.

(3) Application of Methodology

According to Appendix B of "The Simplified Modalities and Procedures for Small-Scale CDM Project Activities[8]", the simplified modalities and procedures are applicable to the following 3 types of projects:

Type I : Renewable energy project activities which have a maximum output capacity of 15 MW (or an appropriate equivalent)

Type II : Energy efficiency improving projects which reduce energy consumption, on the supply and/or demand side, which is limited to those with a maximum output of 60 GWh per year (or an appropriate equivalent)

Type III : Other projects which is limited to those that result in emission reductions of less than 60 kt CO_2 equivalent annually

The project applies to Type I project since the project constructs the 3 MW capacity of hydropower generating station; therefore the simplified modalities and procedures are available to the project.

The remarkable point of the simplified modalities and procedures for SSC (Small Scale CDM) project is as follows[9]:

- Project activities may be bundled or portfolio bundled at the following stages in the project cycle: the PDD, validation, registration, monitoring, verification, and certification;
- The requirements for the PDD are reduced;
- Baseline methodologies by project category are simplified to reduce the cost of developing a project baseline;
- Monitoring plans are simplified to reduce monitoring costs;
- The same DOE (Designated Operational Entity) may undertake validation, verification and certification.

[8] FCCC/KP/CMP/2006/10/Ad1, page 8
[9] FCCC/KP/CMP/2005/8/Ad1, page 45

At present, there are 3 approved methodologies available for Type I hydropower SSC project: AMS-I.A. (Electricity generation by the user), AMS-I.D. (Grid connected renewable electricity generation) and AMS-I.F. (Renewable electricity generation for captive use and mini-grid).

The project supposes to generate electricity with hydropower and transmit the electricity to the non-electrified rural area and the city area of Andulo country with no connection to the national grid in Angola; therefore the approved methodology, AMS-I.F. (Renewable electricity generation for captive use and mini-grid), is considered to be appropriate to the project.

Some requirements are provided for applying AMS-I.F. to the project. The categories of those requirements and the relevant situations of the project are as follows:

Table 4.2-8 Project Applicability to AMS-I.F.

Application conditions in the methodology (outline)	The relevant situations of the project
1. This category comprises renewable energy generation units, such as photovoltaic, hydro, tidal/wave, wind, geothermal and renewable biomass that supply electricity to user(s). The project activity will displace electricity from an electricity distribution system that is or would have been supplied by at least one fossil fuel fired generating unit i.e., in the absence of the project activity, the users would have been supplied electricity from one or more sources listed below: (a) A national or a regional grid (grid hereafter); (b) Fossil fuel fired captive power plant; (c) A carbon intensive mini-grid.	The proposed project will construct a new hydropower plant, and the electricity generated will displace electricity from small diesel fired power plant in Andulo City and consumption of fossil fuel in rural area. Therefore, the proposed project is applicable for this condition.
2. For the purpose of this methodology, a mini-grid is defined as small-scale power system with a total capacity not exceeding 15 MW (i.e., the sum of installed capacities of all generators connected to the mini-grid is equal to or less than 15 MW) which is not connected to a national or a regional grid.	Mini-grid system of Andulo City has one power station that has only two diesel generators, these capacities are 400 kW and 200 kW, and this mini-grid is not connected to any national grid. Therefore, the proposed project is applicable for this condition.
3. Project activities or project activity components supplying electricity to a grid shall apply AMS-I.D. Project activities for standalone off-the-grid power systems supplying electricity to households/users included in the boundary are eligible under AMS-I.A.	The new hydropower plant will not connect to national grid because the location of the proposed project site is too far from the national grid. Therefore the proposed project cannot be applied to AMS-I.D. The proposed project connect to mini-grid of Andulo City, is not standalone off-the-grid power system, therefore the proposed project cannot be applied to AMS-I.A.
4. Hydro power plants with reservoirs that satisfy at least one of the following conditions are eligible to apply this methodology: (a) The project activity is implemented in an existing reservoir with no change in the volume of reservoir; (b) The project activity is implemented in an existing reservoir, where the volume of reservoir is increased and the power density (*) of the project activity, as per	The proposed project results in new reservoirs. The power density of the power plant, as per definitions given in the project emissions section, is 4.16 W/m^2, which is greater than 4 W/m^2. Therefore, the proposed project is applicable for this condition.

Application conditions in the methodology (outline)	The relevant situations of the project
definitions given in the Project Emissions section, is greater than 4 W/m^2; (c) The project activity results in new reservoirs and the power density of the power plant, as per definitions given in the Project Emissions section, is greater than 4 W/m^2.	
5. For biomass power plants, no other biomass other than renewable biomass are to be used in the project plant.	The proposed project will not construct biomass power plants. Therefore, this condition is not applicable for the proposed project.
6. This methodology is applicable for project activities that; (a) install a new power plant at a site where there was no renewable energy power plant operating prior to the implementation of the project activity (Greenfield plant); (b) involve a capacity addition; (c) involve a retrofit of (an) existing plant(s); (d) involve a replacement of (an) existing plant(s).	The proposed project will install 2*1.5MW power generators, and the project site was no renewable energy power plant operating prior to the implementation of the project activity (Greenfield plant) Therefore, the proposed project is applicable for this condition.
7. In the case of project activities that involve the capacity addition of renewable energy generation units at an existing renewable power generation facility, the added capacity of the units added by the project should be lower than 15 MW and should be physically distinct from the existing units.	The proposed project is a green-filed project, not involving the capacity addition of renewable energy generation units at an existing renewable power generation facility. Therefore, this condition is not applicable for the proposed project.
8. In the case of retrofit or replacement, to qualify as a small-scale project, the total output of the retrofitted or replacement unit shall not exceed the limit of 15 MW.	The proposed project is a green-filed project, is not retrofit or replacement project. Therefore, this condition is not applicable for the proposed project.
9. If the unit added has both renewable and non-renewable components (e.g., a wind/diesel unit), the eligibility limit of 15 MW for a small-scale CDM project activity applies only to the renewable component. If the unit added co-fires fossil fuel, the capacity of the entire unit shall not exceed the limit of 15 MW.	The proposed project will only install renewable systems (hydro power), not install non-renewable systems. Therefore, this condition is not applicable for the proposed project.
10. Combined heat and power (co-generation) systems are not eligible under this category.	The proposed project will install electricity generation system only, not install co-generation systems. Therefore, this condition is not applicable for the proposed project.
11. In case electricity produced by the project activity is delivered to another facility or facilities within the project boundary, a contract between the supplier and consumer(s) of the electricity will have to be entered into specifying that only the facility generating the electricity can claim emission reductions from the electricity displaced.	The contract between the project owner and users will have to be entered into specifying that only the facility generating the electricity can claim emission reductions from the electricity displaced. Therefore, the proposed project is applicable for this condition.

(*)Power density
= (Capacity after the project[W]－Capacity before the project[W])/ (Surface area after the project[m^2]－Surface area before the project[m^2])
= (3,000,000-0) / (720,000-0)
= 4.16 [W/m^2]

According to above consideration, it is turned out to be clear the project meets each of the requirements; therefore AMS-I.F. is applicable to the project.

(4) Baseline Establishment

There is one mini-grid system in Andulo County with one power station. The power station has 2 diesel generator whose capacity is 400 kW and 200 kW respectively; both of the generator is run together then supply electricity to those public facilities like street lamp, hospital, hotel and government office building at the level of AC 230V. On the other hand, the power shortage is serious; the generated electricity is supplied to the planned area in rotation for about 4 hours a day from 18:00 to 22:00.

Moreover both Muenga and Chicumbi Villages where the electricity is supplied from the project, are not supplied electricity under the current situation; the majority of those non-electrified households use kerosene lantern or candle except for those own gasoline or diesel generator.

The location of the project site is so far from the service area of national grid that it is natural to consider that the electricity would be supplied from diesel generator unless the national grid expand its service area without the implementation of the project; therefore the baseline scenario is determined where the electricity is generated from the diesel generator which is considered to be popular and realistic technology around the region.

According to AMS-I.F., the baseline emission is calculated from the annual electricity generation through the renewable energy; the emission factor given in the following table.

Table 4.2-9 Emission Factors of Diesel Generator Systems (in kg CO_2e/kWh*) for Three Different Levels of Load Factors**

Cases: Load factors [%]	Mini-grid with 24 hour service 25%	Mini-grid with temporary service (4-6 hr/day) Productive applications Water pumps 50%	Mini-grid with storage 100%
<15 kW	2.4	1.4	1.2
>=15 <35 kW	1.9	1.3	1.1
>=35 <135 kW	1.3	1.0	1.0
>=135<200 kW	0.9	0.8	0.8
> 200 kW***	0.8	0.8	0.8

* A conversion factor of 3.2 kg CO_2 per kg of diesel has been used (following revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories)

** Values derived from figures reported in RET Screen internationals PV 2000 model retrieved from: http://retscreen.net/

*** Default values

The total capacity of the mini-grid system in Andulo country is 600 kW and the electricity is supplied for 4 hours in a day; therefore the baseline emission factor is determined as the default value of 0.8 kg CO_2e/kWh according to the above table.

(5) Description of the Project Boundary

According to AMS-I.F., the physical, geographical site of the renewable generation source delineates the project boundary. As to the proposed project, the project boundary therefore is the hydropower station including the dam, turbines, generators and transformer substation, and the user including Muenga Village, Chicumbi Village and the mini-grid system in Andulo County that will be supplied electricity from the hydropower station.

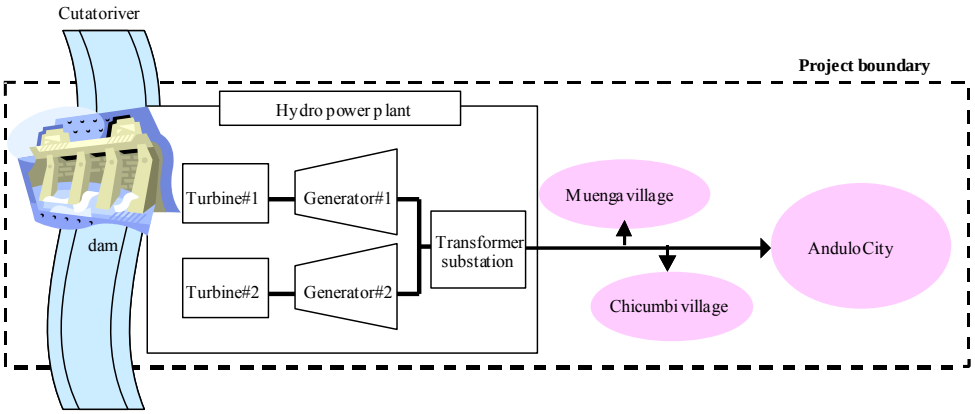


Fig.4.2-17 Project Boundary

(6) Demonstration of Additionality

According to the Annex 15, "Guidelines for Demonstrating Additionality of Renewable Energy Projects =<5 MW and Energy Efficiency Projects with Energy" (Virsion1), of the meeting report of EB54 in May 2010, those renewable energy projects up to 5 MW are additional if any one of the below conditions are satisfied:

(a) The geographic location of the project activity is in LDCs (Least Development Country)/SIDs or in a special underdeveloped zone of the host country identified by the Government before 28 May 2010;

(b) The project activity is an off grid activity supplying energy to households/communities (less than 12 hrs grid availability per 24 hrs day is also considered as .off grid. for this assessment);

(c) The project activity is for distributed energy generation with both conditions ① and ② satisfied (see below);

① Each of the independent subsystem/measure in the project activity is smaller than or equal to 750 kW electrical installed capacity;

② End users of the subsystem or measure are households/communities/SMEs.

(d) The project activity employs specific renewable energy technologies/measures recommended by the host country DNA and approved by the Board to be additional in the host country (conditions apply: The total installed capacity of technology/measure contributes less than or equal to 5% to national annual electricity generation).

The project is a hydropower generation project with capacity of 3 MW which is less than 5 MW; then the above rule can be applied to the project. The implementation of the project is concluded to be additional since the geographical location of the project is in Angola, one of the LDC, applies to (a).

(7) Crediting Period and Ex-ante Estimation of Emission Reduction

1) Crediting period

Project participant selects one of the following crediting periods for a project from the following alternative approaches:

(a) A maximum of 7 years crediting period which may be renewed at most 2 times. (A maximum of total 21 years)
(For each renewal, a DOE determines and informs the EB that the original project baseline is still valid or has been updated taking account of new data where applicable.)

(b) A maximum of 10 years with no option of renewal.
The project takes the crediting period (a); since the project life time is 40 years, moreover the composition of the mini-grid system would be changed and the baseline scenario shall need to be modified considering the situation that the number of population in Andulo country growth rapidly in recent years.

2) Ex-ante estimation of emission reduction

(a) Baseline emission (BE_y)

According to the paragraph 14 of AMS-I.F., the baseline emission is determined as the CO_2 emission for generating the electricity replaced through the project. The amount of the baseline emission is calculated as follows;

$$BE_y = EG_{BL,y} * EF_{CO2,y} \quad \text{..... (1)}$$

BE_y : Baseline emission (tCO_2e/yr)
$EG_{BL,y}$: NET amount of electricity replaced (equals to the supplied electricity) (MWh/yr)
$EF_{CO2,y}$: CO_2 emission factor (tCO_2/MWh)

The estimated net amount of electricity is 19,855 MWh/yr after subtraction of the amount of self-consumed electricity (1% of gross) at the power station and the transmission loss (5% of gross) from the gross amount of electricity generation of 21,113 MWh/yr; then the baseline emission is calculated as 15,884 tCO_2e/yr, according to the above formula (1).

$$BE_y = EG_{BL,y} * EF_{CO2,y}$$

$= 19,855 * 0.8$

$= 15,884$ (tCO_2e/yr)

(b) Project emission (PE_y)

According to the paragraph 18 of AMS-I.F., the project emission of a hydropower project is determined as the GHG emission from reservoir. The amount of the baseline emission is calculated as follows;

Case 1) $4W/m^2 =< \text{Power density} < 10W/m^2$

$$PE_y = (EF_{Res} * TEG_y)/1000 \quad \text{.....(2)}$$

$PE_{,y}$: Project emission (tCO_2e/yr)
EF_{Res} : Default emission factor ($90kgCO_2e/MWh$)
TEG_y : GROSS electricity generation (MWh/y)

Case 2) $10W/m^2 =< \text{Power density}$

$$PE_y = 0 \quad \text{.....(3)}$$

The project newly builds a dam and installs 3 MW capacity of power generating equipment; therefore the water level sure to be raised and the surface area extended.

According to the FSR, the estimated surface area is 720,000 m^2 and its capacity is 3MW; therefore the power density is supposed to be $4.16W/m^2$. Consequently, the project emission is calculated from the above formula (2).

The estimated annual gross electricity generation is 21,113 MWh; hence the project emission is calculated as 1,900 tCO_2e/yr.

$PE_y = (EF_{Res} * TEG_y)/1000$
$= 90 * 21,113 /1000$
$= 1,900$ (tCO_2e/yr)

(c) Emission reduction (ER_y)

According to the paragraph 20 of AMS-I.F., the emission reduction is calculated as follows;

$$ER_y = BE_y - PE_y - LE_y \quad \text{.....(5)}$$

ER_y : Emission reduction ($t\ CO_2e/y$)
BE_y : Baseline emission ($t\ CO_2/y$)
PE_y : Project emission ($t\ CO_2/y$)
LE_y : Leakage emission ($t\ CO_2/y$)

(d) Emission reduction

As a result of above calculation from (a) to (c), the annual emission reduction is estimated as 13,984 $t\ CO_2e/y$.

$$ER_y = BE_y - PE_y - LE_y$$
$$= 15,884 - 1,900 - 0$$
$$= 13,984 \quad (tCO_2e/yr)$$

The following table indicates the baseline emission, project emission and leakage emission during the first crediting period (7 years) of the project; the total emission reduction during the period is estimated as 97,888 tCO_2e.

Table 4.2-10 Estimated Emission Reduction

Years	Estimation of project activity emissions (tCO_2e /yr)	Baseline Emissions (tCO_2e /yr)	Leakage Emission (tCO_2e /yr)	Emission Reductions (tCO_2e /yr)
2016	950	7,942	0	6,992
2017	1,900	15,884	0	13,984
2018	1,900	15,884	0	13,984
2019	1,900	15,884	0	13,984
2020	1,900	15,884	0	13,984
2021	1,900	15,884	0	13,984
2022	1,900	15,884	0	13,984
2023	950	7,942	0	6,992
Total (tonnes of CO_2e)	**13,300**	**111,188**	**0**	**97,888**

(8) Carbon Market

According to the "Carbon Credit Market Report 2010"[10] published by JBIC (Japan bank for International Cooperation) on 30th July 2010 (based on "State and Trends of the Carbon Market 2006-2010" published by WB in May 2010), the price of Kyoto credit fluctuating as follows: 5.7 EUR/tCO_2e (2005), 8.4 EUR/tCO_2e (2006), 9.9 EUR/tCO2e (2007), 11.46 EUR/tCO_2e (2008) and 9.1 EUR/tCO_2e (2009). The price had been gone up by 2008 however; the price in 2009 was due for falls off because of Lehman Shock and global financial crisis from September 2008. The average primary price of CER is 9.76 EUR/tCO_2e as of July 2010 referring to IDEA carbon in UK.

According to the survey, the CER price trend among the primary market is estimated about 9-10 EUR/tCO_2e in 2009-2010.

Assuming that the CER price of the project is 10 EUR/tCO_2e based on the above price trend, the value of annual CER produced from the project is estimated 139,840 EUR (= 16 million JPY, in case 1 EUR = 115 JPY), the cumulative value during the first crediting period (7 years) is estimated 978,880 EUR (= 112 million JPY, in case 1 EUR = 115 JPY).

[10] "Carbon Credit Market Report 2010", JBIC Environment Finance Engineering Department, July 30th 2010

(9) Interview Survey to the Stakeholders

As implementing a CDM project, it is required to implement the hearing survey to the residents around the project site as the stakeholders of the project after the detailed explanation of the conceivable impacts on the environment, society and so on.

For making the draft PDD, an easy informal interview survey has been conducted against the representatives of Muenga, Chimonga and Chicumbi villages around the project site.

Result

The informal interview survey was conducted to the representatives of Muenga, Chimonga and Chicumbi Villages with the officers of MINEA and Andulo County, from 26th to 27th January 2011. The survey was mainly for asking the current situation of energy consumption and the comments against the current environmental situation and the construction of hydropower station.

The following tables are the summary of the survey.

Interview site	Muenga village
Date and time	11:00 – 12:30, 26th January
Eligible people	Representative person, Representative of the households generator, fishers (about 10 people)
Population	8,042 people
The number of households owning generator	3 households (3 generators)
Fuel of the generator	gasoline
Consumer electronics	Stereo components, TV sets
Main lightning equipments and time	Without generator: kerosene lantern or candle With generator: electric lightning as required
Comments on local environmental condition	The environmental condition is good.
Do you expect that the electricity is stably supplied to your village from hydro power plant?	Yes
During construction period, do you accept those concerns that the traffic volume increase or noise that could be occurred?	Yes
Do you accept the part of upriver district going under water due to the hydro power plant that could be occurred?	Yes
Do you accept the change of the haul of fish or location of fishery due to the hydro power plant?	Yes
Do you agree with the construction of the hydro power plant?	Yes
Other comments	There is no electricity supply to the village now, so it is strongly hoped to be supplied with electricity and is acceptable the temporary environmental deterioration for it.

Interview site	Muenga village

Interview in Muenga village

Household in Muenga village

Interview site	Chimonga village
Date and time	13:30 – 14:30, 26th January
Eligible people	Representative person
Population	2,630 people
The number of households owning generator	About 10 households
Fuel of the generator	gasoline
Consumer electronics	Radio, stereo components
Main lightning equipments and time	Without generator: Kerosene lantern or battery-powered electric lamp
Comments on local environmental condition	The environmental condition is good.
Do you expect that the electricity is stably supplied to your village from hydro power plant?	Yes
During construction period, do you accept those concerns that the traffic volume increase or noise that could be occurred?	Yes
Do you accept the part of upriver district going under water due to the hydro power plant that could be occurred?	Yes
Do you accept the change of the haul of fish or location of fishery due to the hydro power plant?	Yes
Do you agree with the construction of the hydro power plant?	Yes
Other comments	The country government has already announced the plan to construct the hydro power plant; there is no concern about the project.

Interview in Chimonga village

Villagers in Chimonga village

Interview site	Chicumbi village
Date and time	11:30 – 12:30, 27th January
Eligible people	Representative person, Deputy representative and Other representatives (about 5 people)
Population	4,812 people
The number of households owning generator	About 3 households

Fuel of the generator	gasoline
Consumer electronics	TV sets, radio and lightning equipments
Main lightning equipments and time	Without generator: Kerosene lantern or battery-powered electric lamp With generator: electric lightning as required around 18:00-20:00
Comments on local environmental condition	The environmental condition is good.
Do you expect that the electricity is stably supplied to your village from hydro power plant?	Yes
During construction period, do you accept those concerns that the traffic volume increase or noise that could be occurred?	Yes
Do you accept the part of upriver district going under water due to the hydro power plant that could be occurred?	Yes
Do you accept the change of the haul of fish or location of fishery due to the hydro power plant?	Yes: However there are fishers in the village, electricity supply is much important for the village that the influence is acceptable to some extent.
Do you agree with the construction of the hydro power plant?	Yes
Other comments	It is hoped to utilise the labours in the village under construction.

Interview in Chicumbi village

Households in Chicumbi village

According to the survey result above, there was neither negative comment nor concerns against the project; moreover it was found out that the villagers expect the construction of the hydropower station.

After this, the project owner is required to conduct the official questionnaire survey to the stakeholders after explaining conceivable impacts on the environment, society and other fields to them for completing the official PDD.

(10) Problems Over the Completion of PDD

The project owner shall be noticed the following points for completing the PDD:

1) Determination of the monitoring scheme

The proper monitoring plan and system shall be determined for issuance of CER as CDM project.

The monitoring parameters of the project are the amounts of gross electricity generation

and the supplied electricity to users; those data shall be recorded and kept for making up in a monitoring report on the responsibility of the project owner. The proper monitoring scheme shall be determined prior to the official start of the project. (The attached draft PDD is estimated monitoring scheme; therefore the PDD shall be revised after the determination of the scheme.)

2) EIA (Environmental Impact Assessment)

The project owner is required to implement the EIA; the impact of the project shall be demonstrated to meet the national and local standard of environmental and eco-system around the project site. The outline of the EIA result shall be described in PDD. (The attached draft PDD is described based on the initial EIA on the stage of feasibility study; therefore the PDD shall be revised after the completion of official EIA).

3) Stakeholders survey

The hearing survey on the stakeholders, the residents around the project site, shall be conducted after the implementation of EIA; the survey aims to confirm any comments to the project from those people supposed to be influenced from the project. The outline of the survey and its result shall be described in PDD. (The attached draft PDD is described based on the easy informal interview survey; therefore the PDD shall be revised after the formal survey has been conducted.)

4.3 Outline Design of the Project

Figs.4.1-1(1), (2) shows the location of Cutato Hydro Power Station Project. The elevation and the catchment area are about 1,400 m and 9,400 m^2, respectively, where the rain, which falls at the plateau over 1,600 m elevation in Huambo and Bie Province, gathers in Cutato River. The installed capacity of the project is 3,000kW using 50 m^3/s river-flow and 8 m total head (river fall is 4m and weir height is 4m).

Fig.4.3-1 shows the feature of the power station, and attached Drawing No.C-002 shows general plan of the project. New power station consists of civil facilities (weir, intake, powerhouse, outlet and temporary facilities), electrical-mechanical facilities (water turbine, generator, main transformer and various facilities) and distribution facilities (high pressure distribution line).
The characteristic of the project needs not only preliminary works before main works but also demining works before preliminary works.

The access road length from Luanda to Cutato River site is about 880 km, which consists of 720 km from Luanda to Cuito, 120 km from Cuito to Andulo and 43 km from Andulo to Cutato River site.

Because the access road is from Luanda to site and from Lobito to site, land-mine investigation and demining works needs not only at the area constructed new power plant but also at the base of bridge on the existing road.

Table 4.3-1 Project Features of Cutato HPS

Item	Cutato HPS	Remarks
Type	Run-of-River Type	
Max. Discharge	50 m^3/s	
Gross Head	8.0 m	
Effective Head	7.5 m	
Max. Output	3 MW (1.5 MW × 2 units)	
Annual Generated Energy	21.1 GWh	
Catchment Area	9,400 km^2	
Weir		
Type	Concrete Gravity	
Height	4.0 m	
Volume	m^3	
Design Flood Discharge	560 m^3/s	
HWL	EL. 1,404.4 m	
Pondage area	0.72 km^2	
Spillway gates	2 sets of Hinged Crest Gate Width: 35.0 m, Height: 3.0 m	
Sand drain gates	1 set Width: 0.5 m, Height: 0.5 m	
Intake		
Width	21.0 m	
Length	14.5 m	
Height	7.0 m	
Screen		
Powerhouse	Semi-underground type	Access Road: 28km (Width: 5m)
Width	21.0 m	
Length	30.0 m	
Height	15.0 m	
Machine hall EL.	EL. 1,394.0 m	
Outlet		
Width	21.0 m	
Length	2.0 m	
Height	15.0 m	
Outlet gates		
Turbine		
Type	S-type Tubular (HK-1RT)	
Capacity	1,500 kW	
Revolution	214.3 min-1	
Unit number	2 units	
Inlet gates	Bi-plane type	
Generator		
Capacity	1,700 kVA	
Frequency	50 Hz	
Unit number	2 units	
Main Transformer		Substation
Capacity	3,400 kVA	
Voltage	6.6 kV / 33 kV	
Connection	Delta/Star	
Unit number	1 unit	
Transmission / Distribution Line		30 kV
Number	1	
Length	46 km (Cutato-Andulo)	

4.3.1 Civil Facilities

4.3.1.1 Basic Conditions

(1) Selection of Design Flood Discharge

The design flood discharge of this site was selected by considering the monthly river-flow data of existing Cambambe site which is in Cuanza River downstream of Cutato River and residence testimony at the site reconnaissance.

Firstly, the monthly maximum discharge is about 2.0 $m^3/s/100\ km^2$ which was calculated with using discharge duration curve (1962 - 1972) of Cambambe site in Cuanza River.

The monthly maximum discharge of Cutato site became 188 m^3/s because the catchment area of Cutato site is 9,400 km^2

At the same time, the ratio of design flood discharge to monthly maximum discharge is about 3.7 ~ 5 times at large catchment area river in Japan.

Design flood discharge of Cutato site becomes 695.6 m^3/s → 700 m^3/s calculated by the ratio of 3.7, because this site is very flat and ratio of discharge is considered to be very small.

Secondly, at the site reconnaissance, residence said that the water level at flood water is 2 m higher than the water level at that site reconnaissance. It means the water depth is about 5 m.

This means that design flood discharge becomes 410 m^3/s by calculating about at 200 m upstream place (A = 284 m^2, V = 1.44 m/s) of the project site.

Finally, design flood discharge becomes 560 m^3/s by using Creager Curve. Because the ratio of river discharge is one-tenth of Japan river, the specific discharge becomes q = 0.0592 $m^3/s/km^2$.

Because of above calculating result, average number of 3 cases was selected as design flood discharge (Q = (700 + 410 + 560) / 3 = 556.7 ≒ 560 m^3/s) of this site.

(2) Selection of Weir Type (Gate Type)

The environmental impact mitigation measures are necessary for raising water level of upstream because the slope of Cutato River is very moderate as 1/1,500. For that purpose, the gate type, which will not raise the water level at flood time, was needed.

At that case, the weir of this site needs base concrete of 1.0 ~ 2.0 m height and gates of 3.0 m height. So the total height of weir becomes about 4.0 ~ 5.0 m.

The width of gates was selected that the water depth at design flood discharge (Q = 560 m^3/s) is under 3 m. So the width of gates became 70 m.

There are below 3 types of gates which are adapted to above conditions and the characteristics of 3 types of gates are described.

1) Rubber Hinged Crest Date

Advantage: Body is light and easy to be settled. Air or water can erect the body. It is able to be low price of construction.

Weakness: It consists of rubber, so it will be injured by river sand gravel and driftwood. Expert of rubber will be needed for maintenance.
V-notch is appeared at partial open. So it is difficult to control water level at partial open.

2) Steel Hinged Crest Gate supported by Rubber

Advantage: The accuracy of water control is better than above type of gate. It will be less injured by river sand gravel and driftwood because of front steel board.

Weakness: Air pressure in this rubber type is ten times of air pressure in above rubber type. If this rubber type is injured, repair work cost will be more expensive than above rubber type.
Expert of rubber will be also needed for maintenance.

3) Steel Hinged Crest Gate

Advantage: The accuracy of water control is the best type in 3 type of gates. It will be almost little injured by river sand gravel and driftwood.
Because there is no rubber, expert of rubber will not be needed for maintenance. Generic steel maker can do the repair work of maintenance.
If the height of gates becomes more than 3m, this gate type becomes cheaper than other gate types.

Weakness: The weight of gates is very heavy and it needs heavy machines at settling work.

The situation of the site is below.

① There are no rivers sand gravel at the reconnaissance but it is considered to be driftwoods.
② It is supposed that there are no maker neither rubber expert who can execute the maintenance.
③ Because there are many gates at several sites, it is supposed to be maker and expert who

can treat steel material and machines.

Because of above characteristics, steel hinged crest gate is the best one and is adopted at this site.

The power of this Steel Hinged Crest Gate is usually electric power of hydro power plant and 30kW diesel generator is used in an emergency. The gate is automatically operated by gauging water level automatically with 2 water level indicator.

(3) Selection of Design Flood Water Level

Design flood water level with steel hinged crest gate is follows.

Base rock elevation	:	EL.	1,399.10 m
Height of concrete	:		1.90 m
Overflow depth	:		3.00 m
Velocity water head	:		0.40 m
Total	:	FWL	1,404.40 m

So design flood water level of this site becomes FWL. 1,404.40 m.

(4) Selection of Design Seismic Intensity

Design seismic intensity is selected to consider design criteria, risk of earthquake and design seismic intensity of existing structure in Angola.

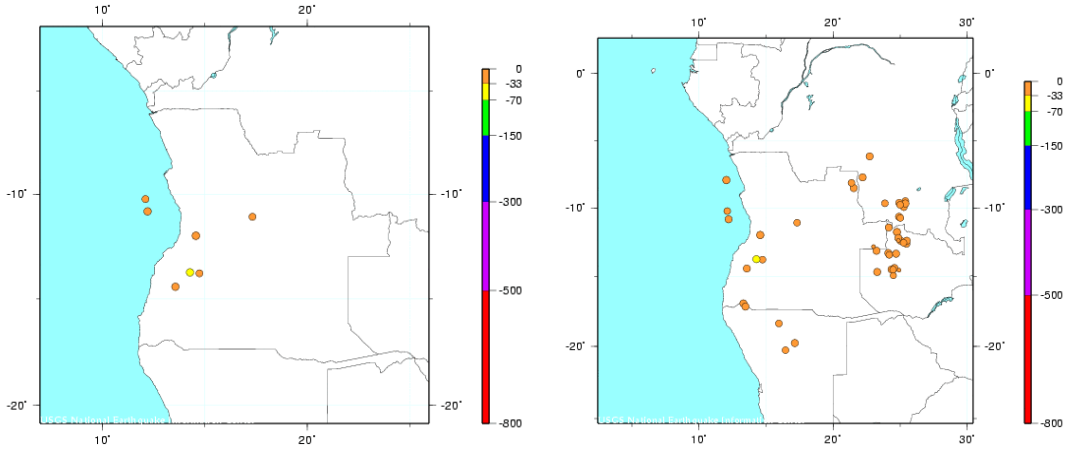
1) Design Criteria in Angola

There is no design criteria of civil construction which selected design seismic intensity in Angola.

2) Risk of Earthquake in Angola

Fig.4.3-1 shows the earthquake center occurred in central area of Angola which is made by using data base of USGS (United States Geological Survey).

There are 7 earthquakes within a 500 km radius and 44 earthquakes within a 1,000 km radius for these 1973 ~ 2011.4 (about 37 years). The maximum scale of these earthquakes is about 5 magnitude, almost all earthquakes occurred near the border between Angola and Zambia. These earthquakes are very few compared to the number of earthquakes occurred in Japan.



[radius : 500 km] *[radius : 1,000 km]*

(500 km = 4.49964°)

Fig.4.3-1 Earthquake Centers occurred near Project Site

Source : USGS homepage

Fig.4.3-2 shows map of earthquake risk in all over the world, which was made by Global Seismic Hazard Assessment Program of United Nations. This map of earthquake risk shows ground acceleration which will occur 10% event probability for next 50 years (event probability is once for 475 years). As for map of earthquake risk, the risk of earthquake in Angola is very small and all of the central area in Angora, excluding a little area of green, is painted in white. The ground acceleration of area painted in white is 0 - 0.04g and the ground acceleration of area painted in green is 0.04 - 0.08g.

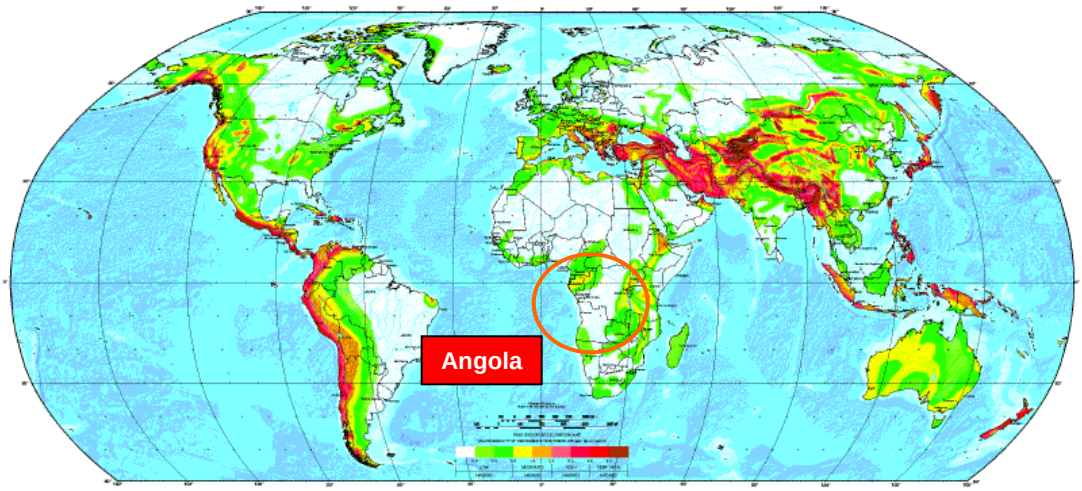


Fig.4.3-2 Map of Earthquake Risk

Source : Global Seismic Hazard Assessment Program

As above reasons, the earthquake risk of target site is extremely small.

3) Design seismic intensity of existing structure

Design seismic intensity of existing structure is investigated by listening to MINEA, design consultant and general contractor. The result of that is showed below.

－South port facilities： kh = 0.04g
－South civil facilities： kh = 0.00g
－North civil facilities： kh = 0.04g

Horizontal Design seismic intensity adopted at civil facilities is 0.0 ~ 0.4g.

Table 4.3-2 Information Collection List of Design Seismic Intensity

Item / from	Information	Design Seismic Intensity	Remarks
Monteadriano co.	Portuguese general contractor in Angola.	0.0	Answered orally
T Japanese business firm	Information of port rehabilitation work in Namibe (South Angola):(JICA grant aid, 2009)	0.04	Reference number
Phil Engineering co.	Filipino construct consultant in Luanda	0.04 (North of Angola)	・North and south number is different in Angola. ・South is unknown
INEA*	Asked through MINEA	unknown	unknown

* INEA : Roads Institute of Angola

The earthquake risk of target site is extremely small, but kh = 0.04g is selected as design seismic intensity, which is maximum number of ground acceleration of area painted in white and design seismic intensity of existing structure, because of considering that the importance of target facilities and the social influence of damaged facilities are very big.

4.3.1.2 Weir

(1) Height of Non Overflow Portion

Height of non overflow portion (elevation) is selected as summation of design flood water level, wave height from wind, wave height from earthquake and allowance height.

1) Design Flood Water Level

FWL : 1,404.400 m

2) Wave height from wind

Wave height from wind is selected by using Wilson's formula in SMB method.
As condition that river length is 1,350 m and average air velocity of 10 minutes is 10 m/s, wave height from wind becomes h = 0.283 m.

3) Wave height from earthquake

Wave height from earthquake is selected by using Seiichi-Sato's formula.
As condition that design seismic intensity is kh=0.04, earthquake frequency is 1.0 sec and water depth of reservoir is 4.50 m, wave from earthquake becomes h = 0.042 m.

4) Allowance height

The type of non overflow portion of weir is concrete gravity, overflow of water is not so serious. So that the allowance height is selected h = 0.275 m.

5) Height of non overflow portion

The crest elevation of non overflow portion is H = 1,404.400 + 0.283 + 0.042 + 0.275 = EL. 1,405.000 m.

(2) Stability Design of Non Overflow Portion

The stability design of non overflow portion is executed at 3 cases which are that water level of reservoir is normal water level, surcharge water level and design flood water level. The result is below.

Crest elevation of weir		EL. 1,405.000 m
Elevation of base rock		EL. 1,399.500 m
Design flood water level		FWL 1,404.400 m
Surcharge water level		SWL 1,404.400 m (it's same at D.F.W.L)
Normal water level		NWL 1,404.000 m
Sediment level		EL. 1401.000 m (crest elevation of overflow portion)
Seismic intensity	(at N.W.L.)	0.040
	(at S.W.L)	0.020 (it is 1/2 of N.W.L.)
Concrete weight per unit volume		22.6 kN/m^3
Water weight per unit volume		9.81 kN/m^3
Sedimentation weight in water		9.82 kN/m^3
Mud pressure ratio		0.5
Uplift pressure ratio		1/3
Downstream water level of weir	(at N.W.L.)	WL 1,400.000 m
	(at S.W.L.)	WL 1,402.000 m
	(at D.F.W.L.)	WL 1,402.000 m
Friction coefficient of base rock and concrete		1.0
Shear force of base rock		1,962.0 kN/m^2
Allowable bearing capacity of base rock		3,924.0 kN/m^2(as short time, it becomes 1.5 times)

As condition that crest width of non overflow portion is B = 1.0 m and down stream slope of weir is 1 : 0.7, the result of the stability design is following.

1) Case of Normal Water Level

Stability for overturning

e = 0.27 < B/6 = 0.64 OK

Stability for sliding

F = 57.70 > Fa = 4 OK

Stability for bearing capacity

q1 = 31.8 kN/m^2 < qa = 5,886.0 kN/m^2.....OK

q2 = 78.0 kN/m^2 < qa = 5,886.0 kN/m^2.....OK

2) Case of Surcharge Water Level

Stability for overturning

e = 0.58 < B/6 = 0.64.....OK

Stability for sliding

F = 52.66 > Fa = 4..... OK

Stability for bearing capacity

q1 = 3.6 kN/m^2 < qa = 5886.0 kN/m^2.....OK

q2 = 72.2 kN/m^2 < qa = 5886.0 kN/m^2.....OK

3) Case of Design Flood Water Level

Stability for overturning

e = 0.45 < B/6 = 0.64.....OK

Stability for sliding

F = 56.08 > Fa = 4.....OK

Stability for bearing capacity

q1 = 11.3 kN/m^2 < qa = 5,886.0 kN/m^2.....OK

q2 = 64.5 kN/m^2 < qa = 5,886.0 kN/m^2.....OK

The stability is good at all cases, so it is selected that crest width is B = 1.0 m and down stream slope of weir is 1 : 0.7.

(3) Stability Design of Overflow Portion (Hinged Crest Gate)

Hinged crest gate, which height is 3m and width is 35 m, is designed by using the example of Japanese Standard which height is 3m and width is 30 m. The result is that the gate of this site has 10% more stress than the gate of example.

Because the example gate has much allowance stress intensity (more than 10%), the gate of this site is decided to use the future of the example gate.

There are many examples in Japanese Standard which height is 6 m and width is 40 m, the detailed design of example gates are well used to this site of gate at any portion.

It's showed at Section 4.3.1.1, (2) that this site needs more than 70 m overflow width not to raise upstream water level. And 2 sets of flap gates are proposed to change the river-flow well for construction and consider the power plant maintenance.

The future of hinged crest gate planned in this site is bellows.

Height of gate:	3.0 m (length of slope 3.603 m)
Width of gate:	35.0 m × 2 sets
Thickness of gate:	0.90 m
Width of cylinder room (single portion):	2.30 m
Width of cylinder room (double portion):	3.26 m
Motor capacity:	12 kW (per 1 unit)

Turning on and off of these gates are done automatically with using 2 water-level gauging meters. Power source of these gates is basically power supply of Cutato HPS, but diesel generators (12 kW × 2 sets), which are installed in powerhouse, are used in a time of emergency

4.3.1.3 Intake

The intake of this plant is designed considering Funatsu HPS of the Kansai Electric Power Co., Inc., because Funatsu HPS is about as same scale as Cutato HPS and Funatsu HPS choose the S-type tubular turbine.

(1) Sedimentation Protecting Measure

There are not coarse aggregate but sand in Cutato River because Cutato River is slow grade of 1/1500. So it is considered for sand to enter the intake. Because of previously described reason, the weir, for protecting measure of entering sand, is designed in front of the intake. The crest of this weir is 0.5 m higher than the crest of the overflow portion of main weir, which elevation is EL 1,401.50 m and height is H = 1.50 m.
A flashing gate (width is B = 0.50 m, height is H = 0.50 m) is designed at the left side of the intake, considering that sedimentation lays down between above weir and the intake.

(2) Selection of the intake width

The intake width is selected that intake water velocity becomes about V = 1.1 m/s, which is as same velocity as intake water velocity of Funatsu HPS.

Maximum intake discharge	Q = 25.0 m^3/s (per unit)
Water depth at the intake	H = 4.0 m
Width of the intake	B = Q / (V × H) = 25.0 / (1.1 × 4.0) = 5.68m → 6.00m

(3) Design of the Intake Cross Section

The intake cross section is designed like Funatsu HPS. It's as below.

Slope of invert	:	50° down from level line
Curve radius of invert	:	R = 4.250 m
Slope of crown	:	60° down from level line
Curve radius of crown	:	R = 1.000 m

(4) Adoption of Beams Preventing Vortex

If intake water velocity is fast, vortex occurs at intake water surface. Funatsu HPS is considered to have vortex. So Funatsu HPS adopts some beams preventing vortex.

It is necessary that beams preventing vortex are adopted in this power station in the same way as Funatsu HPS. Hydraulic model test is needed to confirm preventing vortex in detailed design stage.

(5) Selection of Crest Elevation of Intake and Right Bank Retaining Wall

Intake and right bank retaining wall have to prevent overflow of water in flood, because powerhouse doesn't become submersion under water. The crest elevation of intake and right bank retaining wall needs more than the crest elevation of non overflow portion of the weir. Overflow can not be allowed at powerhouse and its circumference, because there are laborers to work at flood time and unforeseeable circumstances. So it is decided that condition of design at this time is that overflow can not occur if the flap gates don't work at flood time.

River discharge flows 3 parts which are over gates (gates are erected), over cylinder room and over non overflow portion. The water level, when design flood discharge can flow above 3 parts, is WL. 1,406.3 m. The crest elevation of intake and right bank retaining wall is selected that velocity head and allowance height add above water level.
The result is shown as bellows.

① Overflow elevation WL. 1,406.30 m	Portion over gates	Q1 =	469.05 m^3/s
	Portion over cylinder room	Q2 =	21.55 m^3/s
	Portion over non overflow	Q3 =	82.88 m^3/s
	Total	ΣQ =	573.48 m^3/s
② Velocity head	0.38 m		
③ Allowance height	0.32 m		
Total	EL. 1,407.00 m		

The crest elevation of intake and right bank retaining wall is decided to be EL. 1,407.00 m because of above reason.

4.3.1.4 Powerhouse

(1) Size of Powerhouse

Size of powerhouse is selected considering the layout of water turbine, generator and control panel, etc.

The result of powerhouse size considering the layout is following.

Length	:	L	=	27.50 m
Width	:	B	=	20.00 m
Height at water turbine	:	H1	=	12.50 m
Height at generator	:	H2	=	9.50 m

(2) Auxiliary Facilities of Powerhouse

Auxiliary facilities of powerhouse are followings.

1) Opening section for carrying electro-mechanical facilities

Opening section (L = 7.00 m, B = 5.00 m) is planned on the ceiling over water turbine.
Opening section has roof for preventing water entering at carrying facilities. There is a mobile crane and no fixed crane.
Opening section is designed for waterproof against rain.

2) Working pathway

Working pathway is planned to enter the powerhouse from downstream of power station.
Width of working pathway is 2.0 m because pathway has cable rack (B = 0.50 m) on the wall and pathway is used to carry equipments in emergency.
Futures of stair are decided by Japanese Law that its height is less than 230 mm, its depth is less than 150 mm. In this powerhouse, it is decided for safety to carry equipments that stair's height is 200 mm, stair's depth is 300 mm.

Working pathway is settled from ground level to floor level (EL. 1,394.0 m) of generator.

3) Emergency pathway

There is working pathway at downstream of powerhouse, another emergency pathway (vertical type pathway with ladder) is settled.

Emergency pathway is settled from ground level to floor level (EL. 1,391.0 m) of turbine.
Because height is too high as 13.0 m, 2 stair landings are settled in it.
Size of emergency pathway is that length is L = 1.0 m width is B = 2.0 m.

(3) Backfill around Powerhouse

Backfill construction around powerhouse (from hill or intake to powerhouse) is undertaken to powerhouse top (EL. 1,404.0 m). Surplus soil is used as backfill material.

(4) Stability Design of Right Bank Retaining Wall (Upstream and Downstream)

Right bank retaining wall is settled at upstream and downstream of powerhouse because of protection for flood water and easiness of undertaking backfill construction.

The stability design of right bank retaining wall is estimated at 2 cases which are normal case and seismic case. Condition of estimation is following. Basic condition is same as condition of main weir.

1) Upstream right bank retaining wall

Crest elevation of retaining wall	: EL. 1,407.000 m
Elevation of base rock	: EL. 1,400.000 m
Elevation of backfill	: EL. 1,404.000 m
Seismic intensity	: 0.040
Concrete weight per unit volume	: 22.6 kN/m^3
Water weight per unit volume	: 19.6 kN/m^3
Friction coefficient of base rock and concrete	: 1.0
Shear force of base rock	: 1,962.0 kN/m^2
Allowable bearing capacity of base rock	: 3,924.0 kN/m^2 (1.5 times in short time)

As condition that crest width is B = 1.0 m and downstream slope is 1 : 0.25 of retaining wall, result of the stability design is following.

① Normal case

Stability for overturning

e = 0.44 < B/6 = 0.46 ..... OK

Stability for sliding

F = 84.81 > Fa = 4 ..... OK

Stability for bearing capacity

q1 = 244.0 kN/m^2 < qa = 3924.0 kN/m^2 .... OK

q2 = 5.0 kN/m^2 < qa = 3924.0 kN/m^2 .... OK

② Seismic case

Stability for overturning

e = 0.55 < B/3 = 0.92 ..... OK

Stability for sliding

F = 68.11 > Fa = 4 ..... OK

Stability for bearing capacity

q1 = 279.5 kN/m^2 < qa = 5,886.0 kN/m^2.....OK

q2 = - (shape of reactive force is triangular distribution)

The stability is good at all cases, so it is selected that crest width is B = 1.0 m and down stream slope is 1 : 0.25 of upstream right bank retaining wall.

2) Downstream right bank retaining wall

Crest elevation of retaining wall	: EL. 1,404.000 m
Elevation of base rock	: EL. 1,400.000 m
Elevation of backfill	: EL. 1,404.000 m
Seismic intensity	: 0.040
Concrete weight per unit volume	: 22.6 kN/m^3
Water weight per unit volume	: 19.6 kN/m^3
Friction coefficient of base rock and concrete	: 1.0
Shear force of base rock	: 1,962.0 kN/m^2
Allowable bearing capacity of base rock	: 3,924.0 kN/m^2 (1.5 times in short time)

As condition that crest width is B = 1.5 m and downstream slope is 1 : 0.25 of retaining wall, result of the stability design is following.

① Normal case

Stability for overturning

e = 0.40 < B/6 = 0.42 .....OK

Stability for sliding

F = 75.85 > Fa = 4 .....OK

Stability for bearing capacity

q1 = 177.6 kN/m^2 < qa = 3,924.0 kN/m^2 ....OK

q2 = 3.6 kN/m^2 < qa = 3,924.0 kN/m^2 ....OK

② Seismic case

Stability for overturning

e = 0.46 < B/3 = 0.83 .....OK

Stability for sliding

F = 64.46 > Fa = 4 .....OK

Stability for bearing capacity

q1 = 194.4 kN/m^2 < qa = 5,886.0 kN/m^2.....OK

q2 = - (shape of reactive force is triangular distribution)

The stability is good at all cases, so it is selected that crest width is B = 1.5 m and down stream slope is 1 : 0.25 of downstream right bank retaining wall.

(5) Settled Protect Concrete beside River Side

Flood water flows beside river side of powerhouse. Backfill and concrete which depth is 1.0 m are settled for protecting that flood water excavates river floor beside river side of powerhouse.

(6) Water Line on Powerhouse Wall beside River Side at Flood Water

Water line on powerhouse wall beside river side at flood water is calculated because it is afraid that flood water overflows on powerhouse. Fig.4.3-3 shows the water line (depth is about 1.86 m) of the result of calculation when that river discharge is 1/2 of Design Flood Discharge (Q = 280 m^3/s). The result shows that there is non overflow on powerhouse.

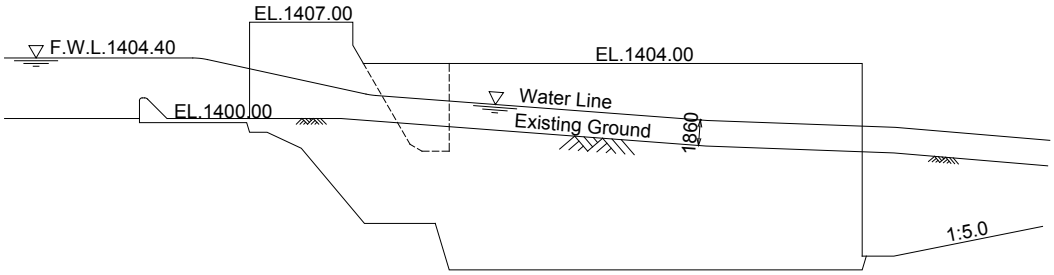


Fig.4.3-3 Water Line on Powerhouse Wall beside River Side

4.3.1.5 Outlet

(1) Location of Outlet and Gate

Outlet is in the end of powerhouse because this powerhouse has no tailrace. Stop logs are needed for maintenance because outlet is usually in water. Gate of stop log is operated by using mobile crane and there is no chance to maintain stop logs at the same time, only 1 unit of gate is made.

Stop log gate is stored on powerhouse roof with sheet cover. But if there is risk of theft, storing house is needed.

(2) Excavation of River Floor

Outlet water level is TWL 1,396.0 m in generation plan, excavation of river floor is needed in this project. River floor of outlet port is excavated at 1 : 5 slope like Funatsu HPS.
Downstream of above is following.

Actual condition of river floor elevation is about EL. 1,396.0 m, this means that water level of river is over TWL 1,396.0 m when maximum discharge (Q = 50.0 m^3/s) is flowing. At this

case, installed capacity can not occur because of shortage of water head. So that excavation of downstream river floor is planned for downstream water level to be TWL. 1,396.0 m.

Necessary river cross section is shown following for keeping water level of TWL. 1396.0m.

(Condition for calculation)

Using formula		:	Maning formula
Discharge	Q	:	50.0 m^3/s
River slope	I	:	1/1500
Roughness coefficient	n	:	0.025
Excavation width	B	:	15.00m
Excavation slope		:	1:1.0

(Result of calculation)

In above case, necessary water depth is 2.03 m when maximum discharge (50.0 m^3/s) flows. Excavation elevation of river floor becomes EL. 1,393.97 m at the end of upstream (excavation slope to downstream is 1/1500).

River excavation width is about 45m and length is about 200m from outlet.

If one-half of Design flood discharge (Q = 280 m^3/s) flows in this cross section, water level becomes FWL 1,399.7 m. (one-half of Design Flood Discharge means maximum discharge from right side hinged crest gate)

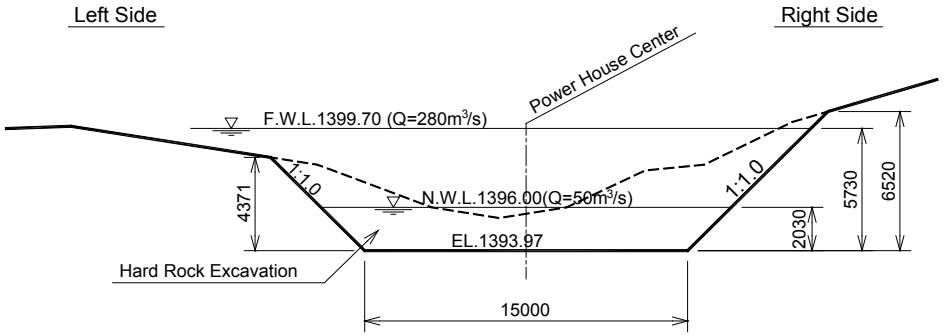


Fig.4.3-4 River Floor Excavation Cross Section

4.3.1.6 Access Road

Access road is planned from Chicumbi to the site, its length is about 28 km.

Design condition of access road, which is based on Japanese law and considered that width and minimum turning radius of semitrailer are 2.5 m and 12 m each, is planned that width is 5m (width for vehicle is 4m and road shoulders are 1 m), curve radius is more than R = 20 m, longitudinal slope is less than 9% (traffic speed is 20 km/h).

In addition, 2 m width space is needed for constructing distribution line. So the total land improvement width for access road and distribution line is 7 m.

The investigation of existing road to access road for carrying material and equipment is needed because existing road condition is not so good and it's afraid to carry on existing road. If there is any problem, repair work or strengthen work is needed before construction.

4.3.1.7 Land Creation of Substation

Substation is land-created at mountain side of powerhouse, its space is 15 m wide and 20 m long.

The road, which is 40 m long and 4 m wide (width for vehicle is 3 m and road shoulders are 1m), is planned for entering the substation.

The road slope and curve radius etc. is on based on same Japanese law as access road because semitrailer can path on it.

4.3.1.8 Temporary Facilities

(1) Temporary Cofferdam

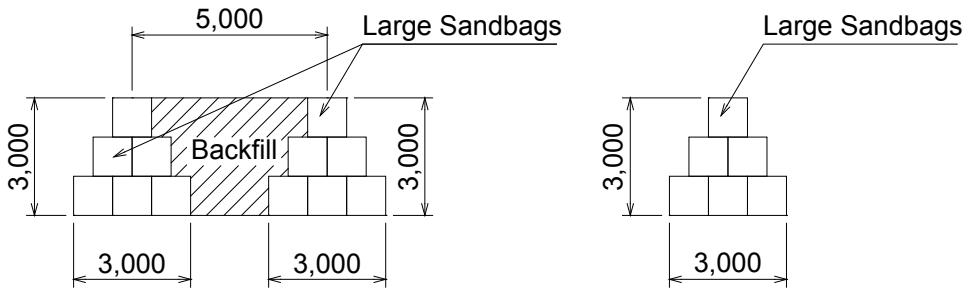
3 temporary cofferdams are planned for construction work which are upstream cofferdams (1st stage, 2nd stage) and downstream cofferdam. Because design water depth is less than 2m, all temporary cofferdams are made by 3 steps large sandbags. (its height is 3 m)

1st stage upstream cofferdam is planned from upstream of powerhouse to crane yard, its length is about 55 m. Upstream cofferdam is used as access road to crane yard for heavy vehicle, its crest width of cofferdam, which is made by backfill between upstream and downstream large sandbags, is settled 5 m.

2nd stage upstream cofferdam is planned for construction of left side weir, its length is about 70 m.

Downstream cofferdam is planned for construction road to crane yard, which is preparation work for 2nd stage, its length is about 55 m and its location is downstream of construction road.

Downstream cofferdam is taken away before start of 2nd stage construction works.



1st stage upstream temporary cofferdam

Downstream temporary cofferdam and 2nd stage upstream cofferdam

Fig.4.3-5 Cross Section of Cofferdam

(2) Crane Yard

Crane yard (length is 20 m, width is 20 m) is land-created at downstream of weir center for carrying flap gates and large sandbags. It consists of large sandbags same as temporary cofferdam.

(3) Construction road

Construction road is planned from access road to crane yard through downstream of powerhouse (length is 645 m). Another construction road is planned from access road to powerhouse (length is 117 m).

Above construction road to crane yard is settled to river towhead in 1st stage. Structure of fording point consists of corrugated pipe (ϕ2.0 m) and large sandbags. Earth covering depth of that is designed more than 0.6 m.

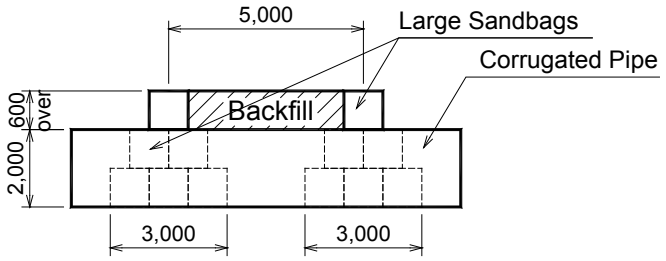


Fig.4.3-6 Cross Section of Fording Point of Construction Road

Design condition of construction road, which is based on Japanese regulation (road construction ordinance) and considered that width and minimum turning radius of semitrailer are 2.5 m and 12 m each, is planned that width is 5 m (width for vehicle is 4m and road shoulders are 1 m), curve radius is more than R = 20 m, longitudinal slope is less than 9% (traffic speed is 20 km/h).

Passing place is not planned because construction road is temporary and passing each other of heavy vehicle can be possible.

(4) Aggregate Manufacturing Plant

This plant is settled for manufacturing fine aggregate (sand) and coarse aggregate and stocking them. Sand needs only stocking yard (no manufacturing yard), because sand is in river and not necessary to manufacture. Coarse aggregate needs not only stocking yard but also manufacturing yard, because coarse aggregate is not in river and necessary to manufacturing it with using surplus rock by crushing.

Necessary space of land-creation is about 20 m × 30 m = 600 $m^{2.}$

(5) Concrete Manufacturing Plant

The scale of this plant is about 50 m^3/h in response to the scale of construction concrete volume.

The location of this plant is beside aggregate plant because aggregate can be carried with belt conveyor from aggregate plant to this plant.

Concrete plant consists of cement silo and batcher plant, its necessary space of land-creation is about 15 m × 20 m = 300 m^2.

(6) Temporary Office and Warehouse

2 kinds of temporary office and warehouse are settled. One is for access road work and another is for main works.

Chicumbi is the suitable location of temporary office and warehouse for access road, but Andulo is the best location if communication condition to be considered.

Scale of this house is less than the house of main works, its office needs the space of about 10 m × 10 m × 2 units = 200 m^2 and its warehouse needs the space of about 10 m × 15 m × 2 units = 300 m^2.

The temporary office and warehouse for main works are built at the site for engineers (civil, architecture, electrical, mechanical) and laborers.

This temporary office needs the space of about 10 m × 15 m × 2 units = 300 m^2 and temporary warehouse needs the space of about 10 m × 20 m × 2 units = 400 m^2.

(7) Material Stockyard

Material stock yard needs not a few area for stocking iron bars, gates, electrical materials, mechanical material and heavy vehicles.

So above plant yards and temporary house yards are placed as widely as possible and they are used as material stock yards. Its elevation is EL. 1,408.0 m because they are not overflowed by flood discharge.

Blasting works for land-creating is considered to be necessary because its foundation is hard rock.

4.3.2 Electro-Mechanical Facility

4.3.2.1 Basic Condition

This power station has no plan to be connected to the electric power grid of Angola and no parallel operation with other power station and is to be operated stand alone. This power station has two unit generators and No.1 generator which starts first is forced to send electricity to the grid but No. 2 generator needs to synchronize with the No.1 generator and is to be operated parallel with No. 2 generator. Choice of generator, No.1 or No. 2 is decided at random after the stoppage of generators.

4.3.2.2 Water Turbine

(1) Water Turbine

1) Type of water turbine

The type of water turbine in the condition of effective head, 7.50 m, water flow of the turbine, 25.0 m^3/s is S-type tubular or Bulb-type is the most appropriate one. Since in the selection table of water turbine S-type tubular is in the middle of the applied area of the Fig. 7.2-7 and S-type tubular is the best suit to small water turbine, S-type tubular water turbine should be chosen for this power station.

The shape of S-type tubular water turbine becomes S-type at the waterway as a whole. Casing of the water turbine is cylindrical shape and water flow is axis direction and head fluctuation is big because of low head. To keep the efficiency of the generator high, open angle of runner vane is movable. This water turbine is special Vertical Axis Kaplan Water Turbine.

2) Rated output

Rated output of the water turbine, P1 is calculated the following formula

$$Pt = 9.8 \times Qt \times H \times \eta t$$
$$= 9.8 \times 25.0 \times 7.50 \times 0.859$$
$$= 1{,}580 \text{ kW} \rightarrow 1{,}500 \text{ kW}$$

Where,

Gravitation acceleration: $g = 9.8 \text{ m/s}^2$

Water flow of one unit : $Qt=25.0 \text{ m}^3/\text{s}$

Effective head : $H = 7.50$ m

Efficiency of water turbine : $\eta t = 0.859$

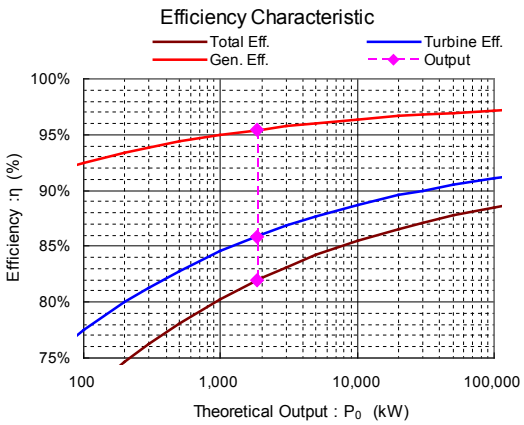


Fig.4.3-7 All Kind of Efficiency

3) Rated rotation speed

Limited velocity of Kaplan Water Turbine is show as following formula.

$Ns_{lim} \leqq 20{,}000 / (H + 20)$

$= 20{,}000 / (7.5 + 20) = 727.3$ m-kW

Limited rotation velocity is calculated from rotation velocity of the water turbine and velocity.

$N_{lim} = Ns_{lim} \times H \wedge (5/4) / Pt \wedge (1/2)$

$= 727.3 \times 7.50 \wedge (5/4) / 1500 \wedge (1/2) = 233.0\ min^{-1}$

In a point of view of cost reduction it is adopted to use high speed rotation equipment as fast rotation equipment as we can adopt. It makes reduction of size, weight of the water turbine and contributes reduction of the size of the power station and good for transportation.

On the other hand, rotation speed of generator: N is fixed by frequency, number of magnetic poles of generator.

Number of magnetic pole of generator must be even number and direct connection between water turbine and generator makes whole rotation speed N is decided as follows.

On the other hand, rotation speed of generator: N is fixed by frequency, number of magnetic poles of generator.

Number of magnetic pole of generator must be even number and direct connection between water turbine and generator makes whole rotation speed N is decided as follows.

$N = 120 \times f / p$

Table 4.3-3 Revolving Speed

No. of magnetic pole	Rotation speed min^{-1}
36	166.7
32	187.5
28	214.3
24	250.0
20	300.0

Where, frequency: f = 50Hz

Number of magnetic pole: P = 28 Less than limited speed minimum even number of magnetic poles

In case of the small generation capacity, speed increase machine is used for increasing speed of the generator. If it is profitable to the generation system, it is acceptable to use this machine in the design of the generation system.

4) Central height of the water turbine

Central height of the water turbine secure resistance against cavitations which occurs at the bottom of runner and give damage of reduction of efficiency of water turbine, erosion of vanes.

Resistance against cavitation is secured that design coefficient of cavitation is bigger than the coefficient which is experimentally decided value. Relation between speed of water turbine and coefficient of cavitation is shown as Fig 4.3-8.

From Fig. 4.3-9 op = 1.084 but height of the site is 1400m and special condition is to be considered. 30% allowance is considered and op' = 1.3 × op = 1.409

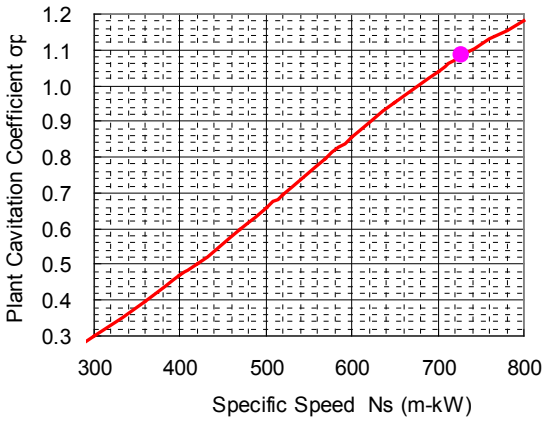


Fig. 4.3-8 Ns–σp

Necessary inhaling height which is given by the following formula.

$$Hs = Ha - Hv - \sigma p' \times H$$
$$= 10.33 - 0.25 - 1.409 \times 7.50$$
$$= -0.49 \rightarrow -1.0 \text{ m}$$

Where,

Atmospheric pressure Ha = 10.33 mAq

Vapor pressure Hv = 0.25 mAq

Accordingly center height of water turbine CL is shown as follows.

$$CL = TWL - Hs = 1{,}396.00 + (-1.00) = 1{,}395.00 \text{ m}$$

Where, Atmospheric pressure Ha = 10.33 mAq

Vapor pressure Hv = 0.25 mAq

5) Others

- Material of runner and guide vane must be stainless steel.
- Material of axis must be steel
- The maximum speed fluctuation rate in case of demand cut off is =/less than 30%.
- Bearing must be ball bearing or roller bearing.
- Free run speed of water turbine for 2 minutes never cause troubles.
- At upper stream of inlet vane short steel pipe must be inserted

(2) Governor

- 2 sets of PID type governor is to be supplied
- Signal of rotation speed is to be speed signal generator
- Setting of governor is to be 3 to 6%.
- For control of water turbine governor is generally used and takes precedence over water level control equipment but in case of emergency water level control system is top priority.
- In principle parallel operation needs the same output of the water turbine.

(3) Water Level Control Equipment

- Water level control equipment should one set for 2 sets of water turbine.
- Low level dam water level signal is adopted if there are two water level existed.
- In case of emergent water level drop it is considered heavy fault and 2 sets of water turbine must be stopped immediately.

(4) Inlet Vane

This power station has 2 sets of water turbine and needs maintenance of each water turbine. Therefore waterway part is to be separated from water for the maintenance. Water pressure of upper steam side of water turbine is high and needs inlet vane but down stream side of water turbine needs seal plate.

(5) Oil Pressure Equipment

Guide vane, runner vane and inlet vane need electric system and oil pressure equipment can be omitted.

(6) Air Compressor

Air compressor is to be omitted by considering omission of oil pressure equipment, break of the generator. It is recommended to use electric type break.

(7) Lubricating Oil Equipment

To be abbreviated

(8) Coolant Supply Equipment

Coolant is to be supplied to bearing and other equipment installed at the power station.

(9) Draft Drainage Equipment

Draft drainage equipment is necessary to take off inlet vane, water turbine runner, inhaling pipe and seal plate from water way. Therefore draft drainage equipment is necessary to set.

4.3.2.3 Generator

(1) Generator

1) Rated output

Rated output of generator: Pg, capacity of generator: kVAg are calculated as follows. Power station output is the same calculation.

Pg = Pt × ηg = 1580 ×0.954 = 1,507 → 1500 kW
kVAg = Pg / pf = 1,500 / 0.9 = 1,667→1700 kVA
P = Pg ×n = 1500 ×2 = 3000 kW

Where,
Output of water turbine: Pt = 1,580 kW
Efficiency of generator: Ng = 0.954
Power factor of generator: pf = 0.9
Number of generator: n = 2 sets

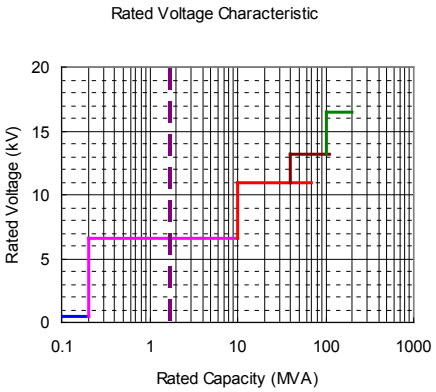


Fig.4.3-9 Selection of Rated Voltage of Generator

2) Rated voltage

Rated voltage of generator: Vg is fixed by the Fig. 4.3-9. The selection of rated generator rated voltage Vg = 6.6 kV.

3) Rotation speed

Rotation speed of water turbine and generator must be the same by direct coupling between water axis and generator axis (without speed up equipment) direct coupling avoid the fault and increase efficiency of the equipment.

(2) Exiting Equipment

Each generator needs each exciting equipment (generator equips brushless exciting equipment and ac generator with rotation rectifier and other control equipment).

(3) Neutral Grounding Resistance

Grounding current of the main circuit of the generator is restricted to 100 A and as continuous grounding current is short, rated continuous time of natural grounding resistance is to be 30 minutes.

Rg = (Vg × 1000) / $\sqrt{3}$ / 100
= (6.6 × 1000) / $\sqrt{3}$ / 100 = 38.1 Ω

(4) Control Panel of the Water Turbine and Generator

It is prepared 2 sets installed near the generator as the equipment of control, protection and supervision for the water turbine and the generator.
Function of control, protection and supervision is shown as below.

1) Control items

- Start and stop of the generator
- Control of output of the generator
- Control of voltage of the generator

2) Protection items

It depends on the faults happened at the generator/water turbine. Those are itemized into 4 kinds.

(a) Emergency stop : 86-1 = Electrical serious fault

- Internal short of generator : G87
- Internal short circuit of generator : G87G
- Overvoltage of generator : G59
- Overcurrent of generator : G51
- Overvoltage of main circuit : G64

(b) Emergency stop : 86-2 = Mechanical serious fault

- Temperature rise of the bearing : 38-2
- Over speed of the water turbine : 12
- Governor fault : 81F
- Serious fault of the auxiliary equipment : 69W

(c) Safety stop : 86-5 = Normal fault

- Temperature rise of the bearing
- Faults of the auxiliary equipment

(d) Alarm : 30A = Slight fault

Indicating defect and alarm

3) Supervision

As the water turbine/generator supervision items are shown as below.

(a) Voltage current, rotation speed of the generator
(b) Each kinds of bearing temperature
(c) Synchronize circuit breaker

(5) Comprehensive Control and Supervision System of the Power Station

Whole control, protection and supervision which includes main circuit of the power station and outdoor substation and station circuit,

1) Comprehensive supervision and control panel

2) Automatic synchronize equipment

While main circuit of the power station is charged, another generator goes into the main circuit by synchronize circuit breaker.

(6) Fire Extinguish Equipment of the Power Station

Fire extinguish equipment for the power station takes care of A: normal fire, B: oil fire and C: electricity fire. Simple and reliable fire extinguishing equipment is set near the generator.

(7) 6 kV Circuit

Connection from high voltage terminal of the generator to the primary terminal of the main transformer, branch circuit of the low voltage circuit to the secondary terminal of the house transformer uses the equipment shown as follows.

1) Synchronize circuit beaker : CB G10 and CB G20
2) Circuit beaker of the primary side of the main transformer : CB 110
3) Station use circuit beaker : CB H10
4) Station transformer : HTrB
5) 6.6 kV power cable

(8) Low Voltage Circuit

The second terminal of the house transformer to the following equipment is connected through low voltage, 3 phase, 400V and single phase 200V circuit.

1) Control center, Unit type
2) AC power source
3) DC power source
   (a) Rectifier
   (b) Battery
4) Cable

Low voltage cable, control cable and communication cable. Specification and quantity are shown in the detailed design.

4.3.2.4 Main Transformer

Electricity generated at the power station is stepped up to high voltage and is sent to the customer. For that procedure a substation is constructed outside the power station. The space of the substation is to be located near the power station and 189 m^2 wide.

(1) Main Transformer

1 set of 3 phase mail transformer is to be installed to transform electricity which is generated by 2 sets of generator to high voltage electricity.

1) Rated output

Rated output of the mail transformer: kVAtr is calculated as follows.

$$kVAtr = kVAg \times n = 1700 \times 2 = 3{,}400 \text{ kVA}$$

Where, Rated capacity of the generator: kVAg = 1700 kVA
Number of the generator : n = 2 sets

2) Rated voltage

Rated voltage of the primary side of wiring is to be set the same voltage of the rated voltage of the generator: Vg = 6.6 kV
Rated voltage of the secondary side of wiring is to be set the same voltage of the rated voltage of the distribution line.

3) Connection system

Main transformer has 3 phases and the primary (low voltage side) connection is delta connection and the secondary is star connection,

4) Cooling system

Outdoor type, oil filled, natural ventilation transformer is simple and reliable.

5) Bushing Current Transformer

The secondary side of the main transformer is high voltage, 33 kV and Bushing CT is adopted. It is simple and raises up reliability.

(2) Neutral Grounding Equipment

The high resistance equipment is adopted so as to detect grounding fault current at the distribution line. The neutral resistance is to be calculated by the rated distribution voltage, 33 kV and its value is Rntr = 750 Ohm.

(3) Leak Oil Protection Facilities

Main transformer has oil in it for insulation. When the serious fault happens at the transformer, leak oil protection facilities protect that insulation oil never flows out from area of the main transformer. Pit is set at the bottom of the main transformer as leak oil protection.

(4) 33 kV Circuit

From the secondary of the main transformer terminal to the first distribution pole which is the border between power station and distribution line the equipment is installed shown as below.

1) Line side circuit beaker :	CB 01	1 unit
2) Line side disconnecting switch :	LS 1	1 unit
3) Potential transformer :	PT	3 units
4) Arrestor :	Ar	3 units

4.3.2.5 Auxiliary Equipment

Auxiliary equipment does not belong to the water turbine, the generator and other mail equipment but need to operate the power station shown as below.

(1) Ceiling Crane

(2) Emergency Power Source Equipment : EG

Even in case of the power station stop, emergency power source equipment supply electricity to important load of the power station.

(3) Drainage Facilities for the Power Station

- Drainage pit
- Water level detecting equipment
- Drainage water pump for normal use
- Drainage water pump for emergency

(4) Grounding Mesh

As lighting protection for whole power station more than 50 mm^2 copper wire is laid in the area of the power station and substation. Each mesh at the power station area and the substation area must be connected each other.

(5) Communication Facilities

The communication equipment is installed at the power station and the office located at Andulo.
Main equipment is to be installed at the Andulo office and sub-equipment is installed at the substation near the power station.

4.3.3 Distribution Line Facilities

4.3.3.1 Basic Study Conditions

Following basic study condition is investigated and listening from the distribution service public company (EDEL), its located and service only for Luanda and Uige city also distribution line constructor. From the view of cost saving point in the procurement, existing local products shall be used as much as possible.

(1) Application Criteria / Standard

In Angola, individual own criteria and standards do not exist now. Following international standards, IEC (International Electro-technical Commission) and Distribution Standard published by Ministry of Energy of Portugal shall be complied as basic standards.

1) Manual de Equipmentos Eléctricos João Mamede Filho LTC (Br) (issued by Federative Republic of Brazil)
2) Edição DGE do Regulamento de Sequrança de Linha Eléctricas de Alta Tensão (issued by ministry of industry and energy)

(2) Supply System (Wiring, Voltage and Frequency)

In Angola, electric power frequency is 50 cycle, and distribution line voltage is 59 kV or less. 30 kV (high voltage) and 15 kV (medium voltage) is three-phase and three-wire, 400 V - 230 V (low voltage) is a three-phase and three-wire, this distribution project shall be conformed to these criteria.

(3) Voltage Regulation

Voltage regulation in Angola is shown below table.

Table 4.3-4 Angola Distribution Line Voltage Regulation

(electric power quality)

Type	Operation Voltage (Nominal)	Voltage regulation (%)
High voltage distribution	30kV	±5
Low voltage distribution	400V-230V	±5

(4) Supply Area

In this project, Andulo City that is the most nearest largest city from Cutato Power Station, so it's a final demanding side.

However, additionally, it shall be considered for supplying by low voltage distribution for the church, church owned school and hospital, and up to pole transformer installation at Muenga Village.

1) High voltage distribution line route

High voltage distribution line route from Cutato River site to Andulo City, shall be planned with consideration for social environment and land mine issue etc., so overall judgment shall be needed. Such are minimization for eviction of residents in these villages as much as possible, and/or less effected for the deforestation and farmland area.

Result of major GPS measurement point on the high voltage distribution line plan route is as shown in Table 4.3-5, and its line plan route is as shown in fig. No. T-001.

Table 4.3-5 High Voltage Distribution Route Plan
(existing road paralleling, GPS measurement result)

Cutato – Andulo 30kV Distribution Network Plan by GPS Sampling * is 400-230V					
Site Name or Sampling Point No. (Corner or Cross point)	GPS (South) Reference	GPS (East) Reference	Rout Road Distance(m)	Proposed line Distance (Sub Total)	Proposed Installed Pole Tr Capacity(kVA)
Sub station(S/S)	11° 18.688	16° 28.688	0	0	(StepUpTR 3,400)
A1	11° 19.373	16° 29.413	1,400	1,400	Non
A778	11° 18.699	16° 30.544	2,200	3,600	Non
A765	11° 18.959	16° 31.123	1,120	4,720	Non
Muenga	11° 19.174	16° 31.385	730	5,450	3 ϕ 100
A767	11° 19.125	16° 31.819	1,000	6,450	Non
A770	11° 20.952	16° 32.994	4,220	10,670	Non
A772	11° 18.688	16° 28.929	1,500	12,170	Non
A773	11° 22.146	16° 33.870	1,100	13,270	Non
A776	11° 24.440	16° 38.575	4,260	17,530	Non
A777	11° 25.395	16° 33.602	1,780	19,310	Non
A781	11° 27.197	16° 35.251	4,630	23,940	Non
A782	11° 27.867	16° 35.425	1,000	24,940	Non
Chicumbi	11° 18.959	16° 31.123	3,150	28,090	3 ϕ 250
A786	11° 28.575	16° 37.971	4,430	30,590	Non
A787	11° 29.115	16° 39.099	3,100	33,690	Non
A788(Small River)	11° 28.981	16° 39.516	660	34,350	Non
A789	11° 28.562	16° 40.021	2,080	36,430	Non
Andulo(West market)	11° 28.796	16° 40.615	1,000	37,430	※(3 ϕ 250)
Andulo(Center 5R cross)	11° 29.096	16° 47.573	2,000	39,430	※(3 ϕ 250)
Andulo(Governer office)	11° 29.1	16° 42.3	500	39,930	※(3 ϕ 250)
Andulo(DG station)	11° 29.178	16° 42.391	2,000	41,930	※(3 ϕ 250×2)
Andulo (Airport)	11° 29.105	16° 42.609	400	41,830	※(3 ϕ 250)
30kV network end	-	-	-	**41,830**	-

※ mark : Pole transformer capacity in the Andulo city is out of Scope, only for reference. Distribution line conductor length is 46km including the around 10% allowance as as line sag.

2) Low voltage distribution line route

Also low distribution line route for church, school and hospital shall be planned by the exiting road paralleling in the Chicumbi Village. GPS measurement result on these route points is as shown in Table 4.3-6. Low voltage distribution line plan route is as shown in Drawing No. T-003.

Pole transformer shall be installed to the most nearest pole along the road which is close to the center of the load in the demanding each area. Also it shall be planned that the construction as low 400 - 230 V 3 phase 4 wire distribution line to be connected to the distribution board of above each building.

Table 4.3-6 Low Voltage Distribution Route Plan
(existing road paralleling, GPS measurement result)

Cutato – Andulo 30kV Distribution Network Plan by GPS Sampling * is 400-230V					
Site Name or Sampling Point No. (Corner or Cross point)	GPS (South) Reference	GPS (East) Reference	Rout Road Distance(m)	Proposed line Distance (Sub Total)	Proposed Installed Pole Tr Capacity(kVA)
Chicumbi (Pole TR point)	11° 18.959	16° 31.123	0	0	3 ϕ 250
(Church, School, Hospital)	(11° 28.683)	(16° 34.709)	1,300	1300	(3 ϕ 400-230V)
(House hold)	(11° 29.036)	(16° 35.270)	200	1500	(3 ϕ 400-230V)
400-230kV network end	-	-	-	**1,500**	-

(5) Study Condition of Distribution Pole Transformer Capacity

It shall be constructed along the GPS point on the high-voltage distribution line plan route, and on the nearest one pole of each Muenga and Chicumbi Villages. These capacity shall be defined based on the following information such as total population of each village and its consuming energy per one household etc. by interviewing from the Andulo province office and residence peoples. Also it must be considered installation capacity limit is up to 250kVA on the pole.

In Andulo Province area, mostly a household and main demand, so load factor shall be assumed as 50%, diversity factor is 1.25 from severe side evaluation, number of the family per one household shall be assumed as 6 persons from interviewing results (6 to 10 people).

a) Andulo Province load demand (from municipal office etc,. information)

- Minimum 150W per one house hold shall be needed from Electrical engineer (a few capacity diesel engine generator in a few house hold)
- At the Muenga Village (5,800 peoples) and the Chicumbi Village (4,810 peoples) etc., main income is agricultural product selling only, so its hard to expect to spread of the appliance as same as Andulo City.
- According to the above information, each village demand shall be assumed as around 100 W per one house hold.
- In Andulo City which has a municipal office, the residence people is 142,712 (Jan in 2011)
- From February 2011, 1m000 household construction was started (around 1 ~ 2 km suburbs from Andulo City)

- 10 years later, Andulo Province city will 0.2 million peoples city (all Andulo Province people is 0.22 million including all village, so 1.5 times glow).

b) Low voltage distribution demand in Chicumbi Village (from Pastor in church information)

- Church, Church owned school and hospital, 3 building total is 400 peoples (200 in it are residence in the church), Chicumbi Village owned school is around 100 peoples. Current diesel installation condition is only one (40 kW), in the future, luck of the power is around maximum 160 kW, so total 200 kW maximum demand shall be needed, so it can be converted to 80 kW (200*0.5/1.25 = 80 kW)

4.3.3.2 Distribution Line

On this project, supply system shall be defined as following Table 4.3-7.

Table 4.3-7 Supply System in the Project

Type	Operation Voltage (Nominal)	Supply system
High voltage distribution	30 kV	3ϕ 3 wire
Low voltage distribution	400V-230V	3ϕ 4 wire

(1) High Voltage Distribution Line Wire

By several kind of the study, basic specification is as follows.

Distribution line wire :	ACSR (Aluminum Conductor Steel Reinforced) Wire 105-AL1/17- ST1A (HARE)
	Wire size : 120 mm^2
Transmission voltage:	30 kV (operation voltage)
Distribution line length :	46 km
Supply system :	3ϕ 3 wire × 1cct

Basic design concept shall be selected as follows.

1) Distribution Voltage

- Economical transmission line voltage check

The following formula is as shown about the relation by considering the economical distribution voltage and its length (Alfred Still experimental formula)

Transmission Voltage =

$$5.5\sqrt{(0.6\times distribution\ line\ length\ (km)+0.01\times transmission\ power\ (kW))}$$

By calculating the above formula, appropriate transmission voltage is 41 kV, under the condition of distribution line length is 46 km up to Andulo City and transmission power is around 3,000 kW case.

The nearest line voltage shall be selected economically, 30 kV shall be given as distribution line voltage.

- Voltage regulation risk checking

  Another point of view as long distance transmission, Inhibit of the distribution line voltage drop also shall be considered.

  As these projects, if load concentration of the line end will be bigger than the other middle load point, voltage drop regulation will bigger and bigger. Voltage regulation formula in the case of the end load concentration is as follows.

  $$Voltage\ drop\ (v) = K*I*reg*L$$

  K : Factor, 3ϕ 3 wires= $\sqrt{3}$

  I : Current (A)

  reg : Voltage regulation = $r \cdot \cos\theta + x \cdot \sin\theta$

  r : Line resistance (Ω)

  x : Line reactance (Ω)

  θ : Phase degree

  cosθ : Power factor

  L : Conductor length (km)

  If distribution line voltage is 30 kV, line wire size 120 mm^2, line end load at Andulo City is 2,500 kVA, line conductor length is 46 km, power factor 0.85, and each line phase distance 60 cm, around 4% voltage drop shall be estimated by calculating of above formula. It is within ±5% of 30 kV.

  So distribution line of this project shall be defined as 30 kV by voltage regulation quality also cost minimization point of view.

2) Wire Type and Size

- Wire size with considering for construction cost merit
  Distribution line distance 46 km and up to 10 MW, so AAAC (All Aluminum Alloy Conductor) or ACSR 120 mm^2 is suitable distribution system for low construction cost and low line loss.

Table 4.3-8 Transmission Voltage, Distance, Capacity and Construction Cost Indication Comparing

Line Voltage	Capable transmission distance (Radius: km)	Transmission Capacity (MW)	Construction Cost (Million yen / km)	Wire Current Density (mm^2)	Reference Wire Cable loss(%)
15kV	25	2~ 3	30~50	AAC120	3.2
30kV	70	10	40~70	AAC120/ACSR120	3.2
30kV	70	20	200	ACSR210	2.8

- Wire type and size

  On this project, from the easy obtaining point of view, easy to apply for the future transmission capacity up and enough to the long pole distance design concept, ACSR shall be selected.

- Tolerance of distribution capacity (Distribution wire capacity check)

  This distribution line route is located at existing load up to Andulo City, so for the better consideration about future load expansion etc., installation capacity shall be given with conforming to some availability and possibility for enough capacity in the future town glows, such are new house hold and/or industrial factory construction, also future connection to the national grid and/or new additional power station was installed.

  If 105-AL1/17-ST1A(HARE) 122.5 mm^2 (AL actual area 105 mm^2) was selected. The maximum allowable transmission current is 370 Arms, and the continuous maximum temperature limit is 90°C (80°C at 370 Arms with allowance, recommendation criteria)

  If the load amount reached to 10 MVA, line current is 192.5 Arms only, so supply capacity is 1.8 times, its allowable and enough transmission capacity.

  $$Transmission\ current = 10MVA/(\sqrt{3} * 30kV) = 192.46\ Arms < 370\ Arms\ (80°C)$$

- Short circuit current (distribution line transient current check by the transformer load side short calculation)

  The transformer secondary short circuit is the strictest condition about transient peak current on the distribution line.

  Following calculation result shall be given to the next detail design, such are protection device setting etc. (calculation parameter shall be changed at final detail design).

  1) Substation step up transformer : 3.96kAo-p (30kVbase)
  2) Pole transformer : 10.2kAo-p (30kVbase)
  3) Distribution line to line short (middle distance point) : 0.9kAo-p (30kVbase)

- 105-AL1/17-ST1A (HARE) 122.5 mm^2 (Aluminum area 105 mm^2) ; R0.273 * X0.323 (Ω/km)
- Transformers % impedance ; 5% (pole transformer ; 4%)
- Accident point of distribution line from power station ; 23 km
- All phase short condition.

(2) Support for Distribution Line (Pole and Insulator)

By several kind of the study, basic specification is as follows.

Pole	:	Iron Pole with mortar courting (estimation), 14 m over
Insulator	:	Maximum operation voltage 36 kV
Line distance	:	(It shall be defined at detail design stage)
Pole distance	:	135 m each at 30 kV (normal in Angola)
Others	:	Line post insulator has Arc horn

Basic design concept shall be selected as follows.

1) Distribution Pole

Usually using type of Luanda City shall be selected from the cost merit also easy supplying. These pole and support are normally used by EDEL. According to the EDEL information, 14 m type pole will be used for not only 15 kV distribution line but also 30 kV one.

On the line route, except the across point of the small river, there are almost no large scale obstacles, so all normal used parts type for distribution equipment in Angola shall be selected by transportation and cost merit.

2) Insulator (suspension and line post)

Usually using type of Luanda City is maximum voltage 12 kV per one unit shall be selected from the cost merit also easy supplying. So in case of 30 kV distribution, conformed with 36 kV by 3 units series connection similarly used in this country.

These pole and support are normally used by EDEL. According to the EDEL information, 14m type pole will often used for not only 15 kV distribution line but also 30 kV one.

Except the across the small river point on the line route, there are almost no large scale obstacles.

3) Line to Line distance

According to the regulation, 60 cm more must be needed under 30 kV line. At the detail design stage, further detail study shall be applied for several type of the suspension arm etc.

4) Pole distance

According to the regulation, minimum 135 m span is needed under 30 kV line pole

distance. At detail design stage, these distance shall be defined on actual b. So on this FS, it is considered only the number of the pole from simplified estimation by total distance per 135 m for cost estimation etc.

(3) Pole Transformer

1) Capacity of transformer

Capacity of distribution transformer shall be defined on the basic design concept.

<Current consumption load estimation>

- Total capacity is minimum 11,523 kVA
- Diversity factor; 1.25, power factor; 0.85, load per house hold (Muenga, Chimonga and Chicumbi Villages); 200W, Andulo City; 500 W (all assumption value)

Demand area	Popluation	Power consumption (kW)		Capacity (kVA)
Muenga	5,800/6 × 0.2kW =	193	193/1.25÷0.85	= 181
Chimonga	5,000/6 × 0.2kW=	167	167/1.25÷0.85	= 157
Chicumbi	4,810/6 × 0.2kW =	160	160/1.25÷0.85	= 150
Andulo city	142,712/6 × 0.5kW =	11,892	1,1892/1.25÷0.85	= 11,192
Sub total	158,322 persons			11,680 kVA

10 years later, population are supposed to increase in Andulo City 0.22 million people. So, it can be estimated as 1.5 time population growing for the other two villages in the Andulo Province too as follows.

<10 years later consumption load and respective installed capacity>

- Total capacity is minimum 16,182 kVA
- Diversity factor; 1.25, power factor; 0.85, load per house hold (Muenga, Chimonga and Chicumbi Village); 200W, Andulo City; 500 W (all assumption value)

Demand Area	Popluation	Power consumption (kW)		Capacity (kVA)
Muenga	5,800 × 1.5/6 × 0.2kW =290		290 /1.25÷0.85	= 272
Chimonga	5,000 × 1.5/6 × 0.2kW = 250		250/1.25÷0.85	=235
Chicumbi	4,810 × 1.5/6 × 0.2kW =240		240 /1.25÷0.85	= 225
Andulo city	200,000/6 × 0.5kW =	16,666	16,666 /1.25÷0.85	= 15,685
Sub total	237,483 persons			16,417 kVA

2) Specification of transformer

Specification of transformer shall be defined for scope of this study area, Muenga and Chicumbi Villages based on the estimation result from item c) 1).

Location site's land height is 1,600m, so the 1000m over. In Angola, there are no need to concerned to air insulation additional consideration about Busing etc. from the safety side design point of view, it must be clearly described on the specification as follows.

(a) Muenga, Chimonga villages

To consider the capacity of transformer 10 years later, basic specification of installed transformer is as following Table 4.3-9.

Table 4.3-9 Transformer Specification (Muenga Village)

Type	3ϕ, out-door, oil-immerse, self-cooling type, Δ-Y connection
Capacity	100kVA × 3 units
Typical voltage	Primary :30 kV Secondary: 400-230V
Location (land height)	1,000 m over

(b) Chicumbi village

To consider the capacity of transformer ten 10 years later, basic specification of installed transformer is as following Table 4.3-10.

Table 4.3-10 Transformer Specification (Chicumbi Village)

Type	3ϕ, out-door, oil-immerse, self-cooling type, Δ-Y connection
Capacity	100kVA × 3 units
Typical voltage	Primary :30 kV Secondary: 400-230V
Location (land height)	1,000 m over

(c) Andulo City

Whole Andulo City distribution line extending and pole transformer installation etc. is out of scope on this FS, so to be provided by Angola. Under the power factor 0.85 condition, also the whole city pole and its transformer is out of scope on this FS, so one end pole shall be installed as the final demanding point in Andulo City (near Airport, see Drawing No.T-007).

(4) Surge Arrester

Valve type and maximum operation voltage is 42 kV. Land height of this project site is 1,600m and lighting stroke often appeared in the rainy season, so this arrester's installation span shall be about 200~300m by 1 ~ 2 number of pole skipped.

(5) Protection Device

For protecting about the distribution line and its pole transformer, when earth fault trouble was occurred. Cut-out with fuse switch for primary side of its transformer and distribution circuit breaker for secondary side shall be installed.

(6) Low Voltage Distribution Line Wire

By several kind of the study, basic specification is as follows.

Distribution line wire	:	AAC Wire
Wire size	:	250 mm^2
Transmission voltage	:	400 - 230 V (operation voltage)
Distribution line length	:	1.5 km
Supply system	:	3ϕ 4 wire × 1cct
Support structure	:	Further study shall be done at detail design stage.

(7) Power Meter (Totalizer)

When the power station operation starts, power meters to check the demand consumption must be installed by CDM application reason on each distribution transformer output cable point. It shall be installed on the cable box at the bottom of each transformer installation pole. As for Andulo City side, whole pole transformer is out of scope, so Andulo City's power meter is out of scope of this FS, to be provided by Angola.

4.3.4 Preventive Work against Landmines

(1) Implemental Organization of Preventive Work against Landmines

1) Total controlling organization of landmine survey and clearance

As mentioned above Section 4.2.7, in planned hydro-electric power construction area, the material transportation and transmit electricity route of Andulo province - Chicumbi Village - Chimonga - Village - Muenga Village - Cutato River area (using terminology of "power transmission route" in relation to countermeasure construction of landmines) do not have a contamination map. Therefore, it is difficult to assume there are no landmine exists. In addition, for rehabilitating or strengthening bridges for material transportation to use route of Lobito - AltoHama - Cuito - Andulo - Chicumbi, it may assume the same condition. In such areas, based on "defend own self or (and) self defense", it will be required survey and landmine clearance before any construction proceeding. When we ask INAD for marking/survey and clearance, we need to send some professionals to supervise them. In such case, total controlling organization of

landmine survey and clearance will be followed as Fig. 4.3-10:

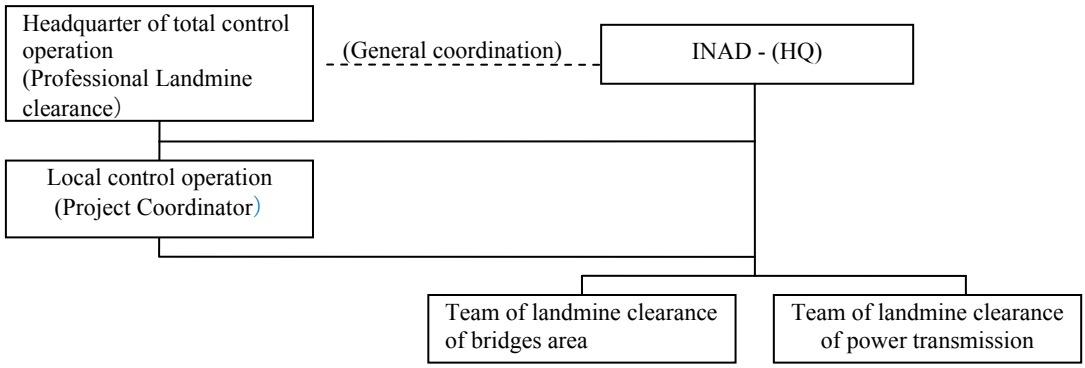


Fig.4.3-10 Controlling Organization of Landmine Survey and Clearance

2) Formation of headquarter for general control operation

Formation of headquarter for general control operation is allocated as a head of "Professional Landmine clearance". Following "Japanese and Portuguese translator" and one vehicle service with driver will be in Headquarter. In addition, "Project Coordinator" of local staffs and a vehicle service with driver will be allocated in control office of field work.

3) Survey and clearance organization for bridges area

Fig.4.3-11 shows planning, coordinating, controlling and adjusting will be implemented under a head of "Project Coordinator".

4

Survey and Clearance for bridges area

Project Coordinator × 1
Staff of Demining (EOD) × 3

Main equipments

Vehicle × 2, Metal detector × 3, Brush Cutter × 2, Motorola × 4,

Blast equipments

Fig.4.3-11 Survey and Clearance Organization for Bridges Area

4) Power transmission route of survey and clearing organization

Power transmission route of survey and clearance has 2 designed projects: demining by machine and by humans. It estimates Andulo Province has less severe landmines, which means to implement mainly survey than demining. Therefore, we conclude the security verification of survey by personnel would be effective. The power transmission route of survey and clearance organization will be shown in Fig.4.3.-12.

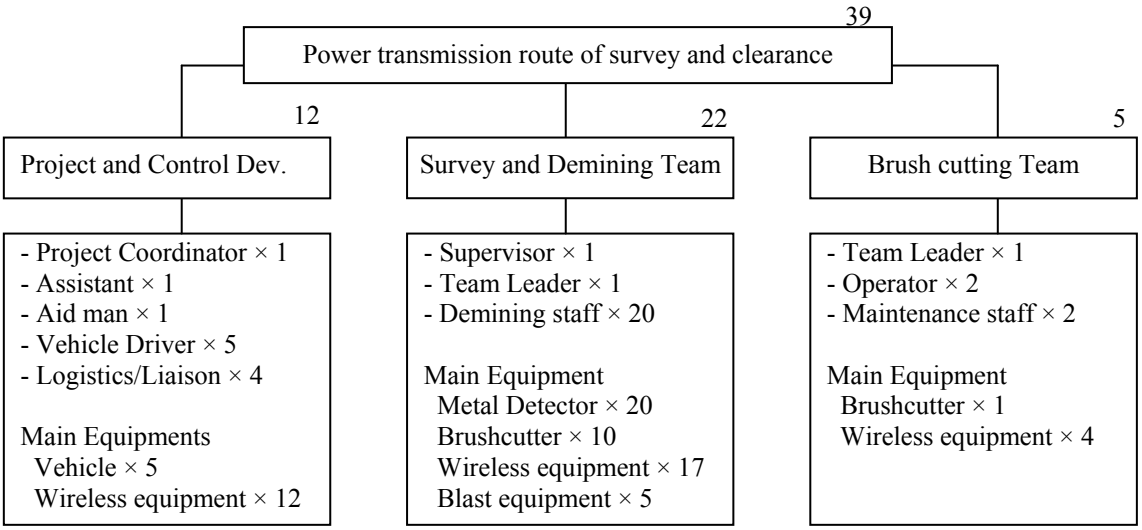


Fig.4.3-12 Power Transmission Route of Survey and Clearance Organization

(2) Area Calculation of Survey and Clearance

1) Survey and clearance for bridges area

From the port of Lobit to planned hydro-electric construction area, we can use the route of Lobito - AltoHama - Cuito - Andulo - Chicumbi to deliver material transportation. However, tome bridges need to strength to pass semi-trailer (including 40 ton class). Estimated number of bridges for strength will be 10. For instance, if the bridge has 30 m width × 100 m depth, total area of bridge survey and clearance will be 30,000 m^2.

2) Survey and clearance for power transmission route area

For the construction of power transmission from Andulo to Chicumbi (14 km distance), it needs 2m width area for being leveled next to the existing road. To make a road will be required survey and clearance. Therefore, area for survey and clearance will be 2m × 14,000m = 28,000 m^2.

The existing narrow road (distance 29 km) between Chicumbi Village - Chimonga Village - Muenga Village - Cutato River area (Planned power transmission construction area) needs to make additional 5 m new road next to the existing road to deliver heavy machines. In addition to that, we will build 2 m width road next to additional one. Therefore, the total area of survey and clearance will be 7 m × 29,000m = 203,000 m^2.

Moreover, temporary facility site (7,000 m^2) for survey and clearance will be required.

Total area of survey and clearance for power transmission route will be 238,000 m^2.

4.4 Construction Plan and Schedule

4.4.1 Basic Conditions

Basic condition of construction plan and schedule is to intend early construction work starting and early operation beginning. Because term of electrical mechanical works is the longest term, so other term of civil works and distribution line works are planned in term of electrical mechanical works.

Main works is executed after land-mine investigation and removal work.

4.4.2 Mines

(1) Required Working Month

1) Execution scheme for survey and clearance of bridges area

It is estimated that 2 days for the execution scheme for survey and clearance of bridges area. To be considered for dispose and back up can be summarized, as follow:

Name of Province	Area for needed strength	Needed Preparation date	Implementation day	Dispose and back up day	Estimated total number of day
Benguila	2	1	4	2	7
Huambo	3	1	6	2	9
Bie	5	1	10	5	16
Total	**10**	**3**	**20**	**9**	**32**

Requirement date set as 32 days and operational date set as 20 days/month. Therefore the execution scheme needs 1.6 month.

2) Execution scheme for survey and clearance for power transmission route area

Request for registration

Area of survey and clearance by deminer (set as 1 person) per day	100m × 1.5m = 150m^2
Area of survey and clearance by demining unit (set as 20 persons) per day	150m^2 × 20 persons = 3,000m^2
Area of survey and clearance per week	3,000m^2 × 5 day/week = 15,000m^2
Requirement week of survey and clearance	238,000 / 15,000m^2 = 16 weeks
Preparation / Clean up	One week before/after execution

Estimate the dispose and back up date for a week before and after operation, requirement for total survey and clearance will be 18 weeks = 4.5 months

(2) Construction Schedule

Schedule of these countermeasures is shown in below.

	Month 1	Month 2	Month 3	Month 4	Month 5
Head of Control Office (professional deminer) (Project Coordinator)	Guide in Angola	Guide in Japan		Guide in Angola	
	Guide in Angola				
Survey and clearance for Bridges area					
Survey and clearance for power transmis-sion route area					

4.4.3 Schedule of Main Works

Main works consist of civil works, electrical mechanical and distribution line works.

(1) Civil Works

Basic condition of civil works schedule is following.

1) Term of civil works and distribution line works is less than 20 months which is the term of designing, manufacturing and transporting electrical mechanical works because of intending early operation beginning.

2) River works in civil works are planned at dry season because it is good for river work that river discharge is a few. Fig.4.4-1 shows river discharge at Cutato HPS site, it's calculated by using data at Cambambe site (refer to Table 4.1-3). Period of river works becomes from May to January (river discharge is less than 80 m^3/s). Other works have no limitation in construction period.

Catchment area at Cambambe Site 121,470 km^2

Cathcmnet area at Cuato HPS Development Site 9,400 km^2

(Unit : m^3/s)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Average discharge at Cambambe Site	1,004.8	1,255.6	1,619.5	1,608.3	959.0	531.7	376.0	305.5	254.3	277.6	418.7	665.6	773.1
Average discharge at Cutato HPS Site	77.8	97.2	125.3	124.5	74.2	41.1	29.1	23.6	19.7	21.5	32.4	51.5	59.8

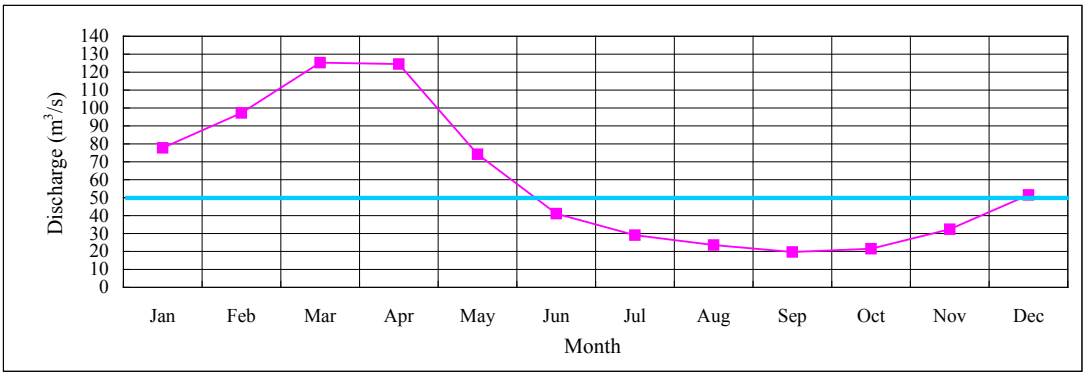


Fig. 4.4-1 River Discharge (Cutato HPS site)

3) Term of designing, manufacturing and transporting flap gates, penstock and draft tube is about 1 year. So the installation of these equipments is about 1 year after contract.

4) Big branch of river is topographical characteristics of this site. Structure in left tributary is only left side weir and structures in right tributary are many for example, right side weir, intake, powerhouse outlet and etc. Construction is separately made by easily changing river discharge from left tributary to right tributary. At first right side construction works are made because there are many works in right tributary.

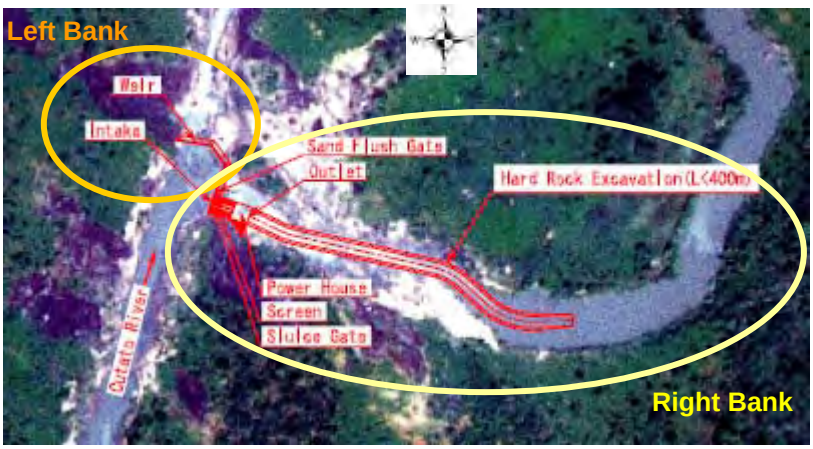


Fig.4.4-2 Construction Area

Table 4.4-1 shows schedule of civil works based on above condition.

(2) Electro-Mechanical Works

The schedule for electro-mechanical works is as follows;

- Design, Manufacture and Delivery:	20 months
- Installation:	3 months
- Test, Adjustment and Operation Guidance:	1 month
Total:	24 months

(3) Distribution Line Works

Distribution line works will be 6 months including laying operation of distribution lines, examination period.

(4) Schedule of Main Works

The Schedule of main works is shown in Table 4.4-2.

Table 4.4-1 Construction Schedule of Civil Works

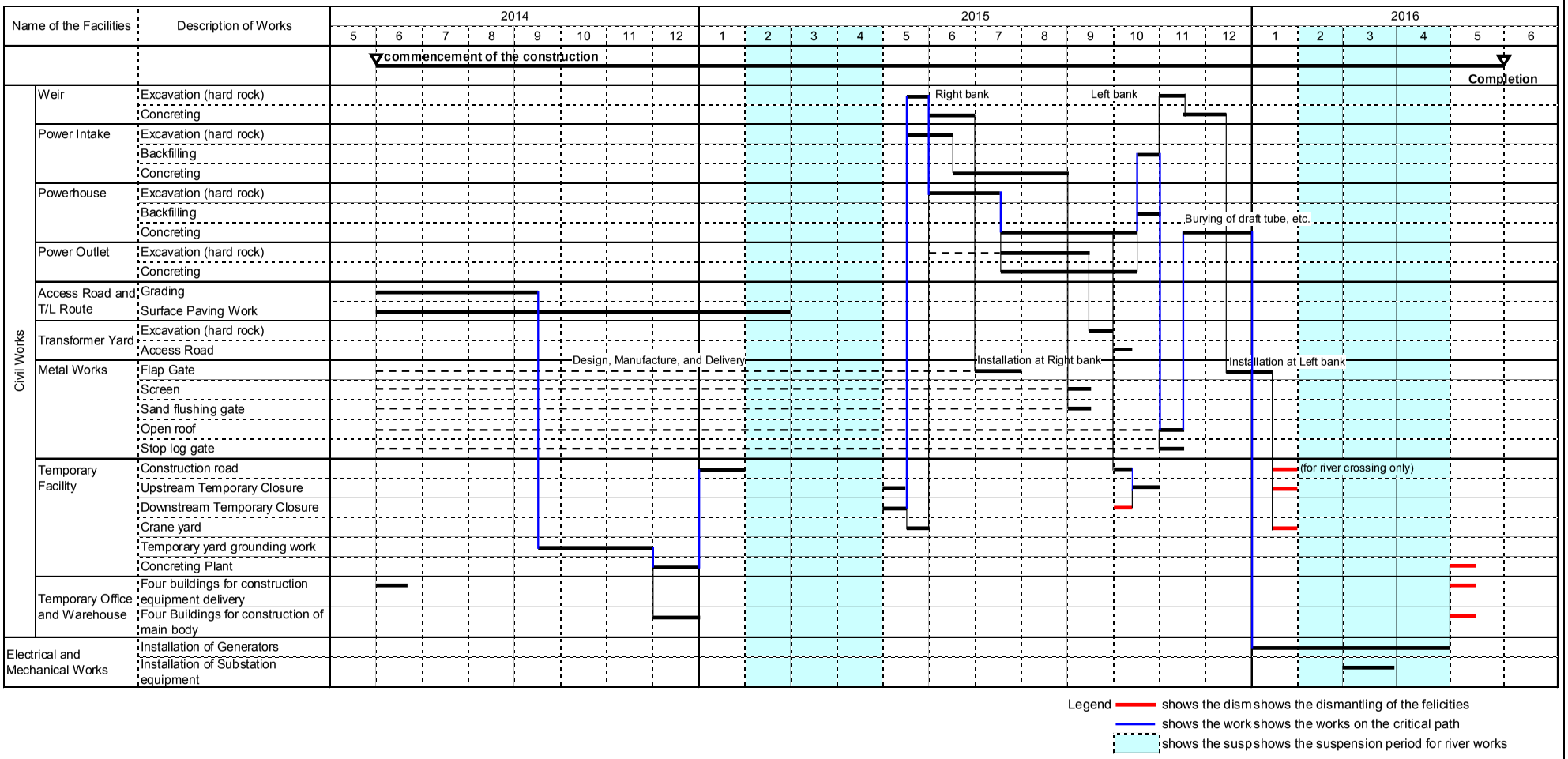
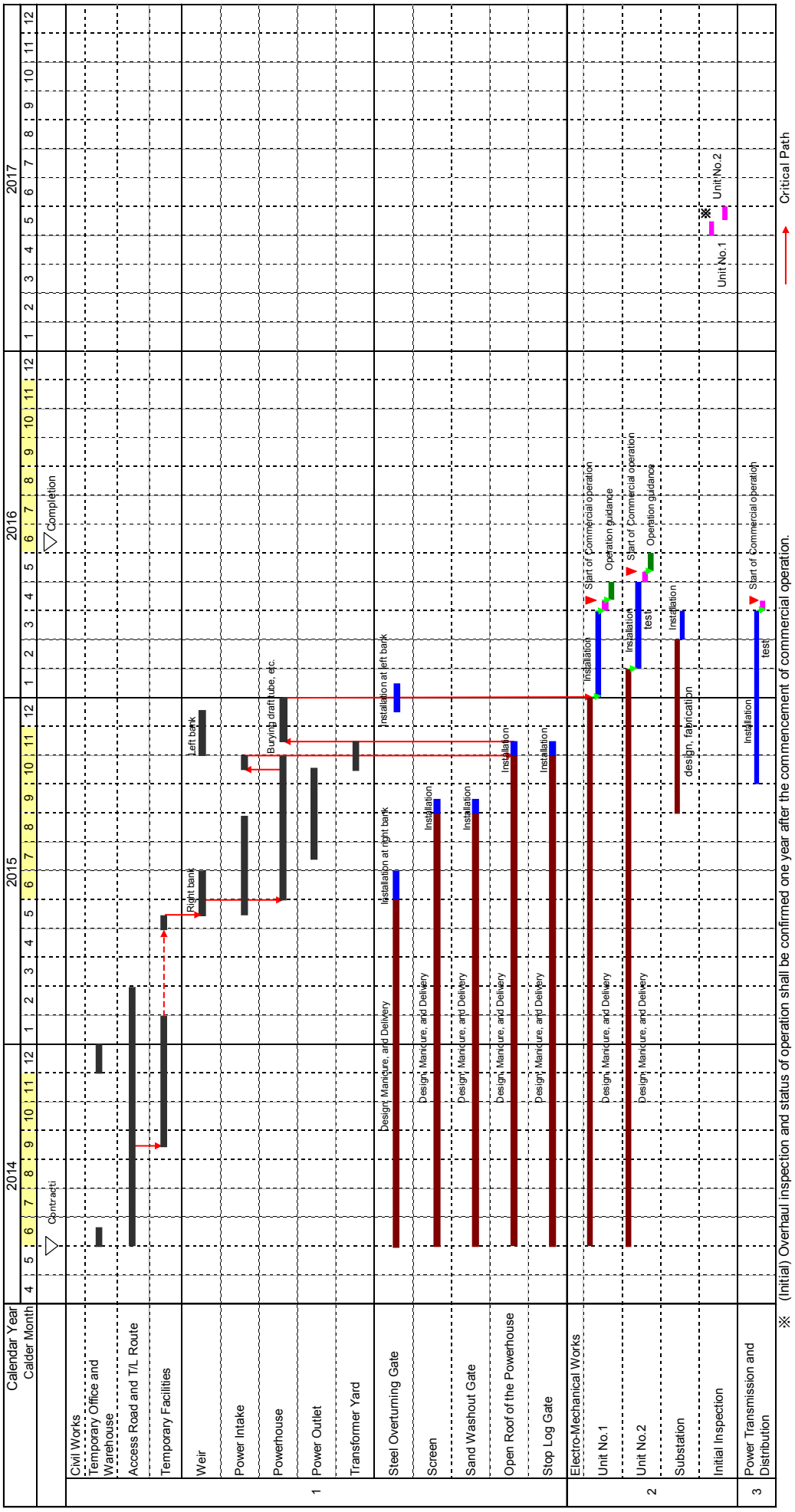


Table 4.4-2 Construction Schedule of Main Works



4.5 Project Implementation Plan

4.5.1 Basic Conditions

Basic conditions for project implementation plan are shown below.

- Loan Agreement time is supposed at the end of November 2011.
- Each term of proceeding procedure are following.

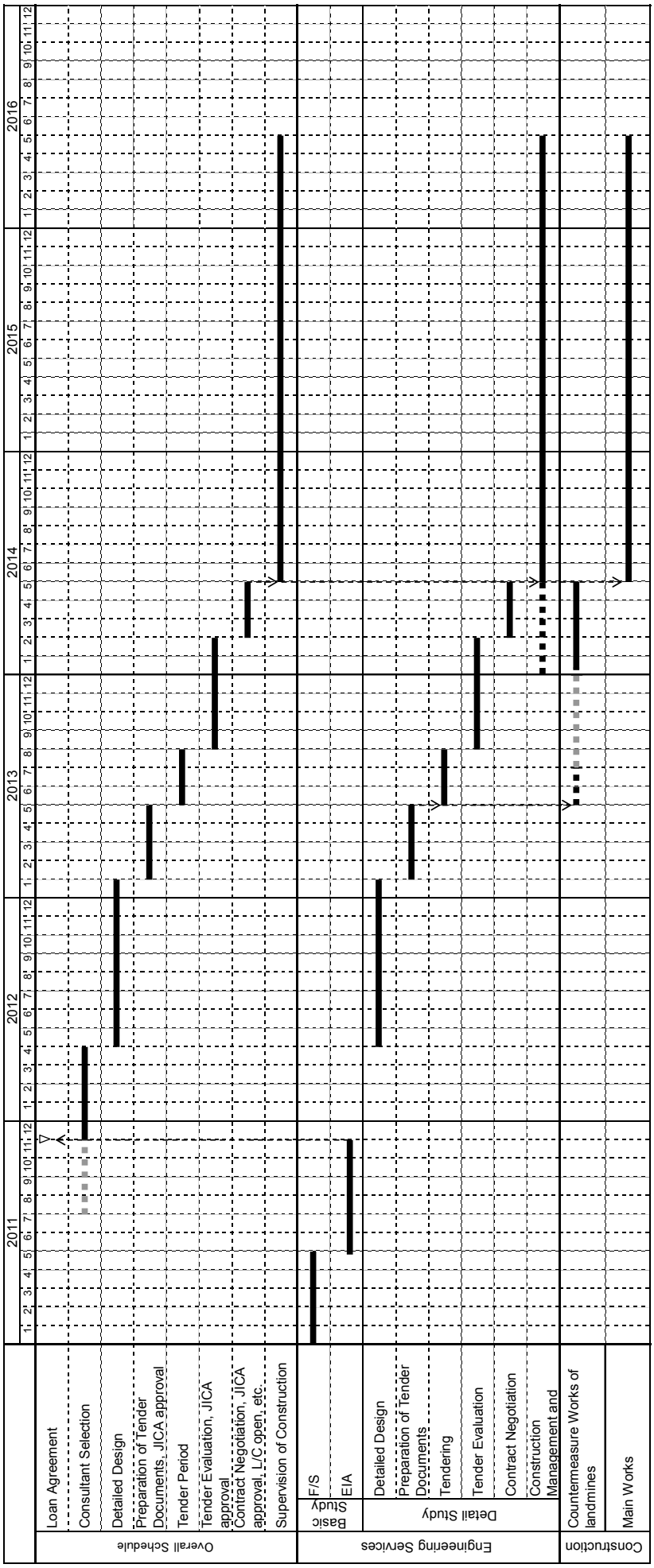
a) Consultant selection	5 months	
b) Detailed design	9 months	Commencement of main works is June 1, 2014.
Preparation of tender documents, JICA approval	4 months	
Tender period	3 months	
Tender evaluation, JICA approval	6 months	
Contract negotiation, JICA approval, L/C open etc.	3 months	
Total	30 months	

- Basically, proceeding procedure is started after advance notice (Pledge) to GOA.

4.5.2 Basic Schedule

Basic schedule consists of 2 works (demining work and main work), which is shown in Section 4.4, and above basic conditions. Table 4.5-1 shows basic schedule.
Table 4.5-1 shows schedule that both works are proceeded in parallel until preparation of tender document, but after tender, each work is carried on along each schedule, for starting earlier construction work forward earlier operation.

Table 4.5-1 Basic Schedule



4.5.3 Schedule of CDM Registration

CDM schedule is mapped out below.

(1) Prior consideration of CDM

In consideration of requests for registration of the project, EB takes notes that the issue of prior consideration of the project as a CDM project is a major element in substantiating the additionality whether the CDM benefits to the project were considered or not.

Accordingly, at the stage of the investment decision of the project, it shall be considered the CDM benefits to the project comparing the situations with and without CDM.

"Guidelines on the Demonstration and Assessment of Prior Consideration of the CDM"[11] introduces the guidance on the means of demonstrating compliance with this requirement. As to the Greenfield project, the guidelines determine: "The Board decided that for project activities with a starting date on or after 02 August 2008, the project participant must inform a Host Party DNA and the UNFCCC secretariat in writing of the commencement of the project activity and of their intention to seek CDM status. Such notification must be made within six months of the project activity start date and shall contain the precise geographical location and a brief description of the proposed project activity, using the standardized form F-CDM-Prior Consideration. Such notification is not necessary if a PDD has been published for global stakeholder consultation or a new methodology proposed to the Executive Board for the specific project before the project activity start date."

The starting date of the project, in other words the date implementation of the project is decided, is supposed to be the date when the loan agreement is contracted between Japanese and Angola's government.

Consequently, the prior consideration shall be notified to the Angola's DNA and UNFCCC in 6 months after the contraction date of loan agreement between Japanese and Angola's government in the document form.

(2) PDD, PCN and PIN

The project owner takes responsibility over the making of PDD, PCN and PIN after the completion of the project detailed design. The latest PDD format of small scale CDM and the latest version of methodology are available by the UNFCCC website; the project shall be described correctly in the PDD based on the guideline. PCN and PIN shall be made following to the Angola's DNA.

[11] EB49 Report Anx22

The attached draft PDD is available as the reference of the official PDD. It shall be noticed that the draft PDD is based on the information at the stage of feasibility study, in brief some parts are just the estimation, not the formal information; therefore some parts should be revised according to the detailed design, environmental impact assessment and the guidance of EB after this.

(3) Acquisition of LoA from Angola's and Japanese Government

The LoA shall be acquired from both Angola's and Japanese government as the government of the host party and Annex I party.

The approval process in Angola can be referred from (2) in this Chapter.

The project use Yen Loan from Japanese Government; it is also need to be acquired the evidence that the financing is neither an appropriation of ODA nor any financial obligations of Japan as same as the LoA from Japanese Government.

(4) Validation

"Validation" shall be carried out by DOE after the PDD completed. The project participant (the project owner or credit buyer) selects the DOE which is appropriate to the project and submits the PDD completed.

Firstly, the PDD shall be checked by DOE primary and then the PDD would be opened on the UNFCCC website for 30 days (called "public comment") to receive comments from those public like signatory parties of Kyoto Protocol, stakeholders, approved NGO and others during the period; after the public comment, the DOE proceeds more detailed check conducting on-site survey and desk review whether it meets those requirements provided in Kyoto Protocol, EB or other related rules, and lastly the survey result would be completed as a Validation Report and then submitted to EB and opened to public.

(5) Request for Registration

The procedure of request for registration to UNFCCC is conducted through DOE.

UNFCCC shall conduct completeness check of the submitted documents and confirm the information, then open them to public. After that the project would be registered as CDM project unless party involved in a proposed CDM project activity or at least 3 EB members request a review of the request for registration.

No registration fee has to be paid for the project since the project is hosted in Angola, one of the least developed countries.

The crediting period of the project is the latest date at which either the official operation started or the project registered; therefore it is better the completion of the construction and the project registration come around the same date.

(6) Monitoring, Verification, Certification and Issuance of CERs

After the registration of the project, it is required to monitor the listed parameters in the PDD and then the monitoring result shall be verified and certified by DOE regularly.

The monitoring parameters of the project are the amounts of gross electricity generated and the supplied electricity to users; those data shall be recorded and kept for making up in a monitoring report on the responsibility of the project owner. The report shall be uploaded on the UNFCCC website and opened to public by DOE; the DOE would verify those documents and evidences provided by the project participant whether it meets the PDD and other requirements. The DOE would conduct on-site survey as required for confirming the credibility of recorded data or testing the accuracy of monitoring equipments. After passing those steps, the DOE certifies the amount of emission reduction as CER completing and publishing the verification and certification reports.

Any procedures for issuance of CER to UNFCCC secretariat shall be preceded by DOE.

UNFCCC secretariat conducts completeness check and after that makes those documents available on the UNFCCC website: the verification and certification reports submitted from the DOE. In keeping those processes, CER would be issued unless any of those parties involved in the project or at least 3 members of EB request review of the proposed issuance of CER; in case any of them request a review, EB reconsiders the proposed issuance of CER.

The project owner shall continue to conduct the above procedures regularly for issuing CER at every term during the crediting period; therefore it is expected to create a long-lasting monitoring system and supporting scheme from CDM consultant for making the every CER issuance smoothly.

(7) Renewal of Crediting Period

The project chooses a renewal crediting period, a maximum of 7 years which may be renewed at most 2 times. It is required to revise baseline for renewing the crediting period at each time of renewal.

The project owner shall revise the original PDD especially the baseline, estimation of emission reduction and monitoring plan comparing to the latest version of the methodology for about 1 year prior to the end of each crediting period. The revised PDD and the selected DOE shall be notified to UNFCCC secretariat within 9 to 6 months prior to the date of

expiration of each crediting period. If the notification of the intention to request a renewal of a crediting period is not received by the secretariat 6 months prior to the date of expiration of the current crediting period, the project participant shall not be entitled to the issuance of certified emission reductions for the period from the expiration date of the crediting period until the date on which the crediting period is deemed renewed.

DOE would valid the credibility of the baseline based on the revised PDD then request to the secretariat for renewal of crediting period; the secretariat conduct the completeness check on those documents. Once the secretariat has determined that the request is complete it shall be made publicly available through the UNFCCC website for a period of 4 weeks. Unless there is a request for review within four weeks after the publication of the request for renewal, the crediting period of the registered CDM project activity shall be deemed renewed.

Table 4.5-2 Time Schedule by the Registration (planed)

4.6 Project Cost

4.6.1 Basic Conditions

(1) Exchange Rate (Effective Digit is 3 Figures)

Average value in 2010 (Central bank of Angola)

① JPY/$ US$1 = 87.6¥

② Kz/$ US$1 = 91.9Kz

③ JPY/Kz Kz1 = 0,953¥

(2) Price Escalation Rate (including engineering service)

① Foreign currency 0.0 %/year

② Local currency 10.0 %/year

(3) Physical Contingency Rate

Physical contingency is set at 3% of the base cost basically. However, the rate for civil related work is set at 5% because civil work has an unforeseeable condition, such as geological condition.

(4) Spare Parts

Project cost includes at least 2 years budget of spare parts because of importance of operation and maintenance.

(5) Base Cost Estimating Time

February 2011

(6) Project Cost Estimating Procedure

① Base cost estimation

② Base Cost × Price Escalation Rate

③ (① + ②) × Physical Contingency Rate

④ Total Cost = ① + ② + ③

Consultant Services Cost includes its Price Escalation and Physical Contingency, Total Contingency excludes those.

(7) Base of Annual Fund Requirement

Calendar Year (from January to December)

4.6.2 Countermeasure Work for Landmines

The personnel in charge of the countermeasure work for landmines consist of the local personnel who execute the work and the Japanese personnel supervising the work undertaken by the local personnel. The personnel in charge of the countermeasure work in Angola and the necessary local personnel are shown below together with their monthly rates.

- Coordinator: $ 2,000/month
- Assistant: $ 1,500/month
- Supervisor: $ 1,000/month
- Team Leader: $ 900/month
- Aid Man: $ 700/month
- Operator: $ 700/month
- Vehicle Driver: $ 650/month
- Logistics/Communications: $ 500/month
- Maintenance: $ 700/month
- Deminers: $ 500/month

(1) Expenses of Total Controlling Center

Experts who will check and supervise the countermeasure work for the landmines to be done by local personnel will be necessary. These works will be carried out by Japanese experts and their local assistants.

Japanese experts: Professional deminer, (one person)
Local Assistants: Coordinator (one person) and Vehicle Driver (two persons)

This expense includes an expense for vehicle and a general and administrative expense in addition to labor costs, travel expenses and local accommodation expenses. The rate of the general and administrative expense is 15%.

(2) Expenses for Survey and Clearance of Bridge Areas

Surveys and clearance work at the bridges areas will be executed by one local coordinator and 3 members of the demining team of Angola, and the time need to complete the work is 1.6 months.

In addition to their labor cost, a pick up model vehicle and such other materials and equipment as miscellaneous materials and equipment, blasting materials, consumables, etc. will be required. The pick up model vehicle will be provided by the landmines countermeasures implementation authority of Angola, and therefore only the fuel cost will be

included as expenses. Other materials and equipment will be estimated at 20% of the labor cost and vehicle fuel cost.

(3) Expenses for Survey and Clearance of Power Transmission Route Areas

It will take three (3) months for transportation of materials, surveys and clearance of the landmines along the power transmission line route and these work requires a coordinator (one person), an assistant (one person), a supervisor (one person), team leaders (two persons), aid man (one person), operators (two persons), vehicle drivers (five persons), communication personnel (four persons), maintenance (two persons), deminers (twenty persons). The same principle of cost calculations is used as in the case of expenses for survey and clearance of bridge areas.

The total cost necessary in items (1), (2) and (3) is twenty-six million JPY as shown in Table 4.6-1, which consists of the foreign currency portion of 7.5 million JPY and the local currency portion of 18.5 million JPY.

Table 4.6-1 Expenses for Countermeasure Work of Landmines

1 US$ = 87.6 JPY

Expenses for Countermeasure Work of Landmines in Equivalent Yen: JPY 26,241,751 Breakdown of Expenses for Countermeasure Work for Landmines: JPY 7,501,220 and 213,933 $						
1	**Expense of Total Controlling Center**		**7,501,220**	**JPY**	**60,375**	**$**
	1.1 Labor Cost	Professional Deminer	1,260,000	JPY		
		Japanese/Portuguese Translator	1,050,000	JPY		
		Coordinator			9,000	$
	1.2 Travel Expenses for Japanese	Professionals/Translator	4,000,000	JPY		
	1.3 Local Accommodation for Japanese	Professionals/Translator			11,000	$
	1.4 Daily Allowance for Japanese	Professionals/Translator	212,800	JPY		
	1.5 Accommodation for Local Staff	Coordinator			4,500	$
	1.6 Expense for Vehicles	Vehicle (1)			5,500	$
		Vehicle (2)			22,500	$
	1.7 General and Administrative Expense	15% of Total of 1.1 to 1.7	978,420	JPY	7,875	$
2	**Expense for Survey and Clearance of Bridge Areas**				**7,488**	**$**
	2.1 Labor Cost	Coordinator			3,200	$
		Deminers			2,400	$
	2.2 Vehicle/Machine Fuel	Pick up Model Vehicle			640	$
	2.3 Other Facilities, Blasting Equipment, Consumables, Reports, Etc.	20% of Total of 2.1 and 2.2			1,248	$
3	**Expenses for Survey and Clearance of Power Transmission Route Area**				**146,070**	**$**
	3.1 Labor Cost	Coordinator			9,000	$
		Assistant			6,750	$
		Supervisor			4,500	$
		Team Leader			8,100	$
		Aid Man			3,150	$
		Operator			6,300	$
		Vehicle Driver			14,625	$
		Communications			9,000	$
		Maintenance			6,300	$
		Aid Man			45,000	$
	3.2 Vehicle/Fuel	Brushcutter			4,500	$
		Pick up Model Vehicle			4,500	$
	3.3 Other Facilities, Blasting Equipment, Consumables, Reports, etc.	20% of Total of 3.1 and 3.2			24,345	$

4.6.3 Civil Work

At first, Japanese unit prices of civil works are estimated by using Japanese Cost Estimated Criteria, and Angolan unit prices of civil works are estimated by using prices difference between Japan and Angola.
It becomes direct cost of each work that Angolan unit price is multiplied by quantity of civil work.
Indirect cost consists of field management cost and general administration.

Iron bar, metal and construction machine are imported from overseas, and other material and equipment are prepared in domestic.
So local currency portion consists of ① labor cost, ② material cost excluding iron bar and metal, ③ fuel oil, ④ miscellaneous, and foreign currency portion consists of ① material cost of iron and metal, ② construction machine cost (including transporting cost), ③ transportation cost of iron bar and metal.

Table 4.6-2 shows detail of civil works, total cost of civil works is 1,351 million JPY.

Table 4.6-2 Civil Work Cost

Description		Base Cos (Million JPY)		
		Local Currency	Foreign Currency	Total
1	Access Road and T/L Routes	53.9	82.2	136.1
2	Temporary Office and warehouse	198.2	14.2	212.4
3	Temporary Facilities	50.5	64.7	115.2
4	Power Intake	33.2	57.3	90.5
5	Weir	14.8	21.9	36.7
6	Powerhouse	52.3	96.2	148.5
7	Power Outlet	16.2	49.8	66
8	Transformer Yard	1.2	5.6	6.8
9	Steel Overturning Gate	12.5	423.8	436.3
10	Screen	0.6	18.5	19.1
11	Sand Washout Gate	0.1	1.1	1.2
12	Open Roof of the Powerhouse	0.6	18.7	19.3
13	Stop Log Gate	0.7	27	27.7
14	Metal Transportation	0.0	35.3	35.3
Total Cost		**434.8**	**916.3**	**1351.1**

4.6.4 Electro-Mechanical Works

The price of equipments such as water turbines, generators, and electric transformers etc. will be estimated based on the estimated amount by Japanese manufacturer who has experiences of construction works in foreign countries.
As a result below, the cost of electro-mechanical works is to be 1,411 million JPY.

Table 4.6-3 Cost for Electro-Mechanical Works

Item	Cost (M. YEN)	Home currency	Foreign currency	Remarks
Turbine	838	42	796	2 units of S-type Tubular type
Generator	429	21	408	1700 kVA × 2 units (6.6 kV)
Transformer	105	5	100	3400 kVA (6.6 kV/33 kV)
Others	39	2	37	
Total	**1,411**	**70**	**1,341**	

4.6.5 Distribution Line Works

(1) High Voltage Distribution Line work

30 kV distribution line cost is calculated by reference to estimated amount of distribution line works of distribution line companies in Angola and track record of Japanese electric company.

- 12,600,000 JPY / km (ACSR 120 mm^2) × 46 km = 579,600,000 JPY

And above the construction cost of high voltage distribution is 579.6 million JPY. The cost is estimated local currency, 90% (521.6 million JPY) and foreign currency, 10% (58 million JPY) supposing that the site work mainly consists of local machinery and material.

(2) Low Voltage Distribution Line Work

400 - 230 V distribution line cost is calculated by reference to estimated amount of distribution line works of distribution line companies in Angola and track record of Japanese electric company.

Low voltage distribution line: 5,900,000 JPY/km (AAC250 mm^2) × 7 km = 41,300,000 JPY

Pre-paid WHmeter : 21,000,000 JPY (single; 2,100 households, three phases; 50 households)

And above the construction cost of low voltage distribution is 62.3 million JPY. It consists of local currency, 90% (56.1 million JPY) and foreign currency, 10% (6.2 million JPY) supposing that the site work mainly consists of local machinery and material.

(3) Total Amount of Distribution Line Construction Cost

Total amount of distribution line construction cost is 641.9 million JPY and it consists of local currency, 577.7 million JPY and foreign currency, 64.2 million JPY.

4.6.6 Base Cost for Construction

Based on the aforementioned discussions, the base cost for construction is estimated 3,430 Million JPY as summarized in Table 4.6-4.

Table 4.6-4 Summary of Base Cost for Construction

Work Items		Base Cost (Mil. JPY)
1	Land-mine investigation and Removal	26
Main Works		3,342
2	Civil Works	1,351
3	Electro-Mechanical Works	1,411
4	Associated Distribution Line	642
Total Base Cost for Construction		3,430

4.6.7 Price Contingency

Taken account of the escalation rate of CPI in Angola described in Section 2.1.1, price escalation rate for local currency portion is set 10 % per annum. On the other hand, price escalation rate for foreign currency portion is set 0% in consideration of CPI in Japan.

The price contingency is calculated by the following formula.

$$Price\ Contingency = Base\ Cost \times (1 + R)^T - Base\ Cost$$

Where: R: Annual escalation rate (= 10%)
T: Median of the objective work (Year & Month)
– Base Year of the Cost Estimation (end of February 2011) (Year)

Based on the above calculation formula, price contingency for local currency and foreign currency portions are estimated 510 Million JPY and 0 Million JPY respectively. Therefore, the total price contingency is estimated 510 Million JPY.

4.6.8 Physical Contingency

Physical contingency for civil work including access road and distribution line routes is set 5% because excavation and concrete volume will be changeable subject to the geological conditions. Physical contingencies for other works such as metal work, electric-mechanical work and associated distribution line are set 3 %.

The physical contingency is calculated by the following formula.

$$Physical\ Contingency = (Base\ Cost + Price\ Contingency) \times physical\ contingency\ rate\ (\%)$$

Based on the above calculation formula, physical contingency for local currency and foreign currency portions are estimated 54 Million JPY and 75 Million JPY respectively. Therefore, the total physical contingency is estimated 129 Million JPY.

4.6.9 Consultant Service Fee and Administration Cost

Consultant Service Fee is assumed 6.0% of construction cost (Base Cost + Contingencies) and resulted in estimation of 244 Million JPY. Breakdown of Consultant Service Fee is assumed 40 % for local currency portion and 60% for foreign currency portion referring to the foregone projects.

Administration cost for the project owner is also assumed 2.5% of the construction cost and resulted in estimation of 102 Million JPY.

4.6.10 Project Cost

Based on the above estimation, the project cost is estimated 4,416 Million JPY as shown in Table 4.6-5.

Table 4.6-5 Breakdown of Project Cost

Exchange Rate 1 US$= 91.9 Kz = 87.6 JPY 1 Kz = 0.953 JPY

Cost / Work Item		Base Cost	L/C	F/C	L/C Portion (Million JPY)							F/C Portion (Million JPY)							Total Cost
					Base Cost	Price Contingency			Physical Contingency		Subtotal	Base Cost	Price Contingency			Physical Contingency		Subtotal	
		Million JPY	%	%	Million JPY	%	Years	Amount	%	Amount		Million JPY	%	Years	Amount	%	Amount		Million JPY
1	Land-mine investigation and removal	26.2	71%	29%	18.7	10%	2.5	5.0	5%	1.2	24.9	7.5	0%	2.5	0.0	5%	0.4	7.9	32.8
2	Civil Work	1351.1			434.8			186.3		23.5	644.6	916.3			0.0		33.0	949.3	1593.9
2.1	Civil Work	812.2			420.3			179.9		23.0	623.2	391.9			0.0		18.3	410.2	1,033.4
2.1.1	Access road and D/L route	136.1	40%	60%	53.9	10%	3.6	22.1	5%	3.8	79.8	82.2	0%	3.6	0.0	5%	4.1	86.3	166.1
2.1.2	Temporary office & warehouse	212.4	93%	7%	198.2	10%	3.6	81.1	3%	8.4	287.7	14.2	0%	3.6	0.0	5%	0.7	14.9	302.6
2.1.3	Temporary facilities	115.2	44%	56%	50.5	10%	3.8	22.0	3%	2.2	74.7	64.7	0%	3.8	0.0	3%	1.9	66.6	141.3
2.1.4	Power intake	90.5	37%	63%	33.2	10%	4.0	15.4	5%	2.4	51	57.3	0%	4	0.0	5%	2.9	60.2	111.2
2.1.5	Weir	36.7	40%	60%	14.8	10%	4.0	6.9	5%	1.1	22.8	21.9	0%	4	0.0	5%	1.1	23.0	45.8
2.1.6	Powerhouse	148.5	35%	65%	52.3	10%	4.0	24.3	5%	3.8	80.4	96.2	0%	4	0.0	5%	4.8	101.0	181.4
2.1.7	Power outlet	66.0	25%	76%	16.2	10%	4.0	7.5	5%	1.2	24.9	49.8	0%	4	0.0	5%	2.5	52.3	77.2
2.1.8	Transformer yard	6.8	18%	82%	1.2	10%	4.0	0.6	5%	0.1	1.9	5.6	0%	4	0.0	5%	0.3	5.9	7.8
2.2	Metal Work	538.9			14.5			6.4		0.5	21.4	524.4			0.0		14.7	539.1	560.5
2.2.1	Steel overturning gate	436.3	3%	97%	12.5	10%	3.8	5.5	3%	0.5	18.5	423.8	0%	3.8	0.0	3%	12.7	436.5	455.0
2.2.2	Screen	19.1	3%	97%	0.6	10%	3.9	0.3	3%	0.0	0.9	18.5	0%	3.9	0.0	3%	0.6	19.1	20.0
2.2.3	Sand washout gate	1.2	8%	92%	0.1	10%	3.9	0.0	3%	0.0	0.1	1.1	0%	3.9	0.0	3%	0	1.1	1.2
2.2.4	Open roof of the powerhouse	19.3	3%	97%	0.6	10%	4.0	0.3	3%	0.0	0.9	18.7	0%	4.0	0.0	3%	0.6	19.3	20.2
2.2.5	Stop log gate	27.7	3%	98%	0.7	10%	4.0	0.3	3%	0.0	1	27.0	0%	4.0	0.0	3%	0.8	27.8	28.8
2.2.6	Metal Transportation	35.3	0%	100%	0.0	10%			0%			35.3	0%	0.0	0.0	0%	0	35.3	35.3
3	Electric-Mechanical Work	1,411.0			70.0			34.5		3.1	107.6	1,341.0			0.0		40.2	1,381.2	1,488.8
3.1	Turbine	838.0	5%	95%	42.0	10%	4.2	20.7	3%	1.9	64.6	796.0	0%	4.2	0.0	3%	23.9	819.9	884.5
3.2	Generator	429.0	5%	95%	21.0	10%	4.2	10.3	3%	0.9	32.2	408.0	0%	4.2	0.0	3%	12.2	420.2	452.4
3.3	Transformer	105.0	5%	95%	5.0	10%	4.2	2.5	3%	0.2	7.7	100.0	0%	4.2	0.0	3%	3.0	103	110.7
3.4	Other Auxiliaries	39.0	5%	95%	2.0	10%	4.2	1.0	3%	0.1	3.1	37.0	0%	4.2	0.0	3%	1.1	38.1	41.2
4	Associated Distribution Line	641.9			577.7			284.4		25.9	888.0	64.2			0.0		1.9	66.1	954.1
4.1	High Voltage Distribution Work	579.6	90%	10%	521.6	10%	4.2	256.8	3%	23.4	801.8	58.0	0%	4.2	0.0	3%	1.7	59.7	861.5
4.2	Low Volatge Distribution Work	62.3	90%	10%	56.1	10%	4.2	27.6	3%	2.5	86.2	6.2	0%	4.2	0.0	3%	0.2	6.4	92.6
Total Construction Cost		3,430.2			1,101.2			510.2		53.7	1,665.1	2,329.0			0.0		75.5	2,404.5	4,069.6
5	Consultant Service Fee (6.0% of Construction Cost)		40%	60%							97.7							146.5	244.2
6	Administration (2.5% of Construction Cost)		100%	0%							101.7							0.0	101.7
Total Project Cost		3,430.2			1,101.2			510.2		53.7	1,864.5	2,329.0			0.0		75.5	2,551.0	4,415.5

注：Price contingency は各工程計画の中央値で算出した。

4.6.11 Cost Reduction Measures

Table 4.6-6 shows cost reduction measures in this project.

Project Name : The Preparatory Survey on Rural Electrification Development Works in Angola
F/S Executed Period : from August 2010 to January 2012
Initial Project Cost : 5,920 million JPY
Project Cost after Cost Reduction Measures : 4,420 million JPY

Table 4.6-6 Cost Reduction List reviewed at Planning Stage

Measure Number	Cost Reduction Item	Reduction Cost (million JPY)	Annex Number
a) Reviewing Best Plan ① Water Transmission Plan			
a-①-1	Reviewing Location of Intake, Powerhouse and Outlet	360	1
a) Reviewing Best Plan ② Preparation of Construction machine			
a-②-1	Reviewing of Preparation of Construction Machine	1,140	2
b)			
b-1			
c)			
c-1			
d)			
d-1			
Total		1,500	
Ratio of Cost Reduction (%)		74.7	

Attachment 1

Form a (common)
Measure Number a-①-1

Cost Reduction Item

Project : Rural Electrification Development Works in Angola

Outline : Cutato HPS site is selected as the best site in 5 rural electrification development candidate sites.

【Future of Power Station】

Installed Capacity	:	3,000kW
Maximum Discharge	:	$50m^3/s$
Gross Head	:	8.0m
Water Turbine Type	:	S-type Tubular

【Review Content】

1) Initial Project : Water Way Type HPS (its water channel length is about 400m) is planned after 1st site investigation because Weir Type HPS needs many hard rock excavation volume.

2) Reviewed Project : Water Way Type HPS needs less hard rock excavation volume, but it needs more concrete Volume. Weir Type HPS cost (its location is just downstream the weir. River floor excavation is needed for 400m) is totally cheaper than Water Way Type HPS cost. So Weir Type HPS is adopted. As well excavation method is blast.

【Reduction Cost】
Reduction Cost about 360 million JPY

【Effect】
Fine aggregate is in river floor but coarse aggregate is not there at the result of 2nd site investigation. It becomes clear that coarse aggregate needs to be manufactured from surplus rock for concrete.
Concrete volume becomes less because of Weir Type HPS adoption, it becomes easy to manufacture coarse aggregate.

【Compared Table or Figure】

Item	Specifications	Unit	Quantity	Unit Rate (Yen)	Construction Cost (Yen)	
					Waterway Type	Weir Type
Concrete Work		m^3	8,350	35,543	296,784,050	
Reinforcement Work	0.1 t/m^3 (concrete)	t	835	70,280	58,683,800	
Excavation	Hard rock II	m^3	13,100	7,760		101,656,000
Formwork	General	m^2	10,800	4,552	49,161,600	
Subtotal (1)					404,629,450	101,656,000
Site Overhead (2)	Subtotal × 15%	L.S.	1		60,694,418	15,248,400
Administration Cost	((1) + (2)) × 3%	L.S.	1		13,960,132	3,507,600
Total					479,284,000 ≒ 480,000,000	120,412,000 ≒ 120,000,000

Attachment 2

Form a (common)
Measure Number a-②-1

Cost Reduction Item

Project : Rural Electrification Development Works in Angola

Outline : Cutato HPS site is selected as the best site in 5 rural electrification development candidate sites.

【Future of Power Station】

Installed Capacity	:	3,000kW
Maximum Discharge	:	50 m^3/s
Gross Head	:	8.0m
Water Turbine Type	:	S-type Tubular

【Review Content】

1) Initial Project : Construction machines are planned to be prepared in Angola.

2) Reviewed Project : It becomes clear that labor and construction machine cost in Angola are about 30% and 630% each of those in Japan. So project cost is reduced by planning that construction machine is imported from Japan.

【Reduction Cost】
Reduction Cost about 1,140 million JPY

【Effect】
As construction term is only 2 years, even used machines are enough to be used in construction. There are many surplus used machines in Japan because of reduction of public work projects, so it is reasonable that used machines are imported and used in Angola.

【Compared Table or Figure】

Comparison of Civil Work Construction Cost (unit : Thousand Yen)

Item	Civil Work Construction Cost at Prices in Japan	Civil Work Construction Cost at Prices in Angola	
		Equipment Lease in Angola	Delivery from Foreign Countries
① Civil Works	456,100	1,021,400	484,600
② Metal Works	609,500	885,100	538,900
③ Temporary Facility Works	106,400	267,200	115,200
④ Temporary Office and Warehouse	173,100	316,700	212,400
Total	1,345,100	2,490,400	1,351,100
	≒ 1,350,000	≒ 2,490,000	≒ 1,350,000

4.7 Economic and Financial Analysis

4.7.1 Project Cost

Table 4.7-1 shows the total project cost once more estimated in Section 4.6. The total project cost including taxes and duties is estimated to 5,350 Million JPY, or 61.1 Million US$ or 5,616 Million Kz. The investment cost consists of the above total project cost, IDC (Interest During Construction) and commitment charge in case that the project is to be implemented by Yen Loan. Tax and duties in Table 4.7-1 is transcribed from Table 4.7-9 Cutato HSP disbursement schedule.

Table 4.7-1 Total Project Cost for Cutato HPS

Case 1	Cutato Hydropower	1 US$ =	87.6 JPY=		91.9 Kz		1 Kz =	0.953 JPY			Million JPY	Million US$	Million Kz
		Base Cost Total	Base Cost		Price Contingency		Physical Contingency		Base Cost + Contingencies	Base Cost + Contingencies	Total	Total	Total
			L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	Base + Cont.	Base + Cont.	Base + Cont.
1. Construction Cost		**3,430.2**	**1,101.2**	**2,329.0**	**510.2**	**0.0**	**53.7**	**75.5**	**1,665.1**	**2,404.5**	**4,069.6**	**46.5**	**4,272.3**
1.1	Land-mine investigation and removal	26.2	18.7	7.5	5.0	0.0	1.2	0.4	24.9	7.9	32.8	0.37	34.4
1.2	Civil Work	1,351.1	434.8	916.3	186.3	0.0	23.5	33.0	644.6	949.3	1,593.9	18.20	1,672.5
1.3	Electro-Mechanical Work	1,411.0	70.0	1,341.0	34.5	0.0	3.1	40.2	107.6	1,381.2	1,488.8	17.00	1,562.2
1.4	Associated Distribution Line	641.9	577.7	64.2	284.4	0.0	25.9	1.9	888.0	66.1	954.1	10.89	1,001.2
2. Consultant Fee for Supervision		**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**97.7**	**146.5**	**244.2**	**2.8**	**256.2**
2.1	Consultant Service Fee (6.0% of Construction Cost)	0.0							97.7	146.5	244.2	2.79	256.2
Subtotal (Eligible Portion)		**3,430.2**	**1,101.2**	**2,329.0**	**510.2**	**0.0**	**53.7**	**75.5**	**1,762.8**	**2,551.0**	**4,313.8**	**49.3**	**4,528.5**
3. Angola Portion (Non-eligible Portion)		**934.6**	**934.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1,036.3**	**0.0**	**1,036.3**	**11.8**	**1,087.4**
3.1	Administration (2.5% of Construction Cost)	0.0							101.7	0.0	101.7	1.16	106.7
3.2	Tax and Duties	934.6	934.6	0.0	0.0	0.0	0.0	0.0	934.6	0.0	934.6	10.67	980.7
Total Cost		**4,364.8**	**2,035.8**	**2,329.0**	**510.2**	**0.0**	**53.7**	**75.5**	**2,799.1**	**2,551.0**	**5,350.1**	**61.1**	**5,615.9**

4.7.2 Economic Analysis

(1) Methodology

"With- Without" method is used in the economic analysis to evaluate the economic benefit of the project. "With" means the project and "Without" means the alternative project attaining the same object (to meet the power demand) in case of the without project. EIRR is derived from comparing the both costs, the project cost (Cost) and the alternative project cost (Benefit), by B – C. If the EIRR exceeds the DR (Discount Rate) of the country, the project is evaluated as the economically feasible. The DR is set at 10 ~ 12% for power sectors in developing countries in general.

A diesel power generator having the same generating capacity with the project is set as an alternative project in case of without the project taken account of the installed capacity of the

project. The alternative diesel power plant is assumed to be installed at Muenga Village, the nearest location from the project site, because the generated power by the project is planned to distribute to Muenga village, Chicumbi Village and Andulo.

The cost includes the following costs:

- Construction cost, fuel cost, fixed O&M (Operation and Maintenance) cost, and Variable O&M cost

In the construction cost, the works such as land-mining investigation & removal, access road (between Chicumbi Village and Muenga Village) and temporary building, and the cost for associated distribution line (between Andulo and Muenga Village) are excluded in the economic analysis because those works are deemed to be common works for the alternative project. Physical contingency and price contingency are also excluded in the economic analysis generally. Furthermore, tax, import duties and subsidies are also excluded in the economic analysis in terms of internal transaction of capital. Since the alternative project cost shown in Table 4.7-3 does not include the consultant service fee and administration cost, the both costs in the Cutato HPS are excluded in the economic analysis. Therefore, the economic project cost after exclusion of the above costs resulted in 28.7 Million US$ as shown in Table 4.7-2.

(2) Cutato HPS (With)

Table 4.7-2 shows the salient feature of the Cutato HPS.

Table 4.7-2 Salient Feature of Cutato HPS

Items	Unit	Cutato Hydropower	Remark
Rated Capacity	MW	3.0	1.5 MW × 2 units
Investment Cost Estimation (From Table 4.7-8)	M.JPY	5,378	Including IDC and Service Charge
	M.US$	61.3	1 US$ = 87.6 JPY in 2010
	M.Kz	5,642	1 US$ = 91.9 Kz in 2010
Project Cost to be used in the economic analysis	M.US$	28.7	Excluding Land-mine, Part of Access Road, Temporary Office, Part of Associated Distribution Line, Contingencies, Taxes & duties, Consultant Service Fee, and Administration
Unit Construction Cost	US$/kW	20,433	= Investment Cost Estimation (M.US$) / Rated Capacity (MW)
Detailed Design + Tendering +Construction Period	Years	5.0	0.8%, 1.5%, 33.9%, 43.8%, 20.0% The above percentage shows for Grand Total excluding Taxes and Duties
Capacity Factor	%	80.3%	= Gross Annul Generation (kWh) / 8760 hours/ Rated Capacity
Gross Annual Generation	GWh	21.10	Based on Chapter 4.3
Energy at Station Exit	GWh	20.89	Station use of 1%
Distribution Loss	%	5%	Excluding commercial loss
Salable Energy	GWh	19.85	
Fixed OM Cost	M.US$/year	0.09	Engineer's Estimation (3 % of Project Cost in economic analysis)
Variable OM Cost	US$/kWh	0.0015	Engineer's Estimation
Service Life Time	Years	40	Engineer's estimation
Commencement of Operation	Years	2016	

(3) Alternative Diesel Power Generator (Without)

Table 4.7-3 shows the salient feature of the alternative diesel power generator.

Table 4.7-3 Salient Feature of the Alternative Diesel Power Generator

Items	Unit	HSD-fired Diesel Plant	Remark
Rated Capacity	MW	3	1,500 kW x 2 unit
Unit Construction Cost	$/kW	900	Engineer's estimation
Project Cost Estimation	M.JPY	237	1 US$ = 87.6 JPY in 2010
	M.US$	2.70	
	M. Kz	248	1 US$ = 91.9 Kz in 2010
Construction Period	Years	2	50%, 50%
Gross Annual Generation	GWh	20.99	
Station use	%	0.5%	Engineer's estimation
Energy at Station Exit	GWh	20.89	
Plant Efficiency (LHV Base)			
HSD-firing		40.0%	Engineer's estimation
Kcal required per 1 kWh Generation			1 kWh = 860 kcal
HSD-firing	kcal/kWh	2,150	
Heat content of HSD	kcal/litter	9,070	Engineer's estimation
Fuel Price of HSD (FOB)	US$/bbl	113.0	Crude oil FOB price 102.7 US$/bbl (last 3 months average) x 1.1
Required HSD for 1 kWh Generation	litter/kWh	0.237	
Fuel Cost per 1 kWh Generation			
High Speed Diesel Oil (HSD)	US$/kWh	0.1684	
Fixed OM Cost	M.US$/year	0.05	Engineer's estimation (2 % of Project Cost)
Variable OM Cost	US$/kWh	0.0015	Engineer's Estimation
Service Life Time	Years	20	Engineer's estimation

HSD (High Speed Diesel Oil) is assumed for the fuel of the alternative diesel power generator and FOB price is used in the economic analysis.

Fig. 4.7-1 shows the spot price (FOB) of crude oil produced in Angola from June 4, 2004 to March 25, 2011. The average crude oil price for the last 3 month (January 2011 ~ March 2011) was 102.7 US$/bbl.

HSD price is about 10 % higher than the price of crude oil because HSD is burning oil. Therefore, FOB price of HSD produced in Angola is estimated at 113.0 US$/bbl (= 102.7 × 1.1).

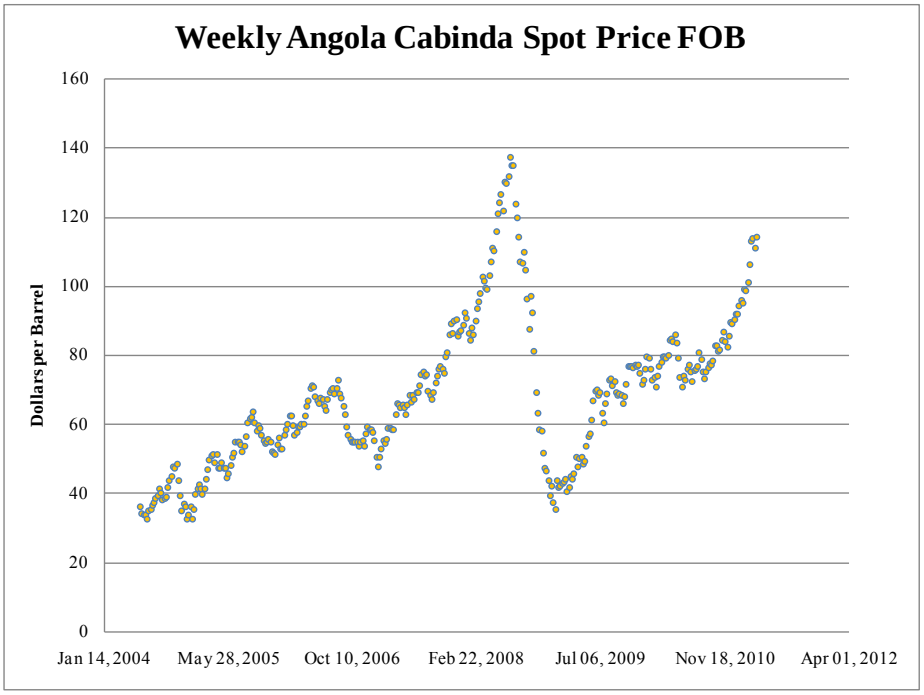


Fig. 4.7-1 Spot Price of Angola's Crude Oil

(4) Cost Comparison between With and Without (W/O) Project

Table 4.7-4 shows the cost comparison between "With" and "Without" project to be used in the economic analysis. In case of "W/O" project, procurement and installation cost of alternative diesel power plant with 2.7 Million US$ (237 Million JPY) is focused on and used. Concerning "With" project, the cost corresponding to procurement and installation cost of alternative diesel power plant, incremental cost relating to associated distribution line and access road and distribution line route are considered, and the cost resulted in 28.7 Million US$ (2,517.2 Million JPY) is used in the economic analysis.

Table 4.7-4 Cost Comparison between With and Without Project (Base Cost)

	Base Cost (Million JPY)		Remarks
	With the Project	W/O the Project	
	Cutato Hydropower Station	Diesel Power Plant	
Installed Capacity (MW)	3	3	1500 kW x 2 units
1 Landmine-investigation and Removal	26.2	26.2	Common work for with and w/o the project
2 Civil Work	1351.1	-	
2.1 Civil Work	812.2	-	
2.1.1 Access road and D/L route	136.1	109.4	Access road and D/L route is 5.5 km shorter than with project because Diesel Power Plant is assumed to be installed at Muenga village.
2.1.2 Temporary office & warehouse	212.4	212.4	Common work for with and w/o the project
2.1.3 Temporary facilities	115.2	237.0	Procurement and installation costs of alternative Diesel Power Plant is 900 US$/kW x 3,000 kW x 87.6 JPY/US$ = 237 Million JPY Unit construction cost of 900 US$/kW is Engineer's estimation.
2.1.4 Power intake	90.5		
2.1.5 Weir	36.7		
2.1.6 Power house	148.5		
2.1.7 Power outlet	66.0		
2.1.8 Transformer yard	6.8		
2.2 Metal Work	538.9		
3 Electric-Mechanical Work	1411.0		
4.1 High Voltage Distribution Work	579.6	502.7	High Voltage Distribution Line is 6.1 km shorter than with project because Diesel Power Plant is assumed to be installed at Muenga village.
4.2 Low Voltage Distribution Work	62.3	62.3	Common work for with and w/o the project
Total Construction Cost	**3,367.9**	**1,087.7**	

Economic cost to be used in the Economic Analysis

		Million JPY	Million US$	Remarks
W/O Project	Diesel Power Plant	237.0	2.7	Focused on procurement and installation costs of Diesel Power Plant
With Project	Cutato Hydropower Station	2,517.2	28.7	(1) Excluding common costs of item 1, 2.1.2. & 4.2 (2) Sum of item 2.1.3 to 2.1.8 and 2.2 & 3. (3) Increased cost of item 2.1.1 & 4.1

(5) Result of Economic Analysis

Table 4.7-5 shows the calculation sheet for the economic analysis. Since the service life time of a diesel power generator is 20 years generally, the alternative diesel power generator

is planned to be reinvested in the 19th and 20th years provided that the salvage value of the plant is 10 %.

The EIRR is resulted in 13.3% under the current conditions and the project can be evaluated as economically feasible in consideration of the discount rate of 10 ~ 12% in power sector. FOB price of HSD being equal to EIRR of 10% is 85 US$/bbl or 77.3 US$/bbl of crude oil FOB price. The Angolan crude oil price lowering 78 US$/bbl has not happened from October 2010 onwards as of the end of April 2011.

The cumulative value of (B) – (C) including construction cost and operation cost is also calculated in Table 4.7-5. The cumulative value of (B) – (C) shows the negative value in the early stage of the commercial operation due to the far expensive construction cost of Cutato Hydropower Plant in comparison of that of the alternative diesel power generator. However, the above negative value expects to turn into positive value in the 8th year after the commercial operation due to the current high fuel price.

Table 4.7-5 Calculation Sheet for Economic Analysis (With – Without Method)

CUTATO Hydropower Project (Cost)	Unit	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	40	Total
Construction Cost	M.US$	0	0	10	12.9	5.7																						28.6
Annual Generation	GWh		0	0	0	10.60	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	834
Fuel Cost	M.US$																											0
Fixed OM Cost	M.US$					0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	3.6
Variable OM Cost	M.US$					0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.8
Total Cost	M.US$	0	0.00	10.00	12.90	5.81	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	33.0

Alternative Diesel Power Plant (Benefit)	Unit	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	40	Total
Construction Cost	M.US$	0.0	0.0	1.4	1.3																			1.3	1.2			5.2
Gross Generation Energy	GWh					20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	20.99	840
Fuel Cost	M.US$					3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	141.20
Fixed OM Cost	M.US$					0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	2.2
Variable OM Cost	M.US$					0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	1.2
Total Cost	M.US$	0.00	0.00	1.40	1.30	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.61	4.91	4.81	3.61	3.61	149.8

EIRR = 13.3%

(B) - (C)	M.US$	0.00	0.00	-8.60	-11.60	-2.20	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	4.80	4.70	3.50	3.50	
Cumulative (B) - (C)	M.US$	0.00	0.00	-8.60	-20.20	-22.40	-18.89	-15.39	-11.88	-8.38	-4.88	-1.37	2.13	5.64	9.14	12.64	16.15	19.65	23.16	26.66	30.16	33.67	37.17	41.98	46.68	50.18	116.76	

Note: Years from 22 to 39 are skipped intentionally.

4.7.3 Financial Analysis

(1) Yen Loan Condition

There are two (2) types of Yen Loan offered by the Japanese Government. One is general Yen Loan and the other is Yen Loan for Climate Change Countermeasures. The applicable Yen Loan will be determined based on the negotiation between GOA and the Government of Japan finally. The Yen Loan for Climate Change Countermeasures is assumed to be applicable to the project in the report because the project is a small hydropower development aiming to be implemented by utilizing CDM. Table 4.7-6 shows the credit conditions for Climate Change Countermeasures. GNI (Gross National Income) per capita in Angola reached 3,750 US$ in 2009. However GOA has not yet submitted the documentations required for shifting to IBRD (International Bank for Reconstruction and Development) to the WB. Angola is still categorized as one of the LDC.

In the financial analysis, Yen loan condition for LDC (Standard) is applied to the project.

Table 4.7-6 Yen Loan Condition for Climate Change Countermeasures

(Applicable to new Projects in advance notice from April 1, 2010 onwards)

Income Level	GNI per capita (2008)	Condition	Standard/ Option	Interest (%)	Maturity Period (years)	Inclusive of Grace Priod (years)	Procument Condition
LDC	Inclusive of Poor Countries	No interest approach		0.01	40	10	untied
		Untied	Standard	0.20	40	10	untied
			Op.1	0.15	30	10	untied
			Op.2	0.10	20	6	untied
Poor Countries	<=975 US$	Untied	Standard	0.25	40	10	untied
			Op.1	0.20	30	10	untied
			Op.2	0.15	20	6	untied
			Op.3	0.10	15	5	untied
		STEP	Standard	0.10	40	10	tied
Low Income Countries	>= 976 US$ <=1,855 US$	Untied	Standard	0.30	40	10	untied
			Op.1	0.25	30	10	untied
			Op.2	0.20	20	6	untied
			Op.3	0.15	15	5	untied
		STEP	Standard	0.10	40	10	tied
Middle Income Countries	>= 1,856 US$ <=3,855 US$	Untied	Standard	0.30	40	10	untied
			Op.1	0.25	30	10	untied
			Op.2	0.20	20	6	untied
			Op.3	0.15	15	5	untied
		STEP	Standard	0.10	40	10	tied
Middle Developed Countries	>= 3,856 US$ <=6,725 US$	Untied	Standard	0.30	40	10	untied
			Op.1	0.25	30	10	untied
			Op.2	0.20	20	6	untied
			Op.3	0.15	15	5	untied
Consulting Service		Interest of 0.01% and other conditions are the same with above.					

(2) Disbursement Schedule

Table 4.7-9 shows the disbursement schedule developed by Table 4.7-1 and Table 4.7-7, and Table 4.7-8 shows the summary of the total investment amount for the project. The total investment will be amounted to 5,400 Million JPY and Yen Loan will cover about 4,300 Million JPY equivalent to about 80% of the total investment amount provided that all construction cost and consultant fee as shown in Table 4.7-1 are to be financed by Yen Loan.

Table 4.7-7 Applicable Loan Condition

A. JICA Loan Condition (Loan Condition for Climate Change Countermeasures)			Note
			IDC
IDC and Interest for main portion	%	0.20%	Applicable to LDC
IDC and Interest for Consulting Service	%	0.01%	
Finance Close	Year	2011	Engineer's assumption
Repayment Term	years	30	Applicable to LDC Excluding Grace period of 10 years
Grace Period	years	10	Applicable to LDC
Commitment Charge	%	0.1%	Applicable to undisbursed amount up to the year

Table 4.7-8 Summary of Total Investment Amount

1USD = 87.6 JPY = 91.9 Kz

(Million JPY)

Cutato Hydropower	Total Investment			Base Cost	Physical Contingency	Price Contingency	Other Costs (IDC etc.)	Total Investment
Total	**5,378**	M.JPY	100.0%	4,711	129	510	28	**5,378**
JICA Loan	4,314	M.JPY	80.2%	87.6%	2.4%	9.5%	0.5%	100.0%
ENE Own Fund (inc. IDC)	1,064	M.JPY	19.8%					

(Million US$)

Cutato Hydropower	Total Investment			Base Cost	Physical Contingency	Price Contingency	Other Costs (IDC etc.)	Total Investment
Total	**61.3**	M.US$	100.0%	53.8	1.5	5.8	0.3	**61.4**
JICA Loan	49.2	M.US$	80.3%	87.6%	2.4%	9.4%	0.5%	100.0%
ENE Own Fund (inc. IDC)	12.1	M.US$	19.7%					

(Million Kz)

Total	Total Investment			Base Cost	Physical Contingency	Price Contingency	Other Costs (IDC etc.)	Total Investment
Total	**5,642**	M.Kz	100.0%	4,942	136	535	29	**5,642**
JICA Loan	4,526	M.Kz	80.2%	87.6%	2.4%	9.5%	0.5%	100.0%
ENE Own Fund (inc. IDC)	1,116	M.Kz	19.8%					

Table 4.7-9 Cutato HSP Disbursement Schedule

Cutato Hydropower											(Unit: Million JPY)
	Cost as of 2010	Annual Escalation	Construction Period 2011	2012	2013	2014	2015	2016	2017	2018	Total
A-1. Foreign Currency Portion	**2,551.0**		**0.0**	**14.7**	**29.2**	**871.0**	**1,126.0**	**510.1**	**0.0**	**0.0**	**2,551.0**
1. Construction Cost	2,404.5	0.0%	0.0	0.0	7.2	834.4	1,082.0	480.9	0.0	0.0	2,404.5
2. Consultant Fee	146.5		0.0	14.7	22.0	36.6	44.0	29.2	0.0	0.0	146.5
A-2. Local Currency Portion	**1,864.5**		**0.0**	**20.0**	**35.0**	**627.6**	**809.1**	**372.8**	**0.0**	**0.0**	**1,864.5**
1. Construction Cost	1,665.1	0.0%	0.0	0.0	5.0	577.8	749.3	333.0	0.0	0.0	1,665.1
2. Consultant Fee	97.7		0.0	9.8	14.7	24.4	29.3	19.5	0.0	0.0	97.7
3. Administration Cost	101.7		0.0	10.2	15.3	25.4	30.5	20.3	0.0	0.0	101.7
Grand Total excluding Taxes and Duties	**4,415.5**		**0.0**	**34.7**	**64.2**	**1,498.6**	**1,935.1**	**882.9**	**0.0**	**0.0**	**4,415.5**
A-3. Import Duties											
1. Construction Cost	2,404.5	20.5%	0.0	0.0	1.5	171.1	221.8	98.6	0.0	0.0	493.0
Subtotal	493.0		0.0	0.0	1.5	171.1	221.8	98.6	0.0	0.0	493.0
A-4. Value Added Tax											
F/C portion	2,551.0	10.0%	0.0	1.5	2.9	87.1	112.6	51.0	0.0	0.0	255.1
L/C portion	1,864.5	10.0%	0.0	2.0	3.5	62.8	80.9	37.3	0.0	0.0	186.5
Subtotal	441.6		0.0	3.5	6.4	149.9	193.5	88.3	0.0	0.0	441.6
A-5. Total Project Cost excluding IDC											
F/C Portion											
(1) Procurement and Construction	2,551.0		0.0	14.7	29.2	871.0	1,126.0	510.1	0.0	0.0	2,551.0
L/C Portion											
(1) Procurement and Construction	1,864.5		0.0	20.0	35.0	627.6	809.1	372.8	0.0	0.0	1,864.5
(2) Import Duties	493.0		0.0	0.0	1.5	171.1	221.8	98.6	0.0	0.0	493.0
(3) Value Added Tax	441.6		0.0	3.5	6.4	149.9	193.5	88.3	0.0	0.0	441.6
Subtotal	**5,350.1**		**0.0**	**38.2**	**72.1**	**1,819.6**	**2,350.4**	**1,069.8**	**0.0**	**0.0**	**5,350.1**
A-6. JICA Loan Arrangement											
(1) JICA Loan	**4,313.8** M.JPY										
Main Portion for F/C & L/C Portion	4,069.6		0.0	0.0	12.2	1,412.2	1,831.3	813.9	0.0	0.0	4,069.6
Consulting Service Portion	244.2		0.0	24.5	36.7	61.0	73.3	48.7	0.0	0.0	244.2
ENE/GoA Own Fund	1,036.3		0.0	13.7	23.2	346.4	445.8	207.2	0.0	0.0	1,036.3
Cumulative Loan Amount for main portion			0.0	0.0	12.2	1,424.4	3,255.7	4,069.6	0.0	0.0	
Cumulative Loan Amount for Consulting Service			0.0	24.5	61.2	122.2	195.5	244.2	0.0	0.0	
IDC for main portion	13.4	0.20%	0.0	0.0	0.0	1.4	4.7	7.3	0.0	0.0	13.4
IDC for Consulting Service	0.0	0.01%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total IDC to be burden by ENE/GoA	13.4		0.0	0.0	0.0	1.4	4.7	7.3	0.0	0.0	13.4
(2) Own Fund by ENE/GoA											
ENE/GoA Own Fund exceeding JICA Loan	1,036.3		0.0	13.7	23.2	346.4	445.8	207.2	0.0	0.0	1,036.3
IDC (to be paid by ENE/GoA)	13.4		0.0	0.0	0.0	1.4	4.7	7.3	0.0	0.0	13.4
Commitment Charge for Undisbursement	14.3	0.1%	0.0	4.3	4.3	3.5	1.8	0.4	0.0	0.0	14.3
Total ENE/GoA Own Fund	1,064.0		0.0	18.0	27.5	351.3	452.3	214.9	0.0	0.0	1,064.0
A-7. Total Cost and Finance Arrangement	**5,377.8**		**0.0**	**42.5**	**76.4**	**1,824.5**	**2,356.9**	**1,077.5**	**0.0**	**0.0**	**5,377.8**
JICA Loan Amount **(Debt)**	4,313.8	**80.2%**	0.0	24.5	48.9	1,473.2	1,904.6	862.6	0.0	0.0	4,313.8
Own Fund by ENE/GoA exceeding JICA Loan	1,036.3		0.0	13.7	23.2	346.4	445.8	207.2	0.0	0.0	1,036.3
Total IDC and Service Charge	27.7		0.0	4.3	4.3	4.9	6.5	7.7	0.0	0.0	27.7
Total Fund by ENE/GoA **(Equity)**	1,064.0	**19.8%**	0.0	18.0	27.5	351.3	452.3	214.9	0.0	0.0	1,064.0

(3) Other Financial Conditions

Other financial conditions used in the financial analysis are shown in Table 4.7-10. Electricity tariff system contributing to the revenue for the project has not been changed since 2004. The escalation rate of 1% in Table 4.7-10 is assumed that power consumption of end-users will be increased in proportion to the economic growth in Angola in the future and

end-users will shift to higher electricity categories, such as from a middle voltage user to a high voltage user.

Table 4.7-10 Other Financial Conditions

1. Power Tariff				
	Average Power Tariff in 2010	Kz/kWh	4.00	The average power tariff of EDEL in 2010 Engineer's estimation, concurred with ENE
		US$/kWh	0.044	1 US$ = 91.9 Kz in 2010 average
	Average Power Tariff Escalation	%/year	1.0%	Shifting to higher category of electricity tariff due to increase of GWh and kVA in proportion to the economic growth in the future. Concurred with ENE
2. Corporate Income Tax and Depreciation *)				
	Corporate Income Tax	%	35%	35 % of Industrial Tax in Angola, Already confirmed by ENE
	Depreciation Method	Straight Line Method		Already confirmed by ENE
	Depreciation Period	years	20	Already confirmed by ENE
3. Import Duties and Value Added Tax *)				
	Import Duties	%	20.5%	Average 18% + 2% of general customs fees +0.5% of stamp duty in Angola
	Value Added Tax (Consumption Tax)	%	10%	10 % of the standard rate. Imposing on importation goods into Angola, local production and services.

Note: *) Provided by Japanese firms in Angola

(4) CER Revenue

As mentioned in Section 4.2.8, the project aims to be implemented by utilizing CDM, CER revenue as shown in Table 4.7-11 is incorporated into the financial analysis.

Table 4.7-11 CER Revenue

	Coefficient of Carbon Emission Reduction	ton.e/MWh	0.8	in comparison with a Diesel Power Plant
	Annual salable energy of Cutato HPS	MWh	19,850	
(1)	Gross CER (Carbon Emission Reduction)	ton.e	15,880	= Coefficient x Salable Energy (MWh)
	Gross Generation Energy of Cutato HPS	MWh	21,100	
	Coefficient of swamp gas (CH_4)	ton.e/MWh	0.09	Default value to estimate CH_4 emission produced by plants in the pond
(2)	Amount of Emission of swamp gas (CH_4)	ton.e	1,899	= Coefficient × gross generation (MWh)
(3)	Net CER { (1) - (2) }	ton.e	13,981	
	CER Revenue per CO_2 ton equivalent	Euro/ton.e	10.0	Engineer's estimation based on the current CER transaction
	Exchange Rate 1 Euro =	US$/Euro	1.33	Based on the average exchange rate in 2010 released by the Central Bank of Angola
	Total CER Revenue	M.US$	0.19	
	Effective period of CER Revenue	year	21	The first effective period is 7 years and twice extended contract (7-years × 2) is available

(5) Financial Indicators for Evaluation

In the financial analysis, profit & loss statement is prepared firstly and then a cash flow sheet is developed based on the profit & loss statement. Financial indicators are derived from the cash sheet. Financial indicators and feasible criteria prevailed generally are shown in Table 4.7-12.

Table 4.7-12 Financial Indicators and Evaluation Criteria

Financial Indicators	Feasible Criteria	Remarks
Project IRR (Project Internal Rate of Return)	Project IRR>WACC	Project IRR indicates the internal rate of return of the project provided that the project will be implemented by 100 % of own equity without loan. Therefore, Project IRR indicates the financial characteristic of the project itself because the Project IRR is not affected by loan conditions, such as IDC and interest payment. WACC (Weighted Average Cost of Capital) indicates the average cost of capital (Debt and Equity) to run the business continuously. Project IRR must be greater than the WACC unless the entrepreneur manager will never invest in the project. Higher inflation leads to higher WACC generally. Since inflation rate in Angola in 2009 is 12 %, WACC seems to be 10 % and more.
ROE (Return on Equity)	ROE > 12~13 %	ROE indicates the return on equity. If the expected ROE is lower return, the entrepreneur manager will invest in other projects of which ROE is higher.
DSCR (Debt Service Coverage Ratio)	DSCR >1.5 (Average) DSCR >1.3 (Each year)	DSCR is an indicator which the Bankers are most concerned. If DSCR is 1.0, all gained money shall be allocated to the interest payment and capital repayment and there is no remaining money.
LPC (Levelised Production Cost)	LPC < Generation Cost in the system	If LPC is lower than the generation cost in the power system, the implementation of the project is expected to contribute to lessen the generation cost in the power system, which means contribution to reinforcing the financial ground of the firm. According to the World Bank Report (March 2010), it is reported that electricity selling from ENE to EDEL costs about 11 US cents per kWh.

DSCR and LPC in the report are derived from the following formula.

$$DSCR = \frac{Business\ Profit - Corporate\ Income\ Tax}{(Interest\ Payment + Capital\ Repayment)}$$

$$LPC = \frac{\sum Discounted\ Present\ Value\ of\ the\ Cost\ (during\ the\ operation)}{Discounted\ Salable\ Energy}$$

Where, Discount Rate is 12 %.

(6) Result of Financial Analysis

The financial calculation sheets are shown in Table 4.7-14 and Table 4.7-15 and summarized in Table 4.7-13. The result of financial analysis shown in Table 4.7-13 indicates that the project is deemed to be financially infeasible even though CER revenue is taken account of.

Table 4.7-13 Result of Financial Analysis

Financial Indicator	Result	Evaluation
Project IRR	Projet IRR = -3.6 % < 10 %	All financial indicators cannot meet the financially feasible criteria.
ROE	ROE = cannot be calculated	
DSCR	Min. DSCR = 0.61 <1.3 Average DSCR = 0.65 <1.5	
LPC	13.68 US cent/kWh > 11 US¢/kWh	

Table 4.7-14 Calculation Sheet for Financial Analysis (Profit & Loss Statement)

Cutato Hydropower

1. Profit and Loss Statement

Year		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38						
Gross Generation	GWh	0.00	0.00	0.00	0.00	0.00	10.60	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	21.10	
Salable Energy	GWh	0.00	0.00	0.00	0.00	0.00	9.90	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	744.35
Power Tariff	c/kWh	4.444	4.488	4.533	4.579	4.624	4.671	4.717	4.765	4.812	4.860	4.909	4.958	5.008	5.058	5.108	5.159	5.211	5.263	5.316	5.369	5.423	5.477	5.532	5.587	5.643	5.699	5.756	5.814	5.872	5.931	5.990	6.050	6.110	6.171	6.233	6.295	6.358	6.422	6.486	6.551	6.617	6.683	6.750	
Sales Revenue	M.US$	0.00	0.00	0.00	0.00	0.00	0.46	0.94	0.95	0.96	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.17	1.18	1.19	1.20	1.21	1.22	1.24	1.25	1.26	1.27	1.29	1.30	1.31	1.33	1.34	42.12
Fuel Cost	M.US$																																												0.00
Fixed O/M Cost	M.US$	0.00	0.00	0.00	0.00	0.00	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-3.42
Variable O/M Cost	M.US$	0.00	0.00	0.00	0.00	0.00	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-1.13
Earning after operation	M.US$	0.00	0.00	0.00	0.00	0.00	0.35	0.82	0.83	0.84	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.05	1.06	1.07	1.08	1.09	1.10	1.12	1.13	1.14	1.15	1.17	1.18	1.19	1.21	1.22	37.57
Depreciation	M.US$	0.00	0.00	0.00	0.00	0.00	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-61.40
Interest Payment for main portion	M.US$	0.00	0.00	0.00	0.00	0.00	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.08	-0.08	-0.08	-0.07	-0.07	-0.07	-0.07	-0.06	-0.06	-0.06	-0.05	-0.05	-0.05	-0.04	-0.04	-0.04	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	-1.89
Interest Payment for Consulting Service	M.US$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CER Revenue	M.US$	0.00	0.00	0.00	0.00	0.00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.99
Earning before Tax	M.US$	0.00	0.00	0.00	0.00	0.00	-2.62	-2.15	-2.14	-2.13	-2.13	-2.12	-2.11	-2.10	-2.08	-2.07	-2.06	-2.04	-2.03	-2.01	-2.00	-1.98	-1.97	-1.96	-1.94	-1.93	1.15	0.98	0.99	1.01	1.03	1.04	1.05	1.07	1.08	1.10	1.11	1.13	1.14	1.16	1.18	1.19	1.21	1.22	-21.73
Income Tax	M.US$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.40	-0.34	-0.35	-0.35	-0.36	-0.36	-0.37	-0.37	-0.38	-0.39	-0.39	-0.40	-0.40	-0.41	-0.41	-0.42	-0.42	-0.43	-6.95
Earning after Tax	M.US$	0.00	0.00	0.00	0.00	0.00	-2.62	-2.15	-2.14	-2.13	-2.13	-2.12	-2.11	-2.10	-2.08	-2.07	-2.06	-2.04	-2.03	-2.01	-2.00	-1.98	-1.97	-1.96	-1.94	-1.93	0.75	0.64	0.64	0.66	0.67	0.68	0.68	0.70	0.70	0.71	0.72	0.73	0.74	0.75	0.77	0.77	0.79	0.79	-28.68

Table 4.7-15 Calculation Sheet for Financial Analysis (Cash Flow)

2. Project IRR, FIRROE, and Debt Service Coverage Ratio

Cutato Hydropower

2-1. Project Cash flow and Project IRR (Million US$)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2052	2053	Total	Project IRR
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	37	38							
Investment	0.00	-0.44	-0.82	-20.77	-26.83	-12.21																										-61.07	
Earning after Operation	0.00	0.00	0.00	0.00	0.00	0.35	0.82	0.83	0.84	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.05	1.21	1.22	37.57	
CER Revenue	0.00	0.00	0.00	0.00	0.00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.00	0.00	0.00	0.00	0.00	3.99	
Corporative Income Tax	0.00	0.00	0.00	0.00	0.00	-0.19	-0.35	-0.36	-0.36	-0.36	-0.36	-0.37	-0.37	-0.37	-0.38	-0.38	-0.39	-0.39	-0.40	-0.40	-0.40	-0.41	-0.41	-0.41	-0.42	-0.42	-0.36	-0.36	-0.37	-0.42	-0.43	-14.56	
Project Cash flow	0.00	-0.44	-0.82	-20.77	-26.83	-11.86	0.66	0.66	0.67	0.67	0.68	0.68	0.69	0.70	0.70	0.71	0.71	0.72	0.73	0.74	0.75	0.75	0.76	0.77	0.77	0.78	0.66	0.67	0.68	0.79	0.79	-26.53	**-3.6%**

2-2. Equity Cash flow and ROE (Million US$)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2052	2053	Total	ROE
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	37	38							
Equity Investment	0.00	-0.21	-0.31	-4.01	-5.16	-2.45																										-12.14	
Earning after Operation	0.0	0.0	0.0	0.0	0.00	0.35	0.82	0.83	0.84	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.05	1.21	1.22	37.57	
CER Revenue	0.00	0.00	0.00	0.00	0.00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.00	0.00	0.00	0.00	0.00	3.99	
Corporative Income Tax	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.40	-0.34	-0.35	-0.35	-0.42	-0.43	-6.95	
Interest Payment	0.00	0.00	0.00	0.00	0.00	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.08	-0.08	-0.08	-0.07	-0.07	-0.07	-0.07	-0.06	-0.06	-0.06	-0.05	-0.05	-0.05	-0.04	-0.04	-0.04	0.00	0.00	-1.89	
Principal Repayment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	-1.64	0.00	0.00	-49.20	
Net Cash inflows	0.00	-0.21	-0.31	-4.01	-5.16	-2.00	0.92	0.93	0.94	0.94	0.95	-0.68	-0.67	-0.65	-0.64	-0.63	-0.61	-0.60	-0.58	-0.57	-0.55	-0.54	-0.53	-0.51	-0.50	-0.89	-1.00	-1.00	-0.98	0.79	0.79	-28.62	**#DIV/0!**
DSCR	-	-	-	-	-	-	6.00	11.22	11.33	11.44	11.44	11.56	0.61	0.61	0.62	0.63	0.63	0.64	0.65	0.66	0.67	0.68	0.68	0.69	0.70	0.70	0.47	0.40	0.40	0.42	-	-	Ave.	0.65

3. LPC Discount Rate = 12%

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2052	2053	Total	LPC
Conversion Factor	1.000	0.893	0.797	0.712	0.636	0.567	0.507	0.452	0.404	0.361	0.322	0.288	0.257	0.229	0.205	0.183	0.163	0.146	0.130	0.116	0.104	0.093	0.083	0.074	0.066	0.059	0.053	0.047	0.042	0.010	0.009		c/kWh
Equity Investment	0.00	0.21	0.31	4.01	5.16	2.45																										12.14	
Fuel Cost																																0.00	
Fixed O/M Cost	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	3.42	
Variable O/M Cost	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	1.13	
Interest Payment	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.00	0.00	1.89	
Principal Repayment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.00	0.00	49.20	
Income Tax	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.34	0.35	0.35	0.42	0.43	6.95	
Cash Outflow	0.00	0.21	0.31	4.01	5.16	2.65	0.21	0.21	0.21	0.21	0.21	1.85	1.85	1.84	1.84	1.84	1.83	1.83	1.83	1.83	1.82	1.82	1.82	1.81	1.81	2.21	2.14	2.15	2.15	0.54	0.55	75.28	
Salable Energy						9.90	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	19.85	744.35	
Discounted Outflow	0.00	0.19	0.25	2.85	3.28	1.50	0.11	0.09	0.08	0.08	0.07	0.53	0.47	0.42	0.38	0.34	0.30	0.27	0.24	0.21	0.19	0.17	0.15	0.13	0.12	0.13	0.11	0.10	0.09	0.01	0.00	13.42	
Discounted Energy	0.00	0.00	0.00	0.00	0.00	5.62	10.06	8.98	8.02	7.16	6.39	5.71	5.10	4.55	4.06	3.63	3.24	2.89	2.58	2.30	2.06	1.84	1.64	1.46	1.31	1.17	1.04	0.93	0.83	0.19	0.17	98.08	**13.68**

Note: The years from 2040 to 2051 are intentionally skipped.

4.7.4 Conclusion of Economic and Financial Analyses

The conclusions of the economic and financial analyses are as follows;

(a) Even in consideration of CER revenue, the project is deemed to be financially infeasible. On the other hand, the project's EIRR of 13.3% is deemed to be economically feasible due to the recent soaring of the crude oil price (FOB) in the world.

(b) Why the project becomes financially not attractive seems to be caused by its expensive construction cost, although the project is economically feasible.

(c) Some reasons resulting in the expensive construction cost are listed in Table 4.7-16.

Table 4.7-16 Reasons of Expensive Construction Cost

1	Due to the specific conditions in Angola	
	1.1	Execution of land-mining investigation and removal
	1.2	High price escalation exceeding 10 % per annum (increase of price contingency)
	1.3	Far expensive lease costs for construction machines and material costs in comparison with those in Japan
2	Due to the specific condition at the project site	
	2.1	Adoption of S-type tubular turbine costing higher in comparison with other types of turbines due to lower effective head of 7.5 m
	2.2	Adoption of a steel overturning gate to protect cultivated land in the upper reaches from the increase of flood water level due to the gentle river gradient of 1/1500 (environmental mitigation cost)

(d) Based on the economic analysis, the project is worth of implementation in terms of rural electrification because about 6,000 households in Andulo City become able to newly access to electricity. The implementation of the project will support the national target that the half of population in Angola becomes able to access to electricity by the year 2015.

4.7.5 Development of Operation & Effect Indicators for the Project

(1) Operation and Effect Indicators released by JICA

In order to evaluate the performance of the project, operation and effect indicators are developed. Operation indicator is defined as the indicator giving a quantitative operation status and effect indicator is defined as the indicator giving a quantitative operation outcome. Table 4.7-17 and Table 4.7-18 shows the typical operation and effect indicators for hydraulic power generation projects released by JICA.

Table 4.7-17 Operation Indicators for Hydraulic Power Generation Project

2. Hydraulic Power Generation (Conventional, Pumping-up)

Operation Indicator

Category	Name	Policy and method of establishing the indicator	Target	Purpose	Remarks
Basic	Unplanned Outage Hours (Hours or Days/Year)	As shown by the name of the indicator	0	To assess if the power plant is adequately operated	Classified according to the cases: mechanical failure, human work, and natural disasters, and others
Basic	Capacity Factor (%)	As shown by the name of the indicator	Capacity factor planned at the time appraisal	To assess if the power plant is adequately operated	Adopted on for conventional hydraulic power plant
Basic	Comprehensive Circulating Efficiency (%)	Comprehensive Circulating Efficiency = (net electric energy)/ (electricity used for pumping) x 100 (%)	Decide on 70 - 75 % by discussion	To assess if the power plant performance of has been maintained	Adopted only for pumped storage power plant
Auxiliary	Operating Hours (Hours)	As shown by the name of the indicator	Decide on 00 - 1000 hours by discussion	To confirm if the power plant is operated for a certain period	Adopted only for pumped storage power plant Classified under the two categories of pumping and generating Not reaching the target does not always lead to low estimation
Auxiliary	Hydraulic Utilization Factor (%)	Hydraulic Utilization Factor - (net electric energy)/(possible power generation in a given year) x 100 (%)	Decided on around 90 % by discussion	To assess if the operation of the power plant is optimum considering the annual volume of inflow	Adopted only for conventional hydraulic power plant It is necessary to check if it is technically computable
Auxiliary	Planned Outage Hours (Hours or Days/Year)		To be discussed with the executing agency	To assess the level of operation of the power plant	Not reaching the target does not always lead to low evaluation
Auxiliary	Annual Total Volume of Inflow to the Reservoir (m^3/Year)	Annual total volume of inflow to the dam reservoir from rivers	To be discussed with the executing agency	Basic indicator to show dam control and drought conditions	Adopt this indicator when a dam is included. However, goals of indicators that are related to dams, etc. should be represented by the value of the base year in the plan as a reference value. It is desirable to keep track of the years with probable drought based on precipitation data.
Auxiliary	Volume of Sedimentation in the Reservoir (m^3/year)	Volume of sedimentation in the reservoir	To be discussed with the executing agency	Important indicator in dam control	Adopt this indicator when a dam is included.

Table 4.7-18 Effect Indicators for Hydraulic Power Generation Project

2. Hydraulic Power Generation (Conventional, Pumping-up)

Effect Indicator

Category	Name	Policy and method of establishing the indicator	Target	Purpose	Remarks
Basic	Net Electric Energy Production (GWh/Year)	As shown by the name of the indicator	Electricity generated per year planned at the time of the appraisal	To check if the assumed electricity generated was actually produced as planned	Can be adopted as an operation indicator In the case of pumping-up power generation, not reaching the target does not always lead to low evaluation
Basic	Maximum Output (MW)	As shown by the name of the indicator Basically represented by instantaneous value	Maximum output planned at the time of the appraisal	To assess if the performance of the power plant is maintained and fully executed	Can be adopted as an operation indicator

(2) Development of Operation and Effect Indicators

Based on the typical indicators shown in Table 4.7-17 and Table 4.7-18, the following operation indicator and effect indicator are proposed in consideration of validity, reliability and accessibility to the data.

Table 4.7-19 Operation and Effect Indicators for the Project

Category	Indicator	Setting Value	RePlant marks
Operation Indicator	Capacity Factor	80 % (= 21,100 MWh/ 8760 hrs/3 MW)	Availability factor (= operation hours/8,760 hours) is expected to almost 100% due to the run-of-river type power station. Therefore, instead of availability factor, capacity factor focusing on electric power generation is set as the operation indicator.
	Unplanned Outage Hours	0 hours/year	Unplanned outage hours per annum for a hydropower plant are remarkably less than those for a thermal power plant generally. Since the Cutato Hydropower Plant is newly constructed, unplanned outage hours are set as 0 hours/year.
Effect Indicator	Maximum Output	3,000 kW	All the relative dimensions and machines are designed so that the Cutato Hydropower Plant can produce the maximum output of 3,000 kW. Therefore, the maximum output of 3,000 kW is set as an effective indicator.
	Gross Electric Power Generation	21,100 MWh/year	Gross electric power generation is set as the effect indicator because installed capacity is as small as 3 MW and power consumption in the power station seems to be small. And accessibility to data collection seems to be easier in comparison with other indicators.

4.8 Environmental and Social Considerations

4.8.1 Systems of Environmental Impact Assessment in Angola

(1) Legal Framework Related to Environment[12]

Angola has also signed a number of regional and continental environment-related protocols and conventions, and is drafting a new constitution. Many of the provisions from the current constitution are likely to be carried over to the new constitution. The 1992 constitution states:

> "All natural resources existing in the soil and subsoil, in internal and territorial waters, on the continental shelf and in the exclusive economic zone shall be the property of the State, which shall determine under what terms they are used, developed, and exploited.
> "The State shall promote the protection and conservation of natural resources by guiding the exploitation and use thereof for the benefit of the community as a whole.
> "All citizens shall have the right to live in a healthy and unpolluted environment.
> The State shall take the requisite measures to protect the environment and national species of flora and fauna throughout the national territory and maintain ecological balance."

The Angolan EFL (Environmental Framework Law) of 1998 is the overarching instrument for the implementation of the constitutional provisions. Article 13 (1) prohibits "all activities that threaten the biodiversity, conservation, reproduction, quality, and quantity of biological resources … especially those threatened with extinction." Article 13(2) states that the government must ensure that adequate measures are taken to "maintain and regenerate animal species, recover damage habitat, and control, especially, the activities or substances likely to be harmful to animal species and their habitat."

Article 14(1) creates the legal basis for the establishment and maintenance of a network of protected areas and specifies that these may have a "national, regional, local, or international scope."

Finally, Article 12 bestows the responsibility on the government to "defend" the environmental patrimony through the involvement of communities and associations for environmental defense among others. The EFL also establishes the necessity to conduct environmental impact assessments of activities likely to impact negatively on the environment, and gives any citizen that is negatively affected by environmental damage the right to take legal action against the perpetrator.

Ministerial Decree No. 51/04 on Environmental Impact Assessment regulates the stipulations

[12] USAID, 118/119 Biodiversity and Tropical Forest Assessment for Angola, May 2008

of the EFL with respect to environmental impact assessments. It refers, but still being vague about what public participation means. The process for validation and approval of EIA is also unclear.

The regulatory framework for the application of the EFL is incomplete or inadequate. This is particularly important in the case of regulations pertaining to environmental impact assessments.

(2) Institutional Framework

MINAMB has legal jurisdiction over environmental matters. However, MINAMB has very little presence in any protected area in the country. It is chronically understaffed and was unable to spend more than $40 million in its budget of 2007. In the light of these functional deficiencies of MINAMB, other ministries, especially the MINADER (Ministry of Agriculture and Rural Development), play an important role in addressing environmental issues.

MINADER has the mandate to establish forestry policies, and to plan and direct all tasks related to forest resource management, but IDF (Forestry Development) of MINADER continues to reduce its role and being ineffective in the management of forests and protected areas.

In addition to MINAMB and MINADER, MINEA and the Ministry of Fisheries are deeply involved in biodiversity conservation and environmental management. The Ministry of Fisheries is supposed to collaborate in the conservation of nature, especially for the marine environment.

There is no set provincial-level institutional structure for the environment that repeats itself from province to province. In most cases, however, jurisdiction over environmental matters is ascribed to the Provincial Directorate for Agriculture Fisheries and Environment. Directorate sectoral responsibilities fall under three ministries: MINADER, MINAMB and the Ministry of Fisheries. In other cases, provincial governments have established an Environment Department under a Directorate of Environment, aligned with MINAMB.

In summary, there is an acute lack of clarity about the environmental responsibilities of certain sectoral ministries and MINAMB. This is particularly serious with respect to the functional overlap of MINAMB and MINADER for the forestry sector.

(3) Regime and Procedures of Environmental Impact Assessment

In Angola, the protection of the environment and natural resources is constitutionally recognized as a duty of the State, which has the responsibility to formulate environmental strategies, policies and laws as well as engage in the international and national programs that

seek to protect the environment and promote sustainable use of natural resources.

The EFL goes further by providing guiding principles for the prevention and combat of pollution, and standards to protect the environment. Angola has developed in the last decade comprehensive environmental legislation regarding water resources, petroleum, mines, and land, and have increased engagement with regional and international bodies and partners.[13]

The EFL goes further as described in several documents.[14]

Projects for energy industry require license of EIA from the responsible environmental organization of the GOA before construction. The proponent will prepare and submit the EIA report to MINAMB. The department of conservation and assessment of environmental impact (Portuguese name, Derecçao National Prevençao Avaleaçao de Impactes Ambiente) in MINAMB will check the EIA report. The Minister of MINAMB will issue the approval for the EIA report.

The content of EIA is as follows:

1) Description of project
2) Guidelines of environmental impact study
3) Alternative technology
4) Identification and evaluation for planning and operation of the project
5) Definition and limitation of the area, population and living organization around the project
6) Alternative plans compatible to the project
7) Other elements to be considered

Technical activities with respect to the following matters will be subject to environmental assessment:

1) Water, air and climates
2) Natural ecosystem
3) Social economics

According to the environmental laws, in the case of hydropower construction with the capacity more than 1,000 kV, the approval of EIA is required.[15] In the case of transmission lines with the capacity more than 230 kV, the approval of EIA is required. However, according to the director of EIA department of MINAMB, any hydropower project requires EIA regardless of the capacity of hydro or transmission lines.
In JICA guidelines, implementation of IEE (Initial Environmental Examination) is mandatory at the stage of master plan, but IEE is not defined as EIA in Angola. The implementation of IEE or EIA requires guidance or support by the expert for environmental assessment.

[13] http://www.ao.undp.org/Energy%20Environment.htm
[14] Diario da republica (Journal of the republic) No.27/1998, No.59/ 2004, No.84/ 2007

In hydropower development, project proponents need to get an environmental license. In the EFL of 1998, article 17 states that "An Environmental License is required for all activities, which, because of their nature, location and scale may have a significant environmental or social impact. The environmental license is issued on the basis of the findings of an EIA and is required prior to any other permits or licenses which may need to be issued under other laws." Then the Decree of Environmental Licensing was established in 2007, which article 1 defines environmental license to be granted in relation to "undertakings and activities using natural resources, deemed to be effective or potential polluters, or which could otherwise cause environmental degradation and/or change."

Also, in the article 25, the fees to be charged for an environmental permit granting were set in Tax Correction Units, and the fees amount is shown in the table in the 1st series – No. 224 of the government gazette in 2009 (Decree No. 130/09).[16] In legislation, there are two kinds of administrative procedures for (1) Authorization and (2) License as described in the Decree on EIA of 2004, which states that DOE shall authorize or license the project according to the results of EIA audit. The latter (2) License is expected to be defined in the Decree of Environmental Licensing of 2007. In the article 24 of the Presidential Order No.82/10 (Approves the Concession Contracts Models, as well, as Electric Energy Buying and Selling for Small Hydro-installations, November 22, 2010), the word of "License" instead of "Authorization" is used for approval. It states that the proponent, who will take over the rights of construction and operation of a hydropower project, needs to acquire the environmental license to the Ministry preceding the construction. Therefore, it can be considered that "environmental license" in this article refers to the license defined in the Decree of Environmental Licensing of 2007.

In fact, it is supposed to leave interpretation of the legislation without any precedent to an environmental consultant because of basic idea that there would be no problem if once the project is licensed by both of MINAMB and MINEA.

(4) Procedures of EIA Study

EIA consists of five components: (1) Preparation of environmental inventory (2) Analysis of a project (3) Definition and evaluation of environmental impact (4) Establishment and presentation of preventive and mitigation measures (5) Establishment and presentation of environmental monitoring program.

Public hearing shall be implemented after environmental impact is defined based on EIA study. Flowchart of EIA process for each category of project proponents is shown below.[17]

[15] Diario Da Republica, NO59/2004
[16] In the case of the investments over 2,830,000UCF (Approx. 196MillionKZ＝ Approx. 2 Million USD), 0.18% of installation license fee and 0.3% of operation license fee shall be charged.
[17] It has been provided by JICA

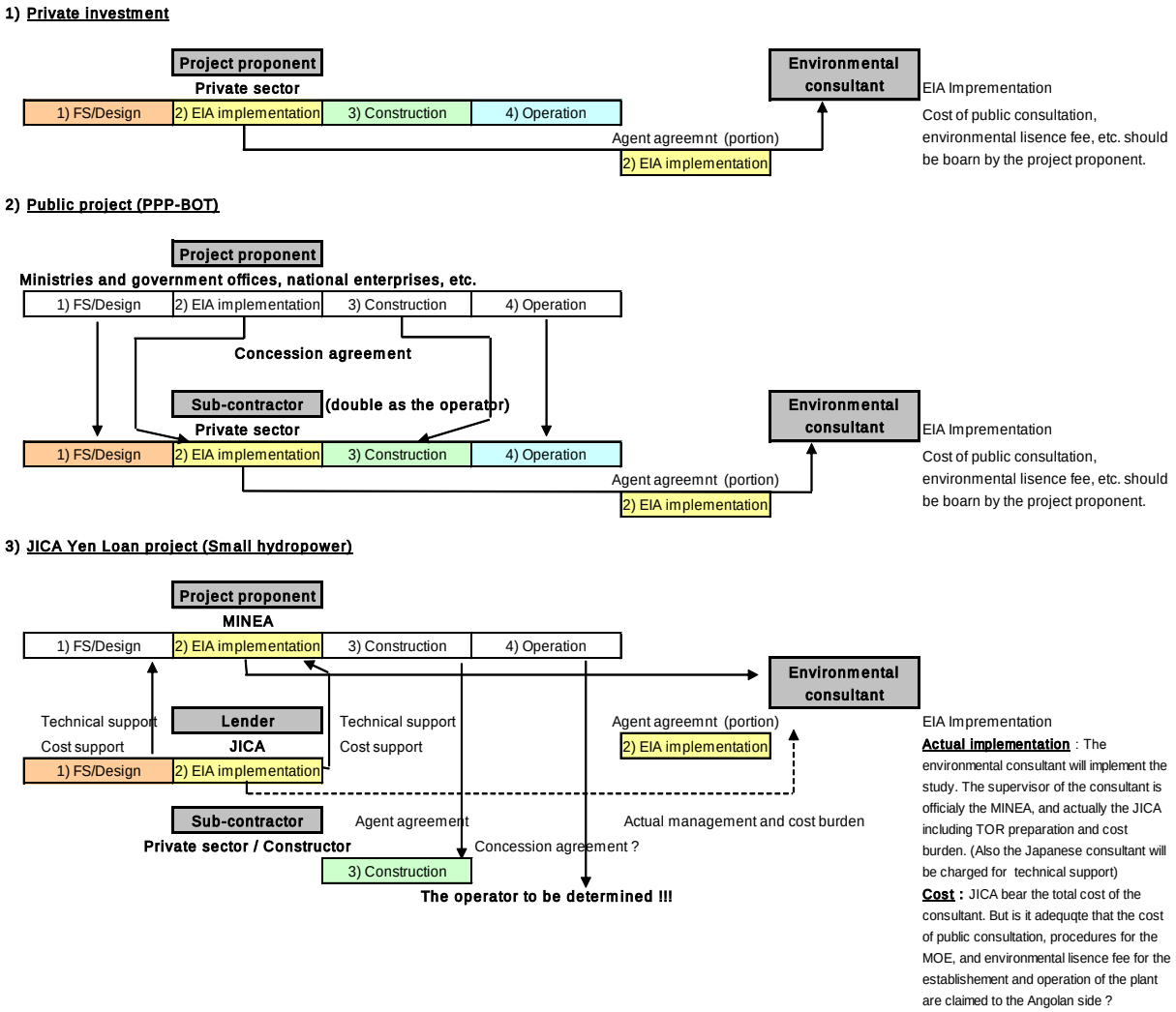


Fig.4.8-1 Flowchart of EIA Process for Each Category of Project Proponents

(5) Water Management

The Biological Aquatic Resources Act of 2004 is perhaps the most important piece of legislation relating to water resources. Some of its objectives are: to establish principles and rules for the protection of biological water resources and marine ecosystems; to promote the protection of the marine environment and coastal areas; and to establish principles and rules for responsible fishing. The act makes provisions for the protection of endangered aquatic species, the creation of marine and fluvial protected areas, setting fishing quotas, regulating fishing, and prohibiting damaging fishing methods, among others.

The Water Law, enacted in 2002, focuses on regulating the management and distribution of water resources. It establishes priorities and recognizes the responsibility of polluters to bear the costs of pollution.

4.8.2 JICA Guidelines for Environmental and Social Considerations

The current JICA Guidelines for Environmental and Social Considerations has come into force on July 1st, 2010, and will be applied to the projects whose applications are made by project proponents etc., on and after the effective date of the guidelines.

(1) Category Classification of Projects[18]

Category classification of projects is as follows.

a. Category classification is decided according to sector, scale, characteristics, and area of projects. (Classification can be reviewed because of additional information)
   Category A: Critical negative impact can be assumed.
   Category B: Negative impact is less than Category A
   Category C: Minimum or No negative impact
   Category FI: Sub-projects cannot be specified prior to JICA's approval of funding Two-step loan, sector loan, etc.)

b. Procedures are defined in accordance with the project category.

c. Environmental review and monitoring are implemented for projects of category A, B, and FI.

Category A projects in the guidelines are as follows.

a. Large-scale projects in sensitive sectors
   Thermal Power, hydropower, dams, roads, railways, airports, ports and harbors, pipelines, waste management and disposal

b. Sensitive characteristics
   - Large-scale involuntary resettlement
   - Large-scale land reclamation, land development, and land clearing

c. Sensitive Areas
   - National parks, nationally-designated protected areas
   - Primary forests or natural forests in tropical areas, and habitats with important ecological value
   - Habitats of indigenous people, etc.

[18] JICA, Lecture materials of "Environmental and social considerations" provided in their skill enhancement training, August 24, 2010

(2) Components of the Guidelines

"Responsibility of JICA" in the Section of 1.5 and "Requirements of project proponents etc." in the Section of 1.6 are composed for each stage as follows.

(1) New JICA guidelines
(2) Preparation stage of projects
(3) Environmental review stage
(4) Monitoring stage

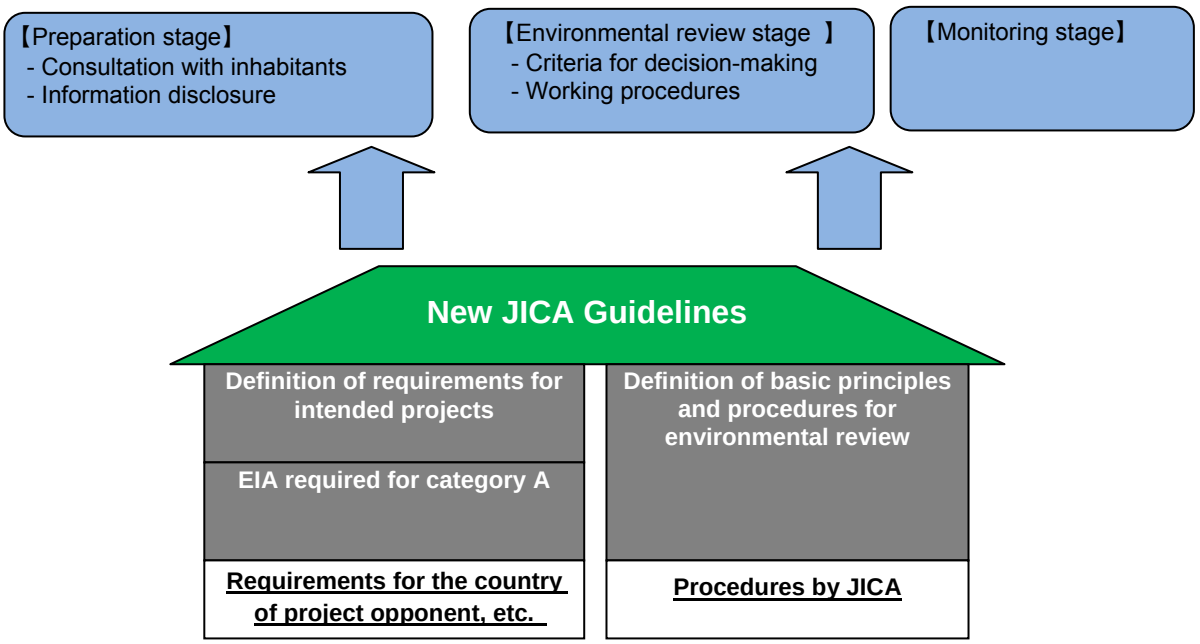


Fig.4.8-2 Components of the Guidelines

(3) Requirements for Intended Projects

1) Basic matters:

a. Alternatives or mitigation measures to avoid or minimize negative impacts of the projects must be examined
b. Analysis must be implemented also including quantitative evaluation
c. Documentation of the conclusions of environmental and social considerations studies
d. Advisory committee composed of experts, etc. will be established accordingly.

2) Scope of impacts to be studied:

a. Impact on human health and safety as well as natural environment
Air, water, soil, waste, accidents, water usage, climate change, ecosystems, biota, etc.

b. Social considerations

Migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poverty group and indigenous peoples, distribution of damages and benefits and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including labor safety

3) Compliance with laws, standards, etc.

a. Projects must comply with the laws, ordinances, and standards related to environmental and social considerations established by the governments that have jurisdiction over project sites

b. Projects must, in principle, be implemented outside of protected areas that are specifically designated by laws or ordinances for the conservation of nature or cultural heritage

4) Social Acceptability:

a. Projects must be adequately coordinated so that they are accepted in a manner that is socially appropriate to the country and locality in which they are planned.

b. Appropriate consideration must be given to vulnerable social groups, such as women, children, the elderly, poverty group and ethnic minorities, because all members of which are susceptible to environmental and social impacts and may have little access to decision-making processes within society.

5) Ecosystem and Biota:

a. Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests

b. Illegal logging of forests must be avoided. Project proponents etc. are encouraged to obtain certification by forest certification systems as a way to ensure the prevention of illegal logging.

6) Monitoring

a. Project proponents etc. should make efforts to disclose the results of the monitoring process to local project stakeholders.

b. When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, consultation should be held to discuss

and examine the countermeasures based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems.

7) Environmental impact: (in the case of large-scale of environmental impact)

a. Preparation and disclosure of EIA report
b. Elements defined in the World Bank Safeguard Policy, OP4.01, Annex B. (Guidelines Appendix 2)

(http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTOPMANUAL/0,,contentMDK:20065951~menuPK:4564185~pagePK:64709096~piPK:64709108~theSitePK:502184,00.html)

8) Indigenous people:

a. Environmental impact on indigenous people must be avoided and minimized.
b. Project proponents etc. should make efforts to obtain the informed consent of indigenous people through free and prior consultations.
c. Preparation and disclosure of indigenous people plan
d. Elements defined in the World Bank Safeguard Policy, OP4.10, Annex B.

(http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTOPMANUAL/0,,contentMDK:20564712~menuPK:4564185~pagePK:64709096~piPK:64709108~theSitePK:502184,00.html)

4.8.3 Initial Environmental Examination for the Power Plant of Cutato River

(1) Scoping

Information intended for the power plant of Cutato River has been collected, and scoping plan has been prepared based on the first and second site surveys.

Table 4.8-1 Scoping List

- Power Plant -

Category	No.	Impact	Evaluation		Reasons
			Before - During Construction	During Operation	
Pollution Control	1	Air pollution	D	D	During Construction: Air quality is expected to temporarily deteriorate due to operation of construction equipment, etc. During Operation: Traffic of inspection vehicles for maintenance is expected.
	2	Water pollution	D	D	During Construction: Water quality can be polluted due to drainage from the construction site, heavy machinery, vehicles, accommodation, etc. During Operation: Cooling water for generation is treated and returned to the river.
	3	Wastes	C-	D	During Construction: Surplus soil and waste materials during construction are expected to occur. During Operation: Wastes which are likely to have negative impact on surrounding environment, is not expected to occur.
	4	Soil pollution	D	D	During Construction: Soil pollution is expected due to oil drainage for construction, etc. During Operation: Impact by soil pollution is expected due to herbicide spraying for maintenance of buildings.

Category	No.	Impact	Evaluation		Reasons
			Before - During Construction	During Operation	
	5	Noise pollution Vibration pollution	C-	D	During Construction: Noise caused by operation of vehicles, etc. is expected to occur. During Operation: Traffic of inspection vehicles for maintenance is expected.
	6	Ground subsidence	D	D	Works that are likely to cause ground subsidence are not expected.
	7	Smell pollution	D	D	Works that are likely to cause smell pollution are not expected.
	8	Bottom sediment pollution	D	D	Works that are likely to cause bottom sediment pollution are not expected.
Natural Environment	9	Protected area	D	D	National parks, protected area, etc. do not exist in the project site and the surrounding area.
	10	Eco-system	C-	C-	During Construction: Impact on eco-system is generally small because this project is new construction of small hydropower plant and construction area is small. (several hundred meter long of extension on the river bed) During Operation: Variation of river discharge before and after the construction is extremely small. Therefore, impact on eco-system is small. Still, existence of valuable species of fauna and flora in the intended project site should be confirmed and impact on eco-system should be evaluated.
	11	Hydrology	C-	C-	During Construction: River-flow will be switched, and small-scale excavation construction of river bed is expected. During Operation: In dry seasons, diversion discharge of the river fork will vary before and after the completion of the power plant (because of preferential use for power generation), but in rainy seasons, it will not vary so much. Height of the river bed will rise in upper stream in long term due to a reservoir caused by the weir.
	12	Topography Geography	D	D	Large-scale cutting earth or embankment is not planned in this project. Therefore, impact on topography and geography will be extremely small.
Social Environment	13	Resettlement	D-	D-	Before construction: During planning: Land acquisition due to a reservoir or road construction is expected. However, potential of resettlement is extremely low.
	14	Poverty group	C-	B+	Before construction: Poverty group can be required for resettlement. During Operation: Living standard will be improved and business opportunity will be increased by power supply to the inhabitants of non-electrified villages around the power plant. Social services such as a school, hospital, etc. will be improved also for poverty group. Positive impact can be expected.
	15	Minority Indigenous people	D	D	Minority and indigenous people do not exist in the project site and the surrounding area. (Ombundo tribe, majority of Angola, inhabit in the surrounding villages)
	16	Local Economy (Employment, Means of livelihood, etc.)	D	B+	This project is development of local electrification to supply electric power for agriculture and industry, and develop the local economy. Positive impact can be expected.
	17	Land use Use of local resources	D	B+/-	This project is development of local electrification to supply electric power for irrigation and then extend the cultivated land. (Positive impact can be expected. On the other hand, existing cultivated land can be submerged or restricted the use due to the reservoir.
	18	Water use	C-	C-	During Construction: Negative impact by murky water is expected during construction because people use river water in the project area. During Operation: Water intake for power generation is expected. However, the river discharge will not be decreased because water will be discharged at the downstream.
	19	Existing social infrastructure Social services	C-	B+	During Construction: Traffic by inhabitants can be restricted during construction. During Operation: Social infrastructure such as road, school, medical institution, etc. and related services will be improved, because electric power will be supplied to those institutions as well as households.
	20	Social capital Social organizations (Local decision-making bodies, etc.)	C	C	This project is expected to have an impact to social capital, local decision-making bodies, etc. regarding the priority of suppliers of power development.

Category	No.	Impact	Evaluation		Reasons
			Before - During Construction	During Operation	
	21	Mal-distribution of damages and benefits	C	C	Sociality, economical efficiency, and fairness of the benefits brought by this project should be maintained regarding the priority of suppliers of power development.
	22	Conflict of interest in the project area	C	C	Conflict of interests in the project area should be avoided regarding the priority of suppliers of power development.
	23	Cultural heritage	D	D	Any cultural heritage does not exist in the project site and the surrounding area.
Social Environment	24	Landscape	C	C	Impact on landscapes will be small because of small hydropower project.
	25	Gender	C	B+	During operation: Labor load for women such as fuelwood procurement for cooking is expected to be decreased. Electric use for cooking (electric pot, etc.) can be also expected.
	26	Children's rights	C	B+	During operation: Study and help housekeeping will be enable for children by power supply after the sunset.
	27	Infection (HIV/AIDS, etc.)	C-	D	During Construction: Although large-scale construction is not expected, infection can be spread because of inflow of construction workers.
	28	Labor Environment (including labor safety)	C-	D	During Construction: Labor environment of construction workers should be considered. During Operation: Works having negative impact to workers are not planned.
	29	Accidents	C-	C-	During Construction: Accidents during construction should be considered. During Operation: Accidents involving management of the power plant should be considered.
Others	30	Impact across the border Climate change	D	B+	This is power generation project without CO_2 emission. Therefore, positive impact in relate to climate change can be expected.

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D: No impact is expected.

- Distribution Lines -

Category	No.	Impact	Evaluation		Evaluation
			Before - During Construction	During Operation	
Pollution Control	1	Air pollution	D	D	During Construction: Air quality is expected to temporarily deteriorate due to operation of construction equipment, etc. During Operation: Traffic of inspection vehicles for maintenance is expected.
	2	Water pollution	D	D	During Construction: Water quality can be polluted due to drainage from the construction site, heavy machinery, vehicles, accommodation, etc. During Operation: Nothing special
	3	Wastes	C-	D	During Construction: Surplus soil and waste materials during construction are expected to occur. During Operation: Wastes which are likely to have negative impact on surrounding environment, is not expected to occur.
	4	Soil pollution	D	D	During Construction: Soil pollution due to oil drainage for construction, etc. is expected. During Operation: Nothing special
	5	Noise pollution Vibration pollution	C-	D	During Construction: Noise caused by operation of vehicles, etc. is expected to occur. During Operation: Traffic of inspection vehicles for maintenance is expected.
	6	Ground subsidence	D	D	Works that are likely to cause ground subsidence are not expected.
	7	Smell pollution	D	D	Works that are likely to cause smell pollution are not expected.
	8	Bottom sediment pollution	D	D	Works that are likely to cause bottom sediment pollution are not expected.
Natural Environment	9	Protected area	D	D	National parks, protected area, etc. do not exist in the project site and the surrounding area.
	10	Eco-system	D	D	Impact on eco-system is expected to be small because distribution lines will be constructed along the road.

Category	No.	Impact	Evaluation		Evaluation
			Before - During Construction	During Operation	
	11	Hydrology	D	D	Works having an impact on hydrology are not expected.
	12	Topography Geography	D	D	Cutting earth or embankment is not planned in this project. Therefore, impact on topography and geography will be extremely small.
Social Environment	13	Resettlement	D-	D-	A route for distribution lines should be decided not to require resettlement.
Social Environment	14	Poverty group	D	B+	During Operation: Living standard will be improved and business opportunity will be increased by power supply to the inhabitants of non-electrified villages around the power plant. Social services such as a school, hospital, etc. will be improved also for poverty group. Positive impact can be expected.
	15	Minority Indigenous people	D	D	Minority and indigenous people do not exist in the project site and the surrounding area. (Ombundo tribe, majority of Angola, inhabit in the surrounding villages)
	16	Local Economy (Employment, Means of livelihood, etc.)	D	B+	This project is development of local electrification to supply electric power for agriculture and industry, and develop the local economy. Positive impact can be expected.
	17	Land use Use of local resources	D	B+	This project is development of local electrification to supply electric power for irrigation and then extend the cultivated land. (Positive impact can be expected.)
	18	Water use	D	D	Water use for construction is extremely small.
	19	Existing social infrastructure Social services	C-	B+	During Construction: Traffic by inhabitants can be restricted during construction. During Operation: Social infrastructure such as road, school, medical institution, etc. and related services will be improved, because electric power will be supplied to those institutions as well as households.
	20	Social capital Social organizations (Local decision-making bodies, etc.)	C	C	This project is expected to have an impact to social capital, local decision-making bodies, etc. regarding the priority of suppliers of power development.
	21	Mal-distribution of damages and benefits	C	C	Sociality, economical efficiency, and fairness of the benefits brought by this project should be maintained regarding the priority of suppliers of power development.
	22	Conflict of interest in the project area	C	C	Conflict of interests in the project area should be avoided regarding the priority of suppliers of power development.
	23	Cultural heritage	D	D	Any cultural heritage does not exist in the project site and the surrounding area.
	24	Landscape	C-	C-	Impact on landscapes will be small because main construction is of small power poles.
	25	Gender	C	B+	During operation: Labor load for women such as fuelwood procurement for cooking is expected to be decreased. Electric use for cooking (electric pot, etc.) can be also expected.
	26	Children's rights	C	B+	During operation: Study and help housekeeping will be enable for children by power supply after the sunset.
	27	Infection (HIV/AIDS, etc.)	D	D	During Construction: Large-scale construction is not expected.
	28	Labor Environment (including labor safety)	C-	D	During Construction: Labor environment of construction workers should be considered. During Operation: Works having negative impact to workers are not planned.
	29	Accidents	C-	C-	During Construction: Accidents during construction should be considered. During Operation: Accidents involving management of the power plant are concerned.
Others	30	Impact across the border Climate change	D	B+	This is power generation project without CO_2 emission. Therefore, positive impact in relate to climate change can be expected.

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D: No impact is expected.

(2) TOR for Study of Environmental and Social Considerations

Evaluation items of environmental impact extracted through scoping and methods and descriptions of the study are shown in Table 4.8-2.

Table 4.8-2 Evaluation Items and Methods and Descriptions of the Study

Evaluation Item	Description of Study	Remarks (reference of evaluation criteria, standard, etc.)
Power Plant		
Study of alternatives	Study of the weir height	To minimize the number of households of resettlement and land acquisition To maximize the benefit of the project
Wastes	In the vicinity of the project site	Japanese environmental criteria, WHO, WB, IFC (private)
Noise	In the vicinity of the project site	Japanese environmental criteria, WHO, WB, IFC (private)
Eco-system	Existence of valuable species of fauna and flora in the intended project site shall be confirmed and impact on eco-system shall be evaluated.	IUCN (International Union for Conservation of nature and Natural Resources) Red list
Resettlement	Resettlement due to a reservoir - Utilization of a 1/25000 topographical map and satellite photographs	Case examples in Angola, JICA guidelines for environmental and social considerations, and Operational Policy 4.12 of the World Bank
Land use Utilization of local resources	Study of land use and local resources (water, fish, etc.) in the scope of reservoir - Hearing at the site - Utilization of a 1/25000 topographical map and satellite photographs	Water rights and fishing rights in Cutato River
Stakeholders Meeting (SHM)	2 stages of SHM 1) Stage of scoping plan 2) Stage of draft report	JICA guidelines for environmental and social considerations * Workshop: relevant organizations, NGO, etc. Seminar: relevant organizations, representatives of the district, councilors, etc.
Distribution Lines		
Wastes	In the vicinity of the project site	Japanese environmental criteria, WHO, WB, IFC (private)
Noise	In the vicinity of the project site	Japanese environmental criteria, WHO, WB, IFC (private)
Eco-system	Existence of valuable species of fauna and flora in the intended project site shall be confirmed and impact on eco-system shall be evaluated.	IUCN Red list
Land use Utilization of local resources	Land use (including rows) along the route of distribution lines - Hearing at the site - Utilization of a 1/25000 topographical map and satellite photographs	Compensation criteria of Angola (Land Law), JICA guidelines for environmental and social considerations, and Operational Policy 4.12 of the World Bank
Stakeholders Meeting (SHM)	2 stages of SHM 1) Stage of scoping plan 2) Stage of draft report	JICA guidelines for environmental and social considerations * Workshop: relevant organizations, NGO, etc. Seminar: relevant organizations, representatives of the district, councilors, etc.

* In the general study of environmental and social considerations, information disclosure and stakeholders meeting shall be held accordingly and the results shall be reflected by JICA.

(3) Initial Environmental Examination for the Power Plant of Cutato River

IEE level study of environmental and social considerations in cooperation with the recipient country was not originally planned because this project had been classified as category C. As a result of the first survey, however, it was defined that this project is new construction of a hydropower plant to be classified as category B. Therefore, environmental examination was implemented within a limited time with awareness of category B of JICA guidelines. In the second survey, IEE level study was implemented for the site of Cutato River plant and the route of distribution lines. At first, inhabitant questionnaire survey was conducted coordinately within a limited time with relevant organizations, and also confirmed the current conditions of preventive measures to avoid or mitigate environmental and social impact (including compensation measures in the case of that negative impact is unavoidable), monitoring, and environmental systems.

1) Public consultation

At first, inhabitant questionnaire survey was conducted to confirm the basic information about this project. The result was shown in Appendix-1.

Workshop must be held in the future to listen to the opinions of the stakeholders of Cuito Hydropower Project after explanation of the project outline and environmental impact. The participants will be MINEA, (senior) officers of each municipality and other people concerned.

And, it was requested to the government of Angola to implement EIA according to JICA environmental guidelines based on the results of FS investigation of this project. Moreover, it must be requested to the government to arrange consultation with local residents as early as possible, who will be affected by the project to be implemented FS investigation.

2) Maintenance of mitigation measures and systems

GOA including the DOE does not have much experience of preventive measures to avoid or mitigate environmental and social impact (including compensation measures in case that negative impact is unavoidable), monitoring, and environmental systems. Generally, a project proponent commissions a private company to prepare an EIA report and monitoring plan[19], because there are local environmental investigation agencies that have experienced in preparation of EIA report of a hydropower projects.

Mitigation measures to be expected at present are shown as follows.

Impact on aquatic life will be mitigated by treatment of polluted water during

[19] It was confirmed by Mr. Julietta Condes who is the manager of the EIA department of MOE

construction, and impact by excavated soil will be mitigated by appropriate disposal and treatment of surplus soil.

Environmental management plan needs to be prepared in order to monitor the effect of suggested mitigation measures. As for treatment of polluted water to mitigate impact on aquatic life, (1) Examination whether the treatment has been actually implemented or not, and (2) Annual investigation of water quality, will be necessary to monitor the effect.

3) Study of alternatives

As alternatives, four options have been qualitatively evaluated on each evaluation item. The results are shown in Table 4.8-3.

Diesel power generation can be considered as alternative of small hydropower generation. The fuel price is relatively low and stable (Diesel 40 Kz per L, Gasoline 60 Kz per L, nationwide, September 13, 2010) because crude oil is produced in their own country. However, the cost is getting higher than small hydropower because of increasing price of crude oil.

Table 4.8-3 Evaluation Results of Alternatives

Evaluation Item	Small hydropower	Alternatives		
		Diesel	PV	No project
Scale of Environmental Impact	B	C	B	A
Construction cost	C	B	C	-
Operation cost	A	C	A	-
Project cost per MW	A	B	C	-
Power generation output for electricity demand	B	A	C	-
Efficiency of utilization of domestic resources	A	B	A	C
Contribution to improvement of electrification rate	A	A	B	C
Total	A	B	B	C

A: No environmental load, low cost, large power generation output, large efficiency of utilization of domestic resources, large contribution

B: Some environmental load, moderate cost, moderate power generation output, moderate efficiency of utilization of domestic resources, moderate contribution

C: Large environmental load, large cost, small power generation output, small efficiency of utilization of domestic resources, small contribution

- : Zero cost, Zero power generation output

As for photovoltaic (PV), power generation is 20 - 40 W and extremely small although load on environment is smaller than small hydropower. Also, batteries will be required at night during the peak time of electricity demand, because PV power is not available after the sunset. It is lead battery which is widely used because of low cost, but it is mostly scrapped without any treatment since the durable period is only several months. Impact by pollution of solid wastes and lead exhaust should not be ignored especially in developing countries. Therefore, the project cost will be higher in the case of all PV

systems.

The objective of this project is to improve electrification rate in local cities and rural villages. No project implementation creates no environmental load, but no improvement of electrification rate at the same time. Compared with other options, small hydropower is equivalent or more eco-friendly in environmental load, and takes advantage in economic efficiency including operation cost. Therefore, small hydropower is the most superior project as an overall judgment.

4) Study of evaluation items of environmental impact

a. Hydrology

Environmental impact by hydrological change is evaluated which will occur during and after the construction. Firstly, the degree of hydrological change is studied as below.

The project site is located on the river branch point which is converged at 600m downstream. The weir will be constructed with diverging water into either diversion, and river discharge in two diversions will be different during construction from the current discharge accordingly. It is concerned that water level of odd diversion descend especially when water discharge is less in dry seasons. However, it is expected to secure 0.9m of water level at least because water level of river is determined by water level of confluence point.

Water discharge of river diversions will be changed in dry seasons before and after the completion of the power plant (preferentially used for power generation), but almost unchanged in rainy seasons. The water level at least 0.9 m will be secured as well as during the construction.

Moreover, the height of riverbed is expected to rise in long term because of a reservoir form caused by the weir. The current riverbed slope is 1/1500 on the average, and it will be 1/3000 because riverbed will generally rise by 1/2 of the slope. Therefore, the water level of the river will rise, and the current river conditions will be changed accordingly. It is expected that elevation level of the weir is 1,400m. And height of the weir is 1 m excluding a flap gate (the height of 3 m), the full water level will be 1,404 m. Even though the riverbed rises and reaches the weir, the maximum effect will be up to approximately 6m of upstream where the water level of the riverbed will be 1,404 m. Therefore, the weir construction will not have impact on the riverbed at higher than 1,404 m.

Even if the maximum flood, 560 m^3/min, occurs, the depth of water will be approximately 4 m at 6 km upstream. Therefore, if the land is higher than 1,408m, there will be no impact by the weir construction.

b. Eco-systems

The project site is not located in environmental protected area as shown in Fig.4.8-3.[20] There are 20 environmental protected areas in Angola, which has total area of approximately 68,000 km^2 and accounts for 6% of national land area. However, it is the smallest rate compared with other African countries. These protected areas are classified as national parks, regional parks, nature reserves and game reserves in Angola's National Biodiversity Strategy and Action Plan. (NBCSAP; MINUA 2006) Protected areas are designated as different categories, but importance of legislative protection for each category is not specified.

Photo 4.8-1 Hearing from the ruling elder of Muenga Village

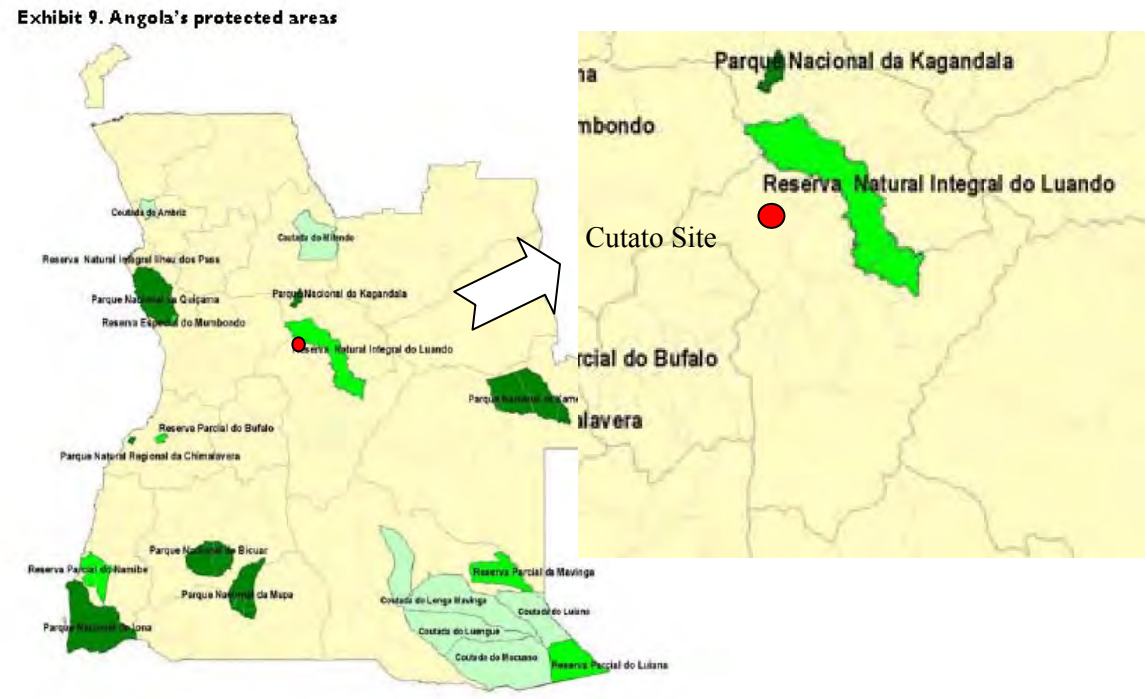


Fig. 4.8-3 Environmental Protected Area

According to satellite photographs, area of Cutato River lower than 1,420m above sea level is divided into marsh land, grass land, and broadleaf forest. There is no cultivated land.

[20] USAID, 118/119 Biodiversity and Tropical Forest Assessment for Angola, May 2008

In the site survey, hearing with ruling elders and other people in Muenga, Chimonga Village and Chicumbi Village has been conducted to confirm wild lives, vegetation, land use, etc. Vegetation of Mimosa family was confirmed in the site area.

According to hearing from the inhabitants at the site[21], mammals of a hippopotamus, crocodile, monkey, rabbit, goat, wild boar, etc. inhabit in the site area. Also, fishes of catfish, tilapia, cacuso, etc. inhabit in the Cutato River.

Mammals of Angola registered in IUCN Red list are shown in Table 4.8-4. According to hearing at the site, the species registered in IUCN Red List may exist in the project site.

Photo 4.8-2 Inhabitants of Chicumbi Village
(MINEA Staff on the far right)

Photo 4.8-3 Inhabitants of Chimonga Village

[21] Hearing with the ruling elder of Muennga Village was implemented on January 26, 2011

Table 4.8-4 (1) IUCN Red List (Mammal)

No.	Common Name	Scientific Name	Status in 2001
1	Black Rhinoceros	Diceros bicormis	CR
2	Western Gorilla	Gorilla gorilla	EN
3	Common Chimpanzee	Pan troglodytes	
4	Fin Whale	Balaenoptera physalus	
5	African Eild Dog	Lycaon pictus	
6	Mountain Zebra	Equus zebra	
7	African Bush Elephant	Loxodonta africana	VU
8	African Manatee	Trichechus senegalensis	
9	Humpback Whale	Megaptera novaeangliae	
10	Cheetah	Acinonyx jubatus	
11	Blac-footed Cat	Felis nigripes	
12	African Golden Cat	Profelis aurata	
13	Lion	Panthera leo bleyenberghi	
14	Hippopotamus	Hippopotamus amphibius	
15	Angolan Marsh	Rat Dasymys nudipes	NT
16	Angolan Epauletted Fruit Bat	Epomophorus angolensis	
17	Angolan Hairy Bat	Cistugo seabrai	
18	Beatrix's Bat	Glauconycteris beatrix	
19	Angolan Long-eared Bats	Laephotis angolensis	
20	Natal Long-fingered Bat	Miniopterus natalensis	
21	Large-eared Free-tailed Bat	Otomops martiensseni	
22	Pel's Pouched Bat	Saccolaimus peli	
23	Intermediate Slit-Faced Bat	Nycteris intermedia	
24	Swinny's Hourseshoe Bat	Rhinolophus swinnyi	

Legend: CR; Critically endangered, EN; Endangered, VU; Vulnerable, NT; Near threatened

Table 4.8-4 (2) IUCN Red List (Except for Mammals)

No	Name	Taxonomy			Assessment Information
		Class:	Scientific Name:	Common English Name/s:	* Red List Category & Criteria:
1	Pinheyagrion angolicum	INSECTA	Pinheyagrion angolicum	Angola Bluet	LC
2	Pseudagrion angolense	INSECTA	Pseudagrion angolense	Angola Sprite	DD
3	Barbus fasciolatus	ACTINOPTERYGII	Barbus fasciolatus	African banded barb, Angola barb, Angolan barb, Barred barb, Orange barb, Red barb, Tiger barb	LC
4	Chetia welwitschi	ACTINOPTERYGII	Chetia welwitschi	Angola happy, Angolan happy	DD
5	Etrumeus whiteheadi	ACTINOPTERYGII	Etrumeus whiteheadi	Whitehead's Round Herring, Whitehead's Round Herring , Redeye, Redeye Roundherring, Round Herring, Whitehead's Round Herring	LC
6	Kneria angolensis	ACTINOPTERYGII	Kneria angolensis	Angola kneria	LC
7	Kneria ansorgii	ACTINOPTERYGII	Kneria ansorgii	-	DD
8	Afrixalus osorioi	Amphibia	Afrixalus osorioi	Angola Banana Frog, Congro Spiny Reed Frog, Osorio's Spiny Reed Frog	LC
9	Amietia angolensis	AMPHIBIA	Amietia angolensis	Angola River Frog, Common River Frog	LC
10	Prosymna angolensis	REPTILIA	Prosymna angolensis	Angola Shovel-snout	LC
11	Batis minulla	AVES	Batis minulla	Angola Batis	LC
12	Cossypha heinrichi	AVES	Cossypha heinrichi	White-headed Robin-chat, Angolan Robin-chat, Angola White-headed Robin	VU
13	Dioptrornis brunneus	AVES	Dioptrornis brunneus	Angola Slaty Flycatcher, Angola Slaty-flycatcher	LC
14	Hirundo angolensis	AVES	Hirundo angolensis	Angola Swallow	LC
15	Mirafra angolensis	AVES	Mirafra angolensis	Angola Lark	LC
16	Prionops gabela	AVES	Prionops gabela	Gabela Helmet-shrike, Angola Helmetshrike, Gabela Helmetshrike, Gabela Helmet Shrike	EN
17	Turdoides hartlaubii	AVES	Turdoides hartlaubii	Angola Babbler, Hartlaub's Babbler	LC
18	Xenocopsychus ansorgei	AVES	Xenocopsychus ansorgei	Angola Cave-chat, Angola Cave Chat	NT
19	Colobus angolensis	MAMMALIA	Colobus angolensis	Angola Colobus, Angolan Black-and-white Colobus, Angolan Colobus	LC

c. Land Use

The submerging site under this project is national land and any compensation will not occur for the land use.[22] There is no irrigated land in the vicinity of the site. According to satellite photographs, there is no cultivated land in the area lower than 1,420 m above sea level.

Photo 4.8-4 Cutato Site (View of the Downstream from the Upstream, Rainy Season, Jan. 26, 2011)

Crops cultivated in Muenga, Chimonga Villages and Chicumbi Village in the vicinity of the project site are as follows.

corns, beans, sweet potatoes, potatoes, bananas, radishes, peanuts, onions, eggplants, spinaches, etc.

d. Resettlement

According to satellite photographs and maps, several houses are found around 1,420 m above sea level in the riverbed area at a tributary, but no houses in the riverbed area of main stream at lower than 1,420 m. Involuntary resettlement due to the project construction is not expected to occur.

e. Rights and compensation

Land acquisition and compensation for transmission lines, passageway for equipment, temporary facilities, spoil bank, quarry, and etc. will be implemented by the Municipality. Compensation cost is 150 Kz per square meter. Compensation for crops is implemented by the Municipality, too.

Water rights are possessed by GOA, and private companies have to pay the utilization fee if they use water.

Fishing rights are controlled by the Ministry of agriculture and fishery. Some inhabitants make income through fishery as side business. They catch fish by installing wooden baskets into the river. (Photo 4.8-5)

[22] Explanation by Mr. Francisco Pereira at the county courthouse of Andulo on January 27, 2011


Photo 4.8-5 Basket fishing at the Cutato River (Downstream of the Site)

5) Conclusion

EFL of 1998 is most fundamental to execute the environmental policy. Concrete framework of the regulation is incomplete to apply the Law. In the EFL of 1998, article 17 states that implementation of EIA is mandatory against construction of hydropower at the capacity more than 1 MW and transmission line at the capacity more than 230 kV.

In this study initial environmental impact survey was undertaken. All the candidate sites are type of run-of-river and little difference in terms of environmental impact among sites. Cutato site is expected to be developed more capacity than the other sites. To mitigate the impact, Cutato site will require a gated-spillway to control the reservoir water level not to increase the water level at floods.

The initial environmental impact examination was undertaken for Cutato site. All the village residents near the site showed agreement of the construction in the field interview. The involuntary resettlement is not estimated to happen due to the reservoir formation. The land inundated which doesn't include cultivated land will be state own and no target of compensation.

It is expected that negative impact on eco-system is small, but further investigation must be implemented in EIA. Especially, confirmation of habitat situations of hippopotamuses at the site is required, in consideration of information by the inhabitants.

The result of Initial Environmental Examination this time has been explained to the environmental department of MINEA.[23] Department and person in charge in MINEA have not been assigned yet. EIA will be carried on.

[23] It was explained to Mr. Osorio Lologio of Environmental department of MOEW.

Appendix-1 Results of Inhabitant Questionnaire

		Answerer1	Answerer2	Answerer3
1. Implementation conditions of hearing				
	Date	January 26, 2011 11:00 ~ 12:30	January 26, 2011 11:00 ~ 12:30	January 26, 2011 11:00 ~ 12:30
	Place	Muennga Village	Muennga Village	Muennga Village
	Answerer	Ruling elder	Francisco Catombela	Muafeca
	Conditions of hearing	Approximately 10 village people gethered, and the ruling elder answered as their representative. There is no peron who understand Portuguese, and hearing was implemented through translation into local language.	He was introduced by the ruling elder as a resident who has a generator at home. Hearing was implemented mainly about a generator.	He was introduced by the ruling elder as a person concerns fishery. Hearing was implemented mainly about impact on fishery.
2. EIA				
(1)	Please describe wiid lives inhabit around the site	hippopotamus, monkey, rabbit, goat, wild boar	–	–
(2)	Please describe the names of flowers, grasses, and trees growing around the site	(Vegetations growing around the village) GANGA,METI,OLONCHA	–	–
(3)	Please describe crops being cultivated around the site	(Crops being cultivated in the village) corns,beans, sweet potatoes, potatoes, bananas, radishes, peanuts, onions, eggplants, spinaches,	–	–
(4)	Is there any people living at riversides of Cutato River? (between the river and the land 10m higher than river)	No	–	–
(5)	Is there any people who earn their own living by fishing in the Cutato River?	Yes	–	(Main fish being caught in the Cutato River) Catfish, Cacuso,Tilapia
(6)	Have you seen the animals in the attached photographs? If yes, please indicate it.	He have seen all animals.	He have seen all animals.	–
3. CDM				
(1)	Do you have any electric products or generator at home?	■ No (there is no electric products at ruling elder's home)	■ Yes	–
	If yes, what is fuel for generation?	Nothing	Gasoline	–
	If yes, what is the electric products?	Nothing	Television, Component stereo	–
(2)	What do you use for lighting at home?	Oil lanterns or candles	Battery lights (power charged during a generator is operated)	–
(3)	What do you think about the environmental conditions in your district?			–
	・Environment is in good conditions.	■	■	–
	・Air environment is bad.	□	□	–
	・Water environment is bad.	□	□	–
	・I am concerned about noise	□	□	–
	・Others	□	□	–
(4)	Do you have a desire for stable electric power supply by a hydropower plant?	■ Yes	■ Yes	–
(5)	There is a possibility that traffic and noise by trucks increase during construction of the hydropower plant. Is it acceptalbe?	■ Yes	■ Yes	Q. There is a possibility that construction of the power plant impacts on fishery (shift of fishing place, etc.) . Is it acceptable? --A. No problem
(6)	There is a possibility that a part of upper area of a hydropower plant will be submerged due to the construction. Is it acceptalbe?	■ Yes	■ Yes	–
(7)	Do you support for construction of the hydropower plant?	■ Yes	■ Yes	■ Yes
4 . Demand survey				
(1)	How many people are there in your family?	3 wives, 19 children	1 wife, 3 children	–
(2)	How long do you burn fuel woods at a time?	I am not sure about time, but I use a log as in a photo for cooking for 3 days.	–	–
(3)	How long do you operate a diesel generator per day?	I don't have a generator.	3L of gasoline per day	–
(4)	How long do you need lighting at night?	Approximately 4 hours	Approximately 4 hours	–
(5)	Popullation of the village	Census of 2010: 8042 people, Census of 2008: 5800 people Population census was not implemented 10 years ago because of the civil war.	–	–
	Remarks		There are 3 households who has a generator. All of them use gasoline as fuel.	

		Answerer1
1. Implementation conditions of hearing		
	Date	January 26, 2011 13:30 ~ 14:30
	Place	Chimonga Village
	Answerer	Rufono Fanguelo (Ruling elder)
	Conditions of hearing	Hearing was implemented to a ruling elder at his home. Other people in the village were absent for cultivation.

2. EIA		
(1)	Please describe wiid lives inhabit around the site	Hippopotamus
(2)	Please describe the names of flowers, grasses, and trees growing around the site	(Vegetations growing around the village) Manda,Omone,Oloncha
(3)	Please describe crops being cultivated around the site	(Crops being cultivated in the village) corns,beans, cassava, peanuts, soy beans
(4)	Is there any people living at riversides of Cutato River? (between the river and the land 10m	■No
(5)	Is there any people who earn their own living by fishing in the Cutato River?	■Yes
(6)	Have you seen the animals in the attached photographs? If yes, please indicate it.	He have seen all animals except for a monkey.

3. CDM		
(1)	Do you have any electric products or generator at home?	■ No (there is no electric products at ruling elder's home)
	If yes, what is fuel for generation?	Nothing
	If yes, what is the electric products?	Nothing
(2)	What do you use for lighting at home?	Battery lanterns
(3)	What do you think about the environmental conditions in your district?	
	・Environment is in good conditions.	■
	・Air environment is bad.	□
	・Water environment is bad.	□
	・I am concerned about noise	□
	・Others	□
(4)	Do you have a desire for stable electric power supply by a hydropower plant?	■Yes
(5)	There is a possibility that traffic and noise by trucks increase during construction of the hydropower plant. Is it acceptalbe?	■Yes
(6)	There is a possibility that a part of upper area of a hydropower plant will be submerged due to the construction. Is it acceptalbe?	■Yes
(7)	Do you support for construction of the	■Yes

4 . Demand survey		
(1)	How many people are there in your family?	One wife, two children
(2)	How long do you burn wooden fuels at a time?	All households cook with fuel woods. A household use a log as in a photo for cooking for 3-7 days.
(3)	How long do you operate a diesel generator per day?	I don't have a generator.
(4)	How long do you need lighting at night?	PM18:00～20:30
(5)	Popullation of the village	2630 people

	Remarks	There are approximately 10 households who has a generator. The chief of county had explained about construction of the hydropower plant.

		Answerer1	Answerer2	Answerer3
1. Implementation conditions of hearing				
	Date	January 27, 2011 11:30 ~ 12:30	January 27, 2011 11:30 ~ 12:30	January 27, 2011 11:30 ~ 12:30
	Place	Chicumbi Village	Chicumbi Village	Chicumbi Village
	Answerer	Ruling elder	Vice ruling elder	
	Conditions of hearing	Approximately 100 village people gethered, and the 2 ruling elders answered as their representative.	Approximately 100 village people gethered, and the 2 ruling elders answered as their representative.	He was introduced by the ruling elder as a resident who has a generator at home. We asked him to show us his generator.
2. EIA				
(1)	Please describe wiid lives inhabit around the site	(Animals inhabit around the village) Goat, monkey, rabbit, chicken	(Animals inhabit around the village) Goat, monkey, rabbit, chicken	–
(2)	Please describe the names of flowers, grasses, and trees growing around the site	(Vegetations growing around the village) GANGA, METI, OLONCHA	(Vegetations growing around the village) GANGA, METI, OLONCHA	–
(3)	Please describe crops being cultivated around the site	(Crops being cultivated in the village) corns,beans, sweet potatoes, potatoes, bananas, radishes, peanuts, onions, eggplants, spinaches	(Crops being cultivated in the village) corns,beans, sweet potatoes, potatoes, bananas, radishes, peanuts, onions, eggplants, spinaches	–
(4)	Is there any people living at riversides of Cutato River? (between the river and the land 10m	■No	■No	–
(5)	Is there any people who earn their own living by fishing in the Cutato River?	■Yes	■Yes	–
(6)	Have you seen the animals in the attached photographs? If yes, please indicate it.	He have seen all animals.	He have seen all animals.	–
3. CDM				
(1)	Do you have any electric products or generator at home?	■No	■No	■Yes
	If yes, what is fuel for generation?	Nothing	Nothing	Gasoline
	If yes, what is the electric products?	Nothing	Nothing	Television, radio, lighting (in each room)
(2)	What do you use for lighting at home?	Battery lantern	Battery lantern	Electric light (18:00 ～ 23:00 at latest)
(3)	What do you think about the environmental conditions in your district?			
	・Environment is in good conditions.	■	■	–
	・Air environment is bad.	□	□	–
	・Water environment is bad.	□	□	–
	・I am concerned about noise	□	□	–
	・Others	□	□	–
(4)	Do you have a desire for stable electric power supply by a hydropower plant?	■Yes	■Yes	–
(5)	There is a possibility that traffic and noise by trucks increase during construction of the hydropower plant. Is it acceptalbe?	■Yes	■Yes	–
(6)	There is a possibility that a part of upper area of a hydropower plant will be submerged due to the construction. Is it acceptalbe?	■Yes	■Yes	–
(7)	Do you support for construction of the	■Yes	■Yes	–
4 . Demand survey				
(1)	How many people are there in your family?	1 wife, 5 children	2 wives, 15 children	–
(2)	How long do you burn wooden fuels at a time?	We cook in the morning and early afternoon. We use a log for cooking for 3-7 days.	We cook in the morning and early afternoon. We use a log for cooking for 3-7 days.	–
(3)	How long do you operate a diesel generator per day?	I don't have a generator.	I don't have a generator.	–
(4)	How long do you need lighting at night?	18:00～20:00	18:00～20:00	–
(5)	Popullation of the village	January in 2011: 4812 people, in 2009: 3800 people	–	–
	Remarks		There are some people who earn their own living by fishery. However, certain impact on fishery is acceptable because the village peple think that electricity is more important.	There are 3 households who has a generator. All of them use gasoline as fuel. The price of a generator is 15,000 KZ. Gasoline cost is high, and economic burden is large.

4.8.4 Environmental Impact Assessment (EIA)

EIA and investigations regarding to EIA were carried out from July 2011 to October 2011. The consequence is shown below.

4.8.4.1 Legal Framework in Angola

(1) Law and Legislation regarding to Environmental and Social Consideration

Law and Legislation regarding to Environmental and Social Consideration in Angola are shown below.

- Environmental Basic Law (19th June 1998)
- Environmental Impact Assessment Legislation (23rd July 2004)
- Environmental Licensing Legislation (13th July 2007)
- Water Law (21st June 2002)
- Aquatic Biological Resources Law (8th October 2004)
- Land Planning and Urbanism Law (25th June 2004)
- Cultural Heritage Law (7th October 2005)

The EIA approval process in Angola is shown in Fig.4.8-4.

(2) Organization regarding to Environmental and Social Consideration

Organizations regarding to Environmental and Social Consideration are shown below.

- MINAMB
- MINANDER
- MINEA
- Ministry of Fisheries
- Ministry of Culture

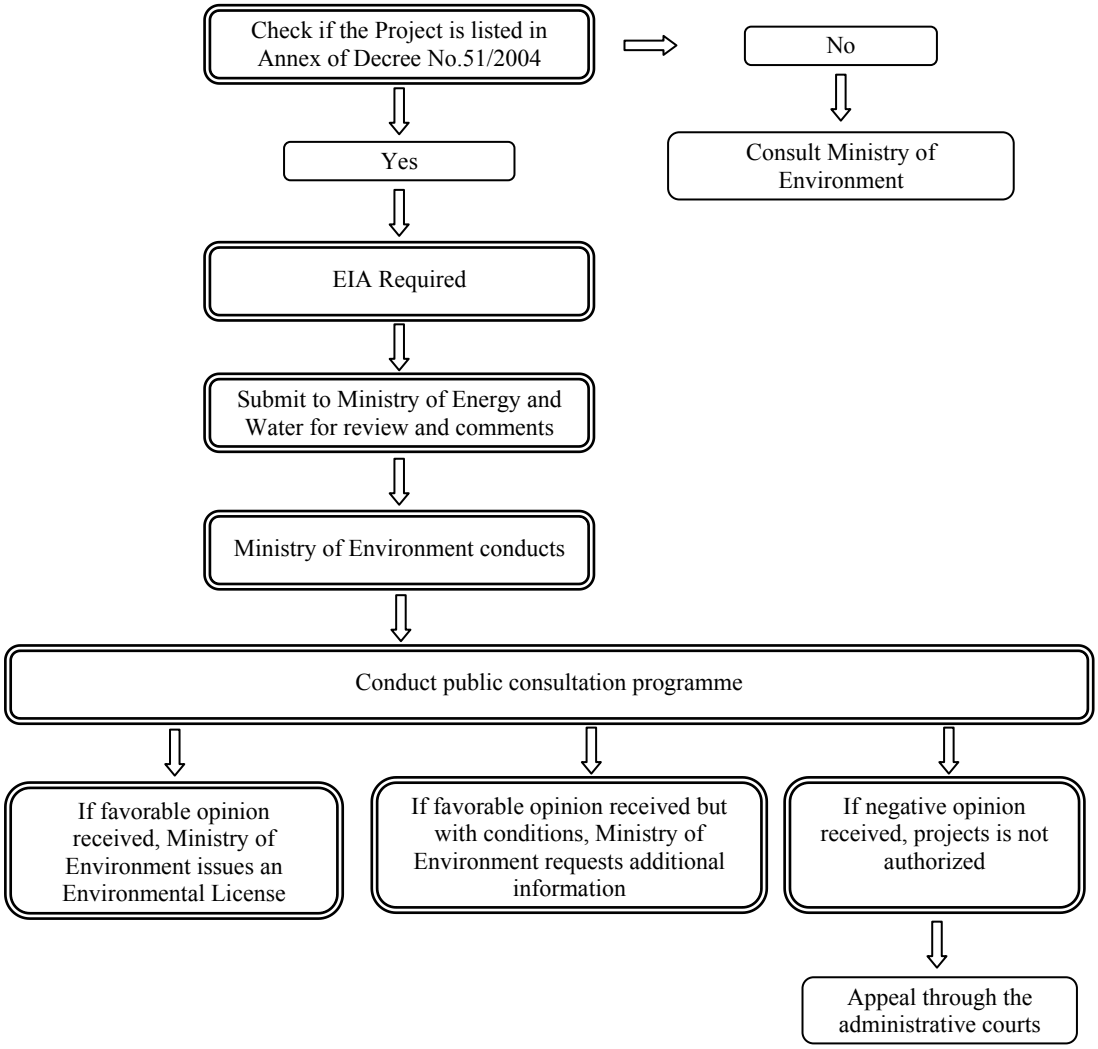


Fig.4.8-4 EIA Approval Process

(3) Gap between Legislation of Environmental and Social Consideration in Angola and JICA Guideline

Gap between Legislation of Environmental and Social Consideration in Angola and JICA Guideline is shown below.

- Legislation concerning protected area and eco-system - No legislation in Angola
- Consideration to illegal logging of forests - No forest certification system in Angola
- Consideration to vulnerable social groups and indigenous people - No legislation in Angola
- Consideration to involuntary resettlement - No legislation and No livelihood reconstruction support in Angola
- Timing of stakeholder consultation - It holds after submission of EIA in Angola
- Mitigation and monitoring plan - No need monitoring of stakeholder

4.8.4.2 Study of Alternatives

As alternatives, Cutato Hydropower Plant was compared on power generation and design (height of weir).

On the power generation, 4 options (mini-hydropower, diesel, photovoltaic, zero option) were compared in terms of environmental impact, construction cost, operation cost, project cost per MW, power generation output for electricity demand, utilization of domestic resources, and contribution to improvement electrification rate. As a result, mini-hydropower is most superior because of the most small construction cost per MW, the small operation cost, the efficient utilization of domestic resources, and the contribution to improvement electrification rate.

The 3 heights of weir (3m, 4m, 5m) were compared on benefit cost (B/C). It was concluded that the optimal option is 4m weir height 4 m and 50 m^3/s maximum charge.

4.8.4.3 Scoping

Direct affected area is assumed as followings.
- River area from about 6 km upstream of the Weir to about 1 km downstream of the powerhouse.
- Access road 28 km long
- Temporary facility ground area of 7,000m^2

Indirect affected area is assumed as followings.
- Andulo and Muenga village, Chimonga village, Chicumbi village

Scoping was based on information around the site and results of site survey. Scoping list is shown in Table 4.8-5.

Table 4.8-5 Scoping List (1/2)

Category	No.	Subcategory	Evaluation		Reasons
			During construction	During operation	
Pollution Control	1	Air pollution	B-	B-	During Construction: Air quality is expected to temporarily deteriorate due to digging and landfill activities, movement of heavy machinery and vehicles assigned to work and all activities involving earth-moving
					During Operation: Low traffic of inspection vehicles for maintenance is expected.
	2	Water pollution	B-	B-/D※	During Construction: Potential degradation of the physical and chemical quality of water masses affected because of the increased concentration of solid matter; organic matter, fats, microorganisms of fecal origin and nutrients, due to presence, operation and decommissioning of construction sites and movement of heavy machinery and vehicles assigned to work; reduction of water clarity by increasing turbidity and TSS content due to digging and landfill activities and all activities involving earth-moving; increase risk of presence of harmful chemicals in the water due to accidental spills from maintenance and movement of heavy machinery and vehicles assigned to work
					During Operation: Eutrophication due to the presence of a reservoir with stagnant water
	3	Wastes	C-	C-	During Construction: Surplus soil and waste materials during construction are expected to occur.
					During Operation: Wastes which are likely to have negative impact on surrounding environment, impacts are unknown.
	4	Soil Pollution	B-	D	During Construction: Soil contamination due to accidental spills of hazardous substances such as hydrocarbons from presence, operation and decommissioning of construction sites and movement of heavy machinery and vehicles assigned to work.
	5	Noise pollution Vibration Pollution	B-	B-	During Construction: Discomfort for the local communities is expected to occur due to presence, operation and decommissioning of construction sites and movement of heavy machinery and vehicles assigned to work. During Operation: Low traffic of inspection vehicles for maintenance is expected.
	6	Ground subsidence	D	D	Works that are likely to cause ground subsidence are not expected.
	7	Smell pollution	D	D	Works that are likely to cause smell pollution are not expected.
	8	Bottom sediment pollution	D	D	Works that are likely to cause bottom sediment pollution are not expected.
Natural Environment	9	Protected area	D	D	National parks, protected area, etc. do not exist in the project site and the surrounding area.
	10	Eco-system	B-	B±/B-	During Construction: Destruction of vegetation and habitats due to deforestation and clearing activities, increase of the disturbance of the animals due to presence, operation and decommissioning of construction sites and movement of heavy machinery and vehicles assigned to work, and increase of exclusion on the faunal community due to the barrier effect from construction of dam are expected.
					During Operation: Barrier effect for aquatic and terrestrial fauna, habitat fragmentation and mortality due to presence of dam, reservoir and access road, distribution line are expected. On the other hand. new biotope that will help to increase biodiversity in the area due to the presence of dam and reservoir will occur.
	11	Hydrology	B-/D	B-/D	During Construction: Potential impacts: decrease of water availability due to activities that increase sealed areas, increase of transport of solids and increase sedimentation consequent allocation of the existing regimes of sedimentation of downstream areas of exploration due to digging and landfill activities and all activities involving earth-moving
					During Operation: Change in flow that will have influence on solid transport; aquatic habitats or sedimentation regime and decrease in water availability downstream is expected.
	12	Topography Geography	B-/D	B-/D	Large-scale cutting earth or embankment is not planned in this project. Therefore, impact on topography and geography will be extremely small.
Social Environment	13	Resettlement	D/C-	D	Before construction: During planning: Land acquisition due to a reservoir is not expected.
					Before construction: route for distribution lines should be decided not to require resettlement.
	14	Poverty group	D	B+	During Operation: Living standard will be improved and business opportunity will be increased by power supply to the inhabitants of non-electrified villages around the power plant. Social services such as a school, hospital, etc. will be improved also for poverty group.
					Positive impact can be expected.

Table 4.8-5 Scoping List (2/2)

Category	No.	Subcategory	Evaluation		Reasons
			During construction	During operation	
Social Environment	15	Minority Indigenous people	D	D	Minority and indigenous people do not exist in the project site and the surrounding area. (Ombundo tribe, majority of Angola, inhabit in the surrounding villages)
	16	Local Economy (Employment, Means of livelihood, etc.)	B+	B+	Increase of the migration to the construction site will provide the dynamism of local economy. This project is development of local electrification to supply electric power for agriculture and industry, and develop the local economy. Positive impact can be expected.
	17	Land use Use of local resources	B-	B±/B+	During Construction: will occur increase of the migration to the construction site, providing a change in local culture, overcrowding of existing resources; potential of changing patterns of health and increase traffic that will contribute for an increase in accidents. During Operation: This project is development of local electrification to supply electric power for irrigation and then extend the cultivated land. (Positive impact can be expected.) On the other hand, existing cultivated land can be submerged or restricted the use due to the reservoir.
	18	Water use	C-	C-/D	During Construction: Negative impact by murky water is expected during construction because people use river water in the project During Operation: Water intake for power generation is expected. However, the river discharge will not be decreased because water will be discharged at the downstream.
	19	Existing social infrastructure Social services	C-	B+	During Construction: Traffic by inhabitants can be restricted during construction. During Operation: Social infrastructure such as road, school, medical institution, etc. and related services will be improved, because electric power will be supplied to those institutions as well as households.
	20	Social capital Social organizations (Local decision-making bodies, etc.)	C	C	This project is expected to have an impact to social capital, local decision-making bodies, etc. regarding the priority of suppliers of power development.
	21	Mal-distribution of damages and benefits	C	C	Sociality, economical efficiency, and fairness of the benefits brought by this project should be maintained regarding the priority of suppliers of power development.
	22	Conflict of interest in the project area	C	C	Conflict of interests in the project area should be avoided regarding the priority of suppliers of power development.
	23	Cultural heritage	D	D	Any cultural heritage does not exist in the project site and the surrounding area.
	24	Landscape	C/ C-	C/ C-	Impact on landscapes will be small because of small hydropower project.
	25	Gender	D	B+	During operation: Labor load for women such as fuel wood procurement for cooking is expected to be decreased. Electric use for cooking (electric pot, etc.) can be also expected.
	26	Children's rights	D	B+	During operation: Study and help housekeeping will be enable for children by power supply after the sunset.
	27	Infection (HIV/AIDS, etc.)	B-/ C-	B-/ C-	During Construction: Although large-scale construction is not expected, infection can be spread because of inflow of construction workers.
	28	Labor Environment (including labor safety)	C-	C-	During Construction: Labor environment of construction workers should be considered. During Operation: Labor environment of operation workers should be considered
	29	Accidents	C-	C-	During Construction: Accidents during construction should be considered. During Operation: Accidents involving management of the power plant should be considered.
Others	30	Impact across the border Climate change	D	B+	This is power generation project without CO_2 emission. Therefore, positive impact in relate to climate change can be expected.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.
※ Power plant / distribution line

4.8.4.4 TOR

TOR of EIA is addressed based on the scoping result. TOR is shown in Table 4.8-6.

Table 4.8-6 TOR

Evaluation Item	Description of Study	Study Methods	Remarks (Reference of Evaluation Criteria, Standard, etc.)
Study of alternatives	Study of the location Study of the power generation Study of the weir height	Benefit-cost relation of three different solutions Preliminary analysis of different surveys	To minimize the number of households of resettlement and land acquisition To maximize the benefit of the project
Wastes	In the vicinity of the project site	Site inspection Contact with entities for characterization of wastes collection, transport and treatment Analysis and evaluation of effects related to the complementary projects (transmission lines, access roads, etc) Proposal of mitigation measures	EU Directives, WB
Noise	In the vicinity of the project site	Site inspection Acoustic noise measurements Analysis and evaluation of effects related to the weir Analysis and evaluation of effects related to the complementary projects (transmission lines, accesses, etc) Proposal of mitigation measures	WHO, WB
Air Quality	In the vicinity of the project site	Analysis and evaluation of effects related to the complementary projects (transmission lines, accesses, etc) Proposal of mitigation measures	WHO, WB
Water Resources	Cutato River, in the project site and upstream	Analysis of Hydrological study Evaluation of the effects related to the weir Proposal of mitigation measures	WHO, WB
Water Quality	Cutato River, in the project site and upstream	Bibliography analysis Analysis and evaluation of effects related to the weir Analysis and evaluation of effects related to the complementary projects (transmission lines, accesses, etc) Proposal of mitigation measures	WHO, WB
Eco-system	Existence of valuable species of fauna and flora in the intended project site shall be confirmed and impact on eco-system shall be evaluated.	Bibliography analysis Site inspection Analysis and evaluation of effects related to the weir Analysis and evaluation of effects related to the complementary projects (transmission lines, accesses, etc) Proposal of mitigation measures	IUCN Red list(version 2011.1), CITES(2011.10)
Resettlement	Resettlement due to submerged area	Site inspection Contact with entities Utilization of a 1/25000 topographical map and satellite photographs	Case examples in Angola, JICA guidelines for environmental and social considerations, and Operational Policy 4.12 of the World Bank
Land use Utilization of local resources	Study of land use and local resources (water, fish, etc.) in the scope of reservoir	Site inspection Contact with entities for collected information about land use planning and projects Utilization of a 1/25000 topographical map and satellite photographs Proposal of mitigation measures	Water rights and fishing rights in Cutato River
Stakeholders Meeting (SHM)	2 stages of SHM 1) Stage of scoping report 2) Stage of EIA report	Stage of scoping report Stakeholders identification Definition of the public Participation Program 1st Interested and affected parties meetings - Kuito 2nd Interested and affected parties meetings - Andulo Key Issues Identification Stage of EIA report Presentation of EIA report results Local Meetings will be defined with Ministry of Environment	JICA guidelines for environmental and social considerations *

4.8.4.5 Environmental Aspect

The project site is located in Miaombe plain at the gentle sloped hill area at around EL. 1,400 m. Cutato River (catchment area: 9,400 km^2) is the tributary of the Cuanza River (catchment area: 147,000 km^2). It diverts at the just upstream of the project site and joins at the downstream through the wide sander. Its average amount of precipitation is 1,250 mm. The project site is located at the distribution area of mainly granite group or gneiss group of Precambrian Period. The both rock groups are composed of the hard and old foundation rocks.

(1) Natural Environment

Vegetation belongs to Meta Panda that is open forest that *Brachystegia* Species is largely dominant. It has been affected by the charcoal production and the fire for hunting. Land use except the forest includes scattered farm around living spaces.

Photo 4.8-6 Vegetation around the Project Site

In terrestrial flora and fauna, it was identified many species of flora that were mainly shrub trees and hippopotamus, crocodiles, flogs etc on foot print and observation. In aquatic fauna, it was identified fishes such as Tilapia and aquatic animals such as Ephemeroptera and Trichotera etc.

It included 11 endangered species (cf. Table 4.8-7). The foot prints of Hippopotamus and Crocodiles are identified near the power plant. However the environment around the project site is different from the habitat environment of hippopotamuses. Therefore the environment around the dam site isn't ecological niche of hippopotamuses and they use there as paths through the vegetation for their favorite places. In addition it was identified African dugs (*Anas sparsa*) and migratory fishes as *Tilapia rendalli and Clarias ngamensis* etc.

Table 4.8-7 List of Endangered species identified in the project site

Category	Scientific Name	IUCN	Cites
Flora	*Pterocarpus angolensis*	NT	-
Birds	*Anas sparsa*	LC	-
Mammals	*Hippopotamus amphibus*	VU	-
Reptiles	*Crocodylus niloticus*	LC	Appendix I
Fishes	*Tilapia rendalli*	LC	-
	Clarias ngamensis	LC	-
	Barbus poechii	LC	-
	Barbus afrovernayi	LC	-
	Barbus paludinosus	LC	-
	Barbus bifrenatus	LC	-
	Hydrocynus vittatus	LC	-

VU-Vulnerable NT-Near Threatened LC-Least Concern

Photo 4.8-7 Location of the Cutato River where Hippopotamus Footprints were found

Photo 4.8-8 Footprints of Hippopotamus

Air quality and water quality, sound were followed to the standard of World Health Organization (WHO) because of the lack of Angolan standard. It was estimated that they were not over WHO standard.

Table 4.8-8 Result of Water Quality Analysis

Color	Smell	pH	Conductivity (NTU)	Turbidity (µS/cm)	Total Coliforms (NMP/1000 ml)	Escherichia Coli (NMP/1000 ml)
Negative	Negative	10,7	476	8	Positive	Positive

Source: Kuito Water Provincial Directorate, June 2011

Table 4.8-9 Result of Sound Analysis

Point Measurement	Orientation of the Microphone	Day Period				Observations
		L_{Aeq}	L5	L50	L95	
Muenga Village	Northeast	23.7	28.5	21.0	14.5	Measuring time (13 h 05 min - 13 h 10 min)
Chimonga Village	East	25.8	30.7	23.0	17.3	Measuring time (14 h 15 min - 14 h 20 min)
Chicumbi Village	North	30.2	35.5	28.9	23.1	Measuring time (16 h 20 min - 16 h 25 min)

(2) Social Environment

Current state of education and employment isn't enough in Andulo Municipality whose population is 311,544. The city's health network consists of 23 public units and 21 private units. The service of the entire network has only 2 ambulances and only 9 physicians. There are 24 schools that have permanent building out of 207 schools. The number of teacher for 92,248 students is 1,369 in 2011. On the situation of employee, around 3,850 people are working in public institutions and approximately 60,000 families are engaging in agriculture. The main crops are cassava and beans. In rural area, fishing and charcoal production and beekeeping have been put in practice. In addition to agriculture there are small canteens and shops including fishmongers and butchers, boutiques, hotels. Andulo is the logistic base of the diamond industry in Nharea. Therefore the market is crowded by many traders coming from Luanda and DOC. The electricity is supplied by 443 generators.

The situation of villages around the project site is very poor. Most of villagers are engaged in Agriculture and get supplementary income from charcoal production. Every village has churches and cemeteries, Acocoto enshrining the chiefs of villages. The water supply is made in the river or in individual water holes. The feature of energy is mainly wood and generators, kerosene.

Muenga where has 8,842 population is the village closest to the Cutato River. There are neither hospitals nor schools. Therefore villagers have to go to Chimonga for health service and teaching is made under the trees. The number of teacher is 3 for 640 students. Two Acocoto are standing along the Cutato River.

The state of Chimonga where is 32 km west of the city of Andulo is better than Muenga. Chimonga has 5,630 population and health center, school, shops. It has been cultivating various vegetables and banana and pineapple.

Chicumbi where is located 12 km west of the city of Andulo has 4,812 population and hospital and school.

Frequent disease is malaria, respiratory, influenza and diarrhea around the project site. The

waste has been treated with the city center of Andulo. Elsewhere, waste treatment has been burned or buried in Andulo and villages.

4.8.4.6 Impact Assessment

In the environment, the following impacts are assumed. Change in water quality of Cutato River caused by dammed impacts to water supply. Contamination of chemical pollutants, oil, fuel, lubricant from materials and vehicles into the river and the soil impacts causes water pollution and soil pollution.

In ecosystem, the following impacts are assumed. The weir cuts the moving path of migratory fishes. The weir and water level fluctuation affect aquatic animals such as hippopotamus and crocodiles. Flap gates settled on the weir (height is 3 m, length is 35 m × 2 units) reduce raising the flood water level and complete interruption of water flow. From above, it is estimated that impact to migratory fishes and hippopotamuses is small.

In terrestrial flora and fauna, the following impacts are assumed. Deforestation reduces habitat of flora and fauna. Traffic accident on the access road occurs in fauna. Transmission line installation affects birds.

In social environment, it is expected that the implementation of this project give positive impacts by the supply of electricity to thousands of residents.

Evaluation of environmental impacts is shown in Table 4.8-10.

Main negative impact is summarized below.

- Reduction in charcoal production materials and habitats of flora and fauna by deforestation
- Impact on water supply and aquatic fauna by change in water quality
- Impact on aquatic fauna by interruption of moving path and water level fracture caused by the weir
- Reduction in habitat of terrestrial flora and fauna caused by deforestation
- Impact on birds caused by installation of transmission line
- Water pollution, soil pollution and groundwater contamination caused by chemical spills from construction materials
- Water pollution, soil pollution and ground water contamination caused by oil and fuel spills from vehicles
- Impact on residents due to exhaust gases, dust, and vibrations caused by dump
- Increase in the risk of traffic accident

Table 4.8-10 Evaluation of environmental impacts

Environmental Aspects	Impact	Const. Phase	Opera. Phase	Nature	Significance
Geology and morphology	Change in the morphology of the land	✓	✓	Negative	Low significant
	Slope instabilities	✓	✓	Negative	Low significant to significant
	Erosion	✓	✓	Negative	Low significant
	Elimination of the geological environment (as a resource)	✓	✓	Negative	Low significant
Soils and land use	Soil compaction	✓		Negative	Low significant
	Soil contamination	✓	✓	Negative	Low to very significant
	Erosion and entrainment of the soils	✓	✓	Negative	Low significant
	Permanent destruction of the existing pedological horizons	✓	✓	Negative	Low significant
	Change on land use	✓	✓	Negative	Low significant
Surface water resources	Changes in hydrological processes	✓	✓	Negative	Low significant
	Changes in water quality	✓	✓	Negative	Low significant
	Water pollution	✓	✓	Negative	Low to very significant
	Changes in the natural drainage	✓	✓	Negative	Low significant
Groundwater resources	Contamination	✓	✓	Negative	Low to very significant
	Increase in the rate of infiltration and recharge of groundwater	✓		Positive	Low significant
	Changes in the distribution of groundwater	✓		Negative	Significant
Flora	Destruction of flora and vegetation	✓	✓	Negative	Low significant
	Habitat fragmentation		✓	Negative	Low significant
Terrestrial fauna	Increase in disturbance	✓		Negative	Low significant
	Loss of habitat/ habitat fragmentation	✓	✓	Negative	Low significant
	Increased mortality	✓	✓	Negative	Low significant
Aquatic fauna	Barrier effect		✓	Negative	Low significant
	Loss of habitat		✓	Negative	Low significant
	Habitat changes	✓	✓	Negative	Low significant
Landscape	Visual disorganization	✓		Negative	Low significant
	Loss of natural features	✓	✓	Negative	Low significant
	Changes on landscape caused by the power line		✓	Negative	Low significant
Air quality	Increase of gases emissions	✓		Negative	Low significant
Sound environment	Increase in noise levels	✓	✓	Negative	Low significant
Socioeconomics	Demographic changes	✓	✓	Positive	Low significant to significant
	Pressure on other natural resources	✓	✓	Negative	Low significant to significant
	Increased business opportunities	✓	✓	Positive	Low significant
	Increase in agricultural production	✓	✓	Positive	Low significant
	Public and private services available (communications, transport, health, other.)	✓	✓	Positive	Low significant
	Employment opportunities	✓	✓	Positive	Low significant
	Changes in cultural structure	✓	✓	Negative or positive	Low significant
	Changes on health quality (malaria, cholera, aids or hiv)	✓	✓	Negative	Significant
	Decrease of poverty group		✓	Positive	Significant
	Gender		✓	Positive	Significant
	Access to electricity		✓	Positive	Very significant

4.8.4.7 Mitigation

It is shown mitigations for negative impact by implementation of the project in Table 4.8-11 and Table 4.8-12.

Important mitigation is summarized below.

- Minimizing the area of deforestation
- Replanting with native species in the logging area
- Periodic water quality survey
- Installation of fish passage
- Installation of Bird Fly Diverter and so on
- Guidance to contractor and workers on disposal of construction materials, equipment maintenance, operation of construction vehicles, and etc.

Table 4.8-11 (1/2) Mitigation (Construction Phase)

Component	Impact	Mitigation Measures
Geology and Geomorphology	Instability of slopes	• Stability limits of the material to be deposit • Adaptation of constructive solutions, which promote stability
	Erosion and sedimentation	• Keeping humidification of the access to use
Soils	Soil compaction	• Soils stir
	Soil contamination	• Proper temporary storage and disposal of waste • Containment/retention of any run-off and/or spills • Immediate removal in the event of a spill of chemicals, oils, and fuels in soil • Maintenance machinery and vehicles in good condition
Land Use	Changes in land use	• Reforestation with natural local and artificial species
Surface Water Resources	Changes in surfaces water resources	• Preferable usage of existing paths • Intervention in water lines or in its surroundings in the dry season • Construction of drainage systems • Maintenance of vehicles • Proper management of waste and materials • Immediate removal in the event of a spill of chemicals, oils, and fuels in soil
Ground Water Resources	Contamination of ground water.	• Minimization of accidental spills of harmful products
Flora and Vegetation	Destruction of vegetation	• Conservation of the forest remnants upstream and downstream of the Cutato river of the affected area • Reforestation with native species
Terrestrial Fauna	Environmental disturbance of birds	• Restrict deforestation only to interventional sites • Signalization with Bird Fly Diverters (BFD)
Semi-aquatic fauna	Impacts in semi -aquatic species habitat	• Construction of ecological ditches along the road for reptiles and amphibians • Conservation of wetland areas for hippopotamus and crocodiles • Monitoring hippopotamus population
Aquatic Fauna	Changes in Aquatic Fauna	• Maintenance of environmental flow • Construction of passages for fish (PPP)
Air Quality	Effects in air quality	• Maintenance machinery and vehicles in good condition • Land transport under appropriate conditions, coverage of the load • Spray water regularly on the roads, particularly in dry weather • Information to the population about the polluting activities and protective measures

Table 4.8-11 (2/2) Mitigation (Construction Phase)

Component	Impact	Mitigation Measures
Sound Environment	Construction of the road that passes very close to villages.	• Running the noisiest activities during the daytime and on weekdays • Maintenance of machinery and vehicles in good condition
Socioeconomics	Effects in Deforestation	• Reforestation with native species • Design of the new access road and transmission line without woods
	Changes in the social structure	• Employment of residents • Respect for local culture, traditions and customs
	Changes in quality of health service	• Development of a health plan • Construction of a health center that suits workers and residents
	Traffic Increasing	• Signalizing • Responsibility of persons qualified and suitable for taking measures for the conduct of all types of vehicles
	Cemeteries	• Avoidance of cemeteries with change of the routes of transmission line
Wastes	Effects of wastes produced	• Environmental education of constructors, workers and residents • Proper management of solid waste and reuse of a part • Conditioning waste with appropriate separation criteria according to the specifics • Acquisition of building materials without harmful substances • Transportation of waste under appropriate conditions • Register of waste generated • Appropriate final treatment of waste

Table 4.8-12 Mitigation (Operation Phase)

Component	Impact	Mitigation Measures
Fauna and Flora	Change in hippopotamuses habitats	• Monitoring hippos population
	Change in migratory species	• Monitoring and management for fish passages
	Deforestation	• Development of environmental monitoring program of implications for plant species

4.8.4.8 Monitoring Plan

It is shown the monitoring plan based on impact assessment and mitigation in Table 4.8-13.

Table 4.8-13 Monitoring plan

Items		Construction phase	Operation Phase	Area
Water Quality	· pH	○	○	· Upstream of submerged area
	· Temperature	○	○	· Submerged area
	· Total hardness	○	○	· Downstream of submerged area
	· Alkalinity	○	○	
	· Total phosphorus	○	○	
	· Nitrates	○	○	
	· Nitrites	○	○	
	· BOD	○	○	
	· COD	○	○	
	· Ammonium	○	○	
	· Total nitrogen	○	○	
	· Phosphate	○	○	
	· Total suspended solids	○	○	
	· Salinity	○		
	· Electrical conductivity	○		
	· Cadmium	○		
	· Chromium	○		
	· Copper	○		
	· Zinc	○		
	· Mineral oils	○		
	· Oils and fats	○		
	· Total hydrocarbons	○		
	· Profile of dissolved		○	
	· Oxygen		○	
	· Secchi Depth		○	
	· Color		○	
	· Turbidity		○	
	· Conductivity		○	
	· Oxidisability		○	
Fishes		○	○	· Upstream of submerged area · Submerged area · Downstream of submerged area
Hippopotamus Crocodiles		○	○	· Surrounding affected area by the weir

4.8.4.9 Resettlement and Compensation

Residences and farming lands were not confirmed in the submerged area. Two Acocotos along Cutato River in Muenga is located out of submerged area. Villagers have been fishing for their own consumption. From above, there isn't target of compensation. However it is necessary to avoid cemeteries and woods along access road and transmission line at detailed design phase.

4.8.4.10 Stakeholder Consultation

Stakeholder consultation was held in Cuito (capital of Bié Province) and Andulo in June 2011. Participants of concerned organizations are following; Provincial Direction of Energy and

Water, Vice Governor of Bié for Technical and Infrastructure Service, Deputy Manager of City, Deputy Commander of Police, Provincial Government of Bié, Municipal Administration of Cuito, Municipal Administration of Andulo. The number of stakeholders is 13 in Cuito and 78 in Andulo including chief of villages (Soba).

Participants mostly agreed with the project in the meetings. The main concerns in the meetings are shown below.

- Extent of economic benefits of the project
- Water use improvement (irrigation, water supply)
- Expansion to other development
- Land exploitation caused by access road (between Chicumbi and the site: 28 km length × 5 m width)
- Compensation for cemeteries and farm
- Impact on fishing
- Risk of accidents occurring along access road and transmission line

Photo 4.8-9 Public Consultation in Andulo

4.8.4.11 Conclusion

As a result of EIA, significant impacts on the environment are mentioned water pollution, soil pollution and groundwater contamination caused by chemical pollutants, oil, and fuel from materials and vehicles. Through guidance to contractors and workers in terms of disposal of materials, maintenance of vehicles will be able to mitigate these impacts.

Migratory fishes and hippopotamus were identified. Impacts on these aquatic and semi-aquatic fauna will be caused by the weir. Flap gates settled on the weir reduce raising the flood water level and complete interruption of water flow. The footprint of hippopotamus was identified near the dam site, but the environment around the dam site, whose water flow is fast and riverbank consists of rock, is not suitable for habitat of hippopotamus. Therefore it is assumed that hippopotamus use around the dam site as not ecological niche but moving path to feeding ground. From above, it is estimated that impact to migratory fishes and hippopotamuses is small. It is recommended installation of fish passage (PPP), and monitoring of usage of PPP and inhabiting situation of hippopotamuses around the site as mitigations for negative impacts on aquatic fauna.

Impacts on terrestrial flora and fauna are mentioned as follows.

- Reduction in habitat of terrestrial flora and fauna caused by deforestation
- Impact on birds caused by installation of transmission line

It is recommended to minimize the area of deforestation, replant with native species in the logging area and install bird fly diverter as mitigations for these negative impacts.

Residences and farming lands were not confirmed in the submerged area. Therefore there isn't target of compensation. However it is necessary to avoid cemeteries and woods along access road and transmission line at detailed design phase.

From the above, the negative impact on natural environment and ecosystem is not significant. Moreover implement of mitigation measures is able to avoid and reduce it. It is assessed that the positive impact on socio-economic in good cause of supply to thousands residents is more significant than the negative one.

4.9 Implementation of the Project by Yen Loan

4.9.1 Relevant Organizations

When the project is implemented by Japanese Yen Loan, MINEA will be in charge of the negotiation with Japanese side on behalf of GOA as a responsible organization, and ENE will be in charge of supervision of construction to be done by a Contactor and operation & maintenance as an implementing organization. The organization chart of the ENE is shown in Fig. 4.9-1. When the project starts, a special project as shown in Fig. 4.9-1 will be established and manage the project.

As mentioned in Chapter 2, GAMEK undertakes the hydropower development in the Cuanza River basin. However, GAMEK is responsible for the development of Cuanza River between Capanda Hydropower Station (520 MW) and Cambambe Hydropower Station (180 MW), of which area has seven (7) to nine (9) big waterfalls and the hydropower potential is estimated at 7,000 MW approximately. And hydropower development except the above area is undertaken by ENE except Cambambe Hydropower Station locating at the most downstream part of the area, and ENE is substantially responsible for the development of the Cuanza river being the upper stream of Capanda Hydropower Station.

ENE has an experience of development of Chicapa-1 Hydropower Station, the first private hydropower station built in Angola by foreign investors, by capital participation. The outline[24] of Chicapa-1 hydropower station is as follows:

- Name of power station — Chicapa-1 Hydropower plant (16 MW = 4 MW × 4 units)
- Rive, Location — Chicapa River in the Province of Luanda Sul
- Investors — ALROSA[25](55%), ENE(45%)
- Construction Period — Start of Construction in 2003, Start of Operation in 2007
- Total Project Cost — About 130 Million US$
- Concession Period — 40 years

[24] Source: //en-alrosa.ru/about/structure/231/sarl/index.html
[25] State-owned Diamond Company in Russia established in 1992.

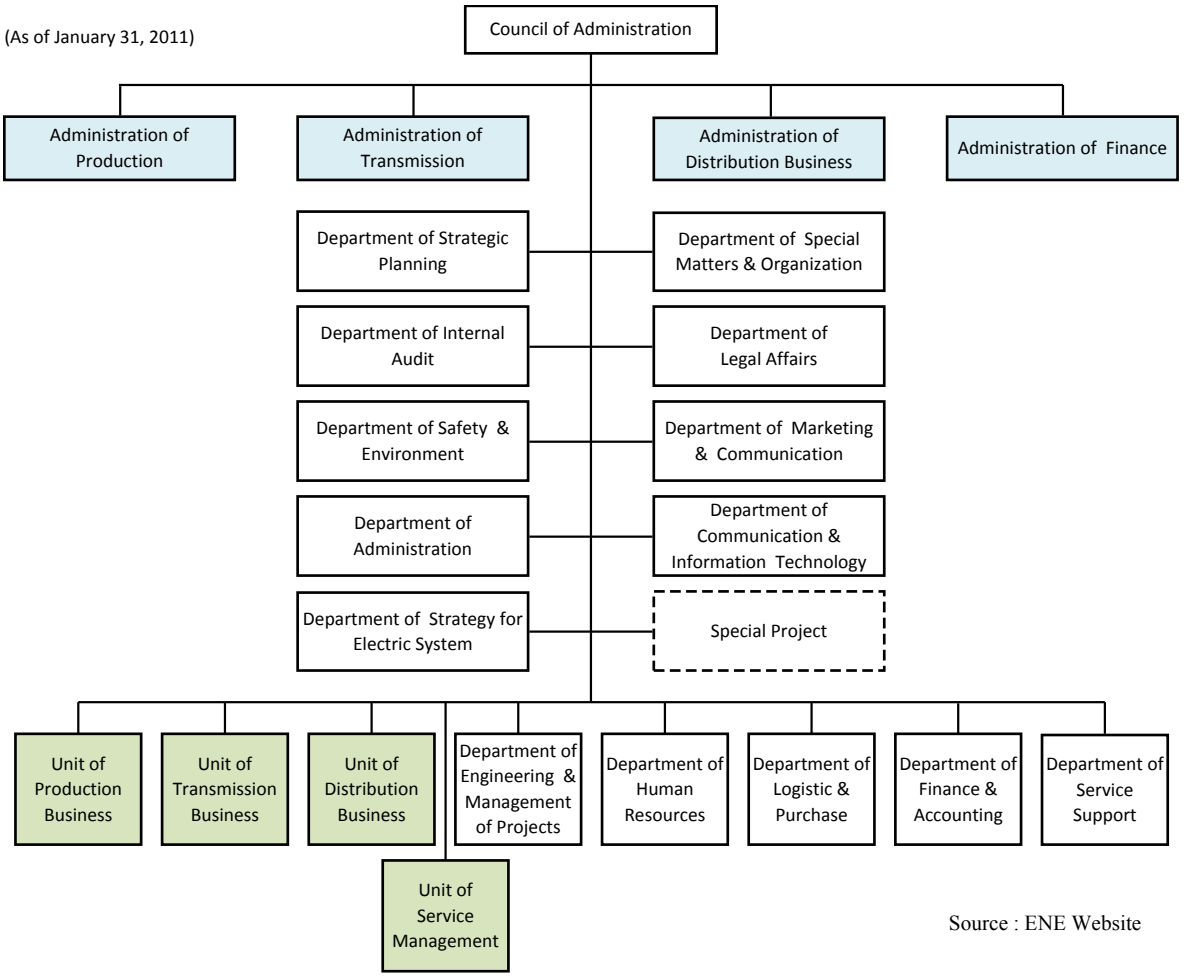
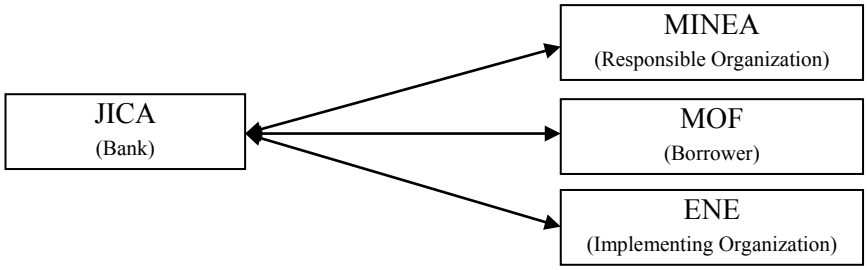


Fig. 4.9-1 Organization Chart of ENE

The relevant organizations towards the implementation of the project will be as follows referring to other Japanese Yen Loan.

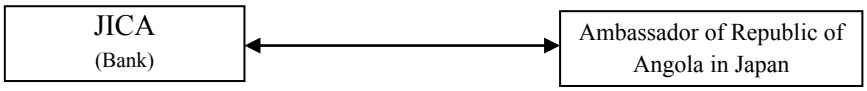
(1) Minutes of Discussion

- Confirmation of the project description and its estimated cost
- Confirmation of implementation schedule and measures to be adopted
- Confirmation of other relevant issues



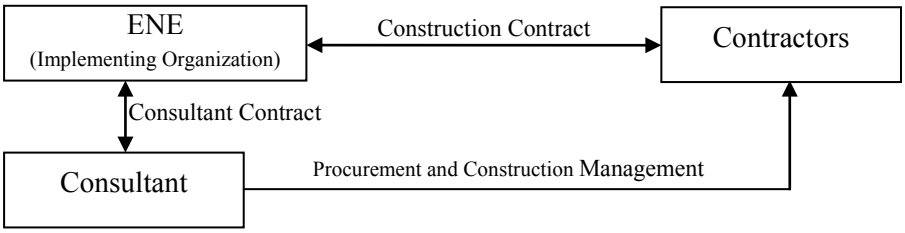
(2) Loan Agreement

Loan Conditions (Amount and purpose of loan, Use of proceeds of loan, Repayment and interest, Particular covenants, etc.)



(3) Implementation

ENE, the executing agency will employ a consultant and the consultant will undertake the management of procurement and construction of the project to be done by contractors.



4.9.2 Terms of Reference for Consultant in Implementation Stage

The consultant will provide the following engineering services (draft) to ENE.

(1) Review of Implementation Program and Feasibility Study

- Review of the implementation schedule and all design concepts of FS report in terms of whether the project can produce the expected benefit and effect.
- Determination of scope of work to be executed in the project
- Determination of design parameters of the main equipment, such as a turbine and a generator and so on

(2) Design and Engineering

- Establishment of detailed design and specifications required for preparation of Tender Documents
- Study and determination of contract lots, if necessary
- Preparation of Tender Documents
- Preparation of evaluation criteria and evaluation methods

(3) Assistance to ENE in International Bidding

- Check and review of bid documents and relevant drawings with due coordination of guidance of ENE and JICA

- Assistance to ENE for pre-bid conference
- Assistance to ENE in replying to Bidder's question and in issuing addenda to bid documents

(4) Assistance to ENE in evaluation of Bidders

- Evaluation of all bids in the light of established PLN and JICA evaluation and approval criteria
- Preparation of evaluation report to ENE
- Assistance to ENE in contract negotiation with a successful bidder and conclusion of contract

(5) Inspection, Testing and Delivery Control during Manufacturing (under Participation of and/or Coordination with ENE)

- Check and approval of manufacturing and delivery schedule
- Check and approval of factory testing procedure and witnessing of factory test
- Check and approval of test reports submitted by the contractor

(6) Site Construction Works Supervision (under Participation of and/or Coordination with ENE)

- Check and approval of work plan submitted by the contractor
- Check and approval of work drawings submitted by the contractor
- Check of invoice submitted by the contractor and assistance for issuance of payment certificates by ENE
- Hosting a progress meeting to be held between ENE, the contractor and the consultant
- Monitoring the work progress and workmanship, and necessary instruction to the contractor on behalf of ENE
- Management of monthly progress (quantity, disbursement) and budget control
- Preparation of monthly progress report to ENE
- Assistance to ENE in preparation of progress report to JICA
- Assistance to ENE in solving contractual claim matters raised by the contractor (if any)
- Check and approval as-built drawings submitted by the contractor
- Preparation of project completion report

(7) Commissioning and Acceptance Test (under Participation of and/or Coordination with ENE)

- Check and approval of various tests procedure for commissioning submitted by the contractor
- Coordination and supervision of all necessary tests in accordance with the contractual conditions and with approved test procedure
- Check and approval of commissioning test reports submitted by the contractor

- Issuance of tentative taking-over and provisional acceptance certificate subject to prior approval of ENE

(8) Assistance to ENE in Operation and Maintenance (O&M)

- Check and approval of operation and maintenance manual
- Advice on ENE's scheme for O&M framework
- Assistance to ENE in preparation of operation and maintenance records (power output, generation energy, river inflow and malfunctions, etc.)

(9) Assistance to ENE for Environment Aspects

- Assistance to ENE in monitoring of environmental and social considerations
- Assistance to ENE in preparation of monitoring reports to Ministry of Environment

(10) Transfer of Knowledge and Technology and Training to ENE Personnel

- Arrangement of technical transfer and training programs relating to mini hydropower development and the latest construction technology in the home country of the consultant

4.9.3 Draft Manning Schedule for Consultants

Table 4.9-2 shows the draft manning schedule for foreign and local consultants. The estimated man-months (M/M) at the moment are shown in Table 4.9-1.

Table 4.9-1 Manning Schedule for Consultants

Consultant	Pre-Construction Stage				Construction Stage	Guarantee Period	Total (M/M)
	Detailed Design Stage	Preparation of Tender Documents	Evaluation	Contract Negotiation			
Foreign Consultant	21.0	8.0	5.0	2.5	41.0	2.5	80.0
	36.5						
Local Consultant	37.0	10.0	15.0*)	3.0	78.0	0.0	143.0
	65.0						

*) Including 3.0 M/M during Tender Period

Table 4.9-2 Draft Manning Schedule for Consultants

Implementation schedule — 2011

Implementation schedule	1	2	3	4	5	6	7	8	9	10	11	12
Stage												
F/S	■	■	■	■	■							
EIA						■	■	■	■	■	■	
Loan Agreement												★
Procuament/Construction												
Consultant Selection												■
Detail Design												
Preparation of Tender Documents												
Tender period												
Tender Evaluation												
Contract negotiation												
SuperVision of Construction												
Civil Work												
Temporary office & warehouse												
Access road												
Temporary facilities												
Power intake												
Weir												
Power house												
Power outlet												
Transformer yard												
Metal Work												
Steel overturning gate												
Screen												
Sand washout gate												
Open roof of the powerhouse												
Stop log gate												
Metal transportation												
Electric Mechanical Work												
Turbine												
Generator												
Transformer												
Transmission line												

Implementation schedule — 2012

Implementation schedule	1	2	3	4	5	6	7	8	9	10	11	12
Stage												
F/S												
EIA												
Loan Agreement												
Procuament/Construction												
Consultant Selection	■	■	■	■								
Detail Design					■	■	■	■	■	■	■	■
Preparation of Tender Documents												
Tender period												
Tender Evaluation												
Contract negotiation												
SuperVision of Construction												
Civil Work												
Temporary office & warehouse												
Access road												
Temporary facilities												
Power intake												
Weir												
Power house												
Power outlet												
Transformer yard												
Metal Work												
Steel overturning gate												
Screen												
Sand washout gate												
Open roof of the powerhouse												
Stop log gate												
Metal transportation												
Electric Mechanical Work												
Turbine												
Generator												
Transformer												
Transmission line												

Implementation schedule — 2013

Implementation schedule	1	2	3	4	5	6	7	8	9	10	11	12
Stage						Pre-Construction Stage						
F/S												
EIA												
Loan Agreement												
Procuament/Construction												
Consultant Selection												
Detail Design	■											
Preparation of Tender Documents		■	■	■	■							
Tender period						■	■	■				
Tender Evaluation									■	■	■	■
Contract negotiation												
SuperVision of Construction												
Civil Work												
Temporary office & warehouse												
Access road												
Temporary facilities												
Power intake												
Weir												
Power house												
Power outlet												
Transformer yard												
Metal Work												
Steel overturning gate												
Screen												
Sand washout gate												
Open roof of the powerhouse												
Stop log gate												
Metal transportation												
Electric Mechanical Work												
Turbine												
Generator												
Transformer												
Transmission line												

Implementation schedule — 2014

Implementation schedule	1	2	3	4	5	6	7	8	9	10	11	12
Stage												
F/S												
EIA												
Loan Agreement												
Procuament/Construction												
Consultant Selection												
Detail Design												
Preparation of Tender Documents												
Tender period												
Tender Evaluation	■	■										
Contract negotiation			■	■	■							
SuperVision of Construction						■	■	■	■	■	■	■
Civil Work												
Temporary office & warehouse						■						■
Access road						■	■	■	■	■	■	■
Temporary facilities									■	■	■	■
Power intake												
Weir												
Power house												
Power outlet												
Transformer yard												
Metal Work												
Steel overturning gate												
Screen												
Sand washout gate												
Open roof of the powerhouse												
Stop log gate												
Metal transportation						- -	- -	- -	- -	- -	- -	- -
Electric Mechanical Work												
Turbine												
Generator												
Transformer												
Transmission line												

Implementation schedule — 2015

Implementation schedule	1	2	3	4	5	6	7	8	9	10	11	12
Stage						Construction Stage						
F/S												
EIA												
Loan Agreement												
Procuament/Construction												
Consultant Selection												
Detail Design												
Preparation of Tender Documents												
Tender period												
Tender Evaluation												
Contract negotiation												
SuperVision of Construction	■	■	■	■	■	■	■	■	■	■	■	■
Civil Work												
Temporary office & warehouse												
Access road	■	■										
Temporary facilities	■				■							
Power intake					■	■	■	■		■		
Weir					■	■					■	■
Power house						■	■	■	■	■	■	■
Power outlet							■	■	■	■		
Transformer yard										■	■	
Metal Work												
Steel overturning gate						■						■
Screen									■			
Sand washout gate									■			
Open roof of the powerhouse											■	
Stop log gate											■	
Metal transportation	- -	- -	- -	- -	- -	- -	- -	- -	- -			
Electric Mechanical Work												
Turbine												
Generator												
Transformer												
Transmission line										■	■	■

Implementation schedule — 2016–2017

Implementation schedule	2016-1	2	3	4	5	6	7	8	9	10	11	12	2017-1	2	3	4	5
Stage											Guarantee Period						
F/S																	
EIA																	
Loan Agreement																	
Procuament/Construction																	
Consultant Selection																	
Detail Design																	
Preparation of Tender Documents																	
Tender period																	
Tender Evaluation																	
Contract negotiation																	
SuperVision of Construction	■	■	■	■	■												
Civil Work																	
Temporary office & warehouse																	
Access road																	
Temporary facilities																	
Power intake																	
Weir																	■
Power house																	
Power outlet																	
Transformer yard																	
Metal Work																	
Steel overturning gate	■																■
Screen																	
Sand washout gate																	
Open roof of the powerhouse																	
Stop log gate																	
Metal transportation																	
Electric Mechanical Work																	
Turbine	■	■	■	■	■												■
Generator	■	■	■	■	■												■
Transformer			■														
Transmission line	■	■	■														■

Manning schedule — 2011

Manning schedule		total	1	2	3	4	5	6	7	8	9	10	11	12
Foreign Engineers														
Project Manager	Int	8.5												
Hydrologist	Int	1												
Geologist	Int	4												
Civil Engineer (Weir, Power Intake & Outlet)	Int	16.5												
Architectural Enginner (Powerhouse)	Int	6												
Metal Engineer (Gate, Screen, Draft Tube etc.)	Int	10												
Electric Mechanical Engineer (Turbine, Generator)	Int	11.5												
Electrical Engineer (Substation, I&C)	Int	2												
Transmission Engineer	Int	9.5												
Construction Planning Engineer	Int	2												
Contract & Claim Engineer	Int	5												
Environmental Engineer	Int	4												
Subtotal		80												
Local Engineers														
Deputy Project Manager	Lo	49												
Hydrologist	Lo	2												
Geologist	Lo	10												
Civil Engineer (Weir, Power Intake & Outlet)	Lo	25												
Architectural Enginner (Powerhouse)	Lo	11												
Metal Engineer (Gate, Screen, Draft Tube etc.)	Lo	13												
Electric Mechanical Engineer (Turbine, Generator)	Lo	9												
Electrical Engineer (Substation, I&C)	Lo	6												
Transmission Engineer	Lo	12												
Environmental Engineer	Lo	6												
Subtotal		143												
Supporting Staff														
Administrator	Lo	37												
Secretary	Lo	70												
CAD Operators	Lo	48												
Drivers	Lo	107												
Subtotal		262												

Manning schedule — 2012

Manning schedule	1	2	3	4	5	6	7	8	9	10	11	12
Foreign Engineers					D/D Stage 21							
Project Manager					1							1
Hydrologist					1							
Geologist					1							
Civil Engineer (Weir, Power Intake & Outlet)					1	1	1					1
Architectural Enginner (Powerhouse)							1	1				
Metal Engineer (Gate, Screen, Draft Tube etc.)							1	1				1
Electric Mechanical Engineer (Turbine, Generator)								1	1			1
Electrical Engineer (Substation, I&C)									1			
Transmission Engineer								1	1			1
Construction Planning Engineer												
Contract & Claim Engineer												
Environmental Engineer												1
Subtotal												
Local Engineers					D/D Stage 37							
Deputy Project Manager					1	1	1	1	1	1	1	1
Hydrologist					1	1						
Geologist					1	1						
Civil Engineer (Weir, Power Intake & Outlet)					1	1	1	1				1
Architectural Enginner (Powerhouse)							1	1	1			1
Metal Engineer (Gate, Screen, Draft Tube etc.)							1	1	1			1
Electric Mechanical Engineer (Turbine, Generator)								1	1			1
Electrical Engineer (Substation, I&C)									1	1		1
Transmission Engineer								1	1			1
Environmental Engineer												1
Subtotal												
Supporting Staff												
Administrator					1	1	1	1	1	1	1	1
Secretary					1	1	1	1	1	1	1	1
CAD Operators					3	3	3	3	3	3	3	3
Drivers					3	3	3	3	3	3	3	3
Subtotal												

Manning schedule — 2013

Manning schedule	1	2	3	4	5	6	7	8	9	10	11	12
Foreign Engineers		T.D 8				T.Period			Evaluation 5			
Project Manager				1						1		
Hydrologist												
Geologist												
Civil Engineer (Weir, Power Intake & Outlet)				1						1		
Architectural Enginner (Powerhouse)												
Metal Engineer (Gate, Screen, Draft Tube etc.)				1								
Electric Mechanical Engineer (Turbine, Generator)				1						1		
Electrical Engineer (Substation, I&C)												
Transmission Engineer				1						1		
Construction Planning Engineer				1								
Contract & Claim Engineer			1	1								
Environmental Engineer												
Subtotal												
Local Engineers		T.D 10				T.P 3			Evaluation 12			
Deputy Project Manager	1	1	1	1	1	1	1	1	1	1	1	1
Hydrologist												
Geologist												
Civil Engineer (Weir, Power Intake & Outlet)				1						1	1	
Architectural Enginner (Powerhouse)				1								
Metal Engineer (Gate, Screen, Draft Tube etc.)				1						1	1	
Electric Mechanical Engineer (Turbine, Generator)				1								
Electrical Engineer (Substation, I&C)				1								
Transmission Engineer				1						1	1	
Environmental Engineer	1											
Subtotal												
Supporting Staff												
Administrator	1	1	1	1	1							
Secretary	1	1	1	1	1				1	1	1	1
CAD Operators												
Drivers	3	1	1	1	1				1	1	1	1
Subtotal												

Manning schedule — 2014

Manning schedule	1	2	3	4	5	6	7	8	9	10	11	12
Foreign Engineers			Nego. 2.5			Construction Stage 41						
Project Manager	1			1								
Hydrologist												
Geologist												
Civil Engineer (Weir, Power Intake & Outlet)				0.5		1				1		
Architectural Enginner (Powerhouse)												1
Metal Engineer (Gate, Screen, Draft Tube etc.)												
Electric Mechanical Engineer (Turbine, Generator)				0.5								
Electrical Engineer (Substation, I&C)												
Transmission Engineer				0.5								
Construction Planning Engineer						1						
Contract & Claim Engineer												
Environmental Engineer						1						
Subtotal												
Local Engineers			Nego. 3			Construction Stage 78						
Deputy Project Manager	1	1	1	1	1	1	1	1	1	1	1	1
Hydrologist												
Geologist												
Civil Engineer (Weir, Power Intake & Outlet)						1	1	1	1	1	1	1
Architectural Enginner (Powerhouse)						1						1
Metal Engineer (Gate, Screen, Draft Tube etc.)												
Electric Mechanical Engineer (Turbine, Generator)												
Electrical Engineer (Substation, I&C)												
Transmission Engineer												
Environmental Engineer												
Subtotal												
Supporting Staff												
Administrator						1	1	1	1	1	1	1
Secretary	1	1	1	1	1	2	2	2	2	2	2	2
CAD Operators												
Drivers	1	1	1	1	1	2	2	2	2	2	2	2
Subtotal												

Manning schedule — 2015

Manning schedule	1	2	3	4	5	6	7	8	9	10	11	12
Foreign Engineers												
Project Manager					1							
Hydrologist												
Geologist						1	1				1	
Civil Engineer (Weir, Power Intake & Outlet)		1			1	1	1	1	0.5		1	1
Architectural Enginner (Powerhouse)							1	1	1			
Metal Engineer (Gate, Screen, Draft Tube etc.)			0.5			1			1		1	1
Electric Mechanical Engineer (Turbine, Generator)			0.5									
Electrical Engineer (Substation, I&C)												
Transmission Engineer			0.5							1		1
Construction Planning Engineer												
Contract & Claim Engineer									1			
Environmental Engineer									1			
Subtotal												
Local Engineers												
Deputy Project Manager	1	1	1	1	1	1	1	1	1	1	1	1
Hydrologist												
Geologist					1	1	1	1	1	1	1	1
Civil Engineer (Weir, Power Intake & Outlet)	1	1			1	1	1	1	1	1	1	1
Architectural Enginner (Powerhouse)							1	1	1	1		
Metal Engineer (Gate, Screen, Draft Tube etc.)						1	1		1	1	1	1
Electric Mechanical Engineer (Turbine, Generator)												
Electrical Engineer (Substation, I&C)												
Transmission Engineer										1	1	1
Environmental Engineer					1				1			
Subtotal												
Supporting Staff												
Administrator	1	1	1	1	1	1	1	1	1	1	1	1
Secretary	2	2	2	2	2	2	2	2	2	2	2	2
CAD Operators					3	3	3	3	3	3	3	3
Drivers	2	2	1	1	4	4	4	4	4	4	4	4
Subtotal												

Manning schedule — 2016–2017

Manning schedule	2016-1	2	3	4	5	6	7	8	9	10	11	12	2017-1	2	3	4	5
Foreign Engineers						Guarantee Period 2.5											
Project Manager					1												0.5
Hydrologist																	
Geologist																	
Civil Engineer (Weir, Power Intake & Outlet)																	0.5
Architectural Enginner (Powerhouse)																	
Metal Engineer (Gate, Screen, Draft Tube etc.)	1																0.5
Electric Mechanical Engineer (Turbine, Generator)	1	1	1	1	1												0.5
Electrical Engineer (Substation, I&C)			1														
Transmission Engineer			1														0.5
Construction Planning Engineer																	
Contract & Claim Engineer	1				1												
Environmental Engineer					1												
Subtotal																	
Local Engineers						Guarantee Period											
Deputy Project Manager	1	1	1	1	1												
Hydrologist																	
Geologist																	
Civil Engineer (Weir, Power Intake & Outlet)																	
Architectural Enginner (Powerhouse)																	
Metal Engineer (Gate, Screen, Draft Tube etc.)																	
Electric Mechanical Engineer (Turbine, Generator)	1	1	1	1	1												
Electrical Engineer (Substation, I&C)			1	1													
Transmission Engineer	1	1	1														
Environmental Engineer	1				1												
Subtotal																	
Supporting Staff																	
Administrator	1	1	1	1	1												
Secretary	2	2	2	2	2												
CAD Operators																	
Drivers	3	3	3	3	3												
Subtotal																	