Department of Energy and Water
The Republic of Angola

FINAL REPORT
OF
THE PREPARATORY SURVEY
ON
RURAL ELECTRIFICAITON DEVELOPMENT WORKS
IN
THE REPUBLIC OF ANGOLA

December 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

NEWJEC Inc.

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CONCLUSION AND RECOMMENDATION

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This preparatory survey is planned from August 2010 to January 2012. This preparatory survey is The Preparatory Survey on Rural Electrification Development Works including Feasibility Study (FS) of Cutato HPS (Hydro Power Station). As the result of survey, Cutato HPS can be feasible to be executed from viewpoints of technology, economy and environment.
Conclusion and Recommendation are shown below.

Conclusion

1. Necessity and Expected Result of the Project

(1) Necessity of the Project

Maximum electricity supply has been increased more than 10% after termination of the civil war in 2002. In the year of 2008, installed capacity was 1,258 MW and maximum electricity supply was 4,050 GWh. The yearly electricity production, in 2008 has been rapidly increased by 23% from 2007. The average yearly electricity production from 2010 to 2016 is estimated 13%/year.

Electric supply in Angola is almost restricted to urban areas. Rural electrification rate of villages is very low, 30.4% and more rural electrification is to be expanded. However, besides governmental electricity company of Angola (ENE: National Electricity Company), consumers have generation facilities by themselves around 900 MW to 1,200 MW and all of them are diesel generation facilities.

Types of the generation facilities are 64% for hydropower and 34% for thermal power. Most of generation facilities are located in the north area of Angola.

In Angola, more than 80% of oil production is exported, so internal supply in the country is limited. Furthermore, it is desirable to use plenty of the hydropower resources existing in the country, in consideration of demerits of higher cost of power generation by fossil fuels due to the rising price of oil and natural gas and the problem of greenhouse effect by massive CO_2 emission.

Electric power system has not cover all over the Angola and there are three main regions, the region of capital city Luanda and its suburbs, Namibe and Lunango region, and Lucapa and Luachimo region. There are five independent electric power systems in Angola and they are controlled by ENE. Transmission line voltage in Angola is 400 kV, 220 kV, 110 kV and 60 kV and Distribution line voltage is 30 kV and 15 kV.

As for power transmission and substation, ENE has responsibility of facilities construction and operation, and EDEL (Empresa de Electricidate de Luanda) has responsibility of power distribution, facilities construction and operation for urban area of Luanda.

MINEA (Ministry of Energy and Water) has a view that the gap of electricity supply between urban area and rural area could be resolved by utilizing the small hydropower generation, leading to avoid that the rural people rushing to the urban area. Consequently MINEA is looking for the support of financing and institutional system to deploy 10 MW class small hydropower stations for rural electrification and planning to apply PPP (Public Private Partnership) scheme to them.

There is a gap between urban and rural areas, and approximately 60% of population is in the rural area. The accessibility to electric power (rate of electrification) is approximately 30% which is lower than other African countries (42%). In 2009, GOA (Government of Angola) prepared and published the strategic electrification plan (medium term development plan 2009-2012). According to this plan, the target of electrification rate is 100% in the cities, 60% in the satellite cities, and 30% in the agricultural villages. And, it aims to expand the power generation of 4,050 GWh to 2.7 times, 11,050 GWh in 2012. Furthermore, MINEA established the National Program for small hydro power stations as strategy and has been promoting rural electrification. This project site is located in relatively rich rainfall region in Angola and along the Cutato River which is the tributary of the Cuanza River, one of the largest river in Angola. Therefore, it is quite reasonable to take advantage of the big head and large amount of water before the Cutato River runs into Cuanza River. Furthermore, the population of the Bie Province is the 3rd of the Angola (194 million), with electric demand of 30 million people in Andulo County. The project could supply approx. 40,000 inhabitants, and selecting this Cutato river site could bring the maximum positive economic effect in the country.

Now Angola depends on crude oil nearly 95% of total export, equivalent to 70 ~ 80% of the government revenue budget, the skyrocketing of recent oil price does affect critically the national financial status. Under circumstances, small hydropower as renewable energy for power sources could lead to the national development as well as the improvement of the gap between urban and rural areas.

(2) Value and Validity of the Project

1) Value of the Project

The Cutato River Hydropower Project has been selected among 5 candidates proposed by the GOA judging from the site surveys and screening results. The Cutato

River Hydropower Plant is run-of-river type hydropower plant which can provide up to 3,000 kW with effective head 7.5 m and maximum plant discharge 50 m^3/s.

GOA and local governments have strong request of electric power supply to Andulo County by this power plant. Electric power supply will be distributed by 30 kV high-voltage power distribution line to the City of Andulo County with distributing Chicumbi on the way to Andulo. After completion of this power plant, 3,000 kW (5 times of present power generation in Andulo County) can be generated in 180 days a year. That can newly provide 6,000 households (0.5 kW/household). However, further expansion of stand-alone system is to be considered to meet 23,000 household demand. Whole power generated at the new station could be consumed effectively if distribution line is installed timely by GOA in parallel with the project schedule.

2) Validity of the Project

This project is hydropower generation project which provides small impact to environment with small CO_2 emission. Furthermore, this project receives little affect of price increase of fossil fuel.

The commencement of main works is assumed June 1st 2014, provided that loan agreement is made at the end of November 2011. After 2 years of main construction work, the operation can start in 2016.

The construction cost, such as (a) land-mine investigation and removal, (b) civil work including metal work, (c) electro-mechanical work, and (d) associated distribution line is estimated 4,076 Million JPY (Japanese Yen) including contingency cost. The project cost including the above base cost, consultant service and owner's administration cost becomes 4,416 Million JPY.

The construction cost seems to be expensive in comparison with the project scale. The reasons is due to the specific condition of Angola and the site as below: a) high price escalation rate exceeding 10% per annum (increase of price contingency) , b) far expensive recovery costs for construction machines and cost for material in comparison with those in Japan, c) execution of land-mining investigation and removal, and d) adoption of S-Type Tubular Turbine costing higher in comparison with other types of turbines due to low effective head and great volume of power intake discharge.

The project can be evaluated as bellow in terms of economic and financial analysis.

- Even in consideration of CER (Certified Emission Reduction) revenue, the project is deemed to be financially infeasible. On the other hand, the project's EIRR (Economic Internal Rate of Return) of 13.3 % is deemed to be economically feasible due to the recently soaring crude oil price (FOB: Free on Board) in the world.

- Why the project becomes financially not attractive seems to be caused by its expensive construction cost and low power tariff of 4 UScent/kWh against the average generation cost of 11 UScent/kWh of ENE.
- 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.

2. Outline Design of the Project

(1) Screening

MINEA has planned the hydropower development in internal regions with undeveloped electrification. The selected sites were following 5 sites of Bie and Huambo Province.

1. Cutato site of Bie (Andulo)
2. Luvolo site of Bie (Chicala)
3. Cunene site of Huambo (socopomo)
4. Põe site of Huambo (Cuima)
5. Cuima site of Huambo (Cuima)

The issues of the first screening for selecting FS in the implementation policy are followings.

1. Rural electrification contributes to the correction of regional differential.
2. The site is not under construction or bidding
3. Output power is over 500 kW
4. There is no dangerousness of land mines.
5. The site is not in National Park or Protective Zone.

Only 2 sites (Cutato site, 1.6 MW and Luvolo site, 0.7 MW) of the FS Candidate Sites, could satisfy the No.3 issue of the implementation policy.

Cutato site is good at geography, geology and access compared to Luvolo site. Installed capacity of Cutato site is 1.6 MW (it is planned initially by using minimum river discharge) which is the biggest capacity in the candidate sites. The demand place of Cutato site is Andulo which population is about 300 thousands, so it appears the all generating energy can be easily consumed.

So Cutato site was selected in second screening as the FS Site because its site is good site that its power plant generates the most energy among the candidate sites and has much demand place where its energy is easily consumed.

(2) Process of Power Plant Location

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

Though Cutato Project is a small-hydro development project which head is low with low weir, the Cutato is a big river of which minimum discharge is about 20 m^3/s. The most important point to select the project site is that it is easy to change river flow and to get much head from river slope. Cutato site has branch and river flow is same at left tributary and right tributary. The branch makes easy to change river flow at construction stage. River slope becomes steep at downstream of branch, even weir type hydro power station can get a few meters head. There is no suitable site at 5 km upstream area of this site.

(3) Project Size and Facilities

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

It is necessary that weir has hinged 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.

Optimum weir height and optimum maximum discharge are checked up in various height and discharge cases and are selected out of the case which cost-benefit ratio (B/C : Benefit/Cost) is the biggest number. The result is that weir height is 4 m (effective head is 7.5 m), maximum discharge is 50 m^3/s and installed capacity is 3,000 kW.

Turbine type has been checking up with various discharges and heads of Cutato site, S-Type Tubular Turbine is selected which is suitable for more discharge and less head like Cutato site.

Generating capacity of hydropower station changes in depending on river discharge in a year. Though maximum generating capacity can be 3,000 kW, 2 units of turbines and generators (installed capacity per 1 unit is 1,500 MW) are settled because only 1 unit can work when power station is in inspection and trouble.

3. Current Status and Forecast of Operation and Maintenance

There are many big and small hydropower stations in Angola. They are well operated and maintained for supplying electric power. The hydropower stations of well operated national company like GAMEK (Office for Exploitation of the Medium Kwanza) are well managed for themselves to operate, maintain and repair. It is assumed that maintenance organizations directly managing hydropower stations have been established and there are many competent engineers in these organizations. But now that there is lack of competent engineers in rural area, it shall be considered that engineering managers and maintenance organizations are to be sophisticated in rural new hydropower plant.

Concrete observation and control system of Cutato Hydropower Station is recommended below. Observation and control system of the hydropower station is temporary patrol system.

The engineer of the hydropower station must patrol at the starting time of the work in the morning and the evening which is the peak period of electricity demand and others.

The director of the hydropower station and 3 engineers operate and maintain the generating facilities and they are mainly in the office of Andulo.

The director of the hydropower station chooses the three engineers who know the knowledge of the hydropower station and supervise those engineers to operate the hydropower station well. When something trouble/accidents happened at the hydropower station and the engineers have some questions/doubt, the director gives advices to the engineers.

It is considered necessary of training, exercise and education from construction stage, leading to good operation of the station.

Recommendation

Electric power supply in Angola is extremely tight, especially construction of new hydropower station for rural area electrification is absolutely necessary. Cutato HPS is hydropower station and its project shall be promoted.

This project is feasible at the viewpoint of technology, economy, finance and environment, and shall be developed for power distribution system in Angola. The schedule is that main works can be started at middle of 2014, and power plant operation starting in 2016, considering all required period of geography/geology survey, hydrology survey, hydro model experiment, detailed design, financing and term of construction after this preparatory survey.

Following items shall be executed before this project.

(1) Detailed design needs additional survey which is shown in Chapter 6 "Future Survey", accuracy improvement of project cost and drawing up tender documents.

(2) Preparation of finance, tender of construction and selection of contractor are shall be completed before construction commencement of this project. Safety for land-mine in construction area must be confirmed and new road construction and existing road repairing to the site shall be completed before main work commencement.

(3) Proper compensation of removal houses, agriculture and fishery and the program in social action plan shall be executed.

Table of Contents

List of Figures

List of Tables

List of Photos

Abbreviations

Abbreviation	Name
AAAC	All Aluminum Alloy Conductor
ACSR	Aluminum Conductor Steel Reinforced
B/C	Benefit / Cost
BOT	Build, Operation and Transfer
CDM	Clean Development Mechanism
CFSVA	Comprehensive Food Security and Vulnerability Analysis
CNIDAH	Inter Sectoral Commission on Demining and Humanitarian Assistance
CED	The executive Commission for Demining
CER	Certified Emission Reduction
CPI	Consumer Price Index
DNA	National Directorate of Water
DNA	Designated National Authority
DNE	National Energy Directorate
DNEL	National Direction of Electrification in Ministry of Energy and Water
DOC	Democratic Republic of Congo
DOE	Designated Operational Entities
DR	Discount Rate
DSCR	Debt Service Coverage Ratio
EDEL	Empresa de Electricidade de Luanda
EIA	Environmental Impact Assessment
EFL	Environmental Framework Law
EIRR	Economic Internal Rate of Return
EL	Elevation
ENE	National Electricity Company
FIRR	Financial Internal Rate of Return
FOB	Free on Board
FS	Feasibility Study
FWL	Flood Water Level
GABHIC	Office for the Administration of the Cunene River Basin Hydroelectric (Gabinete de Administracao da Bacia Hidrografia de Rio Cunene)
GAMEK	Office for Exploitation of the Medium Kwanza (Gabinete de Aproveitamento do Medio Kwanza)
GDP	Gross National Product
GNI	Gross National Income
GOA	Government of Angola
GRN	Angola's National Reconstruction Office
HPS	Hydro Power Station
HSD	High Speed Diesel
IBRD	International Bank for Reconstruction and Development
IDC	Interest During Construction
IDF	Institute of Forest Development
IEE	Initial Environmental Examination
IEL	International Electro-technical Commission
INAD	National Institute for Demining
INAMET	Instituto de Nacianal Meteorologia e Geofisica
INEA	Roads Institute of Angola
IRR	Internal Rate of Return
ITCZ	Intertropical Convergence Zone
IUCN	International Union for Conservation of Nature and Natural Resources
JBIC	Japan Bank for International Corporation

Abbreviation	Name
JICA	Japan International Cooperation Agency
LDC	Least Development Country
LHV	Lower Heating Value
LOA	Letter of Approval
LPC	Levelised Production Cost
MINADER	Ministry of Agriculture and Rural Development
MINEA	Ministry of Energy & Water
MOE	Ministry of Energy
MINAMB	Ministério do Ambiente (Ministry of Environment)
MOF	Ministry of Finance
MOW	Ministry of Water
MPLA-PT	Popular Movement for the Liberation of Angola - Party of Labour
NGO	Non Governmental Organization
NPO	Nonprofit Organization
NVE	Norwegian Water Resources and Energy Directorate
NWL	Normal Water Level
ODA	Official Development Assistance
OM	Operation and Maintenance
PCN	Project Concept Note
PDD	Project Design Document
PEAC	Pool Energetique de I's Afique Central
PIN	Project Information Note
PPIAF	Private Solutions for Infrastructure in Angola
PPP	Private Public Partnership
ROE	Return on Equity
SAPP	South Africa Power Pool
SONANGOL	Sociedad Nacional de Combustives de Angola
SSC	Small-Scale CDM
STEP	Special Terms for Economic Partnership
SWL	Surcharge Water Level
UNITA	National Union for the Total Independence of Angola
UNFCCC	United Nations Framework Convention on Climate Change
UPDEA	Transporters and Distributors of Electricity Power in Africa
USAID	United States Agency for International Development
USGS	United States Geological Survey
WACC	Weighted Average Cost of Capital
WB	World Bank
WEO	World Energy Outlook
WESCOR	Western Power Corridor
WFP	World Food Programme
WL	Water Level

Unit

A	Ampere
bbl	barrel (1 bbl = 159 liter)
EUR	Euro
GW	Gigawatt (=1,000 MW = 1,000,000 kW)
GWh	Gigawatt – hour (=1,000 MWh = 1,000,000 kWh)
Hz	Hertz
JPY	Japanese Yen
km	Kilometer
km^2	square kilometer
kV	Kilo Volt
kVA	Kilo Volt Ampere
kW	kilowatt
kWh	Kilowatt - hour
Kz	Angola Kwanza
m	meter
m^3	cubic meter
mm	millimeter
MW	Megawatt (= 1,000 kW)
MWh	Megawatt – hour (= 1,000 kWh)
s	second
US$	United States Dollars
V	Volt

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background

The shortage of power supply has prevented economic growth and reduction of poverty ratio due to the serious damage to power lines and power plants through the long lasted civil war till 2002. As of 2008, the installed capacity of power generation facilities in Angola is 1,258 MW, and total generating energy is 4,050 GWh.

As for power transmission lines, there exist three independent power supply systems in Angola, i.e. Northern System, Central System and Southern System. Northern System covering Luanda area is the biggest one and accounts for almost 80% of the total system capacity.

Under the above circumstances, in 'Medium-term Development Plan 2009-2013' now under preparation, the government of Angola sets forth a goal that about half of nationwide population can access to electricity by 2015 in manner of refurbishment of power plants and power distribution facilities. GOA also addresses the correction of regional disparities through the expansion of power supply in rural areas.

Now the Japanese Government considers the possibilities to supply Yen Loan for GOA. Japan International Cooperation Agency (JICA) also executed the Pilot Study for Project Formation of Infrastructure Projects for Post-Conflict Assistance to the Republic of Angola from 2008 to 2009 to make project finding under the Yen Loan. Based on the said JICA study, the Japanese Government agreed to execute preparatory study for the improvement of disparity among regions through rural electrification by means of development of hydropower potential (estimated approximately 18,000 MW).

The JICA Study Team conducts the FS for the development of a small hydropower plant in the rural area among the candidate sites, in preparation for the future Yen Loan.

The location of the project is shown in Fig.1.1-1(1) and (2)

Fig. 1.1-1(1) Location of Project Site <Luanda ~ Cuito ~ Andulo ~ Site>

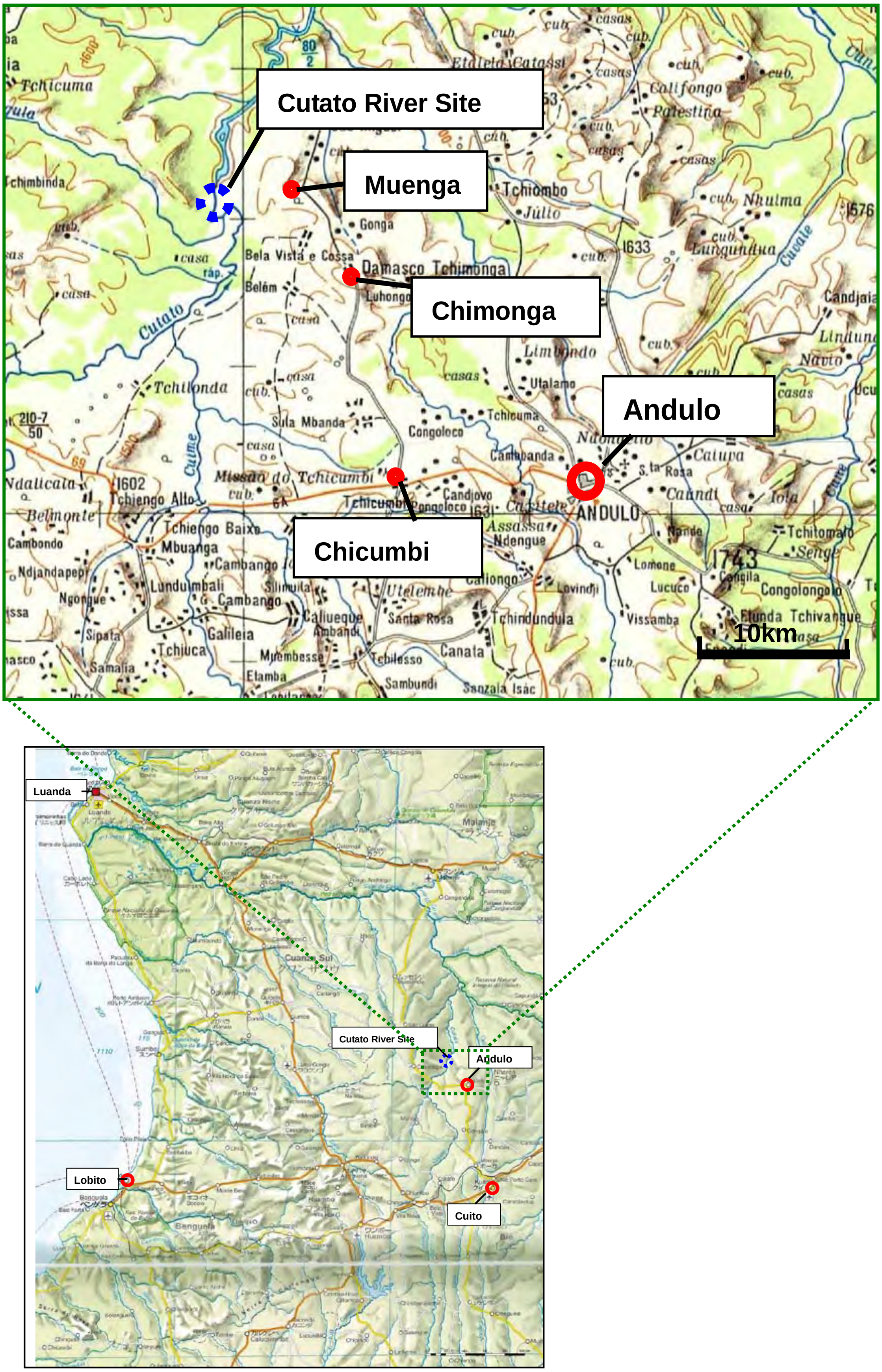

Fig. 1.1-1(2) Location of Project Site <Andulo ~ Site>

1.2 Purpose of Survey

Taking into consideration the Yen Loan supply to rural electrification project, it is the purpose that the survey reviews power supply and power demand of Angola, checks necessity and validity of rural electrification by using small hydro power plants in Angola, selects the FS sites, executes the FS and proposes the implementation plan of the project. The counterpart of Angola is MINEA.

1.3 Scope of Survey

1) Review the power supply sector in Angola
2) Check the activity status of the other donors in Angola
3) Select the FS sites of small hydropower plants
4) Outline design of the project (including measure of demine)
5) Propose how to procure and construct
6) Estimate the construction cost and its breakout of the project
7) Propose the implementation schedule of the project
8) Study the organization of implementation, operation and maintenance
9) Calculate EIRR and FIRR (Financial Internal Rate of Return)
10) Select the effect indicator of project operation
11) Support the environmental social consideration
12) Support to make PDD (Project Design Document) for CDM (Clean Development Mechanism) of the project

1.4 Summary of Site Investigation

The 1st Site Investigation was held from August 18 to September 25, in 2010. The site reconnaissance which was going to feasible 5 candidate sites of small-hydro in Bie and Huambo Province, was held from September 7 to September 11.

The 2nd Site Investigation was held from January 10 to February 8, in 2011. The site reconnaissance which was going to 1 FS site of small-hydro in Bie Province, was held from January 24 to January 28.

1.5 Members of Study Team and Schedule of Investigation

Table 1.5-1 shows the members of the 1st Site Investigation Study Team. Table 1.5-2 shows the members of the 2nd Site Investigation Study Team. Table 1.5-3 shows the schedule of the 1st Site Investigation. Table 1.5-4 shows the schedule of the 2nd Site Investigation.

Table 1.5-1 1st Site Investigation Composition of the Experts

Assignment	Expert's Name	Affiliation
Team Leader/Hydropower Civil Engineering	Masakazu ITAKURA	NEW JEC Inc.
Hydropower Generating Equipment	Takao SHIRAISHI	NEW JEC Inc.
Distribution Plan	Yoshiji HASEGAWA	NEW JEC Inc.
Hydoro-Meteorological Analysis	Takao SARUHASHI	NEW JEC Inc.
Geology / Surveying	Mitsuhiro TOKUSU	NEW JEC Inc.
Environmental and Social Considerations	Satoshi YAMAOKA	NEW JEC Inc.
Coordinator	Satoshi ISHIMARU	NEW JEC Inc.
Interpreter	Yoko MTSUZAKI	-

Table 1.5-2 2nd Site Investigation Composition of the Experts

Assignment	Expert's Name	Affiliation
Team Leader/Hydropower Civil Engineering	Masakazu ITAKURA	NEW JEC Inc.
Hydropower Generating Equipment	Takao SHIRAISHI	NEW JEC Inc.
Distribution Plan	Yoshiji HASEGAWA	NEW JEC Inc.
Economic and Financial Analysis	Yasuharu MATSUDA	NEW JEC Inc.
Environmental and Social Considerations	Satoshi YAMAOKA	NEW JEC Inc.
Mine Countermeasures	Kazuyuki MATSUO	(NPO) Japan Mine Action Service
Clean Development Mechanism	Momoko ONISHI	Tepia Corporation
Civil Design	Fumio TAKEZAWA	OT Design Inc.
Coordinator	Satoshi ISHIMARU	NEW JEC Inc.
Interpreter	Yoko MATSUZAKI	-

Table 1.5-3 1st Site Investigation Schedule (Actual)

	Date	Day	Team Leader/ Hydropower Civil Engineer	Hydropower Generating Equipment	Transmission and Distribution Planning	Interpreter	Project Coordinator	Hydro-Meteo-rological Analysis	Geology/ Surveying	Environmen-tal Social Consideration	Accommoda-tion
			Mr.Itakura NEWJEC	Mr.Shiraishi NEWJEC	Mr.Hasegawa NEWJEC	Ms.Matsuzaki Technostaff	Mr.Ishimaru NEWJEC	Mr.Saruhashi NEWJEC	Mr.Tokusu NEWJEC	Mr.Yamaoka NEWJEC	
1	2010/8/18	Wed	Leave for Angola Kansai - HongKong - Johannesburg -Luanda (CX507-CX749-SA0054)			Leave for Angola Narita - HongKong - Johannesburg - Luanda (CX521-CX749-SA0054)					Luanda City
2	2010/8/19	Thu	Arrival in Luanda by SA0054, Visit JICA								Luanda City
3	2010/8/20	Fri	AM10:00 Embassy of Japan, PM13:00 MOEW Mr.Serafim Silveira (Director), Mr.Dongara (ENE)								Luanda City
4	2010/8/21	Sat	Internal meeting								Luanda City
5	2010/8/22	Sun	Internal meeting								Luanda City
6	2010/8/23	Mon	AM 11:00 Kick off meeting with MOEW								Luanda City
7	2010/8/24	Tue	ENE								Luanda City
8	2010/8/25	Wed	PM 14:00 Ministry of Ambiente Mr.Giza Martin								Luanda City
9	2010/8/26	Thu	MOML								Luanda City
10	2010/8/27	Fri	AM 11:00 UNDSS Mr.Samuel Odei								Luanda City
11	2010/8/28	Sat	Internal meeting								Luanda City
12	2010/8/29	Sun									Luanda City
13	2010/8/30	Mon	MOEW (1ST Screening result), ENE								Luanda City
14	2010/8/31	Tue	Follow up								Luanda City
15	2010/9/1	Wed	Follow up								Luanda City
16	2010/9/2	Thu	MOID, Follow up								Luanda City
17	2010/9/3	Fri	MOEW (2ND Screeing result), ENE								Luanda City
18	2010/9/4	Sat	Internal meeting								Luanda City
19	2010/9/5	Sun						Leave for Angola Kansai - HongKong - Johannesburg -Luanda (CX507-CX749-SA0054)			Luanda City
20	2010/9/6	Mon	MOEW,ENE,EDEL (on Site survey)					Arrival in Luanda by SA0054			Luanda City
21	2010/9/7	Tue	Move to Cuito (site survey)								Cuito
22	2010/9/8	Wed	Site survey in Bie Province								Cuito
23	2010/9/9	Thu	Site survey in Bie and Move to Huambo Province								Huambo
24	2010/9/10	Fri	Site survey in Huambo								Huambo
25	2010/9/11	Sat	Move to Luanda								Luanda City
26	2010/9/12	Sun									Luanda City
27	2010/9/13	Mon	Data collection, Followup								Luanda City
28	2010/9/14	Tue	INAMET (Data collection)								Luanda City
29	2010/9/15	Wed	Data collection, Followup								Luanda City
30	2010/9/16	Thu	MOEW (Preparation of MD)								Luanda City
31	2010/9/17	Fri	Data collection, Followup								Luanda City
32	2010/9/18	Sat	Internal meeting								Luanda City
33	2010/9/19	Sun									Luanda City
34	2010/9/20	Mon	Signing of MD with MOEW					Follow up			Luanda City
35	2010/9/21	Tue	Data collection and Follow up								Luanda City
36	2010/9/22	Wed	Data collection and Follow up								Luanda City
37	2010/9/23	Thu	Leave for Johannesburg by SA055 (Stay at Johannesburg)								Johannesburg
38	2010/9/24	Fri	Leave for Japan via Hongkong(CX748-CX506)			Leave for Japan via Hongkong (CX748-CX520)		Leave for Japan via Hongkong (CX748-CX506)			
39	2010/9/25	Sat	Arrival in Japan								

MD: Minuta de Discusiones

MOEW	Ministry of Energy and Water
ENE	Empresa Nacional de Electicidade (National Enterprise Electricity)
EDEL	Empresa de Distribuciao de Electricidate de Luanda
INAD	Instituto National De Desminagem
CNIDAH	Commisao Intersectorial de Deminagem e Assistencia Humanitaria
MOML	Ministry of Meteorology
INAMET	Instituto de National Meteorologia e Geofisica

Table 1.5-4 2nd Site Investigation Schedule (Actual)

	Date	Day	Team Leader/ Hydropower Civil Engineer	Hydropower Generating Equipment	Transmission and Distribution Planning	Interpreter	Project Coordinator	Hydro-Meteorological Analysis	Geology/ Surveying	Environmental Social Consideration	Accommoda-tion
			Mr.Itakura NEWJEC	Mr.Shiraishi NEWJEC	Mr.Hasegawa NEWJEC	Ms.Matsuzaki Technostaff	Mr.Ishimaru NEWJEC	Mr.Saruhashi NEWJEC	Mr.Tokusu NEWJEC	Mr.Yamaoka NEWJEC	
1	2010/8/18	Wed	Leave for Angola Kansai - HongKong - Johannesburg -Luanda (CX507-CX749-SA0054)			Leave for Angola Narita - HongKong - Johannesburg - Luanda (CX521-CX749-SA0054)					Luanda City
2	2010/8/19	Thu	Arrival in Luanda by SA0054, Visit JICA								Luanda City
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12	2010/8/29	Sun									Luanda City
13	2010/8/30	Mon	MOEW (1ST Screening result), ENE								Luanda City
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15	2010/9/1	Wed	Follow up								Luanda City
16	2010/9/2	Thu	MOID, Follow up								Luanda City
17	2010/9/3	Fri	MOEW (2ND Screeing result), ENE								Luanda City
18	2010/9/4	Sat	Internal meeting								Luanda City
19	2010/9/5	Sun						Leave for Angola Kansai - HongKong - Johannesburg -Luanda (CX507-CX749-SA0054)			Luanda City
20	2010/9/6	Mon	MOEW,ENE,EDEL (on Site survey)					Arrival in Luanda by SA0054			Luanda City
21	2010/9/7	Tue	Move to Cuito (site survey)								Cuito
22	2010/9/8	Wed	Site survey in Bie Province								Cuito
23	2010/9/9	Thu	Site survey in Bie and Move to Huambo Province								Huambo
24	2010/9/10	Fri	Site survey in Huambo								Huambo
25	2010/9/11	Sat	Move to Luanda								Luanda City
26	2010/9/12	Sun									Luanda City
27	2010/9/13	Mon	Data collection, Followup								Luanda City
28	2010/9/14	Tue	INAMET (Data collection)								Luanda City
29	2010/9/15	Wed	Data collection, Followup								Luanda City
30	2010/9/16	Thu	MOEW (Preparation of MD)								Luanda City
31	2010/9/17	Fri	Data collection, Followup								Luanda City
32	2010/9/18	Sat	Internal meeting								Luanda City
33	2010/9/19	Sun									Luanda City
34	2010/9/20	Mon	Signing of MD with MOEW					Follow up			Luanda City
35	2010/9/21	Tue	Data collection and Follow up								Luanda City
36	2010/9/22	Wed	Data collection and Follow up								Luanda City
37	2010/9/23	Thu	Leave for Johannesburg by SA055 (Stay at Johannesburg)								Johannesburg
38	2010/9/24	Fri	Leave for Japan via Hongkong(CX748-CX506)			Leave for Japan via Hongkong (CX748-CX520)		Leave for Japan via Hongkong (CX748-CX506)			
39	2010/9/25	Sat	Arrival in Japan								

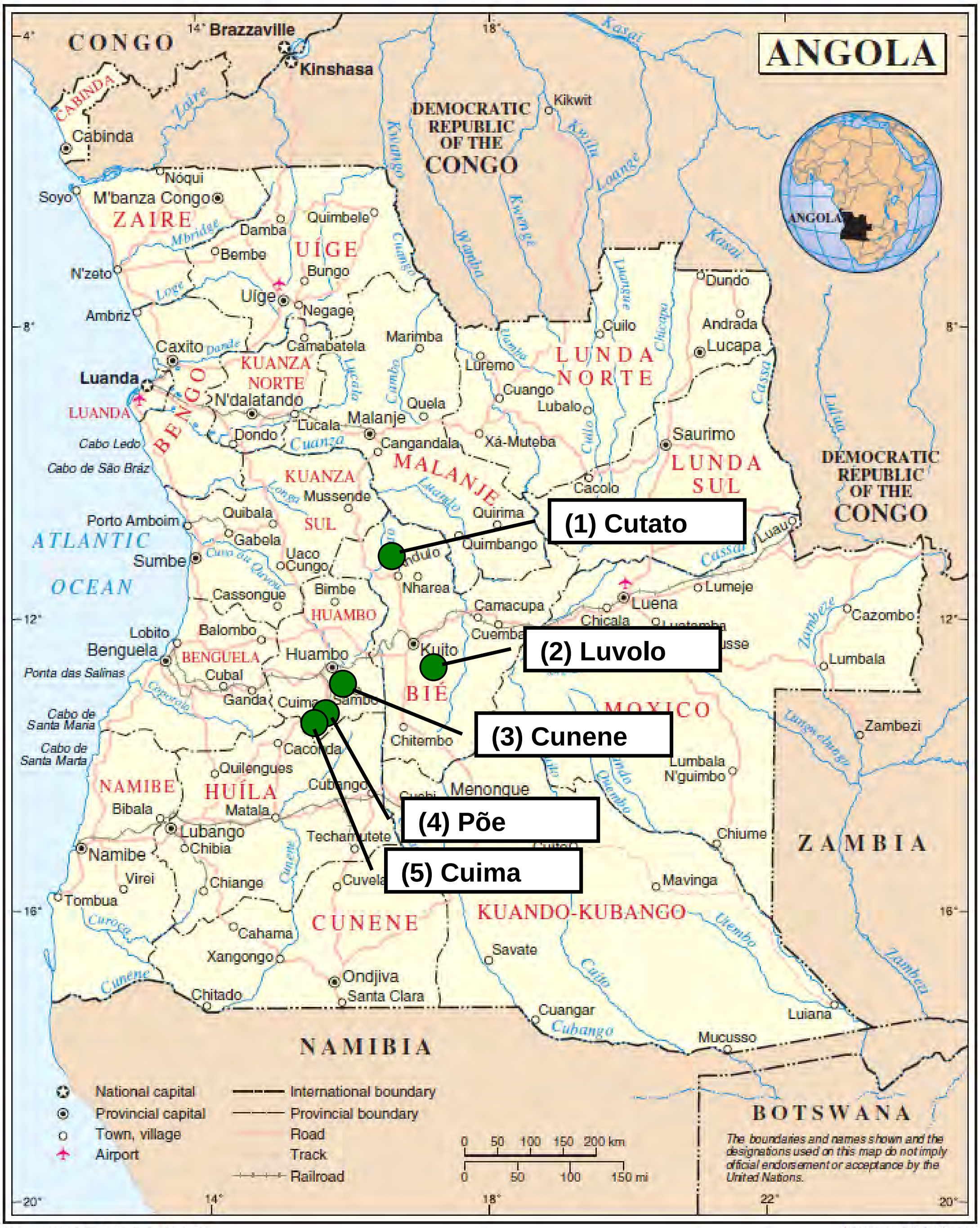
MD: Minuta de Discusiones

MOEW	Ministry of Energy and Water
ENE	Empresa Nacional de Electicidade (National Enterprise Electricity)
EDEL	Empresa de Distribuciao de Electricidate de Luanda
INAD	Instituto National De Desminagem
CNIDAH	Commisao Intersectorial de Deminagem e Assistencia Humanitaria
MOML	Ministry of Meteorology
INAMET	Instituto de National Meteorologia e Geofisica

1.6 Places of Site Investigation

The places of the 1st Site Investigation were Capital Luanda and feasible 5 candidate sites of small-hydro in Bie (Cutato site of Andulo, Luvolo site of Chicala) and Huambo (Cunene site of Socopomo, Põe site of Cuima, Cuima site of Cuima) province (refer to Fig. 1.6-1).

The places of the 2nd Site Investigation were Capital Luanda and 1 FS site of small-hydro in Bie (Cutato site of Andulo) Province.



Map No. 3727 Rev. 4 UNITED NATIONS
August 2008

Department of Field Support
Cartographic Section

Fig.1.6-1 Location of Investigation Sites

CHAPTER 2

PRESENT SITUATION OF ANGOLA

CHAPTER 2 PRESENT SITUATION OF ANGOLA

2.1 Social Environment Aspect

2.1.1 Social Economic Condition of Angola

(1) Country Feature

Angola is the republic country located in south-west Africa and faces Zambia in east, Namibia in south, Democratic Republic of Congo (DRC) in north and the Atlantic Ocean in west. The land area is 1,246,700 km^2 and 3.3 times bigger that Japan. The land is covered by the high land area which covers 2/3 of all land area.

The weather of north Angola is high temperature and humid, middle area is savanna and south area is mild and dry. The sea shore area is influenced by Benguela current and it is rather calm weather than other area.

(2) Dynamic Statics of the Population

Angola people consist of more than 60% of Mbundu (Ovimbundu, Kimbundu), 13% of Congo, 2 % of Mestico and 1% of European.
Total population is 18,020,000 and population growth is 2.6 % /year.

(3) Economy

- From the independence in 1975 to 2002, there had been a long civil war and happened large destruction of the infrastructure and it gave huge damage of human resources in Angola. Therefore this country has just started economic development recently.

- The natural resources of Angola are rich and they produce oil in the sea shore area and diamond in inland. Further main agricultural products are coffee, sisal hemp, maize.

- Angola is the largest oil-producing country along with Nigeria. Oil production account for 95% of the Angola's exports and its profit account for 70 - 80% of government revenue budget.

- CPI (Consumer Price Index) of Angola from 2003 to 2010 is shown in Fig. 2.1-1. Inflation rate in 2003 was more than 100%. However, price of commodity is getting more and more stable, and remains 12 - 13 % after 2007.

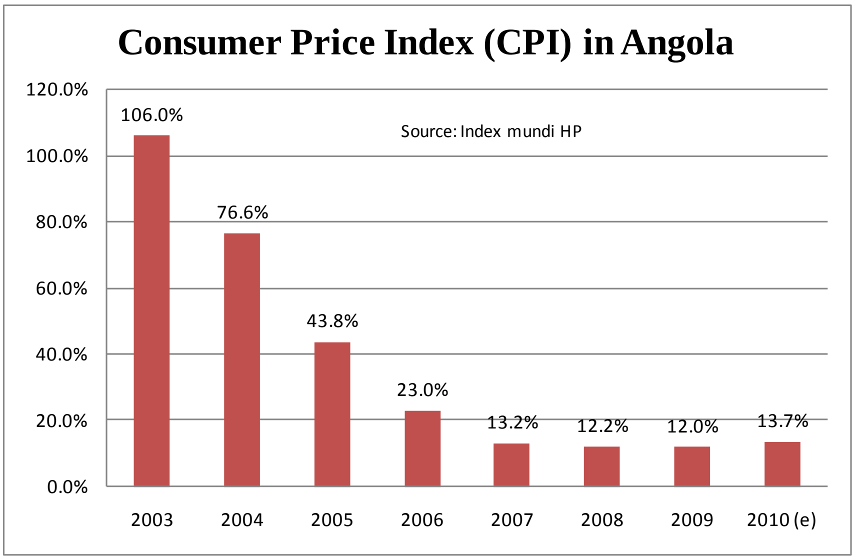


Fig. 2.1-1 Consumer Price Index in Angola

2.1.2 Present Status and Future Plan of Electricity Supply, Yearly Electricity Production and Transmission Line System

(1) Maximum Electricity Supply (MW), and Yearly Electricity Production (MWh)

- Maximum electricity supply has been increased more than 10% after termination of the civil war in 2002. In the year of 2008, installed capacity was 1,258 MW and maximum electricity supply was 4,050 GWh. The yearly electricity production, in 2008 is rapidly increased in 23% from 2007. In the future, average, average yearly electricity production from 2010 to 2016 is estimated 13%/year.

- Installed capacity of Angola is 65% of Japanese smallest private electric company, OKINAWA (The Okinawa Electric Power Company Inc.) (1,925 MW 2008) and 55% of yearly electricity production of OKINAWA (7,345 GWh, 2008).

- Rural electrification rate of villages is very low, 30.4% and more rural electrification is to be expanded. However, besides governmental electricity company of Angola, consumers have generation facilities by themselves around 900 MW to 1,200 MW and all of them are diesel generation facilities.

- Kinds of fuel for the generation facilities are 64% is hydropower and 34% is thermal power as shown in Table 2.1-3. Most of generation facilities are located in the north area of Angola.

- The difference between generation capacity and transmission capacity is 15%. This difference is due to loss at the power station and is bigger than 4% of Japan.

- In addition, there is 28% difference between transmission capacity and demand electric energy. This difference is due to transmission loss and stealing electricity and is much larger than 5% of Japan.

Table 2.1-1 Maximum Electricity Supply and Yearly Energy Production

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy [GWh]	1,295	1,425	1,634	1,781	1,995	2,244	2,649	2,982	3,293
Growth rate		10%	15%	9%	12%	12%	18%	13%	10%
Peak load [MW]	226	250	270	295	303	365	397	441	535
Growth rate		11%	8%	9%	3%	20%	9%	11%	21%

Source: ENE 2009

Table 2.1-2 Angola: Key Electricity Data 2008-2012

	2008	2009(e)	2010(f)	2011(f)	2012(f)
Installed capacity (MW)	1258	1672	1913	2029	2382
Generation (GWh)	4050.3	5280	7028.5	8950	11050
Distribution (GWh)	3442.8	4488	5974.2	7607.5	9392.5
Consumption (GWh)	2476.8	3220.3	4287.4	5459.5	6740.5
Consumption per capita (kWh)	149	188	242	300	359
Access (%)	30.4	33	36.1	40.1	44.9

e: estimate; f: forecast

Source: MINEA, Luanda, May 2010

Table 2.1-3 ENE Electricity Production by System (in 2004)

	Northern	Central	Southern	Isolated	Total	
Capacity production share	81%	5%	6%	8%	100%	
Thermal [MWh]	564,192	67,351	14,252	172,624	818,419	36%
Hydro [MWh]	1,254,104	50,414	117,434	3,266	1,425,218	64%
Energy production by region [MWh]	1,818,296	117,765	131,686	175,890	2,243,637	

Source: ENE 2004

- DNE (National Energy Directorate) estimates that total investment of electric facilities of Angola from 2010 to 2025 is US$ 8.3 Billion and recommends using the PPP scheme.

- In March 2010, WB (World Bank) got into agreement with GOA about the following survey area.
  - Wide spread of fluorescent light use all over the country
  - Proposal of small hydropower station business and its system model
  - Analysis of investing precedence t for expansion of the electric power sector.

- MINEA has a view that the gap of electricity supply between urban area and rural area should be resolved by utilizing the small hydropower generation, leading to avoid that the rural people rushing to the urban area. Consequently MINEA has been looking for the support of financing and institutional system to deploy 10 MW class small hydropower stations and proceeding to apply PPP scheme.

(2) Institutions and Organizations of Electric Power Sector

- Institutions and organizations of electric sector are in transitional condition. MOE (Ministry of Energy) and MOW (Ministry of Water) were merged into MINEA. MINEA and MOF (Ministry of Finance) have responsibility for electricity control, water supply, sanitary systems, electricity tariff and water rate including related grant provisions. MINEA develops plans and place regulations for electricity and water resource sector through internal department of DNE and DNA (National Directorate of Water).

- There are two public corporations in Angola. One is ENE and the other is EDEL. ENE has the responsibility of power generation, power transmission and distribution for principal cities in 15 states of 18 states. EDEL has the responsibility of power distribution for urban area of Luanda. Both do not have exclusive right for electric power supply in the area of responsibility.

- ENE has responsibility of generation, transmission and distribution electricity for 3 major stand-alone power network systems and isolated systems in Angola. ENE was established in 1980 by integrating several entities. ENE operates hydropower plants and backbone transmission lines.

- EDEL has responsibility of power supply for the capital, Luanda and its suburbs. Electric power consumption in this capital region comprises of 65% of total in the whole country. EDEL buys the electricity generated by ENE.
  EDEL operates the 60 kV transmission line including 13 substations. The 15 kV middle voltage distribution line of 362 km length is equipped with 814 public transformers and 862 private transformers. The 400 V low voltage distribution line of 1,850 km is equipped with 1,488 distribution boxes. The shortage of transformer capacity is regarded as the serious issue in the distribution system, because the consumption load amounted to 15 ~ 20 MW is forced to be restricted at 18:00 ~20:00.

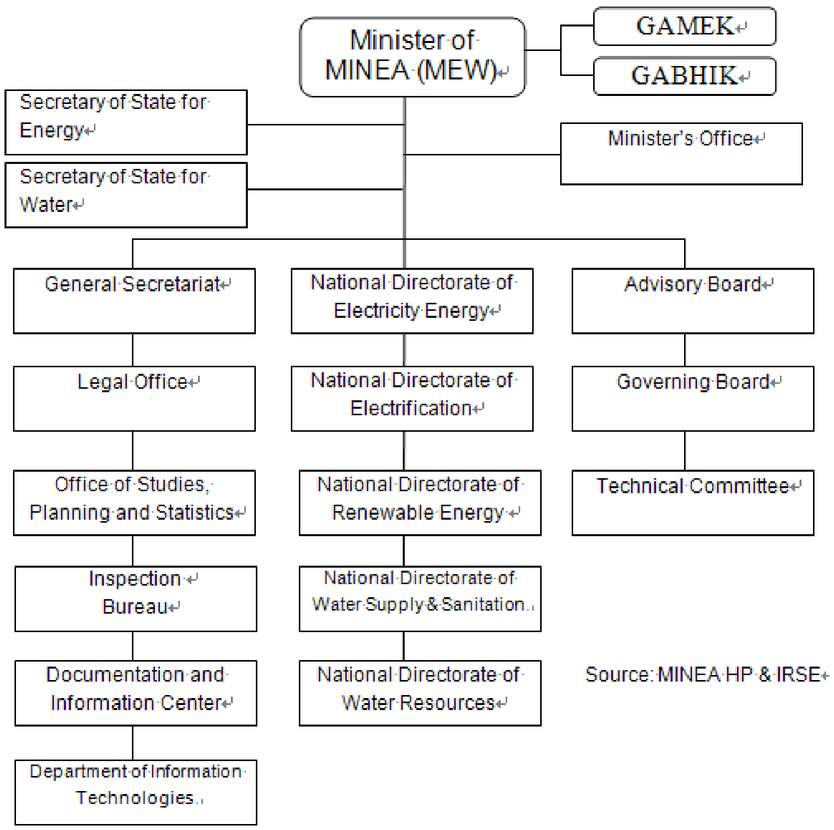


Fig. 2.1-2 Organization Chart of MINEA

(3) Hydro Power Generation Organization in Angola

- ♦ Angola has 40 rivers and the electric power generation potential of 18 GW.

- ♦ GABHIC (Gabinete de Administracao da Bacia Hidrografia de Rio Cunene)

  - The organization of control and utilization for the Cunene River water resource. The Cunene River is flowing from the south of Angola highland and runs along the border of Namibia then flows into the Atlantic Ocean. The length of the river is more than 1,000 km. It is difficult to know precise river potential for hydropower generation because the gauging station of the river was destroyed by the independence war in 1975 but it is estimated about 5 GW.

  - Then Gove Dam Power Station (60 MW) which was destroyed by the civil war is under restoration and it will be completed in the middle of 2011. That power station will send electricity to the Capital City Huambo of Huambo State by 220 kV transmission line.
    Total cost of the construction is US$ 150 Million and Contractor is Brazilian company, Odebrecht.

- In Cunene River there are plans to construct Jama ya Mina Dam Power Station (120 MW) and Jamba ya Oma Dam Power Station (50 MW) downstream of Gove Dam Power Station.

♦ GAMEK

- The organization of control and utilization for the Cuanza river water resource.
  The Cuanza River is flowing from 1,500 m of highland and in Bie State and flows into the Atlantic Ocean. The length of the big river is more than 1,000 km and its electric power potential is estimated 6 GW.

- At present there are two hydropower stations named Cambambe Dam Power Station (180 MW) and Capanda Dam power station (520 MW).
  Recently Utilizing PPP scheme, they are planning to construct Lauca Dam power station (2,120 MW), Caculo Cabaca Dam Power Station (1,560 MW), Nhange Dam Power Station (450 MW).

(4) Efficiency of Power Operation

- Technical and commercial efficiency of the power systems both of ENE and EDEL is low and the system loss of ENE is estimated as 18 ~ 23%. The system loss of EDEL is more serious, which technical loss is estimated at 15% and commercial loss at 21%. It is explained that the reasons why the commercial loss is higher than technical loss are default of electricity charge, electricity theft, shortage of electricity meters, and inefficient charge system. Especially, electricity charge is not collected by force and it makes the problem more serious. On the other hand, most of the technical loss is caused by the current situation that transmission and distribution line systems have to be operated at the limit of the capacity. Both of ENE and EDEL have not been able to not only repair the power systems damaged by the civil war for the long time but extend the systems to meet increasing the electricity demand.

- According to DNE, electricity rate is charged only for 40% of power generation. Collecting rate of electricity charge of ENE was 70.5% in 2008. Collecting rate of EDEL has been much improved as 10% (2001), 54% (2004), and 68% (2008), but EDEL pay the electricity charge to ENE only for approximately 27% for the large power purchased from ENE in 2008.

- Inefficiency of technical and commercial power system makes the financial loss of ENE and EDEL worse. GOA has compensated for the shortage amount against low internal cash flow of both companies so that they can keep the power system extension project.

- The amount of a loss of EDEL in 2001 was approximately US$ 15 Million in spite of the subsidy from the government of US$ 10 Million. And in the case of ENE, the amount of a loss reached US$ 4 Million although including direct subsidy of US$ 7 Million and indirect subsidy on fuel. Chain of default of electricity charge extends from the customers of EDEL to EDEL, ENE, and finally to SONANGOL (Sociedad Nacional de Combustives de Angola). As a result, it causes a vicious cycle that GOA has to compensate for the cost of system operation and investment. The roots of this problem are inappropriate electricity rate, large losses of the power systems, electricity theft, and default of electricity charge.

- In the Article No.3 of General Law of Electricity published in May 1996, it defines about the government responsibility and states that "the government has to promote the policy toward electrification all over the country in consideration of the development status and high-priority subjects." According to this article, the government grants EDEL and ENE the subsidies for the compensation of their cost of system operation and investment.

(5) Electric Tariff

- GOA sets a rate in consideration of suggestion from MINEA. In 2008, the mean electric tariff of EDEL was approximately 4 US¢/kWh (1US$ = 69 Kz) whereas the mean selling power unit price to EDEL was approximately 11 US¢/kWh.
In Article 41 (Electric Tariff System) of the electricity general law said as below;

  "cover a budget, a tax, depreciation, capital collection in all generation, transmission, supply of electric power company, there is not lack and shall bring proper profit".

  Though it is declared, both public corporations have a business loss like statement above practically and do not give it off with pricing bringing proper profit.

Power Factor	Adjustment Coefficient
0.75 equivalent	1.035
0.70 equivalent	1.078
0.65 equivalent	1.123
0.60 equivalent	1.181
0.55 equivalent	1.248
0.50 equivalent	1.331
0.45 equivalent	1.423
0.40 equivalent	1.573

Source : ENE Homepage

- In addition, the electric tariff system is left unredeemed since 2004, and the following electric bill systems are applied now.

- The electric tariff as shown in Table 2.1-4 does the thing which took the following adjustment coefficients with the electric tariff of the month when power factors are more than 0.8 when a power factor is less than 0.8.

Table 2.1-4 Electric Tariff

Classification-1	Classification-2	Electric Tariff
Low voltage consumers	House	3.35 Kz/kWh
	Social rate of house (<= 200 kWh)	1.16 Kz/kWh
	Special rate of house (<= 200 kWh)	4.40 Kz/kWh
	Industry	4.40 Kz/kWh
	Commercial / Services	4.40 Kz/kWh
	Street Light	2.46 Kz/kWh
Middle voltage consumers (1 - 30 kV)	Industry	F = Kz 240.42 × P + Kz 2.02 × W
	Commercial / Services	F = Kz 240.42 × P + Kz 2.02 × W
High voltage consumers (over 30 kV)	Industry	F = Kz 324.47 × P + Kz 1.83 × W

F : Invoice Amount (Kz)
P : Maximum electric power consumption in previous 3 months (kW)
W : Power consumption (kWh)

(6) Electrification and Power Demand

- Access rate to electricity has not been exactly comprehended because of unclear numbers of proper customers and population, but electrification rate is estimated as 30 ~ 32%. Recently, population of Luanda is rapidly expanding because of demographic shift to cities seeking for business opportunities and safety, and most of people who immigrated to Luanda live in the districts which have no city project or outer districts of Luanda. This phenomenon causes the lack of unified street system and proper numbering of street and uncertified land owners, and it makes difficult to comprehend the exact access rate to electricity. Also, it creates the illegal power distribution market, and some brokers connect to the power system using their own small generator and transformer and manage the illegal network by thieved electricity. In fact, their “new customers” connect to the power system unfortunately through the equipment of inefficient safety protection and measures which have a risk of accidents.

- In 2009, GOA prepared and published the strategic electrification plan (medium term development plan 2009-2012). According to this plan, the target of electrification rate is 100% in the cities, 60% in the satellite cities, and 30% in the agricultural villages. And, it aims to achieve the power generation of 4,050 GWh in 2008 and expand it to 2.7 times, 11,050 GWh in 2012. Furthermore, MINEA established the National Program for small hydropower stations as the strategy and is going to promote rural electrification. The promotion department for the rural electrification is Department of Electrification of MINEA, and MINEA has Department of Renewable Energy and Department of Electricity Energy as well in relation to the power sector.

- ENE and EDEL, who supply the power in Angola, ordinarily face a shortage of power and set a limit to the loads because they cannot supply sufficient power to meet the aggregate demand. For example, 84% of all companies have experienced 8 times a month of power failure on average. Especially, it is more serious for large companies and they have experienced 16 times a month (8 hours per one time) of power failure. Also, manufacturing factories have been received further damage by such power failures.

- Because of the above circumstances, approximately 68% of companies in Luanda possess their own power generation. It is more outstanding in other districts and 90% of companies in such districts possess their own power generation. Such private power generation accounts for approximately 31% of total demand. Dependence on private power generation of large companies accounts for 49% of total demand and it is higher than that of small companies (28%) and medium companies (43%). Installation capacity of private power generation is estimated 900 MW, but reliable statistical data is not available.

(7) Electric Power System in Angola

- The maximum electric power system voltage in Angola is 400 kV and it is adopted for the transmission line of Cambambe Hydropower Station (180 MW) shown in Fig.2.1-3.

- Then next voltage for the transmission line is 220 kV. However electric power system has not cover all over the Angola and there are three main areas, Capital City Luanda and its suburbs, Namibe and Lunango areas, and Lucapa and Luachimo areas. There are five independent electric power systems in Angola and they are controlled by ENE.

- Transmission line voltage in Angola is 400 kV, 220 kV, 110 kV and 60 kV and distribution line voltage is 30 kV and 15 kV.

- Rural electrification is mainly managed by ENE but recently new management body for rural electrification is considered by GOA and it is not clear which management body is applied to the rural electrification.

- WB has recently applied the plan, “the Energy Multi-sector Recovery Program Phase II” to the distribution line system of the three cities, Uige, Iuena, Cuito.

- The urgent rehabilitation plan of distribution facilities is proceeding in the main cities like Luanda City and Ndalatando City. WB is expected to financing for design, bidding, construction (approximately US$ 30 Billion).

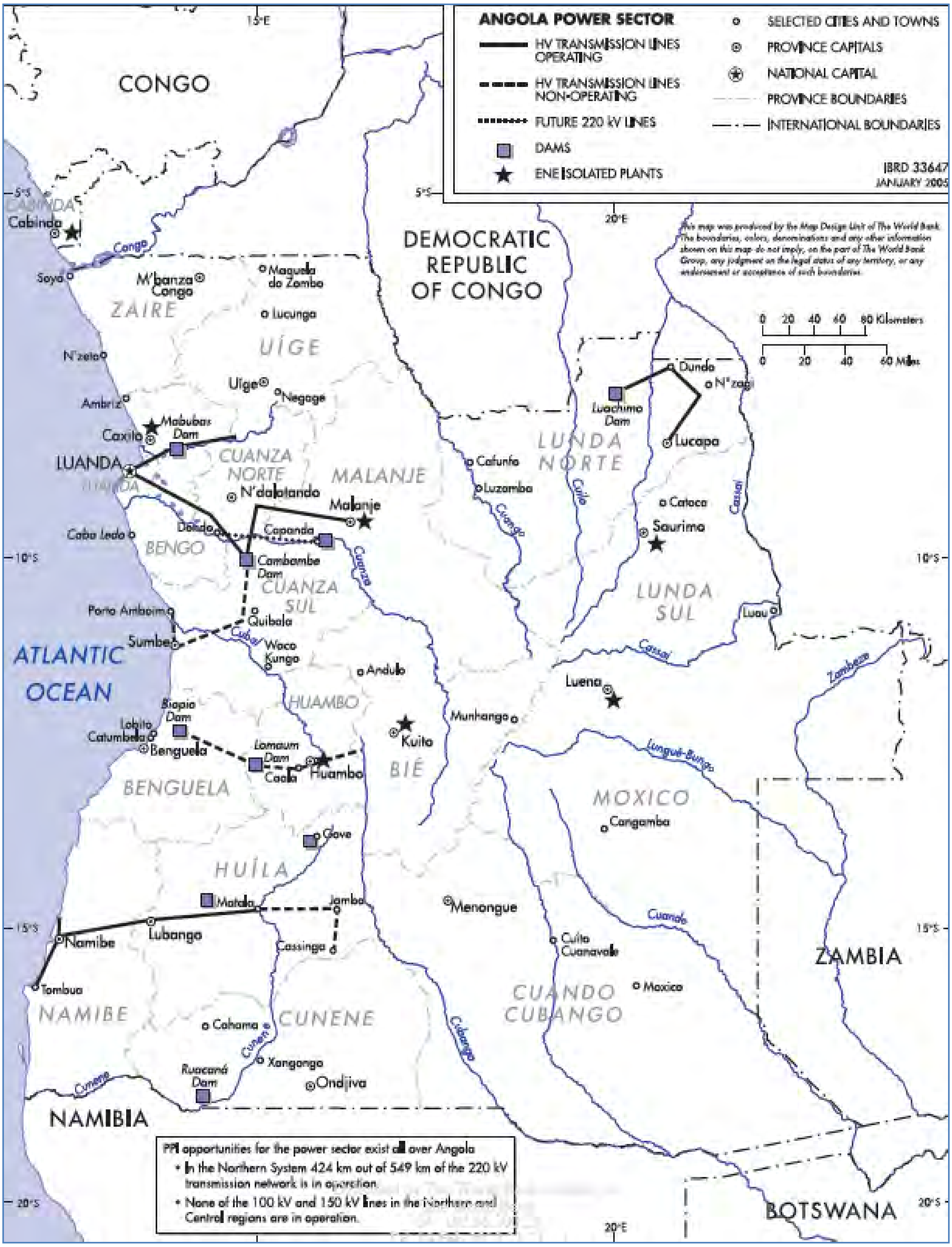


Fig.2.1-3 Angola Electric Power System

Source : PPIAF (Private Solutions for Infrastructure in Angola), 2005

(8) Plans of Power Generation, Transmission, and Distribution until 2016

- The energy and water sector established the targets as follows in relation to the target No.1 (Eradicate Extreme Hunger and Poverty) and target No.7 (Ensure Environmental Sustainability) of *Millennium Development Goals*.
  - Increase the power consumption per capita
    Main target to be accomplished by the end of 2016 is to construct power stations of 7,000 MW, especially renewable energy plants. Due to these constructions, sufficient power generation will be available to meet the demand of 4,000 kWh[1] per capita, which is 8 times of the current capacity.
  - Expand the numbers of distribution lines to households and access to electricity
    The number of non-electrified households is estimated as 2 million at present.
  - Installation of a separate-type power network and national transmission network
  - Increase the power generation by 1.5% by the souses of new energy and renewable energy (wind power + solar power generation) which are the base of every energy

- Ongoing and future projects
  - Construct power stations of 7,000 MW output equivalents to 6 times increase of existing power output
  - Install the transmission networks of 2,607 km at 400 kV level and 2,010 km at 220 kV level
  - Secure power output of 180 MW in total by construction of small hydropower stations at 46 places
  - Install 2,350 km of ingathering distribution network for Luanda area and newly construct substations at 37 places as well as 1,300 pieces of distribution poles

- Construction plans of power generation, transmission, and distribution facilities from 2012 to 2016 are shown in Table 2.1-5 and Fig.2.1-4.

Table 2.1-5 Construction Planning for Power Transmission Facilities (2012-2016)

Project Name	Scope	Completion period	Remarks
The repair construction for the 2nd period for Cambambe hydropower station	Construction of the hydropower stations of 700MW power output	December 2015	Investigation done
Construction of transmission lines and a substation in relation to the above repair construction	*220kV transmission lines, Cambambe-Gabela *220kV transmission lines, Cambambe-Gabela C2 *220kV transmission lines, Gabela-Waco-Kungo *220kV transmission lines, Secc. Capanda-Cambambe *400kV transmission lines, Cambambe-Catete *400kV transmission lines, Cambambe-Ramiros *400kV transmission lines, Catete-Viana *220kV/400kV Cambambe substation *400kV/220kV Catete substation	December 2015	Investigation done
Construction of Laúca Hydropower station	Construction of the hydropower stations of 2,067MW power output in the Cuanza River basin	Unknown	FS: done
Construction of substations of 400kV and 220kV and installation of transmission lines	*220kV transmission lines, Camama-Ramiros *220kV transmission lines, Capanda-Malange *400kV transmission lines, Laúca-Catete C1 *400kV transmission lines, Laúca-Catete C2 *400kV transmission lines, Laúca-Waco-Kungo *400kV transmission lines, Laúca-Laúca *Laúca L2 substation *220kV/60kV Malange substation *220kV/60kV Waco-Kungo substation *400kV/220kV Waco-Kungo substation *220kV sub-transmission lines, Capanda-Cambambe	December 2015	Planning of investment program ongoing
Construction of Caculo and Cabaça hydropower stations	Construction of the hydropower stations of 2,000MW power output in the Cuanza River basin Cuanza	December 2016	FS at final stage
Construction of substations of 400kV and 220kV and installation of transmission lines in relation to construction of Caculo Cabaça hydropower station	*Expansion plan of the substation in Ramiros *Expansion plan of the substation phase II in Cambambe *400kV transmission lines, Caculo Cabaça-Cambambe L1 *400kV transmission lines, Caculo Cabaça-Cambambe L2 *400kV transmission lines, Cambambe-Ramiros L1 *400kV transmission lines, Cambambe-Ramiros L2 *400kV transmission lines, Laúca-Caculo Cabaça	December 2017	FS ongoing
Construction of substations of 400kV and 220kV and installation of transmission lines in relation to construction of Keve hydropower station	*Expansion plan of the substation in Cambambe *220kV transmission lines, Cafula-Gabela *400kV transmission lines, Gabela-Cambambe *400kV/220 kV Gabela substation phase II *220kV transmission lines, Capunda-Gabela *Expansion plan of the Gabela substation *220kV transmission lines, Dala-Capunda *220kV transmission lines, Gabela-Sumbe *220kV/60 kV Sumbe substation	December 2016	FS ongoing
Construction of substations of 400kV and 220kV and installation of transmission lines in relation to combined-cycle thermal power station at Sayo	*400kV transmission lines, Soyo-Kapari *400kV transmission lines, Kapari-Catete *220kV transmission lines, Soyo-M'Banza Congo *220kV transmission lines, Soyo-N'zeto *220kV transmission lines, Kapari-Cacuaco *400kV/220kV Soyo substation *400kV/220kV Kapri substation *220kV/60kV M'Banza Congo substation *220kV/60kV N’zeto substation	December 2015	FS ongoing

Project Name	Scope	Completion period	Remarks
Contructions of Jamba Ya Oma(JYO)and Jamba Ya Min(JYM) hydropower stations	*Construction of the JYO hydropower station of 65MW power output *Construction of the JYM hydropower station of 180MW power output	JYO Hydropower: December 2016 JYM Hydropower December 2017	Preliminary investigation of FS done
Construction of 220kV substation and installation of transmission lines in relation to JYO and JYM hydropower stations	*220kV transmission lines, Gove-JYO *220kV transmission lines, JYO-Matala *220kV transmission lines, Lubango-Matala *220kV/60kV Matala substation *220kV transmission lines, JYM-JYO	December 2015	FS ongoing
Construction of Luachimo and Chiumbe-Dala phase II hydropower stations	*Construction of the Luachimo hydropower station of 10MW power output *Construction of the Chiumbe-Dala hydropower station of 26MW power output *Construction of the Chicapa phase II hydropower station of 42MW power output	Luachimo and Chiumbe-Dala hydropower stations: December 2013 Chicapa phase II hydropower station: December 2014	Luachimo hydropower station: investigation for repair construction done Chiumbe-Dala hydropower station: investigation done Chicapa phase II hydropower station: preliminary investigation for FS ongoing.
Construction of 220kV substation and installation of transmission lines in relation to Luachimo, Chiumbe-Dala, and Chicapa phase II hydropower stations	*220kV transmission lines, Luena-Chicapa *220kV transmission lines, Chicapa-Luo *220kV transmission lines, Luo-Lucapa *220kV transmission lines, Lucapa-Luachimo *220kV/60kV Luena substation, Chicapa substation, Luo substation, and Lucapa substation *60 kV transmission lines and substation	December 2016	FS ongoing

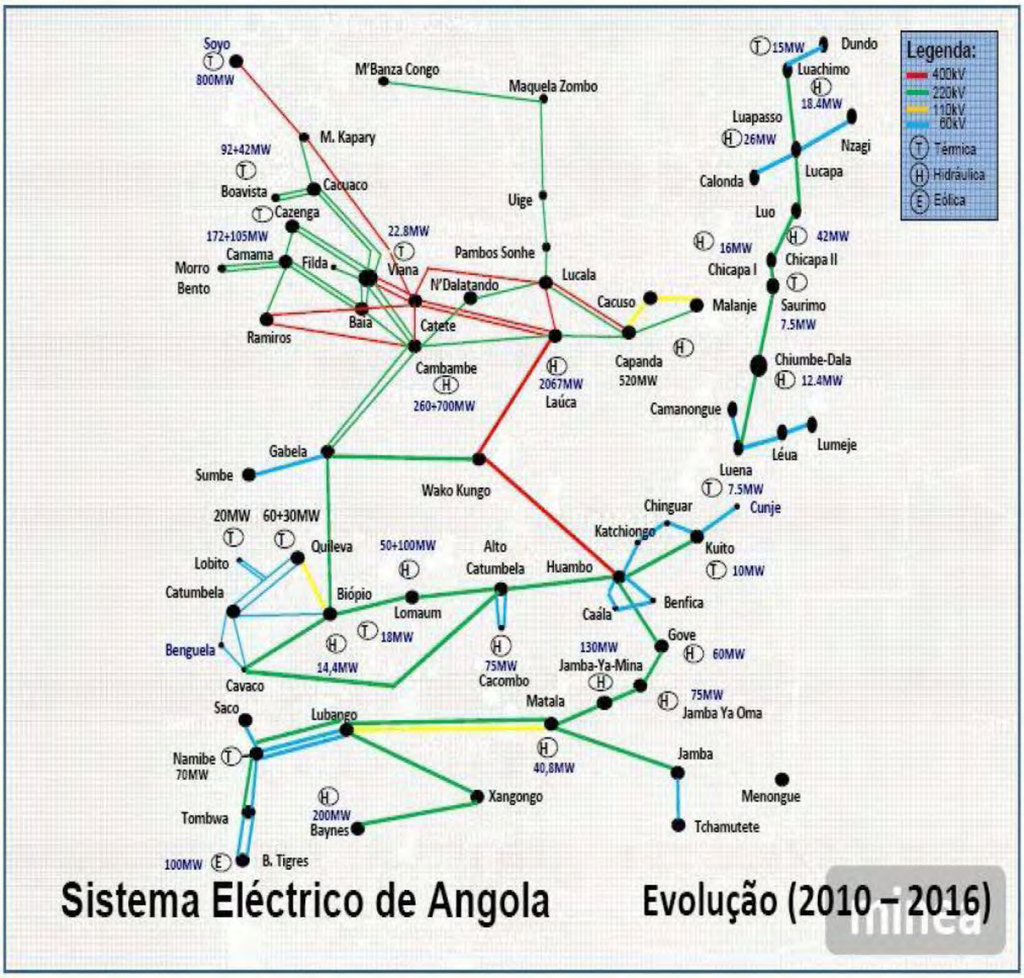


Fig.2.1-4 Power System Planning for Year 2016 in Angola

(9) South Africa Power Pool

- In the south area of Africa continent, there is SAPP (South Africa Power Pool) which is consisted of 16 countries, South Africa, Namibia, Angola, Mozambique, Zambia and others. However, because of a long period of the civil war in Angola, there are no interconnection transmission lines from those countries to Angola other than 1.5 MW power flow from Namibia to Angola.

- In the future, there is a plan to construct the interconnection transmission lines with surrounding countries, which is shown in Fig.2.1-5.

- In the south area of Africa continent, besides SAPP, there are several interconnection transmission line organizations, PEAC (Pool Energetique de I's Afique Central), UPDEA (Transporters and Distributors of Electricity Power in Africa), WESCOR (Western Power Corridor).

Fig. 2.1-5 Interconnecting Transmission Lines in South Africa Continent

Source: SAPP report 2009

(10) Validity of Promotion of Small Hydropower Generation

- It has been discovered from the investigations of hydropower resources that Angola has a potential of 18 GW hydropower generation because there are no less than 40 rivers suitable for hydropower generation.
- It is desirable to use plenty of the hydropower resources existing in the country, in consideration of demerits of higher cost of power generation by fossil fuels due to increasing the price of oil and natural gas and the problem of greenhouse effect by massive CO_2 emission.
- For rural areas in Angola of low density of population, is generally more efficient to implement rural electrification through small transmission network by small-scale distributed power supply from hydropower and other resources, compared to the long transmission by large power supply.
- Moreover, rural electrification by small hydropower generation is very effective to resolve the electrification gap between cities and rural area and also to prevent the population inflow to the large cities (53% of total population live in cities and 33% in Luanda as of 2008).

2.1.3 Necessity of Rural Electrification

- In 2008 electrification rate of village in Angola is very low, 30.4%. In the long plan of GOA, by 2016, 100% of Angola will be electrified and rural electrification has to be accelerated. Therefore GOA has proceeded hydropower development including rehabilitation of the small hydropower stations destroyed by the civil war through BOT (Build Operation and Transfer). However the cost of construction and operation of the small hydropower station is high, and in recent years the developed countries have recommended to adopt “Feed in Tariff Scheme” to disseminate renewable energy. However this scheme asks the customer to bear the additional cost and the electric tariff becomes high.

- Then it is inappropriate to apply this scheme to the developing countries and the governmental subsidy to be supplied to the renewable energy project in the developing countries to accelerate the rural electrification.

- It is necessary to give the financial and institutional assistance of international and foreign financial organizations for the rural electrification by the 10 MW class small hydropower station and PPP scheme is essential and to be applied to those renewable projects.

- Finally this FS has been carried on, in terms of applying the Japanese Government Financing Scheme to this small hydropower project.

2.2 Natural Environment

2.2.1 Topography and Geology

(1) Regional Topography

Angola has nearly square shaped national land of latitudinally and longitudinally about 1,400 km. The topography is classified as “Costal Lowland area” along the Atlantic coast, “Mountains area” running north and south next to coastal lowland, and “Highland area” spreading to inland area in the east of mountains. Highlands more than 1,000 m account for over two-thirds (2/3) of national land, and coastal area is flat land.

According to a topographic map published by the Ministry of Geology and Mines, the topography of Angola is divided into the east area and the west area, and segmented each area as follows. West area: 1) Central Highland, 2) Mountains in peripheral Angola, 3) Miaombe Plain, 4) Zenza-Loge Mountains, 5) Cuanza-Longe Undulating Plain, 6) Cuango (Dissect) Plain, 7) Cassanji Basins, 8) Coastal lands (<300m) East area, 9) Luanda Plain, 10) Eastern Plains, 11) Cunene Plain, 12) Cameia-Lumbate Basin, and 13) AltoZambeze Highland (refer to Fig.2.2-1).

Lowland area of coastal upland consists of narrow sandy beach, sand spit, sand bar and low terrace along the Atlantic Ocean and plateaus bordering terrace cliffs of 20 ~ 50 m height. There are some deep coves, but mostly shallow gulfs.

Plateau area is located in inland 30m ~ 100m far from the coastal lands. It is generally low water content and kind of barren land. It has gentle slope across the land and altitude is getting higher toward the east. However, the height is approximately under 300 m and almost flat but some cliffs. This plateau area involves coastal terrace of the south area (145 m ~ 175 m height) and Mocamades Plain (lower than 200 m) which is eolian dune of the south-east area.

The project area (Huambo Province, Bie Province) is located in the mountain area at around EL. 2,000 m as shown in bellow figures. The mountains gently undulate such as highland landscape.

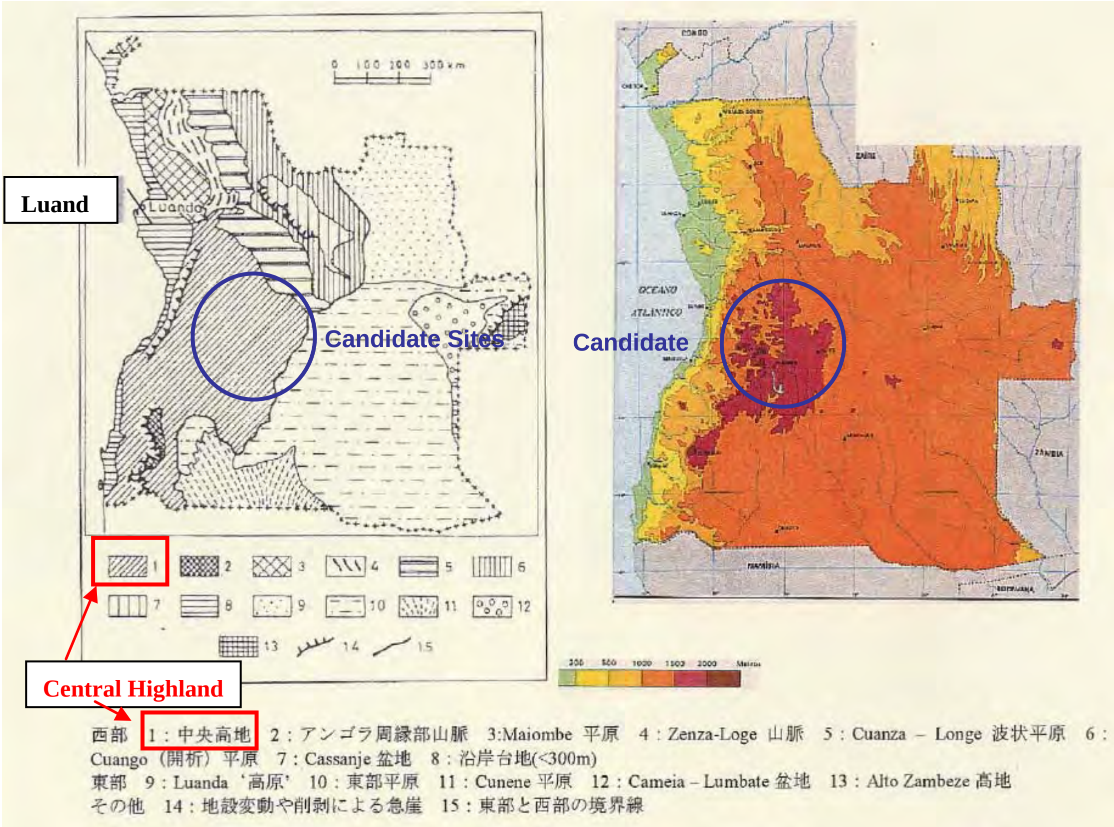


Fig. 2.2-1 Regional Topography of Candidate Area

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

(2) Regional Geology

Geology in Angola is classified as characteristic three areas; "Coastal area", "Mountains area", and "East area of Central Plain".

In coastal area, sandstones of the Tertiary period and Cretaceous period are distributed. Sandstones of Cretaceous period having a characteristic red color are distributed mainly in the region of Dombe Grande near Benguela, and sandstones of Tertiary period can be found near Luanda.

In central mountains area, granites ~ gabbros before Proterozoic era are mainly exposed at the ground surface. And in the east area of Central Plain, granite ~ gabbro between Archeozoic era and before Proterozoic era are covered by sandstones, pudding stones, and limestones of later Proterozoic era, and moreover, the stone layer is covered by pudding stones and sandstones of Paleogene period (Cenozoic era). The surface layer is mostly covered by laterite.

Petroleum, diamonds, and decorative rocks (anorthosites, marbles, red granites, etc.) are mined at present as mineral resources distributed in Angola. Also, small amount of clay, limestones, gypsum, sand, burga, etc. are mined as construction materials. Once in Angola, there were eighteen (18) kinds of mines (petroleum, diamonds, iron ore, manganese, copper, lead, zinc, crystal quartz, etc.) and fourteen (14) mines out of them have been operated for export purpose. The development of mineral resources in the future can be expected to be activated by the revival of those mines and development of new resources (salt, fluorite, titanium, gypsum, etc.)

The project area (Huambo Province, Bie Province) is located at the distributing area of mainly granite group or gneiss group of Precambrian Period as shown in bellow figures. The both rock groups are composed of the hard and old foundation rocks.

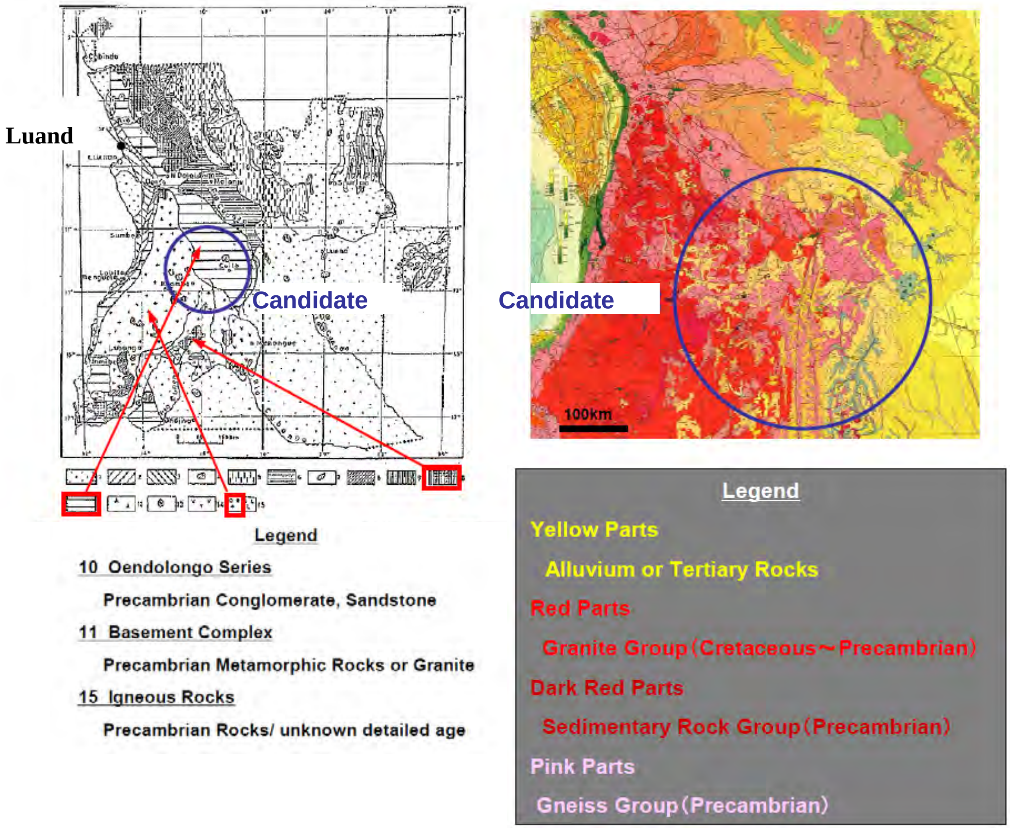


Fig. 2.2-2 Regional Geology of Candidate Sites Area

2.2.2 Meteorology and Hydrology

(1) Overview of Meteorology [1, 2, 3]

Climate in Angola is categorized to north region of hot and humid, central region of savanna climate, south region of warm and dry, coastal lowland region of tropical climate. It is

[1] JICA, "Basic Design Study Report on the Project for Water Supply in Luanda Province", 2001
[2] JICA "Basic Study Report on Project of emergencial water supply in the provinces (Bengo and Cuanza Sul Provinces)", 2005
[3] USAID, "Biodiversity and Tropical Forest Assessment for Angola", 2008

extremely dry in coastal area and area of near the border with Namibia. Generally, climate in Angola is characterized by cool and dry season from May to October and hot and wet season from November to April.

Two factors have a strong effect on Angola's climate: the South Atlantic high-pressure cell and the cold northward flowing Benguela current. The high-pressure cell limits the southward migration of the ITCZ (Intertropical Convergence Zone); the Benguela current generates a strong temperature inversion along the coast that has a pronounced stabilizing effect on the lower atmosphere. This preempts the upward movement of cloud-forming moist air along the Namibian and southern portions of the Angolan coastline. The result is a gradient of increasing precipitation from south to north and from west to east.

As one move inland, the effect of the Benguela current is attenuated and topographic highs create conditions that favor cloud formation and therefore increased precipitation. The elevated areas (higher than 1,500 m) surround Huambo receive more than 1,500 mm of rainfall.

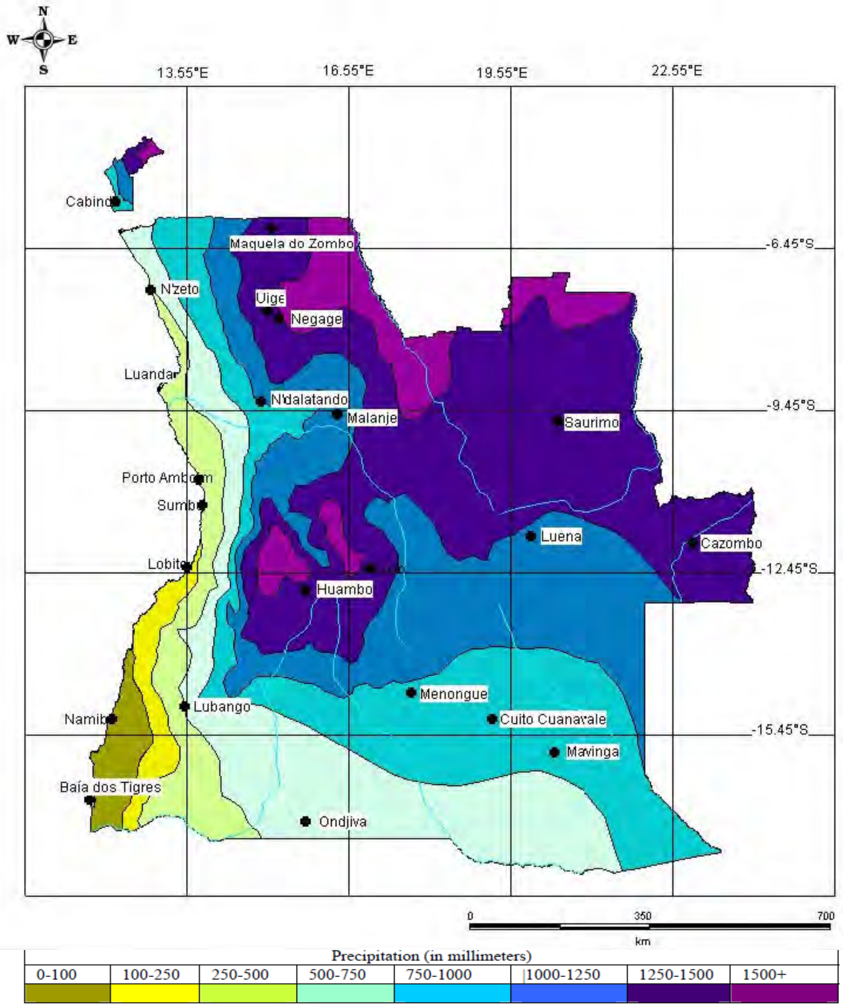


Fig. 2.2-3 Annual Precipitation of Angola

Source: USAID, "Biodiversity and Tropical Forest Assessment for Angola", 2008

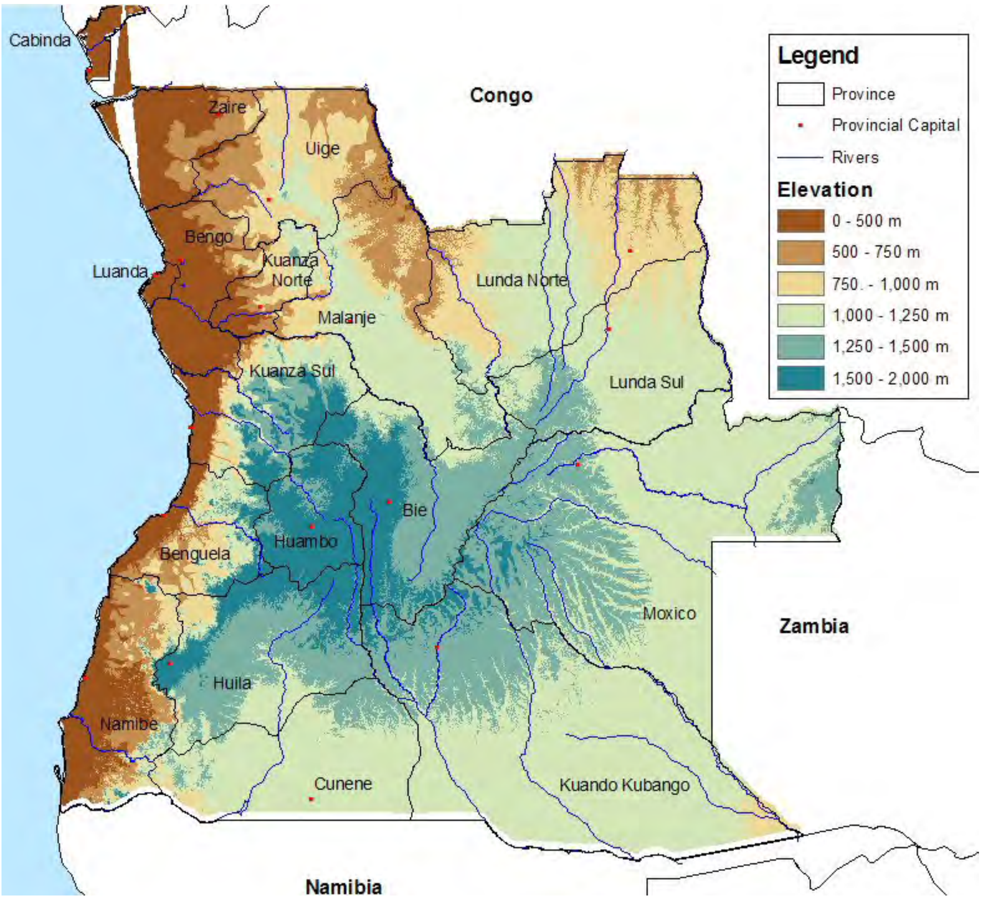


Fig. 2.2-4 Topography of Angola

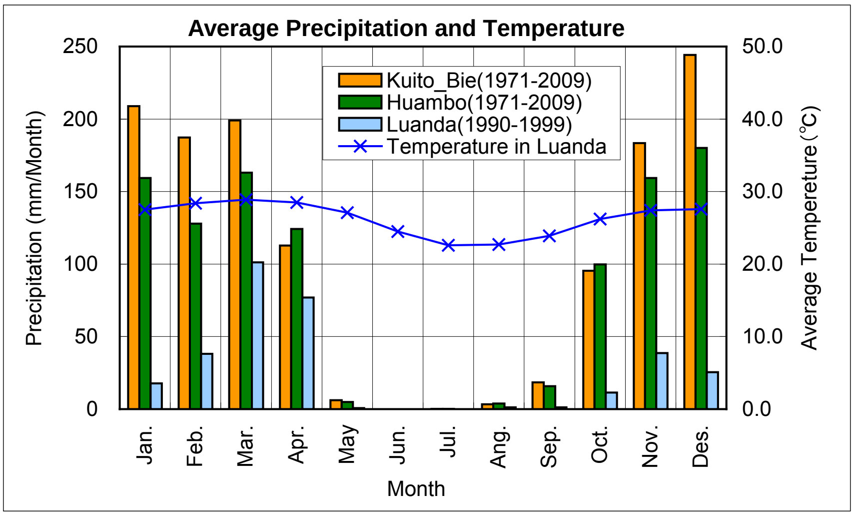
Source: WFP (World Food Programme) "Angola: CFSVA (Comprehensive Food Security and Vulnerability Analysis)", 2005

(2) Meteorological Data

Meteorological data of Luanda and projected area (Huambo Province, Bie Province) are shown below.

Coastal lowland area in Angora is arid region having an annual rainfall of less than 500 mm. Luanda has an annual rainfall of 312 mm, and 95% of the rainfall is concentrated in rainy season between November and April.

In the case of estimation by Thornthwaite method as water balance index, potential evapotranspiration will be monthly 74.9 mm (June) ~ 183.6 mm (March) and annually 1,612 mm which is much larger for rainfall amount. Therefore, it can be considered that outflow to the river and penetration to the ground near Luanda occurs particularly in the heavy rain.



	Kuito* : Average of 1971−2009
	Huambo* ; Average of 1971−2000
	Luanda** : Average of 1990−1999

Fig. 2.2-5 Precipitation (Cuito(=Kuito), Huambo, Luanda) and Temperature (Luanda)

Source : * INAMET (Instituto de Nacianal Meteorologia e Geofisica)
** JICA, "Basic Design Study Report on the Project for Water Supply in Luanda Province", 2001

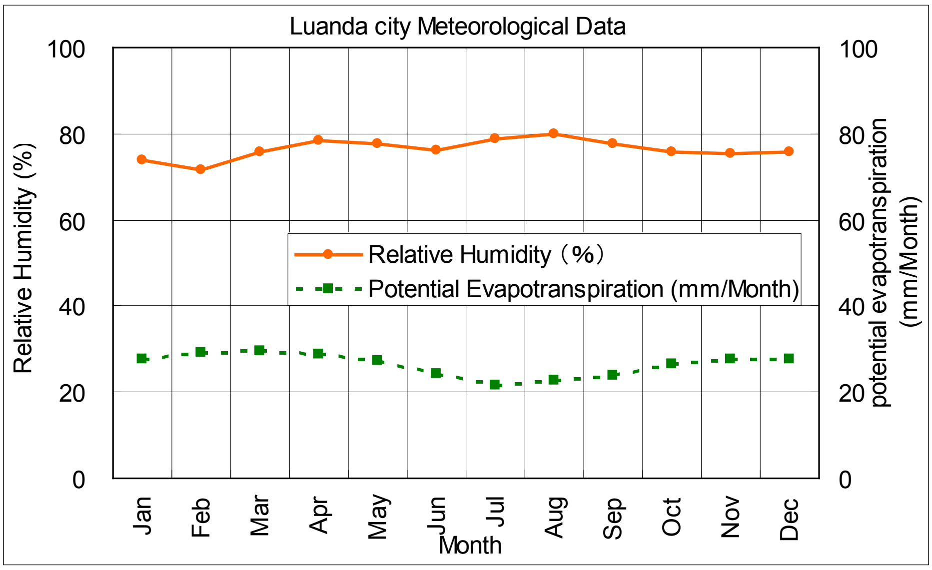


Fig. 2.2-6 Relative Humidity and Potential Evapotranspiration (Luanda)

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

Table 2.2-1 Meteorological Data of Luanda

Meteorological data of Luanda

Luanda(1990-1999)

S8°49′ E13°13′ Elevation 44m Source : INAMET

Monthly Precipitation (mm/Month)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Ang.	Sep.	Oct.	Nov.	Des.	Total
1990	1.0	17.0	14.6	39.7	3.9	0.0	0.0	0.7	1.3	3.1	31.2	10.7	123.2
1991	25.9	0.0	77.6	183.3	0.0	0.0	0.0	0.5	0.0	2.1	3.5	0.5	293.4
1992	2.4	0.8	47.7	6.4	0.0	0.0	0.0	0.0	1.7	7.0	19.1	13.3	98.4
1993	5.2	2.8	48.3	168.8	0.0	0.0	0.0	3.7	0.6	0.0	21.5	13.2	264.1
1994	3.2	0.0	140.7	85.9	0.0	0.0	0.0	1.5	1.7	2.6	94.3	67.9	397.8
1995	128.0	204.1	107.4	65.8	0.0	0.0	0.0	0.0	0.6	0.8	99.4	42.1	648.2
1996	2.4	114.0	321.0	144.0	2.8	0.0	0.0	0.0	2.3	14.0	10.2	2.1	612.8
1997	3.1	0.6	32.6	53.2	0.0	0.0	0.0	1.7	3.2	71.7	44.0	37.2	247.3
1998	5.1	8.7	102.1	22.3	0.0	0.0	0.0	3.4	1.4	1.2	40.3	0.0	184.5
1999	1.0	32.7	120.0	0.0	0.0	0.0	0.0	0.0	0.4	12.4	22.1	66.6	255.2
Average(mm)	17.7	38.1	101.2	76.9	0.7	0.0	0.0	1.2	1.3	11.5	38.6	25.4	312.6

Monthly Average Temperature(℃) Temperature in Luanda

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	average
1990	27.8	29.0	29.4	28.8	27.2	24.2	21.6	22.6	24.0	26.4	27.8	27.7	26.4
1991	27.2	28.7	28.8	28.6	28.4	24.8	22.7	22.0	22.7	24.4	26.2	26.6	25.9
1992	26.6	28.0	28.4	27.6	25.7	22.7	21.1	21.6	23.0	25.9	27.2	27.0	25.4
1993	28.3	28.9	28.6	28.0	26.4	24.7	23.6	22.8	24.0	26.5	27.8	28.6	26.5
1994	26.6	26.9	28.9	28.2	26.8	24.0	22.2	23.3	23.8	27.0	28.0	28.6	26.2
1995	28.4	29.2	29.4	29.2	26.8	24.8	22.6	22.6	23.8	26.4	27.4	27.0	26.5
1996	27.3	28.5	28.8	29.0	27.4	24.5	22.4	22.2	24.6	25.9	26.6	26.6	26.2
1997	26.9	27.2	28.1	27.0	26.2	23.4	22.6	23.0	25.0	27.6	27.3	27.9	26.0
1998	28.5	29.4	29.5	29.1	28.4	26.1	23.7	23.2	25.4	27.2	28.3	28.2	27.3
1999	27.0	28.5	29.0	29.1	28.0	25.4	23.4	23.2	23.0	25.1	27.8	27.8	26.4
Average	27.5	28.4	28.9	28.5	27.1	24.5	22.6	22.7	23.9	26.2	27.4	27.6	26.3

Potential Evapotranspiration (mm/Month)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	153.0	173.8	183.6	174.2	146.6	100.5	74.9	75.4	92.6	129.7	152.3	155.7	1612.3

Relative Humidity (%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	average
1990	72	71	75	78	76	76	82	81	74	74	76	73	76
1991	75	74	76	78	76	76	79	81	80	80	79	74	77
1992	77	74	74	78	78	78	78	80	79	76	74	76	77
1993	72	70	74	80	80	78	78	80	79	76	72	76	76
1994	74	67	76	80	80	79	81	80	78	74	78	79	77
1995	76	73	75	77	78	78	80	82	80	73	76	76	77
1996	74	74	75	78	78	76	78	78	78	78	73	76	76
1997	75	72	77	77	74	77	76	78	76	76	74	74	76
1998	71	70	78	81	76	70	78	82	75	76	79	76	76
1999	74	72	76	78	80	74	77	78	78	76	72	76	76
Average	74	72	76	79	78	76	79	80	78	76	75	76	76

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

(3) Overview of Hydrology[4]

The river system of Angola can be divided into five principal drainage basins or regions: 1) the drainage of Western Angola, 2) the drainage basin of River Zaire (Congo), 3) the Cuvelai drainage basin, 4) the Okavango drainage basin, and 5) the Zambezi drainage basin.

Targeted rivers of this study belong to region 1) above, one is the Cuanza River and the other is the Cunene River. The Cuanza River is the largest river basin in Western Angola with an area of 147,000 km^2. The river has its sources in the central highland of Angola. The Cunene River also comes from the central highland of Angola, and covers 106,500 km^2, of which 94,000 km^2 is situated within Angola.

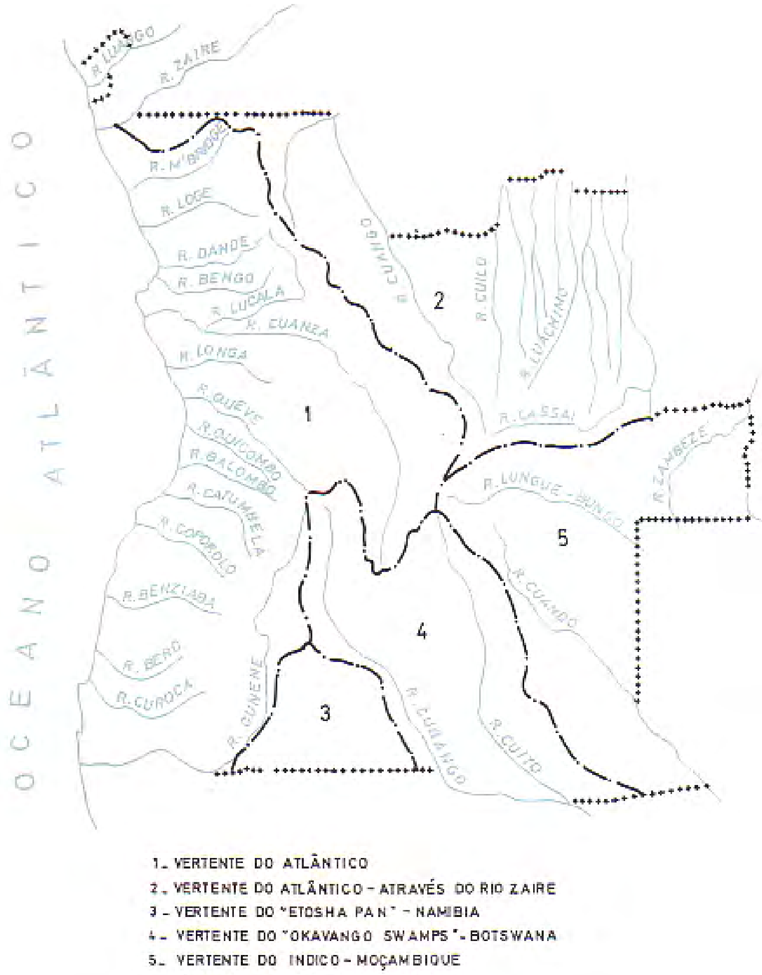


Fig. 2.2-7 River Basins in Angola

Source: NVE (The Norwegian Water Resources and Energy Directorate), "National strategy plan for rehabilitation of the hydrometric network in Angola", 2004

4 NVE, "National strategy plan for rehabilitation of the hydrometric network in Angola", 2004

(4) Hydrological Data

Riverflow of the Cuanza River at the Cambambe is shown bellow. Minimum monthly average riverflow in September is $254 m^3/s$ and maximum monthly average riverflow in March is $1,620 m^3/s$.

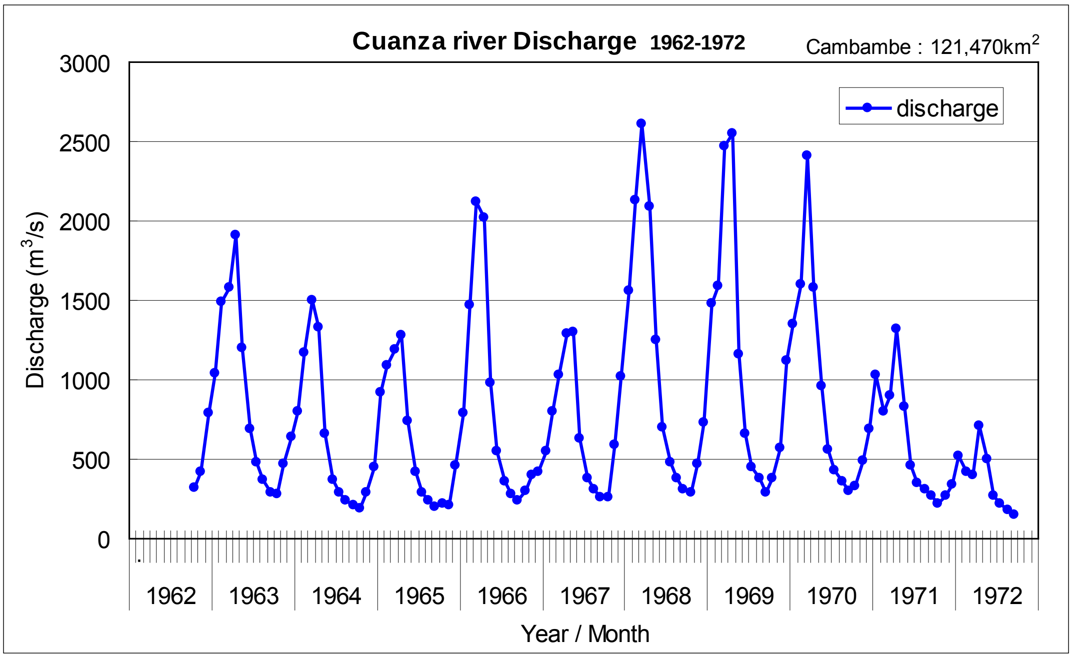


Fig. 2.2-8 Riverflow of the Cuanza River (at Cambambe, 1962 - 1972)

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

Table 2.2-2 Riverflow 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

CHAPTER 3

FEASIBILITY STUDY CANDIDATE SITES

CHAPTER 3 FEASIBILITY STUDY CANDIDATE SITES

3.1 Selection of Candidate Sites

The MINUTES OF DISCUSSION of Jun.8 2010 between Government Angola and JICA, says that its title is “SCOPE FOR THE FEASIBILITY STUDY ON THE REHABILITATION PROGRAM OF RURAL HYDROPOWER STATION”, so it was thought that the FS candidate sites would be selected in the rehabilitation sites of small-hydro. But GOA (MINEA) proposed that complete new sites should be selected as the FS candidate sites and they selected them.

MINEA has planned the hydropower development in internal regions where electrification undeveloped. The selected sites were following 5 sites of Bie and Huambo provinces, then the JICA Study Team has completed site reconnaissance of these 5 sites from Sep.7 to Sep.11.

1. Cutato site of Bie (Andulo)
2. Luvolo site of Bie (Chicala)
3. Cunene site of Huambo (socopomo)
4. Põe site of Huambo (Cuima)
5. Cuima site of Huambo (Cuima)

3.2 Characteristics of Candidate Sites

The estimation and evaluation by the survey team on the feasible 5 candidate sites through only the site reconnaissance is indicated as Table 3.2-1, and the catchment area of each sites shown as Fig. 3.2-1. “Candidate sites and river basin areas”

The characteristics of candidate sites are followings.

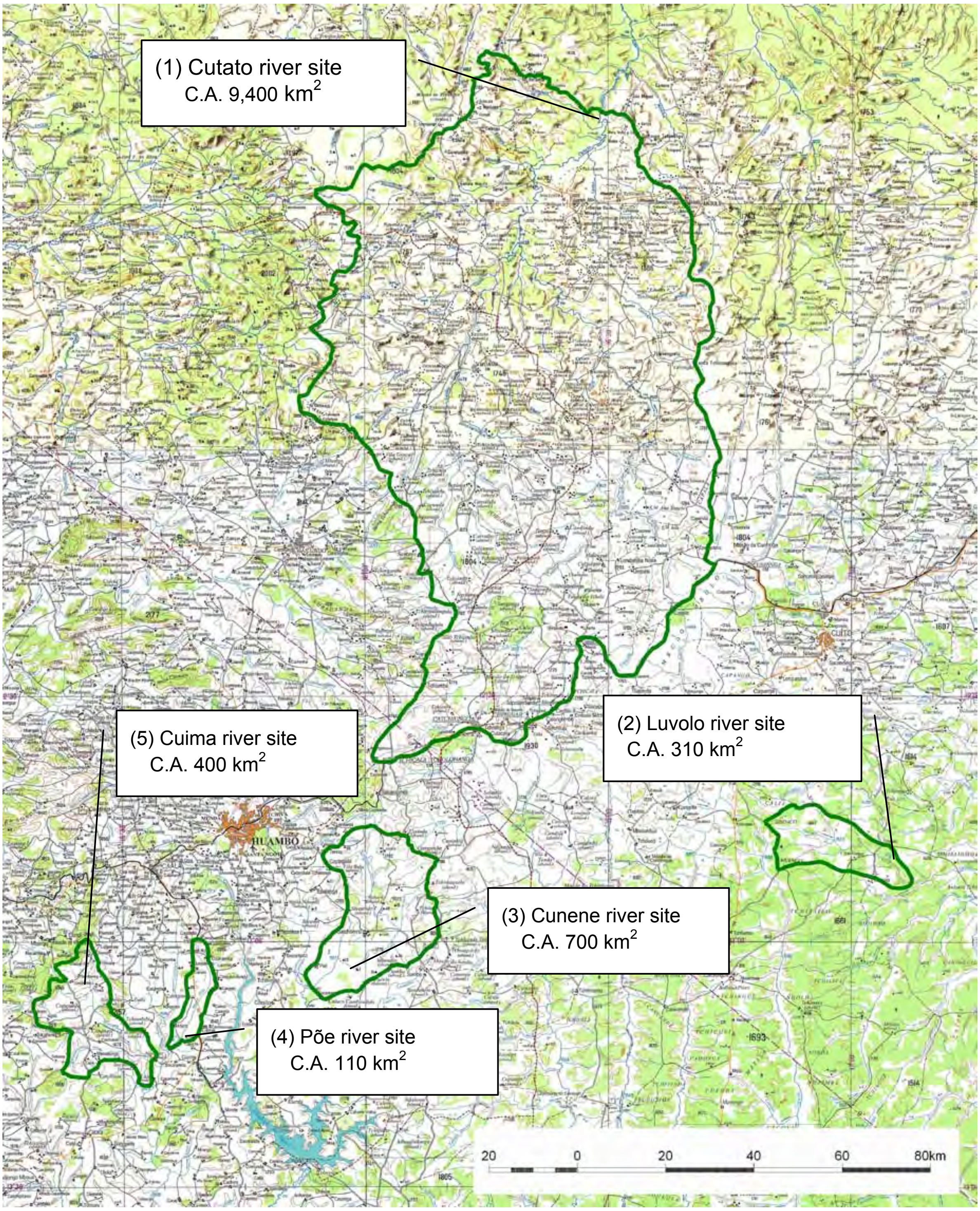


Fig. 3.2-1 Candidate Sites and River Basin Areas

Table 3.2-1 Summary Table of Investigated Site for Small Hydro Electric Power in Angola (1/2)

No.	Item		1	2	3	4	5	Remarks
Project Features	**Site Name**		Cutato River Site	Luvolo River Site	Cunene River Site	Pōe River Site	Cuima River Site	
	River Basin		Cuanza	Cuanza	Cunene	Cunene	Cunene	
	Stream Name		Cutato	Luvolo	Cunene	Pōe	Cuima	
	Drainage Area, square kilometers		9,400	310	700	110	400	1/500,000 Topographic map
	Project Type		Run-of-River	Run-of-River	Run-of-River	Run-of-River	Run-of-River	
	Gross Head, meters		10	25	6	9	10	
	Hydraulic Capacity (m3/s)		18	3	5	0.8	3	Annual Mimimum riverflow
	Estimated Average Annual Net Energy Production (MWh)		12,457	5,203	2,050	315	2,050	Assumed outage power rage = 10 %
	Proposed Capacity (kW)		1,600	660	260	40	260	
	User or Purchaser of Output							
	Plant Factor		100	100	100	100	100	
Location	Province		Bie	Bie	Huambo	Huambo	Huambo	
	Municipal		Andulo	Cuito				
	Commune / Village							
Project Study	Utility or Cooperative Servicing Project Area							
	Demand area		Andulo	Chicala	Socopomo	Cuima	Cuima	
	Demand Households		50,000	4,000	500	2,000	2,000	
	Damand area Latitude (degree South)		11.48833333	12.8025	0	13.24444444	13.24444444	
		Dam_Lat_deg	11	12		13	13	
		Dam_Lat_min	29	48		14	14	
		Dam_Lat_sec	18	9		40	40	
	Damand area Longitude (degree East)		16.695	17.05888889	0	15.63833333	15.63833333	
		Dam_Lon_deg	16	17		15	15	
		Dam_Lon_min	41	3		38	38	
		Dam_Lon_sec	42	32		18	18	
	Study Date		2010.9.8	2010.9.9	2010.9.10	2010.9.10	2010.9.10	
	Study Sponsor							
	Study Author		JICA Study Team	JICA Study Team	JICA Study Team	JICA Study Team	JICA Study Team	
Economic	Stated Construction Cost from Study		1700 Million yen	800 Million yen	400 Million yen	100 Million yen	400 Million yen	1 Million yen /kW, 20%, 40%, 60%
	Internal Rate of Return							
Environment	Permit and Approval Status							
	Water Rights							
	Environmental Clearance Certificate							
	Local Government Approval							
	Indigenous Peoples Approval							
	Environmental Impact Assessment		No Resettlement	No Resettlement	No Resettlement	No Resettlement	No Resettlement	
Dam	Dam Type		Concrete Gravity	(Existing)	Concrete Gravity	(Existing)	(Existing)	
	Hydraulic Height (m)		3m	(3m)	3m	(1m)	(3m)	
	Crest Length (m)		30+10+20=60m	(30m)	60m	(2m)	(20m)	
	Active Reservoir Storage (M.m^3)		0	0	0	0	0	
Proposed Water Conductors (Headrace, Penstock, Surge Tank, Head tank)	Intake	Number						
		Length (m)	10 m	5 m	5 m	3 m	5 m	
		Type						
		Material						
		Dimension						
	Settling Basin, Headrace, Headtank	Number						
		Length (m)	370 m	10 m	40 m	37 m	75 m	
		Type						
		Material						
		Dimension						
	Penstock	Number						
		Length (m)	20 m	85 m	15 m	20 m	20 m	
		Type						
		Material						
		Dimension						
	Total Length (m)		400 m	100 m	60 m	60 m	100 m	

Table 3.2-1 Summary Table of Investigated Site for Small Hydro Electric Power in Angola (2/2)

No.	Item		1	2	3	4	5	Remarks
Proposed Power Station plant	Powerhouse Latitude (degree South)		11.31083333	12.83166667	13.09416667	13.22	13.29472222	
		Lat_deg	11	12	13	13	13	
		Lat_min	18	49	5	13	17	
		Lat_sec	39	54	39	12	41	
	Powerhouse Longitude (degree East)		16.48111111	17.06083333	15.88444444	15.59083333	15.55361111	
		Lon_deg	16	17	15	15	15	
		Lon_min	28	3	53	35	33	
		Lon_sec	52	39	4	27	13	
	Number & Rating of Units		1 unit / 1,700 kW	1 unit / 700 kW	1 unit / 280 kW	1 unit / 50 kW	1 unit / 280 kW	
	Turbine Type		S-type tubular turbine	Horizontal axis type Francis	S-type tubular turbine	Cross flow type	S-type tubular turbine	
	Generator Type		Synchronous generator	Synchronous generator	Synchronous generator	Synchronous generator	Synchronous generator	
	Generator Rating (kVA)		1,800	740	290	50	290	
	Generator Voltage							
	Governor and Controls		installed	installed	installed	installed	installed	
Substation	Number of Transformers		1	1	1	1	1	
	Number of phases (φ)		3 phase	3 phase	3 phase	3 phase	3 phase	
	Transformer Voltages (kV)		0.4 / 30	0.4 / 15	0.4 / 15	0.4 / 15	0.4 / 15	
	Transformer Rating Capacity (kVA)		2,000	1,000	400	100	400	
SW gear	Number of Power SW gears		1	1	1	1	1	
	Number of phases (φ)		3 phase	3 phase	3 phase	3 phase	3 phase	
	SW gear Voltages (kV)		36	24	24	24	24	
	SW gear Breaking Capacity (kVA)							
Substation (Demand side)	Number of Transformers		1	1	1	1	1	
	Number of phases (φ)		3 phase	3 phase	3 phase	3 phase	3 phase	
	Transformer Voltages (kV)		30 / 0.4	15 / 0.4	15 / 0.4	15 / 0.4	15 / 0.4	
	Transformer Rating Capacity (kVA)		2,000	1,000	400	100	400	
Distribution Line	Total Distance (km)		46	10	20	10	20	
	Type of poles		Concrete or Iron	Concrete or Iron	Concrete or Iron	Concrete or Iron	Concrete or Iron	
	Number of phases (φ)		3 phase	3 phase	3 phase	3 phase	3 phase	
	Network Voltages (kV)		30	15	15	15	15	
	Line wire size (mm2)		ACSR210mm	ACSR120mm	ACSR120mm	ACSR120mm	ACSR120mm	
Access Road	Existing Access Road	Distance of Road	Cuito→Andulo: 120km Andulo→Cutato: 46km	Cuito→Chicala : 53km Chicala→Luvolo : 6km	Huambo→Cunene : 46km Cunene→Socopomo : 3km	Huambo→Cuima : 75km Cuima→Põe : 5km+12min歩(1km)	Huambo→Cuima :75km Cuima →Cuima : 17km+12min歩(1km)	
		Situation of Road	Normal	Bad Condition for main road	Normal	Normal, but on foot near the site	Normal, but on foot near the site	
	New Access Road	Distance of Road	-	-	-	-	1km new road is required	
	Special Affairs		Imporovement of the existing road is required	Imporovement of the existing road is required	Imporovement of the existing road is required. Replacement of the bridge may be required for rainy season	Imporovement of the existing road is required. Replacement of the one bridge is executing	-	
Comments	Comments		Andulo; 600kW(400+200kW) Diecel Engine Generator(DG) (S11°29′ 10.5″, E16°42′ 23.3″)	Chicara; 35kW DG Weir was constructed, national independence before	No DG in srounding vilrage	Cuima; 220kW(110kW×2) DG Weir was constructed, national independence before	Cuima; 220kW(110kW×2) DG Weir was constructed wihle countrys independence 30years before	

3.2.1 Cutato River Site

(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 continuously expose 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

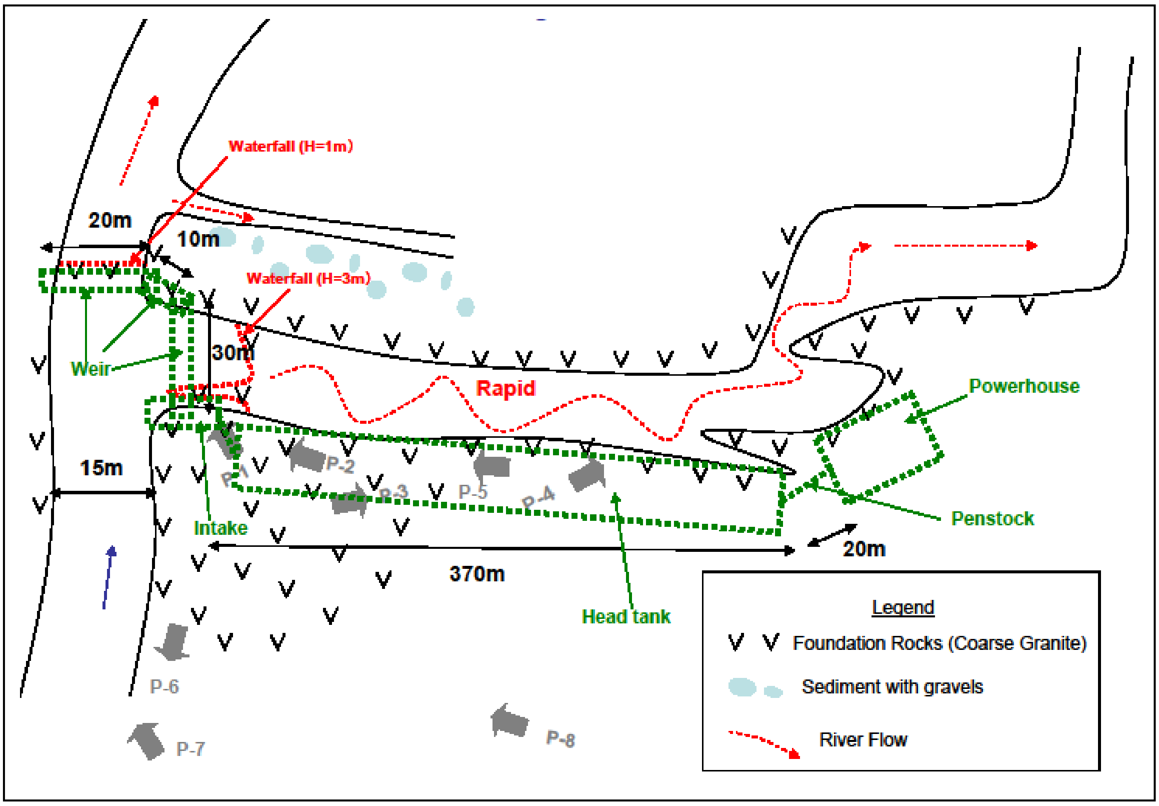


Fig. 3.2-2 Image Map of Cutato River Site

Photo 3.2-1(1) View of the Cutato River Site (Dry Season: Sep 8, 2010)

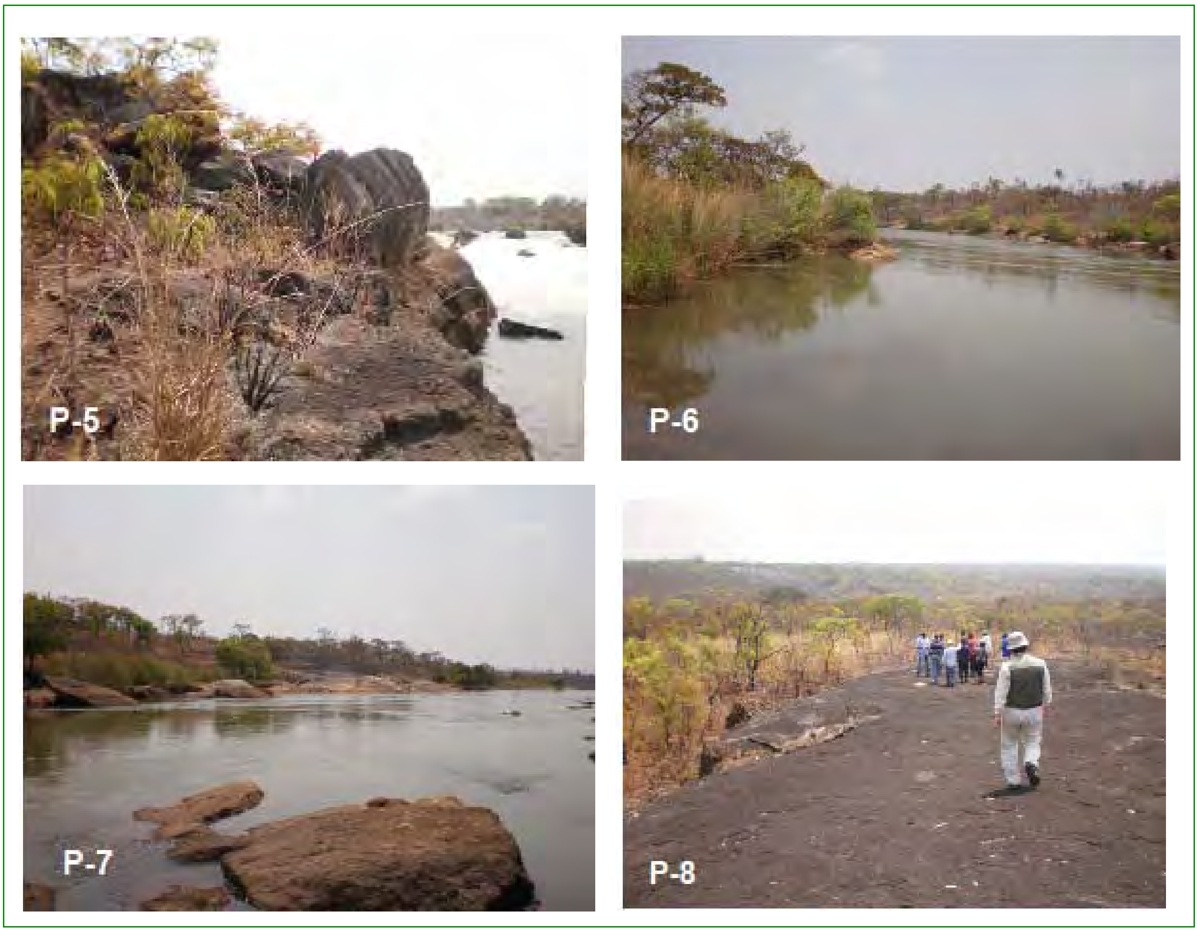


Photo 3.2-1(2) View of the Cutato River Site (Dry Season: Sep 8, 2010)

(2) Hydrology and Meteorology

Projected site of Cutato River site is located in the Cutato River which is the tributary of the Cuanza River (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 (refer to Fig.3.2-4, Fig. 3.2-5). This projected site is located in the relatively wet region in Angola with annual rainfall of more than 1,250 mm/yr.

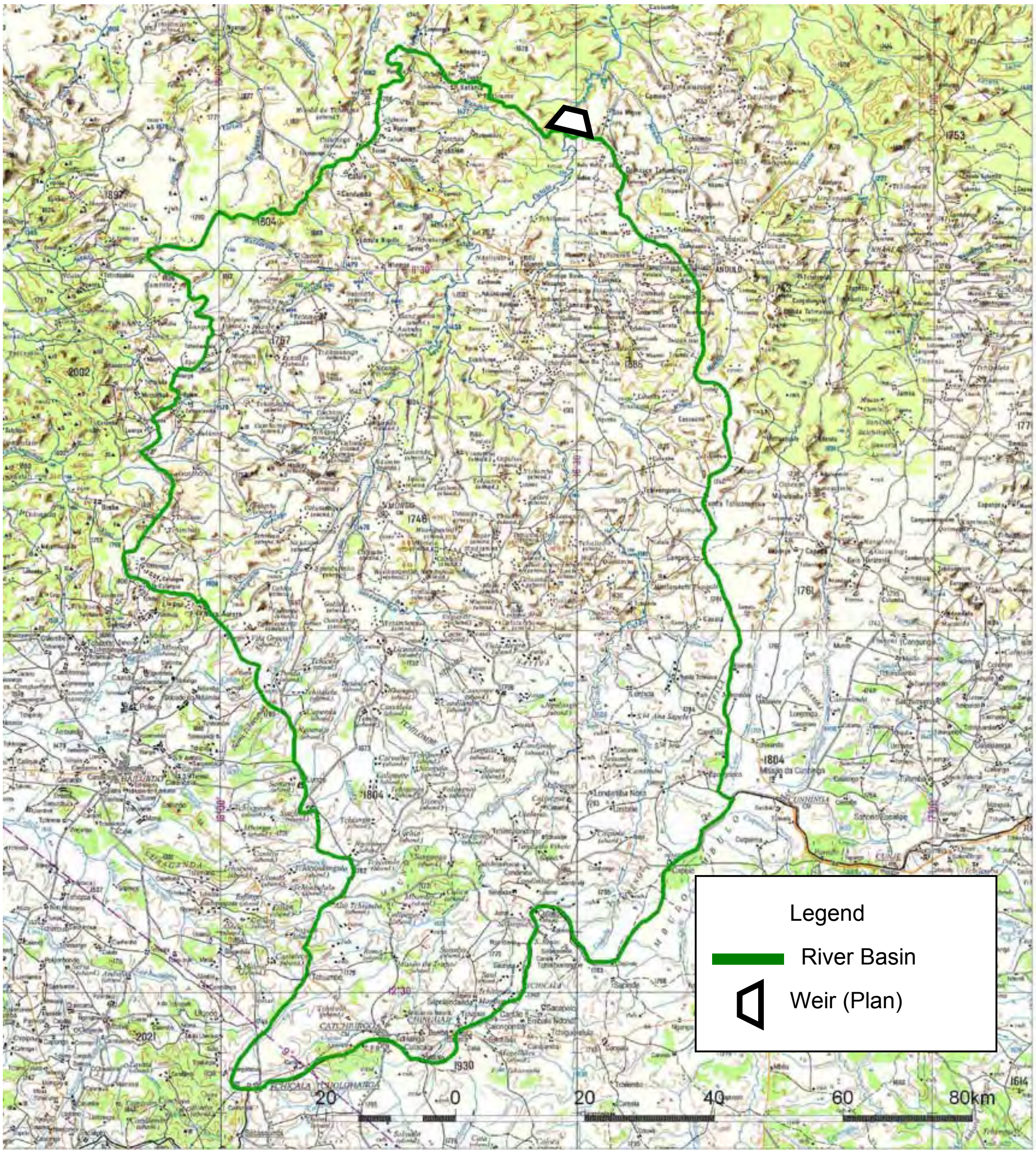


Fig. 3.2-3 Cutato River Basin

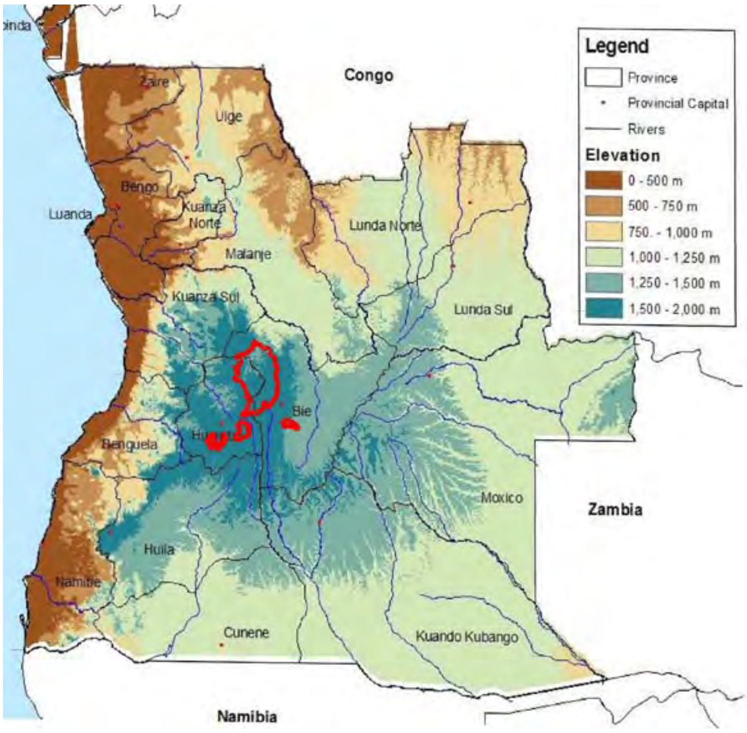


Fig. 3.2-4 Topographic Map and Candidate Site (Red Areas: Candidate Site)

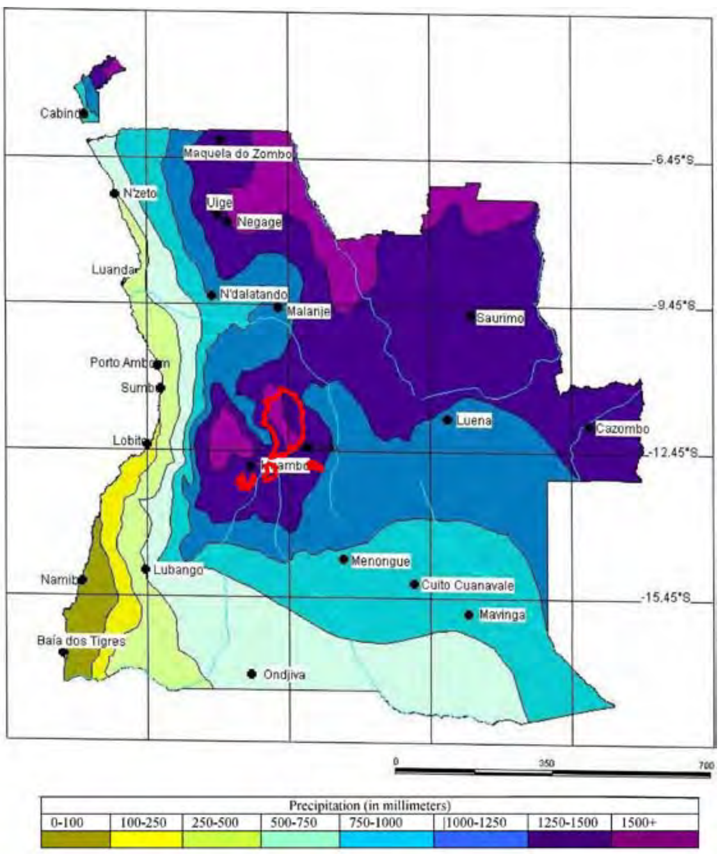


Fig. 3.2-5 Isohyetal Map and Candidate Site (Red Areas: Candidate Site)

(3) Hydropower Civil Engineering

The big character of this project plan is that its site has enormous river flow and low water head. The catchment area of this site estimated from 1:500,000 map is 9,400 km^2 and this is the fifth largest river in Japan. But if the minimum riverflow (18 m^3/s) is selected as maximum discharge, only small hydropower plant (output power is about 1.6 MW) can be planned because the water head is a few meters (It's about 10 m including the height of weir). But this Cutato site is suitable site for constructing hydropower. Because there is towhead and it is convenient for temporally weir work easily.

It is selected that the weir height is 5 m because we can reduce the bad influence (rising water surface) of upstream which is occurred by constructed weir and construct the temporally weir cheaply (the length of the weir is extend over several dozen meters).

The intake which can take the maximum discharge is planned at the right side of the river. The intake water is discharged to the river from the outlet through settling basin, headrace, head tank, penstock and powerhouse of about total 400 m length. The type of power station is run-of-river (generating energy is about 12.5 GWh).

So that the length of water reducing area is less than 400 m, this means that the project is the good one which has a little influence on the marginal environment. But if the river slop of upstream is steep and when flood is coming, the ability of rising water for several kilometers will occur.

The access road is about 720 km from Luanda to Cuito, Bie Province. The access road is about 120 km from Cuito to Andulo and the access road is about 46 km from Andulo to Cutato site. The conditions of the roads are not so bad, but probably new road of several kilometers shall be needed for construction.

(4) Hydropower Generation

It is roughly designed with conditions (gross head: 10 m and hydraulic capacity: 18 m^3) at the Cutato River point and the type of the water turbine is shown as the Fig.3.2-6, S-type Tubular.

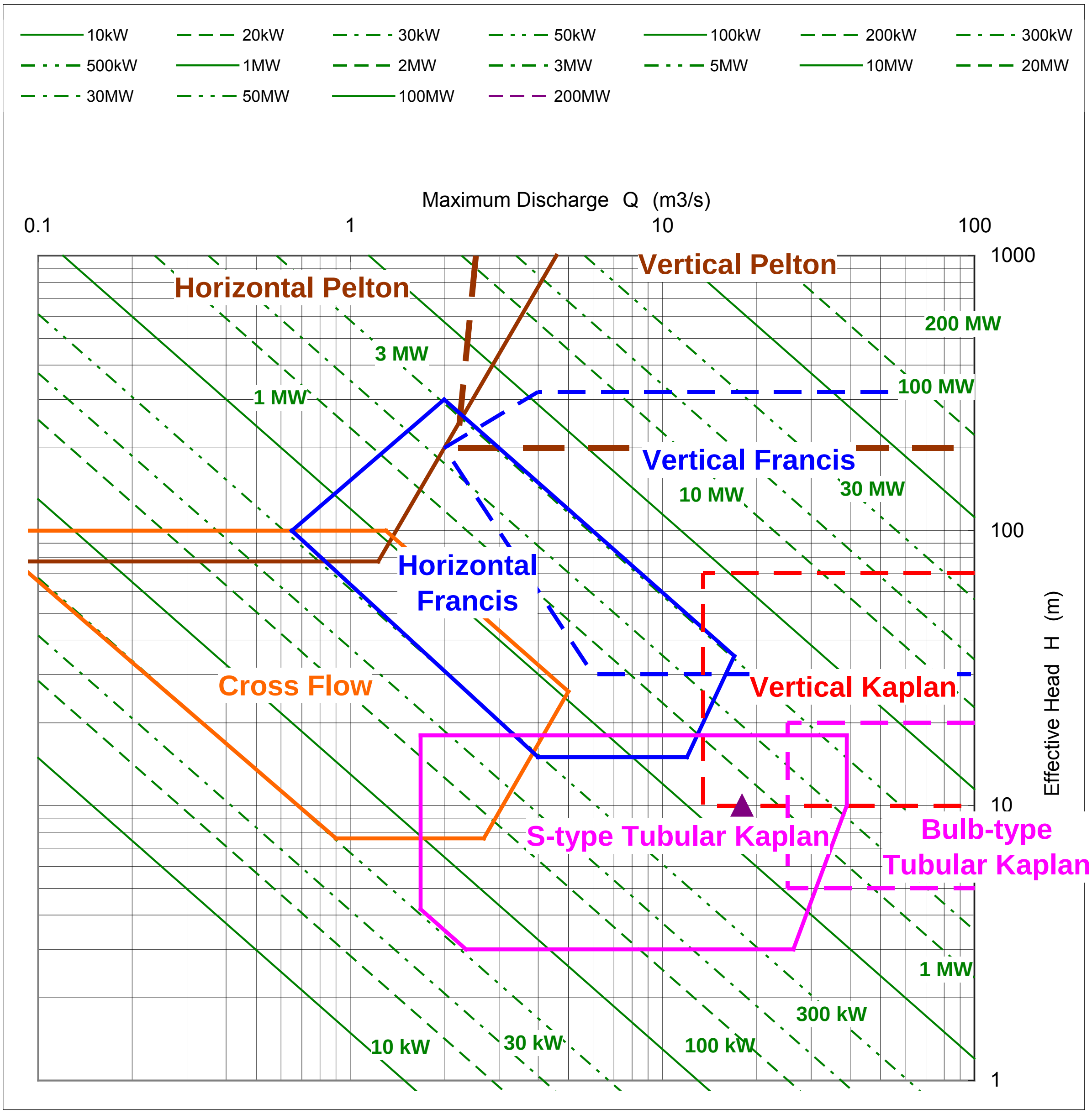


Fig. 3.2-6 Selection of the Water Turbine at Cutato River Point

(5) Distribution Plan

The red line on Fig 3.2-7 indicates planning transmission line route along the existing road. The distance is around 46 km from the small hydropower station at the Cutato River site to Andulo municipality. Now there is neither transmission line nor distribution line on the route.

On this FS, it is out of the scope about distribution plan for Andulo County area. Generation capacity is 1,600 kW, thus preferable distribution line voltage will be 30 kV and 3 phases & 3 wires type. And the step-down transformer shall be installed at the Andulo Municipality, and low voltage will be 400 V and/or 230 V and 3 phases & 4 wires type. In addition, distribution pole will be planned as the same type in the Luanda City, also the electric power shall be supplied by the nearest pole with pole transformer for the village of the Muenga and the Chicumbi, which has the hospital, reconstructing church and school presently. Furthermore, special specification about the air insulation level will be considered for the electric equipment to entire the easy break-down by the low atmospheric pressure like these highland condition 1,380 m (Cutato River site) ~ 1,635 m (Andulo Municipality).

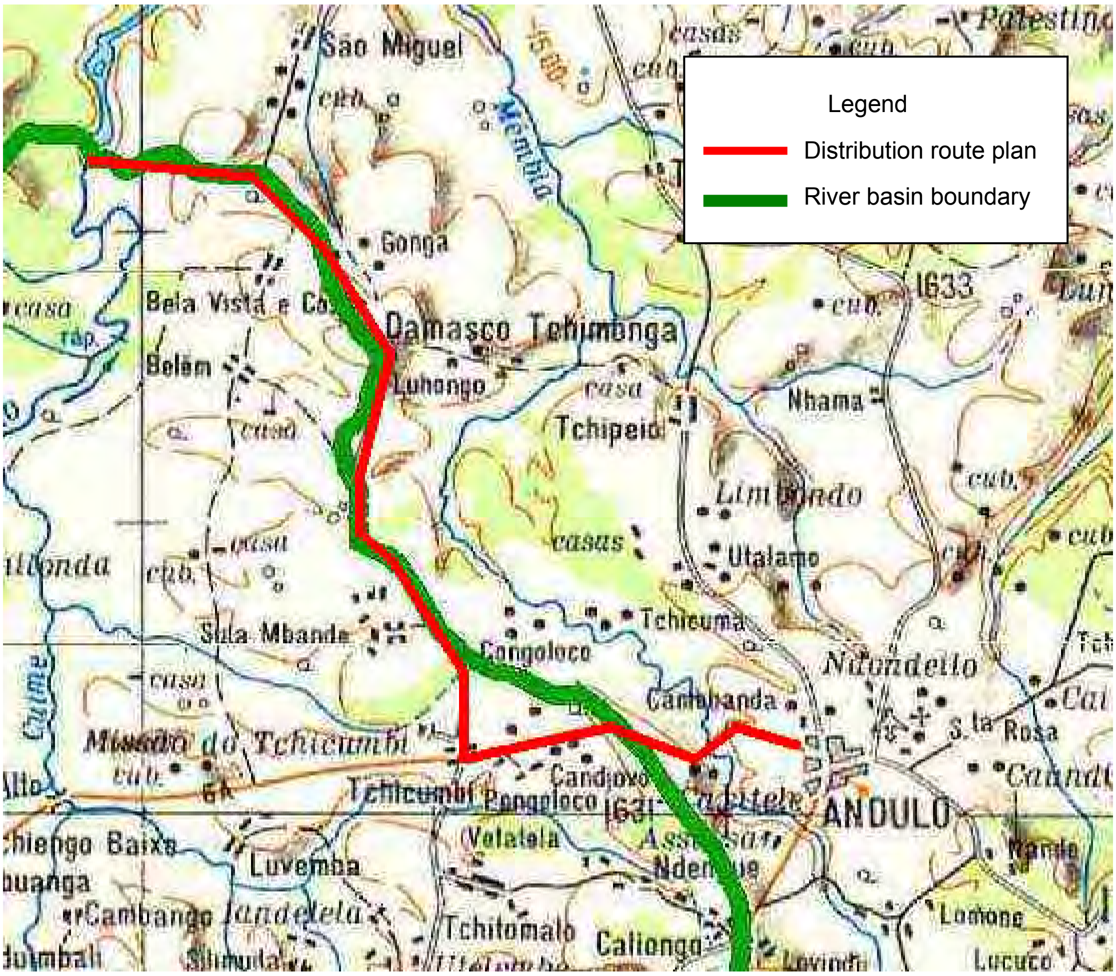


Fig. 3.2-7 Distribution Line Route Plan from Cutato River Site to Andulo Municipality

(6) Social and Natural Environment

The results in the preliminary study regarding (a) project outline, (b) social and natural environment in the project area, (c) probable environmental impact, are described as follows:

Cutato Hydropower Plant

No.	Item	Results of preliminary study
1	Project outline	This is a run-of-river type small hydropower plant, approximately 1,600 kW, on Cutato River. The development scale is the largest among candidate project sites and most promising toward the FS. This project requires construction of a weir, intake, conduit, power facility, distribution line, and access road.
2	Social and natural environment in the project area	The project site is located in the forest area of Andulo Municipality in the northeast of Bie Province. Muenga and other villages are scattered in the vicinity of this project site. Muenga Village is found at 3 km east of the project site which has 60 households, 360 habitants who are of Ombundo tribe, major group in Angola, and speak only their own language. Approximately 10 villages of such scale exist in this area. They live nearly self-sufficient, and grow soy beans, potatoes, cabbages, bananas, and minioc and sell them at the market of Andulo to obtain oil, salt, clothes, and other household utensils. It is said that average of household income is 4,000 Kz (approximately US$45). They equip some 5 kW generators in the village. Coffee peeling factory is under construction in the municipality, and they have a construction plan of factory area in Andulo taking advantage of this power plant. Also, they have a plan of housing construction for 5,000 households by the year of 2012. There is Chicumbi Village in 23 km south-southeast and Andulo Municipality in 27 km southeast from the project site. Road from Cuito to Chicumbi has two lanes and is maintained with asphalt paving, but the further road of approximately 20 km up to the project site is unpaved. Chicumbi has approximately 150 households and a church, hospital, and school. The population of Andulo is approximately 310,000 and 79,000 people out of it live in Calsunga district. In urban area of the Andulo, power has been transmitted to street lights, government offices, and houses by diesel generation. This project does not require involuntary resettlement, and any environmental protected area is not involved in this project implementation area.
3	Potential environmental impact	Impact on downstream river water use (irrigation, water for living, etc.) and aquatic lives, and occurrence of excavated rock and soil must be considered in this small hydropower project

3.2.2 Luvolo River Site

(1) Topography and Geology

1) Topographic Features

The project site is located at the gently sloped hill area at around EL.1,350 m.

2) Geological Features

The foundation rocks are composed of the gneissose fine grained granite of Precambrian Period. The hard rocks continuously expose along the riverside. The river deposits cover with the rocks in the vicinity of the powerhouse. However, it can be constructed on the rocks with the excavation of some meter in depth.

3) Other Items

The existing weir about 3 m height can be reused for the weir. Though the minor cracks with free lime are confirmed in the existing weir body, it can be used after minor repair by using mortar paste.

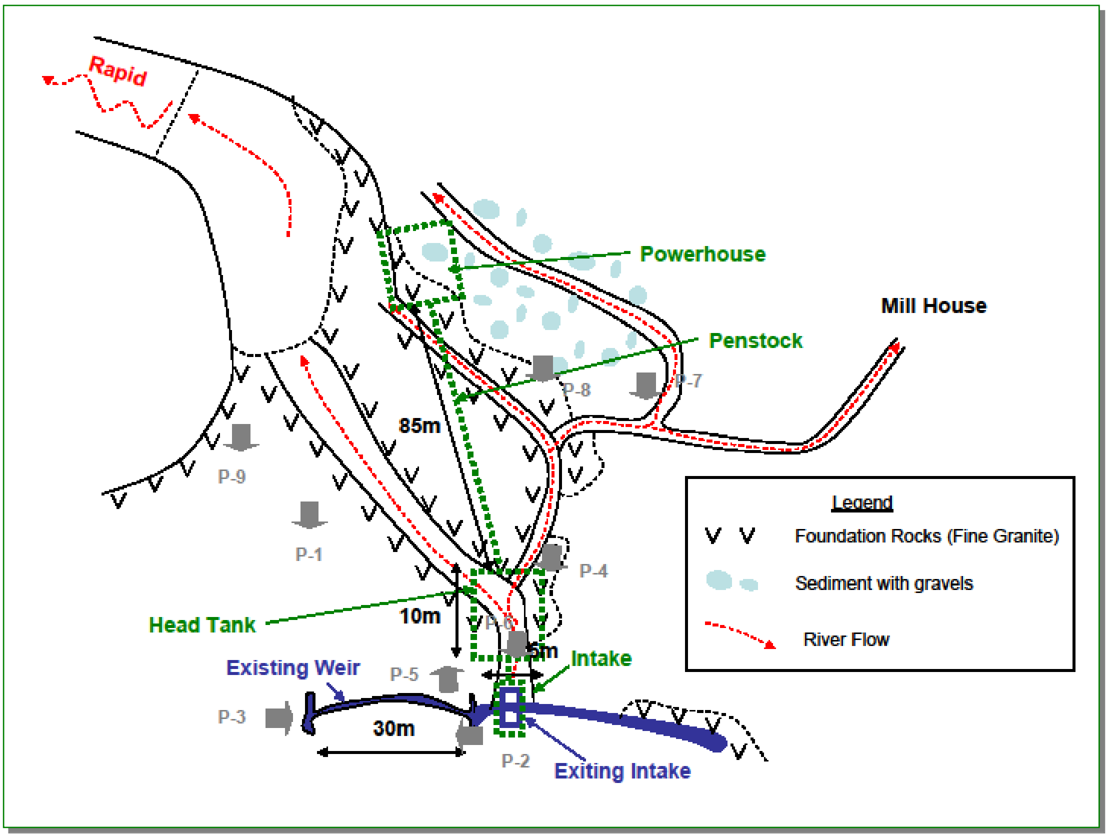


Fig. 3.2-8 Image Map of Luvolo River Site

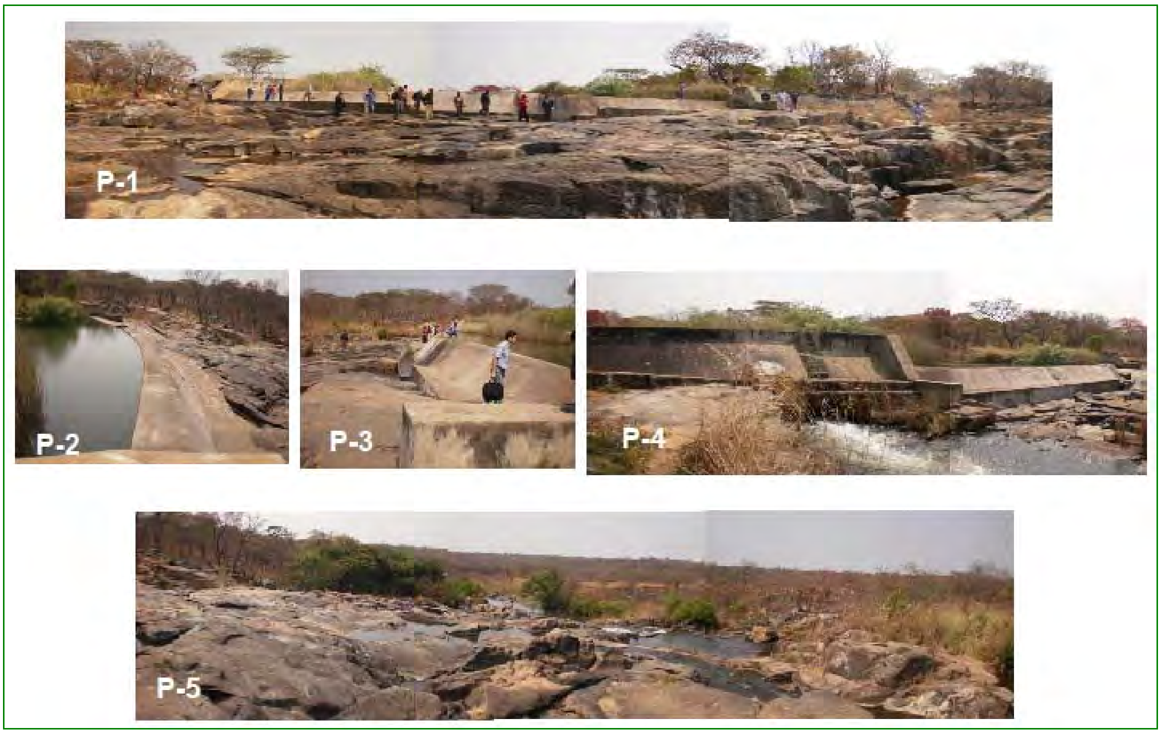


Photo 3.2-2 (1/2) View of Luvolo River Site (Dry Season: Sep. 9, 2010)

Photo 3.2-2 (2/2) View of Luvolo River Site (Dry Season: Sep.9, 2010)

(2) Hydrology and Meteorology

Projected site of Luvolo River site is located in the Luvolo River which is the tributary of the Cuanza River (147,000 km^2). The catchment area of the projected site is 310 km^2. Most part of the catchment is located on the highland which is higher than EL. 1,250 m with annual rainfall of more than 1,250 mm/yr (refer to Fig.3.2-4, Fig. 3.2-5).

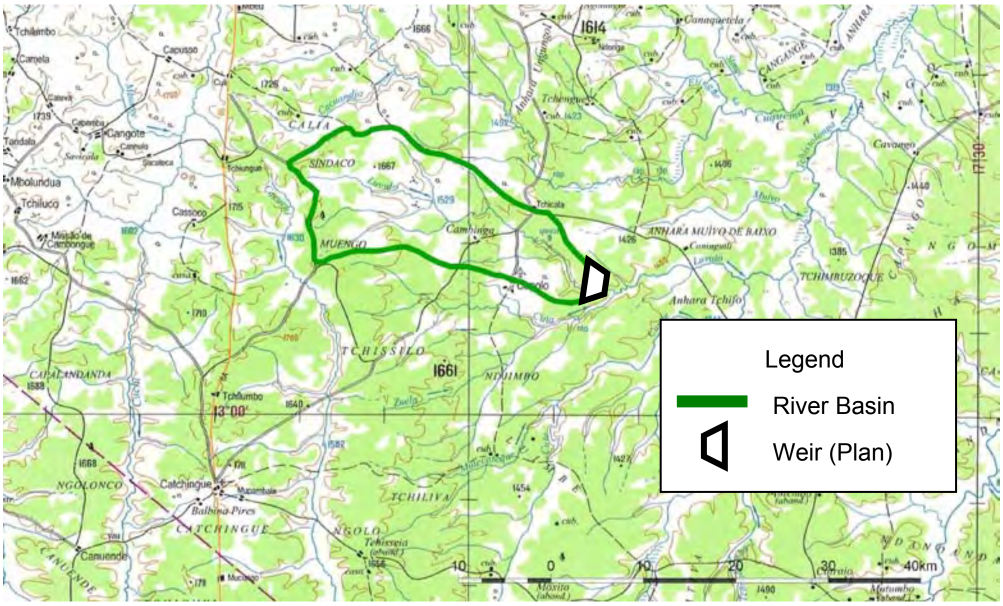


Fig. 3.2-9 Luvolo River Basin

(3) Hydropower Civil Engineering

The big character of this project plan is that its site has already had the weir and the intake which Lusitanian constructed before the civil war. Those structures are used for agriculture and motive energy.

This site has the highest water head (about 25 m) in the sites which we had site reconnaissance this time, but if the minimum riverflow of 3 m^3/s (excluding water volume for agriculture and motive energy. catchment area is about 310 km^2) is selected as maximum discharge, only mini hydropower plant (output power is about 0.7 MW) can be planned.

The intake which can take the maximum discharge is made improvements at the right side of the river. The intake water is discharged to the river from the outlet through head tank, penstock and powerhouse of about total 100 m length. The type of power station is run-of-river (generating energy is about 5.2 GWh).

So that the length of water reducing area is about 100m and riverflow has already used for agriculture and motive energy, this means that the project has little impacted the marginal environment.

The access road is about 720 km from Luanda to Cuito, Bie Province. The access road is about 53 km from Cuito to Chicala and the access road is about 6 km from Chicala to Luvolo site. The condition of the access road from Chicala to Luvolo is not so bad (or new road can be easily planned), but the condition of the access road from Cuito to Chicala is very bad to go to dry season site survey even using 4WD at dry season. If the construction works begin at this site, many troubles will probably occur at transportation of main equipment and material.

(4) Hydropower Generation

It is roughly designed with conditions (gross head: 25 m and hydraulic capacity: 3 m^3/s) at the Luvolo River point and the type of the water turbine is shown as the Fig. 3.2-10, horizontal axis type francis.

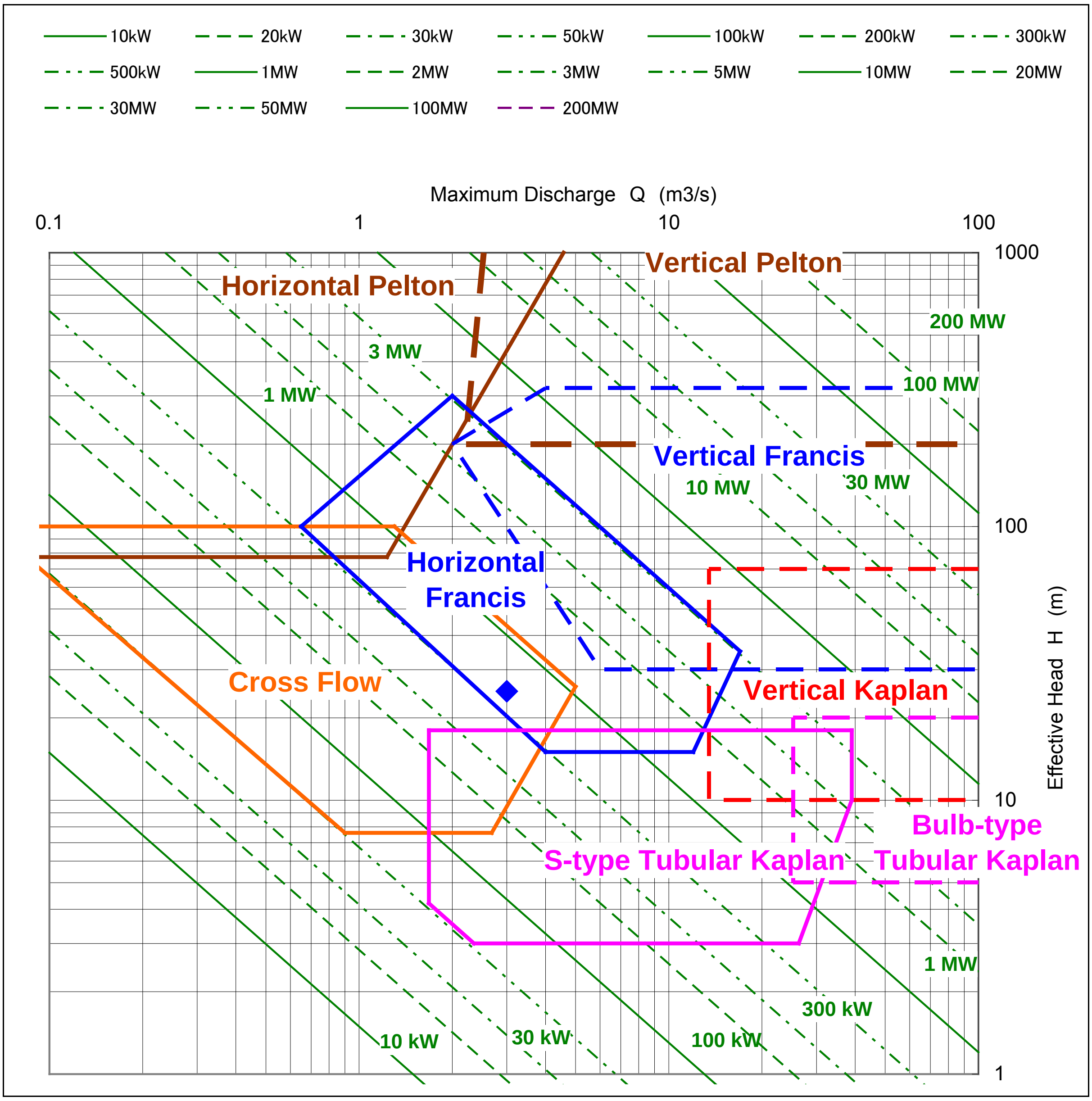


Fig. 3.2-10 Selection of the Water Turbine at Luvolo River Point

(5) Distribution Plan

The red line on Fig 3.2-11 indicates planning distribution line route along the existing road. The distance is around 6 km from the small hydropower station at the Luvolo River site to Chicala Village. Now there are no transmission lines also distribution line on the route.

On this FS, it is out of the scope about distribution plan for inside Chicala Village. Generation capacity is 660 kW, thus preferable distribution line voltage will be 15 kV and 3 phases & 3 wires type. And the step-down transformer shall be installed at the village, and low voltage will be 400 V and/or 230 V and 3 phases & 4 wires type. In addition, distribution pole will be planned as the same type in the Luanda City. Furthermore, special specification about the air insulation level will be considered for the electric equipment to entire the easy break-down by the low atmospheric pressure like these highland condition 1,355 m (Luvolo River site) ~ 1,630 m (Chicala Village).

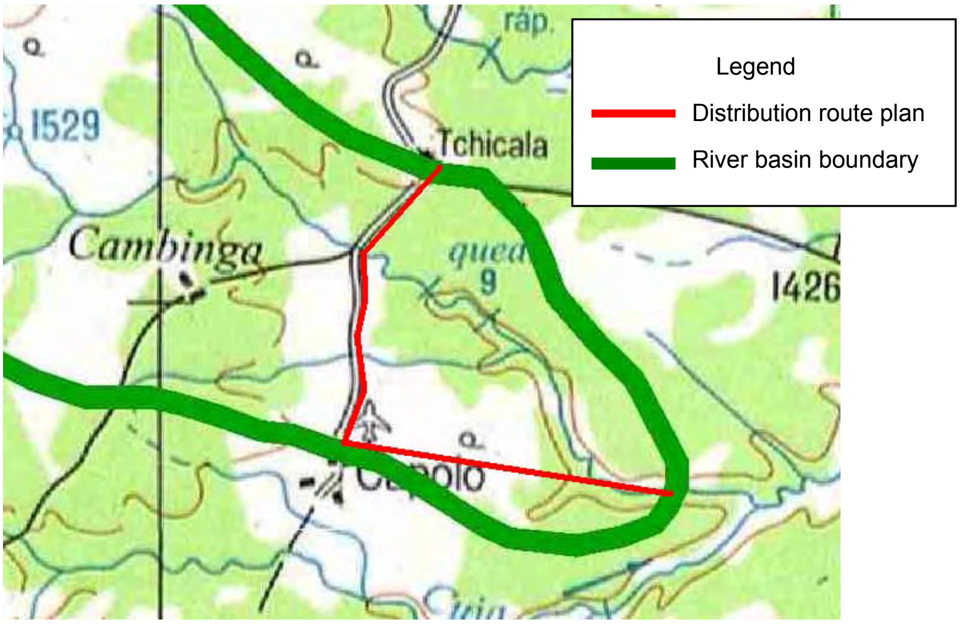


Fig. 3.2-11 Distribution Line Route Plan from Luvolo River Site to Chicala Village

(6) Social and Natural Environment

The results in the preliminary study regarding (a) project outline, (b) social and natural environment of project area, (c) potential environmental impact, are described as follows:

Luvolo Hydropower Plant

No.	Item	Results of preliminary study
1	Project outline	This is a run-of-river type small hydropower plant, approximately 700 kW, on Luvolo River. This project requires construction of a weir, conduit, power facility, transmission line, and access road.
2	Social and natural environment of project area	The project site is located in forest area in south-southeast of Cuito Municipality in Bie Province. Unpaved road of two lanes runs from Cuito to Chicala Village. Chicala Village (population of 22,000) having a hospital and a school in 5 km north-northwest, and Capolo Village (population of 160 including prisoners) having a prison in 6 km southwest, exist in vicinity of the project site. In Chicala Village, power is transmitted to street lights, government offices, and a hospital by diesel generation (40 kVA). This project does not require involuntary resettlement, and any environmental protected area is not involved in this project implementation area.
3	Potential environment al impact	Impact on downstream river water use (irrigation, water for living, etc.) and aquatic lives, and occurrence of excavated rock and soil must be considered in this small hydropower project

3.2.3 Cunene River Site

(1) Topography and Geology

1) Topographic Features

The project site is located at the gentle sloped hill area at around EL.1,600 m.

2) Geological Features

The foundation rocks are composed of the hard ande-site dyke. The layout of the structures should be considered based on the distribution of the outcrops.

3) Other Items

The repair for the existing bridge is necessary, because it is heavily damaged.

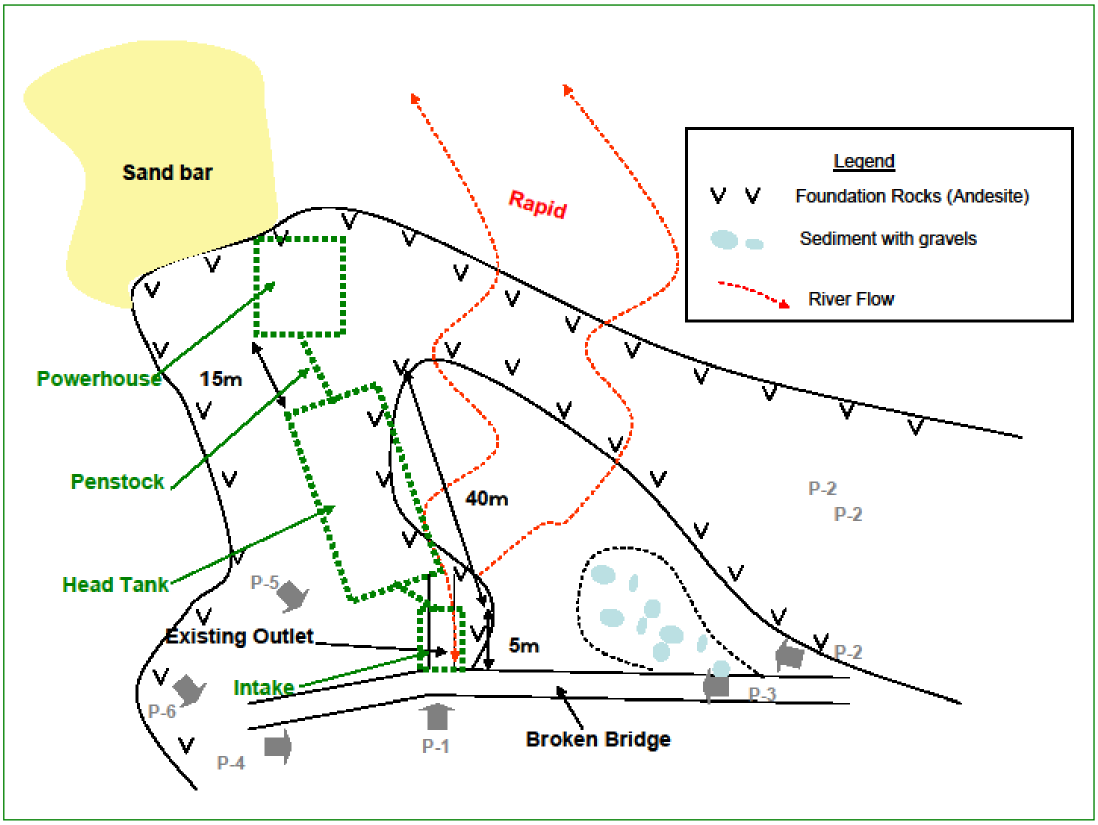


Fig. 3.2-12 Image Map of Cunene River Site

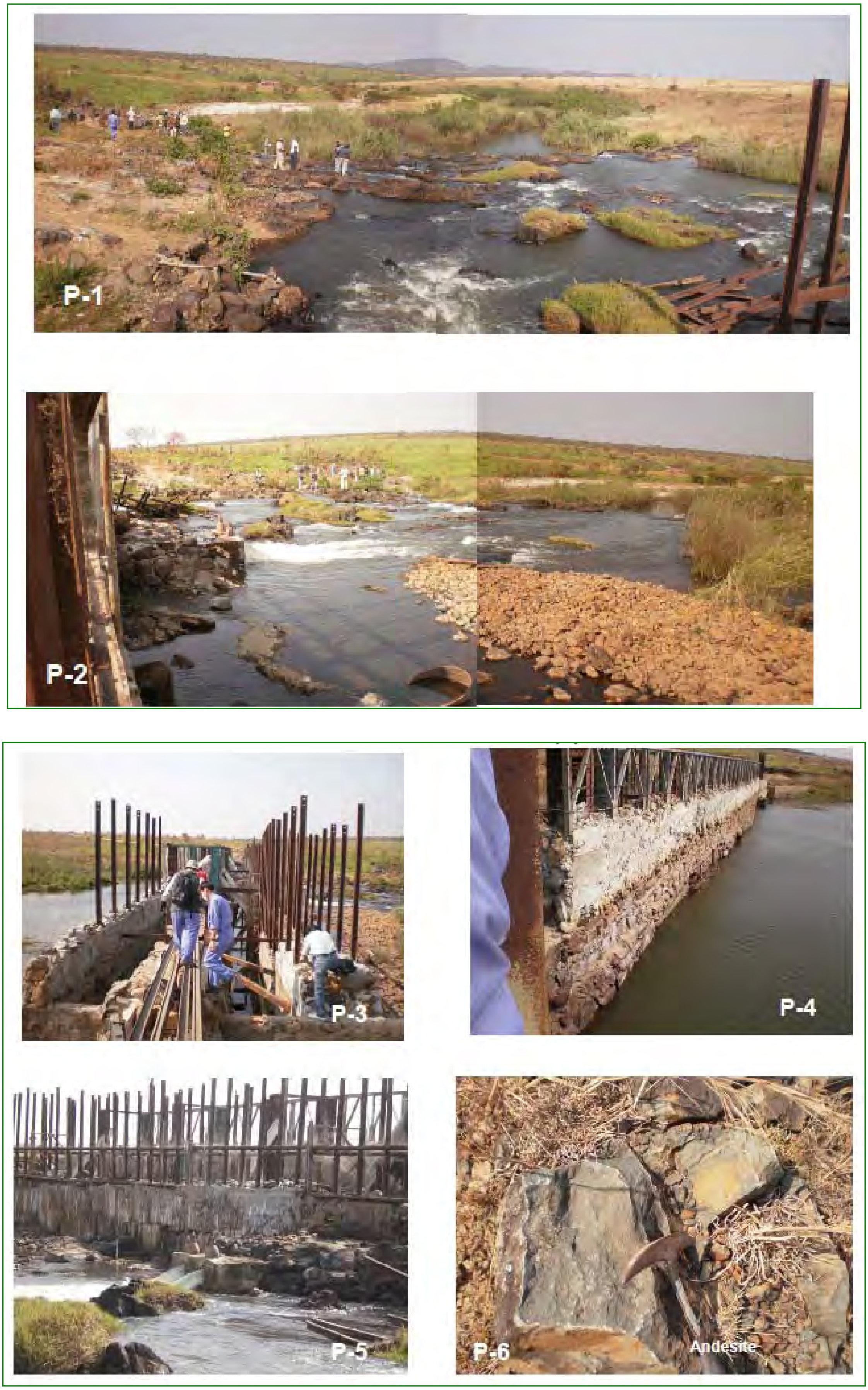


Photo 3.2-3 View of Cunene River Site (Dry Season: Sep. 10, 2010)

(2) Hydrology and Meteorology

Projected site of Cunene River site is located in the Cunene River which is the tributary of the Cunene River (106,500 km^2). The catchment area of the projected site is 700 km^2. Most part of the catchment is located on the highland which is higher than EL. 1,500 m with annual rainfall of more than 1,250 mm/yr (refer to Fig.3.2-4, Fig. 3.2-5).

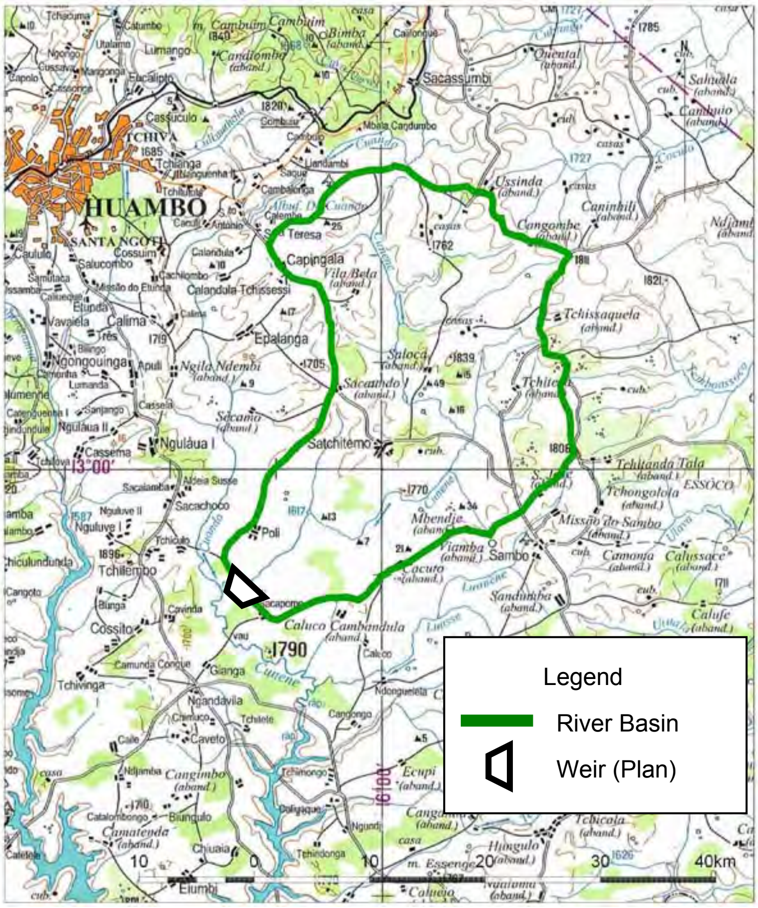


Fig. 3.2-13 Cunene River Basin

(3) Hydropower Civil Engineering

The character of this project plan is that its site has already had the weir under construction which Lusitanian constructed before the civil war.

The height of water head is about 6 m and if the minimum river flow 5m^3/s (catchment area is about 700 km^2) is selected as the maximum discharge, only mini hydropower plant (output power is about 0.3 MW) can be planned.

The intake which can take the maximum discharge is made improvements of the weir at the left side of the river. The intake water is discharged to the river from the outlet through settling basin, head tank, penstock and powerhouse of about total 60 m length. The type of power station is run-of-river (generating energy is about 2.0 GWh).

So that the length of water reducing area is about 60 m, this means that the project has little impacted the marginal environment.

The access road is about 600 km from Luanda to Huambo, Huambo Province. The access road is about 46 km from Huambo to Cunene site. The length of transmission line is about 11 km from Cunene site to Sacapomo. The condition of the access road from Huambo to Cunene site is not so bad (or new road can be easily planned), the road from Cunene site to Sacapomo can't be made sure this time.

(4) Hydropower Generation

It is roughly designed with conditions (gross head: 6 m and hydraulic capacity: 5 m^3/s) at the Cunene River point and the type of the water turbine is shown as the Fig. 3.2-14, S-type Tubular.

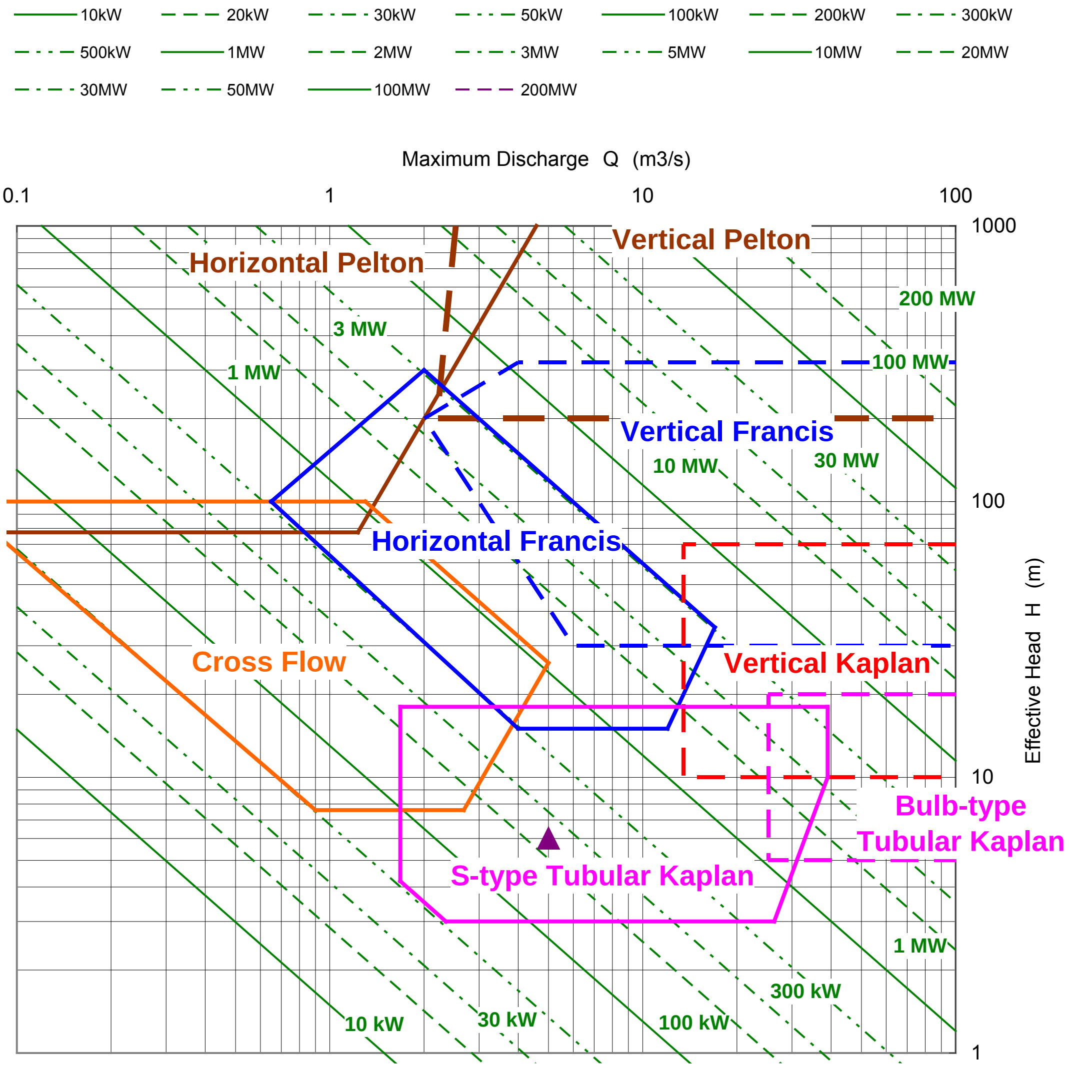


Fig. 3.2-14 Selection of the Water Turbine at Cunene River Point

(5) Distribution Plan

The red line on Fig 3.2-15 indicates planning distribution line route along the existing road. The distance is around 3 km from the small hydropower station at the Cunene River site to Sacapomo Village. Now there are no transmission lines also distribution line on the route.

On this feasibility study, it is out of the scope about distribution plan for inside Sacapomo Village. Generation capacity is 260 kW, thus preferable distribution line voltage will be 15 kV and 3 phases & 3 wires type. And the step-down transformer shall be installed at the village, and low voltage will be 400 V and/or 230 V and 3 phases & 4 wires type. In addition, distribution pole will be planned as the same type in the Luanda City. Furthermore, special specification about the air insulation level will be considered for the electric equipment to entire the easy break-down by the low atmospheric pressure like these highland condition 1,580 m (Cunene rRiver site) ~ 1,700 m (Sacapomo Village).

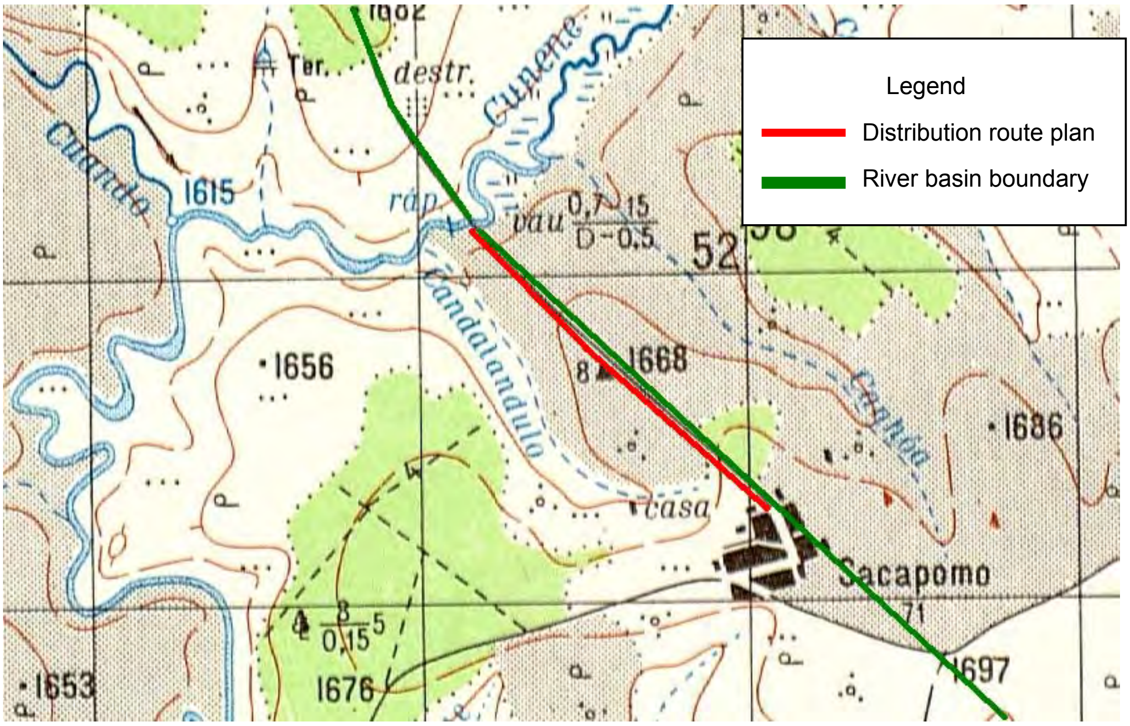


Fig. 3.2-15 Distribution Line Route Plan from Cunene River Site to Sacapomo Village

(6) Social and Natural Environment

The results in the preliminary study regarding (a) project outline, (b) social and natural environment of project area, (c) potential environmental impact, are described as follows:

Cunene Hydropower Plant

No.	Item	Results of preliminary study
1	Project outline	This is a run-of-river type small hydropower plant, approximately 300 kW, on Cunene River. This project requires construction of a weir, conduit, power facility, transmission line, and access road.
2	Social and natural environment of project area	The project site is located in savanna area in 40 km south-southeast of Huambo Municipality in Huambo. Unpaved road of two lanes runs from Huambo to the vicinity of project site. Three villages of 1000 population each are scattered around the project site. Nearest village is Sacapomo and located in 2.5 km southeast of the project site. Also, there are Poli Village in 5 km north-northeast and Tchiculo Village in 6 km northwest of the project site. However, this project does not require involuntary resettlement, and any environmental protected area is not involved in this project implementation area.
3	Potential environmental impact	Impact on downstream river water use (irrigation, water for living, etc.) and aquatic lives, and occurrence of excavated rock and soil must be considered in this small hydropower project.

3.2.4 Põe River Site

(1) Topography and Geology

1) Topographic Features

The project site is located at the gentle sloped hill area at around EL.1,600 m.

2) Geological Features

The foundation rocks are composed of the coarse grained granite of Precambrian Period. The hard rocks continuously expose along the riverside. 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

The existing weir at about 1 m high can be reused for the weir. The weir, which is made of the assemblage of rock’s blocks and mortar, can be reused enough.

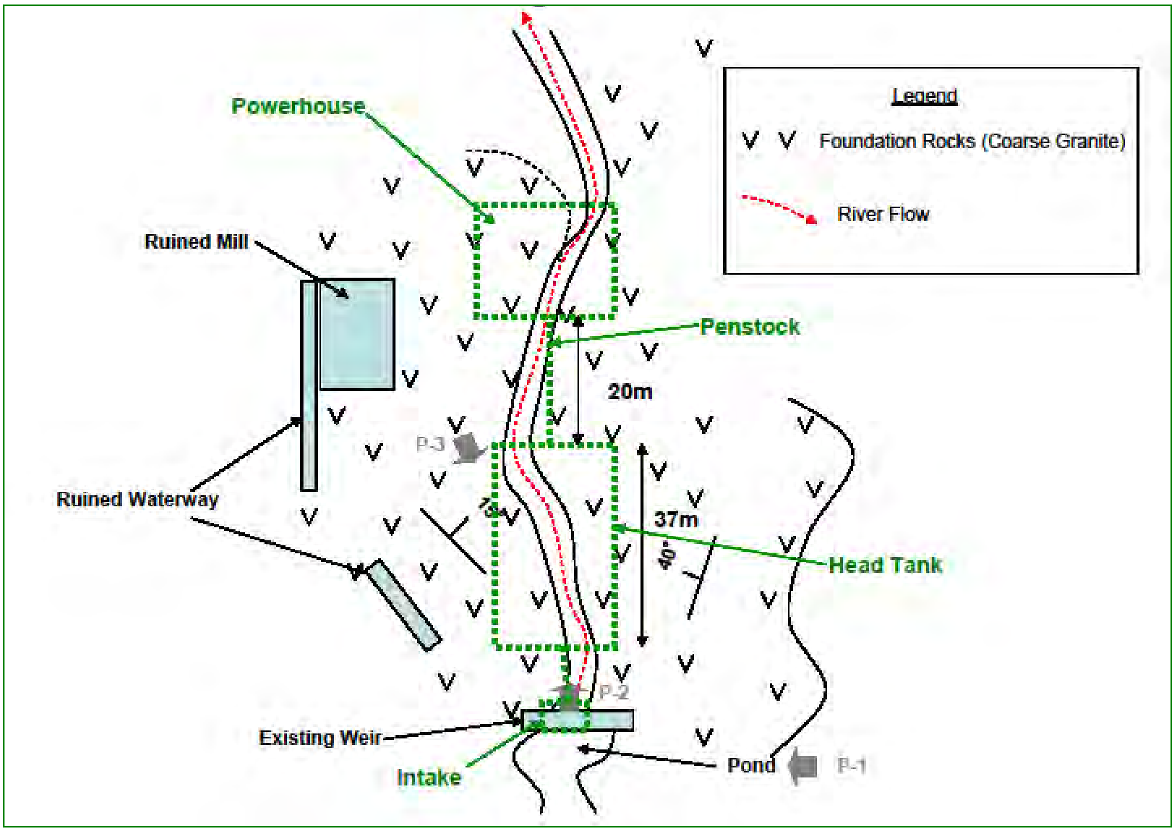


Fig. 3.2-16 Image Map of Põe River Site

Photo 3.2-4 View of Põe River Site (Dry Season: Sep. 10, 2010)

(2) Hydrology and Meteorology

Projected site of Põe River site is located in the Cunene River which is the tributary of the Cunene River (106,500 km^2). The catchment area of the projected site is 110 km^2. Most part of the catchment is located on the highland which is higher than EL. 1,500 m with annual rainfall of more than 1,250 mm/yr (refer to Fig.3.2-4, Fig. 3.2-5).

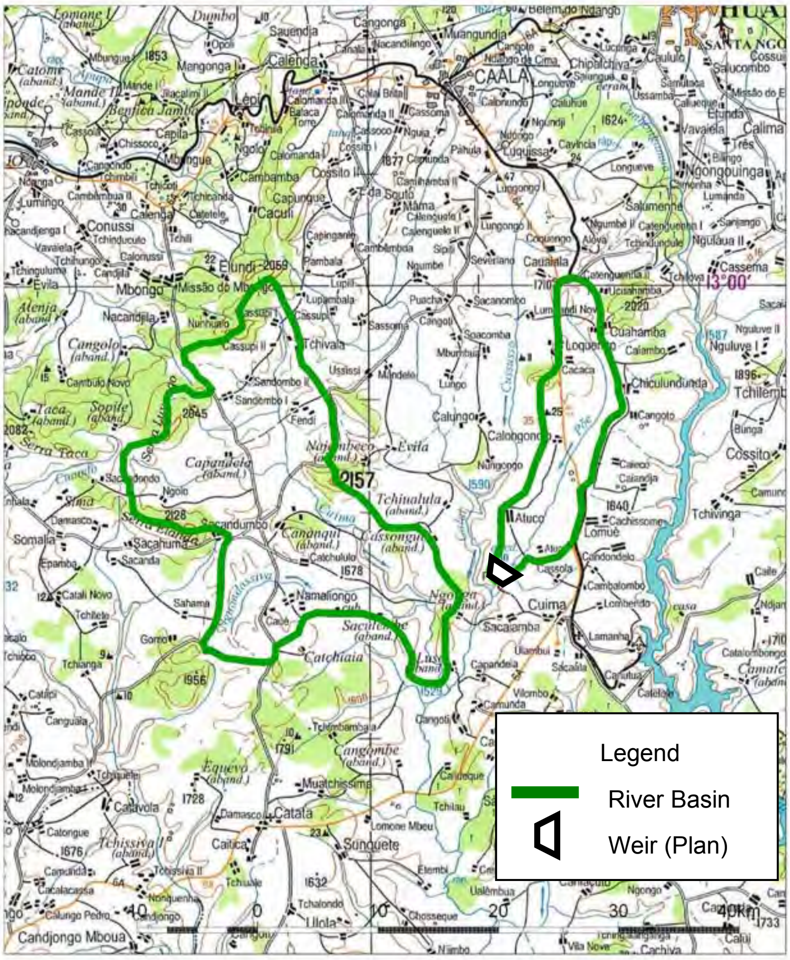


Fig. 3.2-17 Põe River Basin (Right Basin)

(3) Hydropower Civil Engineering

The height of water head is about 10m and if the minimum river flow 0.5 m^3/s (catchment area is about 110 km^2) is selected as the maximum discharge, only micro hydropower plant (output power is about 0.04 MW) can be planned.

The intake which can take the maximum discharge is made at the left side of the river. The intake water is discharged to the river from the outlet through settling basin, headrace, head tank, penstock and powerhouse of about total 60 m length. The type of power station is run-of-river (generating energy is about 0.3 GWh).

So that the length of water reducing area is about 60 m, this means that the project has little impacted the marginal environment.

The access road is about 600km from Luanda to Huambo, Huambo Province. The access road is about 75 km from Huambo to Cuima and the access road is about 6 km from Cuima to Põe site. The condition of the access road from Huambo to Põe site is not so bad (or new road can be easily planned).

(4) Hydropower Generation

It is roughly designed with conditions (gross head: 9 m and hydraulic capacity: 0.8 m^3/s) at the Põe River point and the type of the water turbine is shown as the Fig. 3.2-18, cross flow turbine.

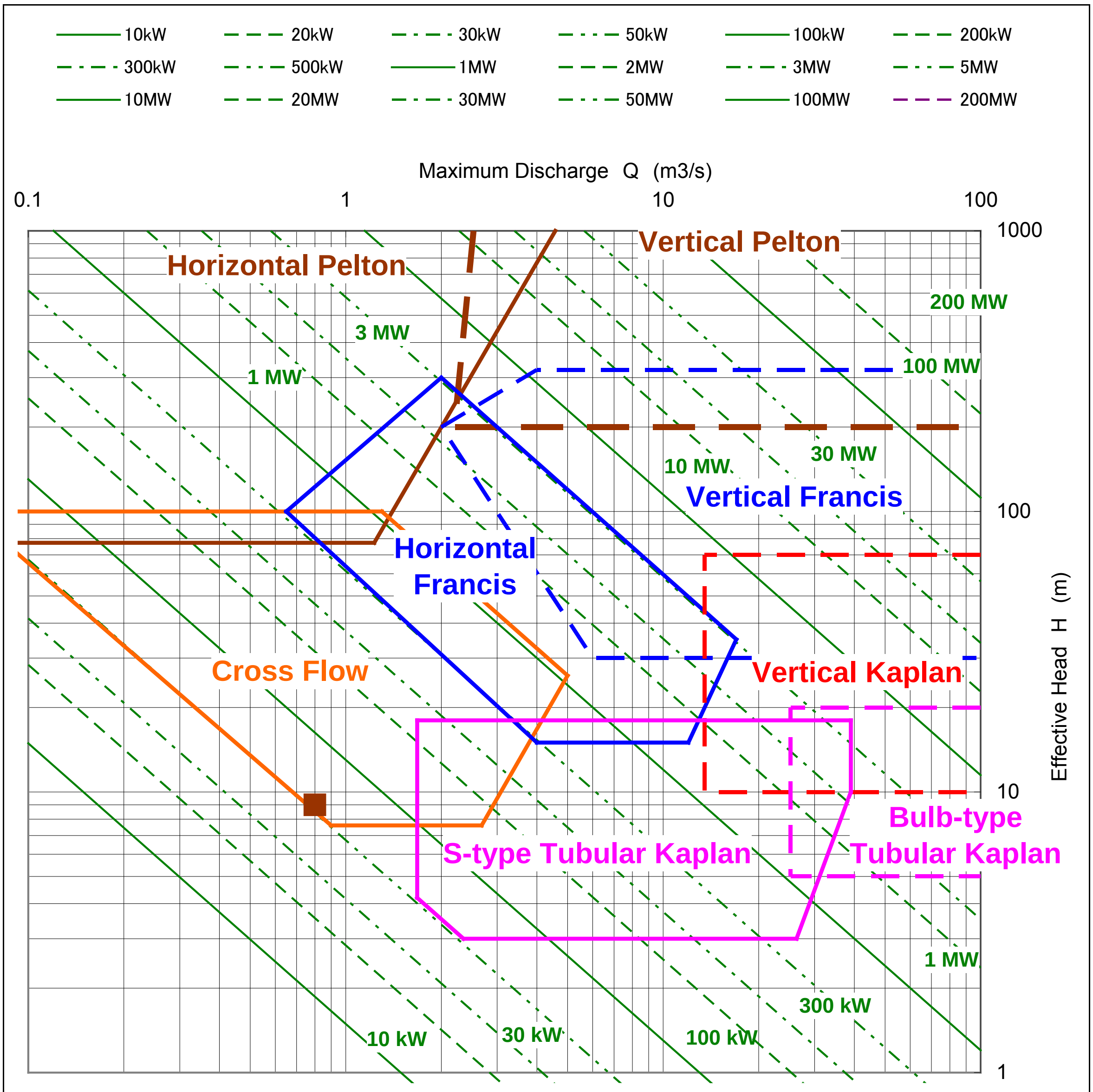


Fig. 3.2-18 Selection of the Water Turbine at Põe River Point

(5) Distribution Plan

The red line on Fig 3.2-19 indicates planning distribution line route along the current road. The distance is around 6 km from the small hydropower station at the Põe River site to Cuima Village. Now there are no transmission lines also distribution line on the route.

On this FS, it is out of the scope about distribution plan for inside Cuima Village. Generation capacity is 40 kW, thus preferable distribution line voltage will be 15 kV and 3 phases & 3 wires type. And the step-down transformer and distribution cubicles shall be installed at the village, and low voltage will be 400 V and/or 230 V and 3 phases & 4 wires type. In addition, distribution pole will be planned as the same type in the Luanda City. Furthermore, special specification about the air insulation level will be considered for the electric equipment to entire the easy break-down by the low atmospheric pressure like these highland condition 1,595 m (Põe River site) ~ 1,660 m (Cuima Village).

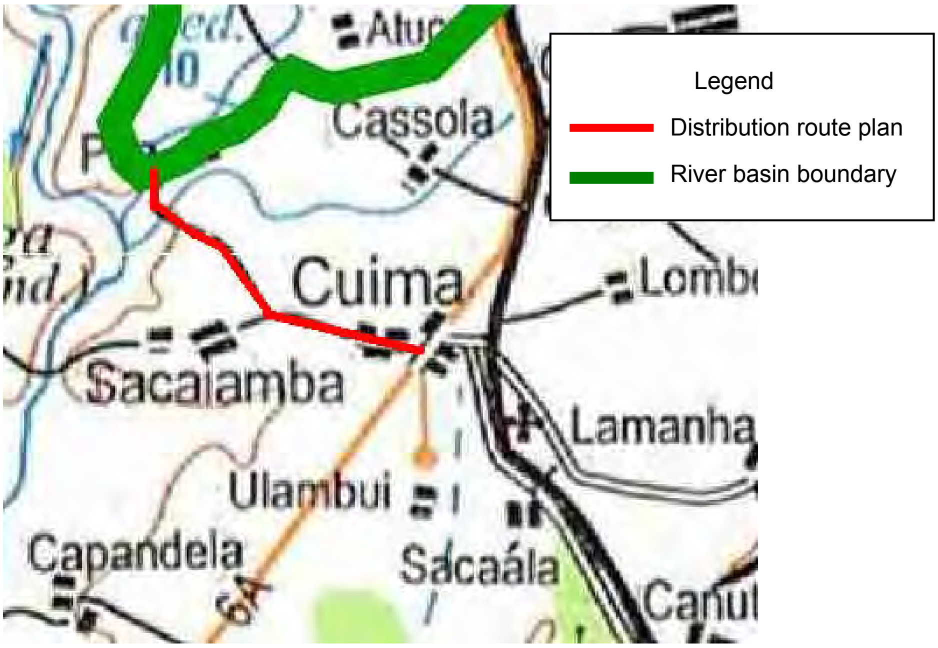


Fig. 3.2-19 Distribution Line Route Plan from Põe River Site to Cuima Village

(6) Social and Natural Environment

The results in the preliminary study regarding (a) project outline, (b) social and natural environment of project area, (c) potential environmental impact, are described as follows:

Põe Hydropower plant

No.	Item	Results of preliminary study
1	Project outline	This is a run-of-river type small hydropower plant, approximately 40 kW, on Põe River. This project requires construction of a weir, conduit, power facility, transmission line, and access road.
2	Social and natural environment of project area	The project site is located in savanna area in 60 km south-southwest of Huambo Municipality in Huambo Province. There is Cuima Village in 5 km east-southeast and nearest village is Põe Village in 1 km northeast of the project site. Unpaved road of two lanes runs from Caala Municipality to Cuima Village. Road from Cuima Village to Põe Village is also unpaved. Three diesel generators (@100 kVA) and a solar generator (approximately 4 kW) are installed in Cuima Village. The solar generator is used for communication facilities like telephones. However, approximately one-fourth of solar panels have been missing. This project does not require involuntary resettlement, and any environmental protected area is not involved in this project implementation area.
3	Potential environmental impact	Impact on downstream river water use (irrigation, water for living, etc.) and aquatic lives, and occurrence of excavated rock and soil must be considered in this small hydropower project.

3.2.5 Cuima River Site

(1) Topography and Geology

1) Topographic Features

The project site is located at the gentle sloped hill area at around EL.1,550 m. The Cuima River joins the Calai River at the downstream area.

2) Geological Features

The foundation rocks are composed of the coarse grained granite of Precambrian Period. The hard rocks partly expose along the riverside, however, the river deposits partly cover with the foundation rocks. The detailed geological reconnaissance for the outcrops will be necessary for the structural design

3) Other Items

The existing weir at about 3m high can be reused for the weir. However, the weir should be repaired, because there are some leakage holes in the weir body.

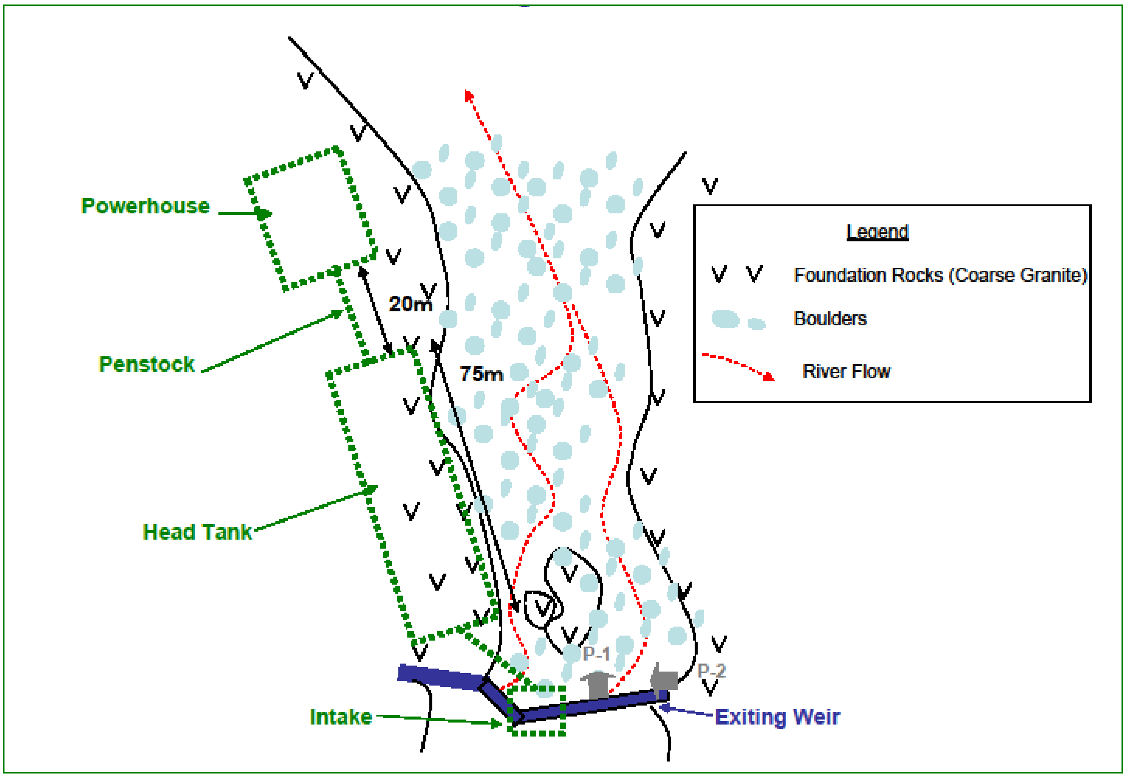


Fig. 3.2-20 Image Map of Cuima River Site

Photo 3.2-5 View of Cuima River Site (Dry Season: Sep. 10, 2010)

(2) Hydrology and Meteorology

Projected site of Cuima River site is located in the Cunene River which is the tributary of the Cunene River (106,500 km^2). The catchment area of the projected site is 400 km^2. Most part of the catchment is located on the highland which is higher than EL. 1,500 m with annual rainfall of more than 1,250 mm/yr (refer to Fig.3.2-4, Fig. 3.2-5).

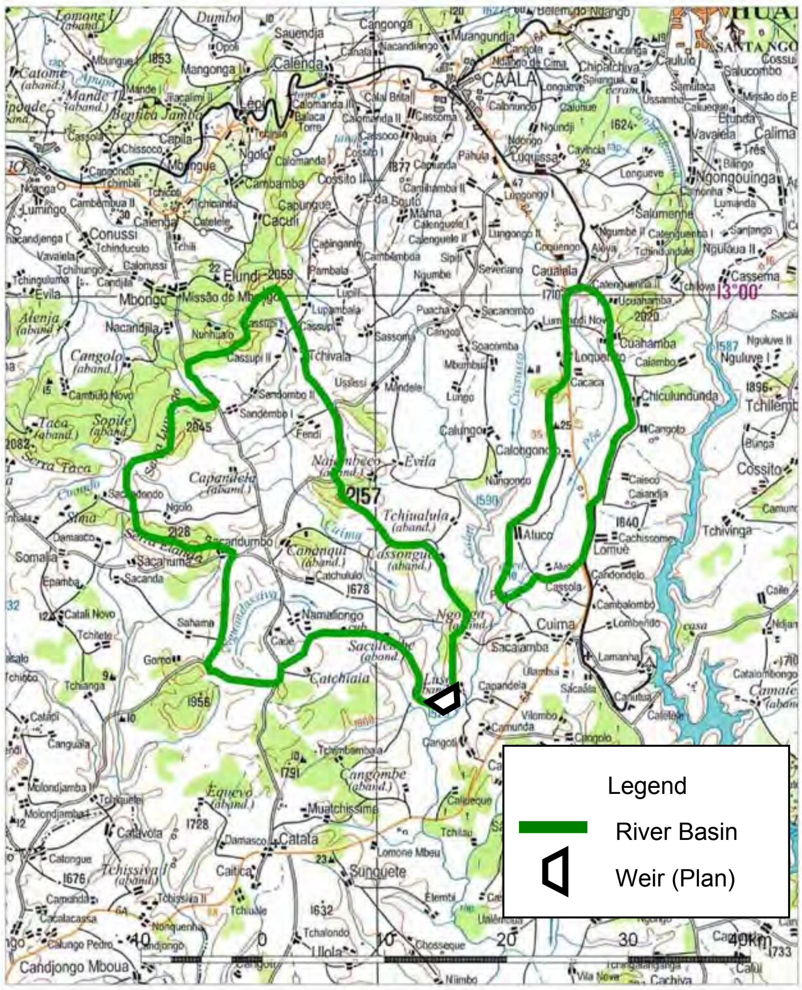


Fig. 3.2-21 Cuima River Basin (left basin)

(3) Hydropower Civil Engineering

The height of water head is about 10m and if the minimum riverflow 3 m^3/s (catchment area is about 400 km^2) is selected as the maximum discharge, only mini hydropower plant (output power is about 0.3 MW) can be planned.

The intake which can take the maximum discharge is made at the left side of the river. The intake water is discharged to the river from the outlet through settling basin, headrace, head tank, penstock and powerhouse of about total 100m length. The type of power station is run-of-river (generating energy is about 2.1 GWh).

So that the length of water reducing area is about 100 m, this means that the project has little impacted the marginal environment.

The access road is about 600km from Luanda to Huambo, Huambo Province. The access road is about 75 km from Huambo to Cuima and the access road is about 16 km (including no road area of 1 km) from Cuima to Cuima site. The condition of the access road from Huambo to Cuima site is not so bad (or new road can be easily planned).

(4) Hydropower Generation

It is roughly designed with conditions (gross head: 10 m and hydraulic capacity: 3 m^3/s) at the Cutima River point and the type of the water turbine is shown as the Fig. 3.2-22, S-type Tubular.

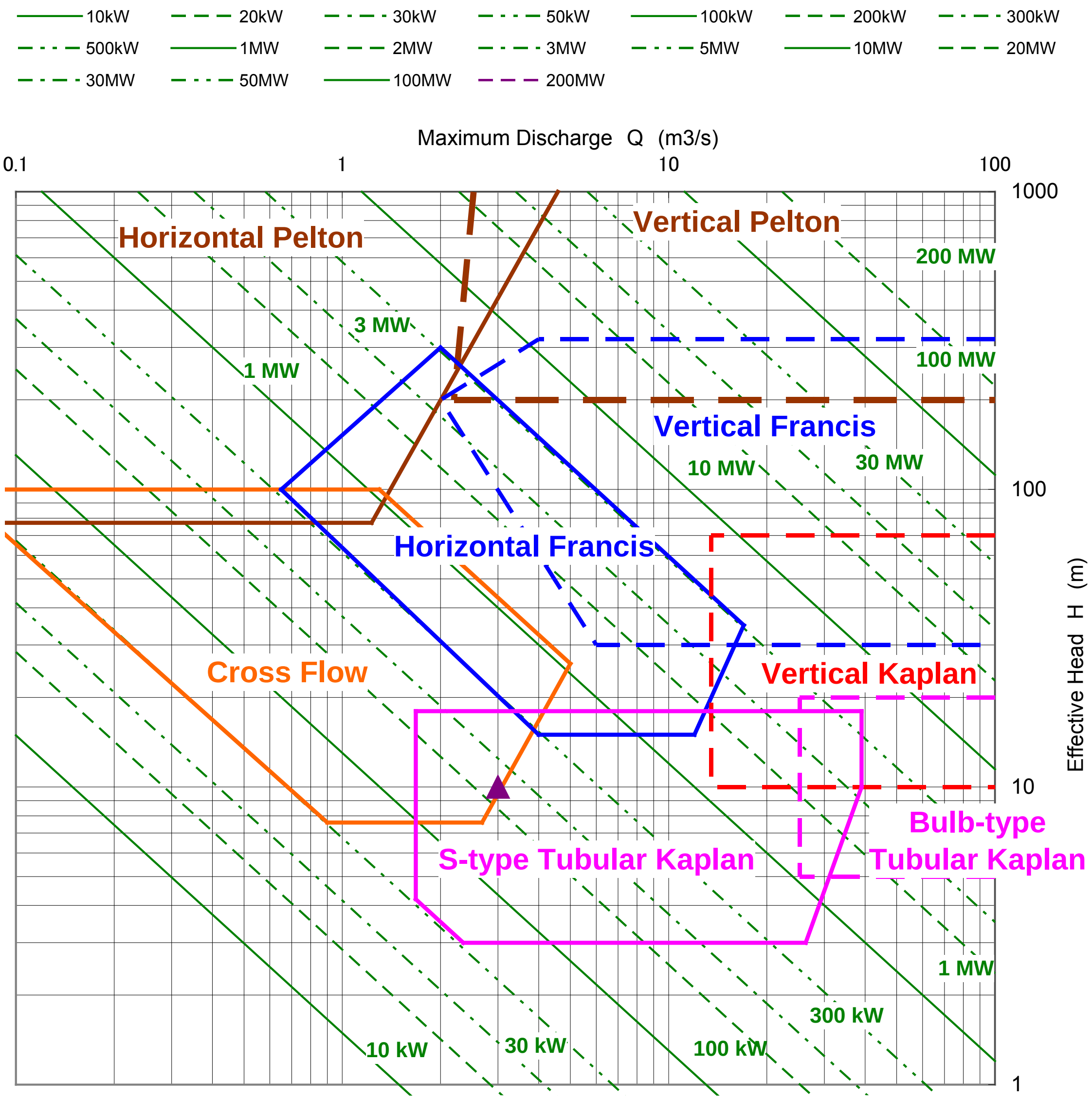


Fig. 3.2-22 Selection of the Water Turbine at Cuima River Point

(5) Distribution Plan

The red line on Fig 3.2-23 indicates planning distribution line route along the current road. The distance is around 18 km from the small hydropower station at the Cuima River site to Cuima Village. Now there are no transmission lines also distribution line on the route.

On this FS, it is out of the scope about distribution plan for inside Cuima Village. Generation capacity is 260 kW, thus preferable distribution line voltage will be 15 kV and 3 phases & 3 wires type. And the step-down transformer shall be installed at the village, and low voltage will be 400 V and/or 230 V and 3 phases & 4 wires type. In addition, distribution pole will be planned as the same type in the Luanda City. Furthermore, special specification about the air insulation level will be considered for the electric equipment to entire the easy break-down by the low atmospheric pressure like these highland condition 1,535 m (Cuima River site) ~ 1,660 m (Cuima Village).

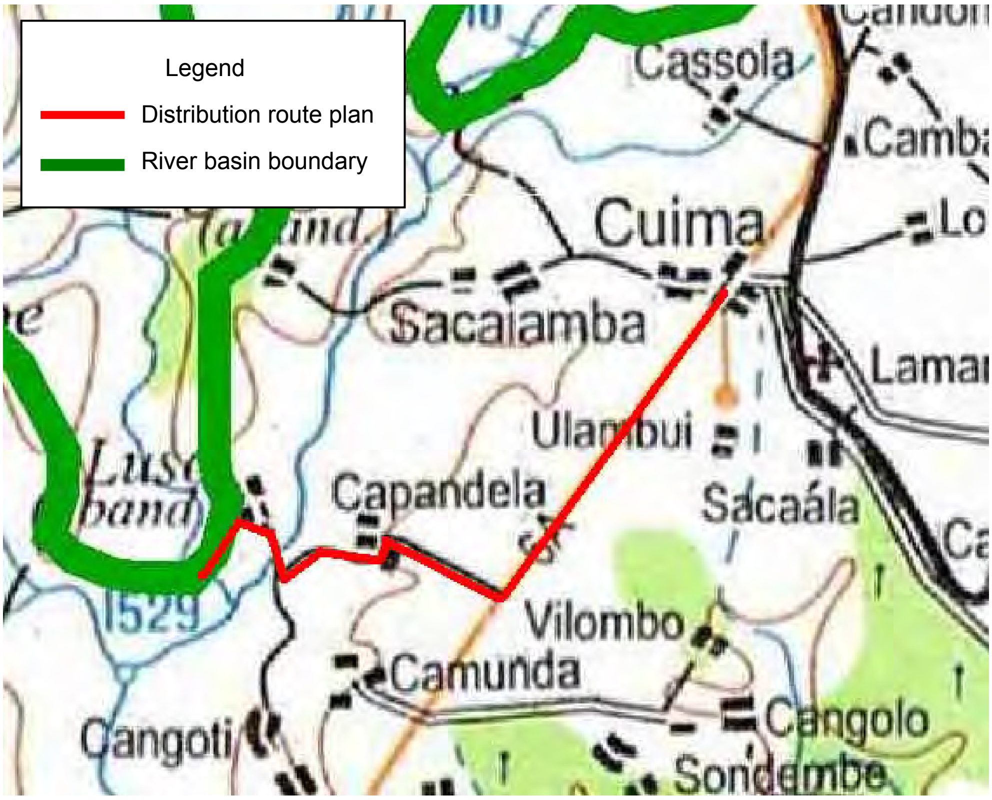


Fig. 3.2-23 Distribution Line Route Plan from Cuima River Site to Cuima Village

(6) Social and Natural Environment

The results in the preliminary study regarding (a) project outline, (b) social and natural environment of project area, (c) potential environmental impact, are described as follows:

Cuima Hydropower Plant

No.	Item	Results of preliminary study
1	Project outline	This is a run-of-river type small hydropower plant, approximately 200 kW, on Cuima River. This project requires construction of a weir, conduit, power facility, transmission line, and access road.
2	Social and natural environment of project area	The project site is located in forest area in 65 km south-southwest of Huambo City in Huambo. There are Cuima Village in 10 km east-northeast and other villages including the nearest Luso Village in the vicinity of the project site. Unpaved road of two lanes runs from Caala County to Cuima Village. Road from Cuima village to the project site via Sacaiamba Village is unpaved single lane. This project does not require involuntary resettlement, and any environmental protected area is not involved in this project implementation area.
3	Potential environmental impact	Impact on downstream river water use (irrigation, water for living, etc.) and aquatic lives, and occurrence of excavated rock and soil must be considered in this small hydropower project

3.3 Selection of Feasibility Study Sites

The issues of the first screening for selecting FS in the implementation policy are followings.

1. Rural electrification contributes to the correction of regional differential.
2. The site is not under construction or bidding
3. Output power is over 500 kW
4. There is no dangerousness of land mines.
5. The site is not in National Park or Protective Zone.

Only 2 sites (Cutato site, 1.6 MW and Luvolo site, 0.7 MW) of the FS candidate sites, could satisfy the No.3 issue of the implementation policy.

The 5 sites evaluation of other 4 issues is same. In fact the all 5 sites could satisfy the other 4 issues. That is that all candidate sites are necessary to be electrified, not under construction or bidding, no dangerousness of land mines (this intelligence is gotten from hearing from the residences) and not in National Park or Protective Zone.

The second screening of the implementation policy is targeting nature-social environment, data of hydrology, construction cost, water right and beneficial efficient.

Access road especially main road to Luvolo site is very bad. If it needs road repair and pavement for construction (transportation of materials, turbines and generators), it costs a large amount of money. The 2nd Site Reconnaissance of this study in rainy season will be dangerous at transportation. Furthermore adjustment of water utilization will become more important in future because people are using water for agriculture.
Therefore, Luvolo site was rejected as the FS site because of above reasons.

Cutato site is good at topography, geology and access compared to Luvolo site. Installed capacity of Cutato site is 1.6 MW (it is planned initially by using minimum river discharge) which is the biggest capacity in the candidate sites. The demand place of Cutato site is Andulo which population is about 300 thousands, so it appears the all generating energy can be easily consumed.

So Cutato site was selected in second screening as the FS site because its site is good site that its power plant generates the most energy in the candidate sites and has much demand place where its energy is easily consumed.

Table 3.3-1 shows the 5 sites comparison of environment impact assessment which is especially important. As for environment impact, there is little different estimation in each site compared to the intersectional estimation. Cutato site can be in same small environment impact as well as other sites, if environment impact mitigation measures will be done in design stage at Cutato site.

Because of above reasons, Cutato site was only selected to be the FS site in MINUTES OF MEETING of Sep.20, 2010 between DNEL and JICA Study Team, which title is “FINAL DISCUSSION BETWEEN NATIONAL DIRECTION OF ELECTRIFICATION”.

After that, same conclusion was made after the first and second screenings at JICA HQ in Tokyo on October 1, 2010.

Table 3.3-1 Comparison of Environmental Impact Evaluation for Five (5) Sites

COMMON	
Item	Evaluation
General	All the five projects, which are run of river type using a several meters high weir, will give smaller magnitude of environmental impact to a river ecosystem than that of dam type.
Natural Environment	
Protected Area	National parks and protected area do not exist in the project area or surrounding the project site.
Aquatic Creatures (Ecosystem)	During construction: This project is a new construction of small hydropower plant and construction area is small (probable affected area on riverbed is several hundred meters long). Therefore, negative impact to ecosystem looks generally small. During operation: Change of riverflow before and after the construction is extremely small. Therefore, negative impact to ecosystem is generally small. Still, it is necessary to confirm the existence of endangered species of fauna and flora and evaluate the impact to ecosystem in the project area.
Hydrology	During construction: Diverting river flow etc. is required. Also, small- scale excavation of riverbed is supposed. During operation: Compared with the phenomena before and after the completion of hydropower plant, river discharge will be only changed in dry season (because river water is prior to power generation), but not so different in rainy season. Reservoir is so formed by a weir that river bed level will be higher in the long term in upper area of reservoir
Topography and Geology (Impact by Excavation)	Large scale of cut or embankment is not planned for this project. Therefore, it can be considered that topographic and geological impact is a little.
Social Environment	
Involuntary Resettlement	Land acquisition for reservoir and access road will be required. However, possibility of involuntary resettlement is extremely low.
Water Use	During construction: Muddy water will affect the water use of the river, etc. surrounding the project sites. The muddy water should be treated. During operation: Total discharge of the river is not decreased in spite of intake for power generation, because power inflow is discharged just downstream.
Land Use	This is a project for development of local electrification. Cultivated area will be extended by supplying power for irrigation (Positive impact is expected). On the other hand, existing cultivated area may be submerged under the water or limited for use because of the reservoir.
Comprehensive Evaluation	In the stage of pre-scoping, significant difference of social environmental impact among each site has not been found in each evaluation item. However, environmental impact of each site is different depending on the scale of power generation and existence of construction facilities.
INDIVIDUAL SITE	
Site Name	Evaluation
Cutato	This is a new construction. Impact to upstream by the weir is larger because the power scale is larger than other sites. For example, in the case of design flood of 1,000 m^3/sec, it will have an impact up to approximately 15 km upper stream. However, socio-environmental impact is rather small because the both banks of riverbed look scarcely used.
Luvolo	It has an existing weir but needs to be repaired. Also, ancillary facilities for power plant will be required. Residents at the site use the river water for living, so compensation will be necessary during construction and operation.
Cunene	It has an existing weir but needs to be repaired. Also, ancillary facilities for power plant will be required. Residents at the site use the river water for living, so compensation will be necessary during construction and operation.
Poe	This is a new construction. The scale is extremely small and environmental impact is small.
Cuima	It has an existing weir but needs to be repaired. Also, ancillary facilities for power plant will be required. Residents at the site use the river water for living, so compensation will be necessary during construction and operation.
Comprehensive Evaluation	Compared with evaluation result of common part, it is considered that the difference of environmental impact among individual sites is smaller.

Evaluation table for site selection is shown below.

Table3.3-2 Evaluation Table for Site Selection

	Item \ Site name	1 Cutato	2 Luvolo	3 Cunene	4 Põe	5 Cuima	Remarks
1st Screening	1.1 Demand of Rural electrification	○	○	○	○	○	○ : Rural electrification is important in the project area × : Not so important
	1.2 Situation of Construction	○	○	○	○	○	○ : Nor bidding nor construction × : Under bidding or under construction
	1.3 Project scale	○	○	×	×	×	○ : More than 500 kW × : Less than 500 kW
	1.4 Safety	○	○	○	○	○	○ : No risk or small risk of landmines × : High risk of landmines
	1.5 Environmental impact	○	○	×	×	×	○ : Not in natural parks or protected areas × : In natural parks or protected areas
	Result of 1st screening	○	○	×	×	×	
2nd Screening	2.1 Accessibility	○	×	–	–	–	○ : Good accessibility × : Bad accessibility
	2.2 Impact to natural-social environment	△	△	–	–	–	○ : No impact △ : Small impact × : Big impact
	2.3 Availability of natural-social environmental data	△	△	–	–	–	○ : Data at the site is available △ : Data near the site is available × : No data
	Result of 2nd screening	○	△	–	–	–	
Evaluation		○	△	×	×	×	