Context of Appendix

Appendix A General information of Zambia

A.1 History

Between 1890 and September 1923, the territory now known as Zimbabwe and Zambia, which came to be called Rhodesia later after the name of Cecil John Rhodes, was administered by the British South Africa Company (BSAC) in terms of a Royal Charter granted by Queen Victoria. The Charter empowered the BSAC to, inter alia, make treaties, promulgate laws, preserve the peace, maintain a police force, acquire new concessions and generally provide, at the Company's expense, the infrastructure of a new Colony. In 1923, the British government chose not to renew the Company's charter, and instead accorded 'self-governing' colony status to Southern Rhodesia (present-day Zimbabwe) and protectorate status to Northern Rhodesia (present-day Zambia).

The capital of Northern Rhodesia was moved from Livingstone to Lusaka in 1935. In 1953, Northern Rhodesia with Nyasaland (present-day Malawi) and Southern Rhodesia formed the Federation of Rhodesia and Nyasaland (Central African Federation). Upon dissolution of the Federation in 1963, Northern Rhodesia achieved independence from the United Kingdom as the Republic of Zambia on October 24, 1964.

As for the colony of Southern Rhodesia, following the aforementioned dissolution of the Federation, it unilaterally declared its independence from the United Kingdom as the Republic of Rhodesia on November 11, 1965, and continued to apply policies based on racial discrimination. The African racial administration was inaugurated as a result of the general elections in 1980, and the country then achieved formal independence from the United Kingdom as the Republic of Zimbabwe.

As the history of power development in Zambia will be detailed in Section C.**1**, most of the still operating big projects were installed before the independence of Zambia, such as Victoria Falls in 1938 and Kariba Dam in 1958.

A.2 Geography

A.2.1 Land Area

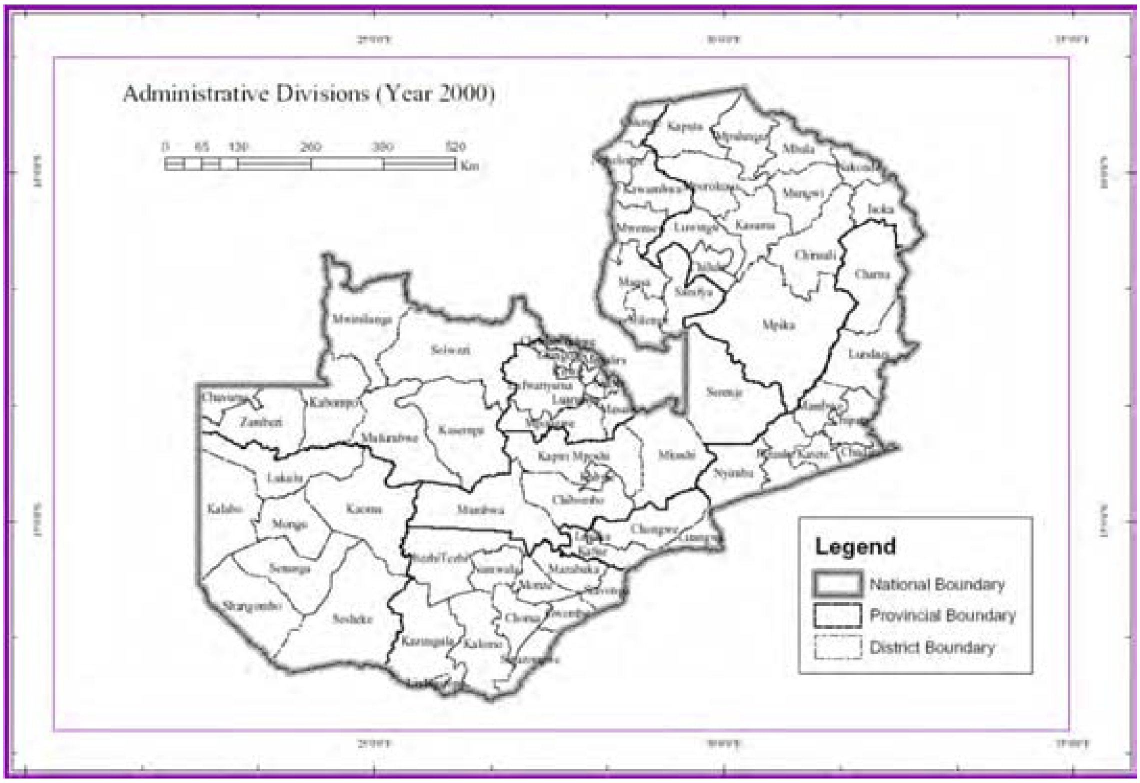
The territory of Zambia lies in the inland of southern Africa and measures 752,614 square kilometers. It shares borders with a total of eight countries: the Democratic Republic of the Congo (DRC) and the United Republic of Tanzania to the north, the Republic of Malawi and the Republic of Mozambique to the east, the Republic of Zimbabwe and the Republic of Botswana to the south, the Republic of Namibia to the southwest, and the Republic of Angola to the west.

Zambia's border is 5,664 kilometers long. The length of the border with each neighbor is shown in Table A. 1. The border with Botswana is at the point of intersection with those of Namibia and Zimbabwe.

Table A. 1 Length of Border

Country	length of border (km)
Angola	1,110
Botswana	--
DR Congo	1,930
Malawi	837
Mozambique	419
Namibia	233
Tanzania	338
Zimbabwe	797
Total	5,664

Zambia consists of nine provinces (Central, Copperbelt, Eastern, Luapula, Lusaka, Northern, North-Western, Southern, and Western). The capital is Lusaka, sited in the Lusaka Province, almost center of the country. Each province is divided into districts, which number 72 nationwide, which are themselves divided into wards, the smallest administrative unit. The 2000 National Census found a total of 1,286 wards. Figure A. 1 shows the administrative divisions and Table A. 2shows the outline of each province in Zambia in year 2000.



(Source) 2000 Census of Population and Housing

Figure A. 1 Administrative divisions in Zambia

Table A. 2 Outlines of provinces in Zambia

	Province	Capital	Area (km²)	Number of Districts	Number of Wards
1	Central	Kabwe	94,394	6	112
2	Copperbelt	Ndola	31,328	10	202
3	Eastern	Chipata	69,106	8	154
4	Luapula	Mansa	50,567	7	111
5	Lusaka	Lusaka	21,896	4	75
6	Northern	Kasama	147,826	7	201
7	North Western	Solwezi	125,826	12	122
8	Southern	Livingstone	85,283	11	172
9	Western	Mongu	126,386	7	137
	Total		752,612	72	1,286

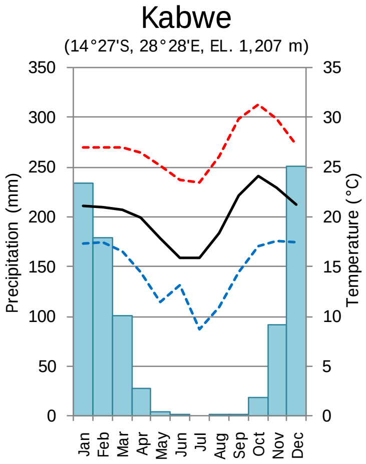
(Source) 2000 Census of Population and Housing

A.2.2 Climate

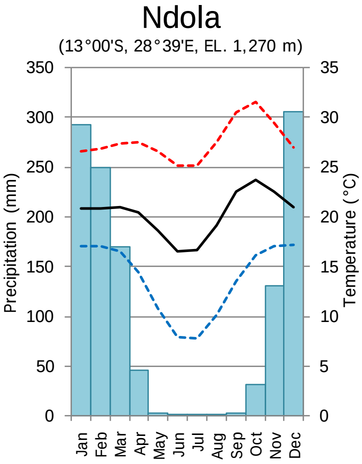
Zambia lies between 8 and 18 degrees in latitude south, and between 23 and 24 in longitude east (Lusaka, the capital is located at 15 degrees 25' 0" south and 28 degrees 17' 0" east). Climatically, it is situated in the tropical zone. With the exception of the Zambezi and Luangwa river basins, however, it consists of highlands ranging in elevation from 1,000 to 1,300 meters. Although the climate is classified as tropical, it is fairly moderate. In Lusaka, the average temperature is 21 degrees (centigrade) in January and 16 degrees in July.

The yearly rainfall is in the range of 500 - 1,500 millimeters, but there is a big difference between the rainy and dry seasons. The dry season lasts from May to August, and the rainy season, from December to April.

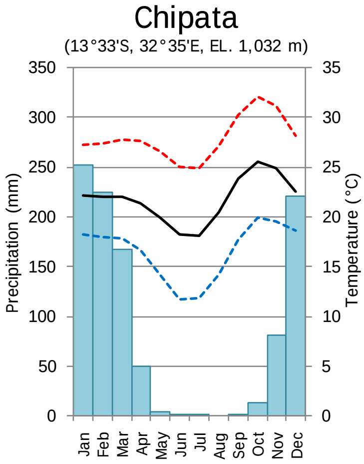
Figure A. 2 shows the trend of monthly temperature (average, maximum and minimum) and precipitation in the nine provincial capitals. Table A. 3 also shows annual temperature (average, maximum and minimum) and precipitation in the observation points in Zambia.



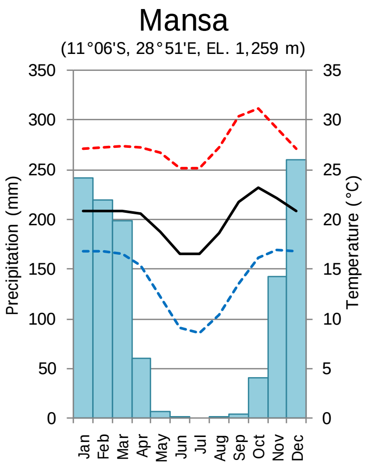
(a) Central Province



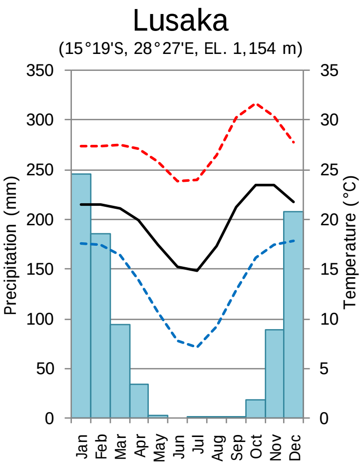
(b) Copperbelt Province



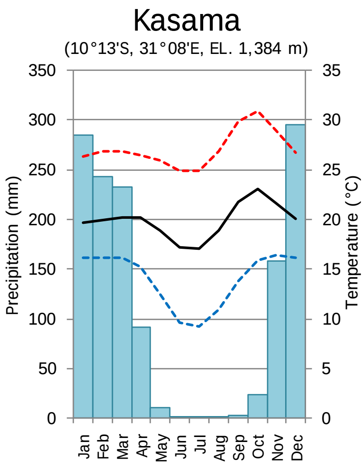
(c) Eastern Province



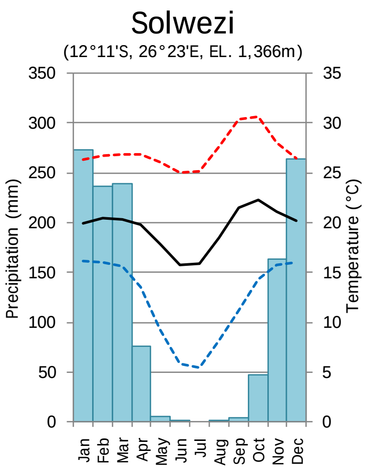
(d) Luapula Province



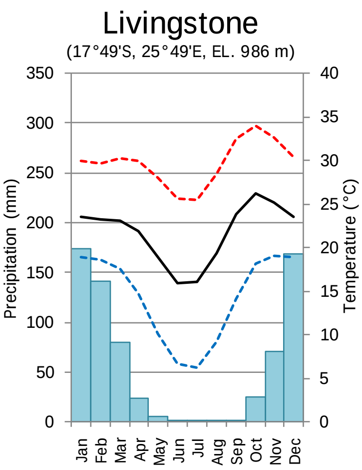
(e) Lusaka Province



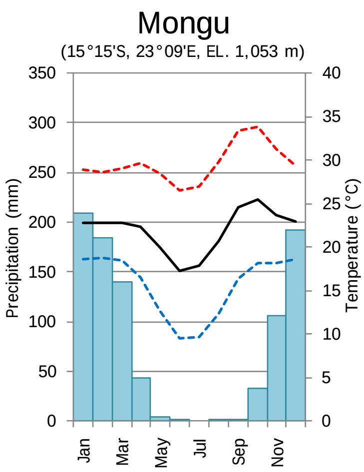
(f) Northern Province



(g) North-Western Province



(h) Southern Province



(i) Western Province

(Source) Made by the Study Team based on NOAA Global Climate Normals 1961-1990.

Figure A. 2 Precipitation and Temperature

Table A. 3 Annual average temperature and precipitation at observation stations

	Station	Province	South Latitude	East Longitude	Altitude (masl)	Temperature annual mean value (°C)			Annual Precipitation (mm)
						average	high	low	
1	Kabwe	Central	14°27'	028°28'	1,207	20.1	27.0	14.7	907.7
2	Kabwe Agric	Central	14°24'	028°30'	n/a	n/a	27.9	13.6	917.7
3	Mumbwa	Central	15°04'	027°11'	1,218	n/a	27.7	13.8	891.2
4	Serenje	Central	13°14'	030°13'	n/a	n/a	26.1	12.8	1,133.6
5	Kafironda	Copperbelt	12°36'	028°07'	n/a	19.1	28.2	11.5	1,309.1
6	Ndola	Copperbelt	13°00'	028°39'	1,270	20.3	27.6	13.8	1,232.8
7	Chipata	Eastern	13°33'	032°35'	1,032	21.8	27.9	16.5	1,016.9
8	Lundazi	Eastern	12°17'	033°12'	n/a	n/a	27.5	14.1	922.9
9	Mfuwe	Eastern	13°16'	031°56'	570	n/a	32.2	16.5	817.5
10	Msekera	Eastern	13°39'	032°34'	n/a	n/a	28.5	15.9	1,011.7
11	Petauke	Eastern	14°15'	031°17'	1,036	n/a	26.6	15.6	966.8
12	Kawambwa	Luapula	09°48'	029°05'	1,324	20.8	27.6	15.1	1,378.6
13	Mansa	Luapula	11°06'	028°51'	1,259	20.1	27.6	14.1	1,176.6
14	Lusaka City A.	Lusaka	15°25'	028°19'	n/a	19.9	26.3	14.8	1,078.1
15	Lusaka Int'l	Lusaka	15°19'	028°27'	1,154	19.9	27.5	13.7	882.1
16	Mount Makulu	Lusaka	15°33'	028°15'	n/a	20.3	27.1	14.5	856.7
17	Isoka	Northern	10°07'	032°38'	n/a	20.0	27.2	14.4	1,090.0
18	Kasama	Northern	10°13'	031°08'	1,384	19.9	27.1	14.0	1,343.2
19	Mbala	Northern	08°51'	031°20'	1,673	18.6	24.9	13.7	1,239.1
20	Misamfu	Northern	10°06'	031°15'	n/a	19.6	26.6	13.0	1,349.7
21	Mpika	Northern	11°54'	031°26'	1,402	19.2	25.8	14.0	1,040.0
22	Kabompo	North-Western	13°36'	024°12'	n/a	21.1	29.8	14.0	1,034.4
23	Kasempa	North-Western	13°32'	025°51'	1,234	n/a	28.2	13.2	1,146.8
24	Mwinilunga	North-Western	11°45'	024°26'	1,363	19.3	27.4	12.9	1,057.4
25	Solwezi	North-Western	12°11'	026°23'	1,366	19.5	27.2	12.3	1,309.7
26	Zambezi	North-Western	13°32'	023°07'	1,078	21.4	29.5	13.9	1,057.4
27	Choma	Southern	16°50'	027°04'	1,278	19.1	26.6	11.8	801.6
28	Kafue Polder	Southern	15°46'	027°55'	978	21.3	28.7	n/a	n/a
29	Livingstone	Southern	17°49'	025°49'	986	21.7	29.7	14.4	691.7
30	Magoye	Southern	16°00'	027°36'	1,018	n/a	28.8	13.8	737.3
31	Kaoma	Western	14°48'	024°48'	1,213	n/a	29.3	13.5	902.4
32	Mongu	Western	15°15'	023°09'	1,053	21.9	29.6	15.7	918.2
33	Senanga	Western	16°06'	023°16'	n/a	n/a	30.5	15.6	729.7
34	Sesheke	Western	17°28'	024°18'	951	21.5	30.1	13.1	756.3

(Source) Made by the Study Team based on NOAA Global Climate Normals 1961-1990.

A.3 Society

A.3.1 Population

The first National Census was conducted in 1969 and the second census was in 1980. The following censuses have been supposed to be once every ten years and the latest one was in 2000.

The past National Censuses indicate that the total population rose from 5.7 million in 1980 to 7.4 million in 1990 and 9.9 million in 2000. The rate of population growth is in gradual decline; it went from 3.1 percent over the years 1970 - 1979 to 2.7 percent over those of 1980 - 1989 and 2.4 percent over those of 1990 - 1999.

According to the results of the 2000 National Census, the province with the largest population then was Copperbelt at 1,581,221 or 16.1 percent of the total, and that with the smallest was North-Western at 583,350 or 5.9 percent. In the 1990s, the highest average annual population growth rates were posted by the provinces of Lusaka, Luapula, and Northern at 3.4, 3.2, and 3.1 percent, respectively. In Copperbelt, the most populous province, the corresponding rate was 0.8 percent, the lowest of all provinces.

Table A. 4 Trend of population and population growth ratio

Residence	1969-1980		1980-1990		1990-2000	
	Population Size 1980	Annual Growth Rate	Population Size 1990	Annual Growth Rate	Population Size 2000	Annual Growth Rate (de jure)
ZAMBIA-Total	5,661,801	3.1	7,383,097	2.7	9,885,591	2.4
Rural	3,403,281	1.6	4477814	2.8	6,458,729	3.0
Urban	2,258,520	6.0	2905283	2.6	3,426,862	1.5
PROVINCE						
Central	511,905	3.3	720,627	3.5	1,012,257	2.7
Copperbelt	1,251,178	4.0	1,427,545	1.3	1,581,221	0.8
Eastern	650,902	2.3	965,967	4.0	1,306,173	2.6
Luapula	420,966	2.1	525,160	2.2	775,353	3.2
Lusaka	691,054	6.3	987,106	3.6	1,391,329	3.4
Northern	674,750	2.0	855,177	2.4	1,258,696	3.1
North-Western	302,668	2.5	387,552	2.5	583,350	2.9
Southern	671,923	2.8	907,150	3.0	1,212,124	2.3
Western	486,455	1.6	606,813	2.2	765,088	1.8

(Source) CSO, 1990 and 2000 Censuses of Population and Housing

On the other hand, the Central Statistical Office estimated that the population in 2008 is 12.5 millions and that the rate of population growth after 2000 is 3.0 percent after 2000 rebounding again as shown in Table A**. 5**. As stated in Section B**.1**, the government has officially expressed the vision to become a middle income nation by 2030, and claimed that it required restriction of population growth along with high economic growth. Specifically, the average population growth rate up to 2030 less than 1.0 percent was laid as an indicator.

Table A. 5 Estimation of the latest trend of population

	2001	2002	2003	2004	2005	2006	2007	2008
Total Population	10,089,492	10,409,441	10,744,380	11,089,691	11,441,461	11,798,678	12,160,516	12,525,791
Population Growth Rate	3.1	3.1	3.1	3.1	3.1	3.0	3.0	2.9
Life Expectancy at Birth	51.8	51.9	52.4	52.4	52.6	51.9	51.4	51.3
POPULATION BY PROVINCE								
Central	1,032,574	1,066,992	1,103,387	1,141,256	1,180,124	1,219,980	1,260,491	1,301,776
Copperbelt	1,611,569	1,662,155	1,714,225	1,767,165	1,820,443	1,874,081	1,927,576	1,980,824
Eastern	1,348,070	1,391,690	1,436,120	1,482,290	1,530,118	1,579,960	1,631,890	1,684,910
Luapula	791,067	817,326	845,076	873,969	903,746	934,317	965,605	997,579
Lusaka	1,413,010	1,453,690	1,495,730	1,538,000	1,579,769	1,620,730	1,660,070	1,697,730
Northern	1,277,250	1,315,650	1,357,540	1,401,340	1,445,730	1,490,330	1,534,170	1,577,310
North-western	596,010	616,496	638,004	660,322	683,367	707,074	731,351	756,261
Southern	1,235,134	1,275,470	1,318,161	1,362,382	1,407,433	1,453,324	1,499,462	1,545,880
Western	774,929	795,247	816,983	839,757	863,294	887,540	912,226	937,419

(Source) C.S.O., Population Projections Report

As for population density, the average number of persons per square kilometer increased from 7.5 in 1980 to 9.8 in 1990, and 13.1 in 2000. There are big interprovincial disparities in respect of population density; in 2000, the corresponding number was highest in Lusaka Province at 63.5 and lowest in North-Western Province at 4.6.

Table A. 6 Trend of population density in each province

Province	Area (km^2)	Percent Distribution of Population			Population Density (per sq.km)		
		1980	1990	2000	1980	1990	2000
Central	94,394	9.0	9.9	10.2	5.4	7.6	10.7
Copperbelt	31,328	22.1	18.8	16.0	39.9	45.6	50.5
Eastern	69,106	11.5	12.9	13.2	9.4	13.9	18.9
Luapula	50,567	7.4	7.3	7.8	8.3	10.4	15.3
Lusaka	21,896	12.2	12.8	14.1	31.6	45.1	63.5
Northern	147,826	11.9	11.9	12.7	4.6	5.8	8.5
North Western	125,826	5.4	5.6	5.9	2.4	3.1	4.6
Southern	85,283	11.9	12.4	12.3	7.9	10.6	14.2
Western	126,386	8.6	8.2	7.7	3.9	4.8	6.1
Total	752,612	100.0	100.0	100.0	7.5	9.8	13.1

(Source) 2000 Census of Population and Housing, Summary Report

A.3.2 Ethnicity, Languages and Religions

(1) Ethnicity

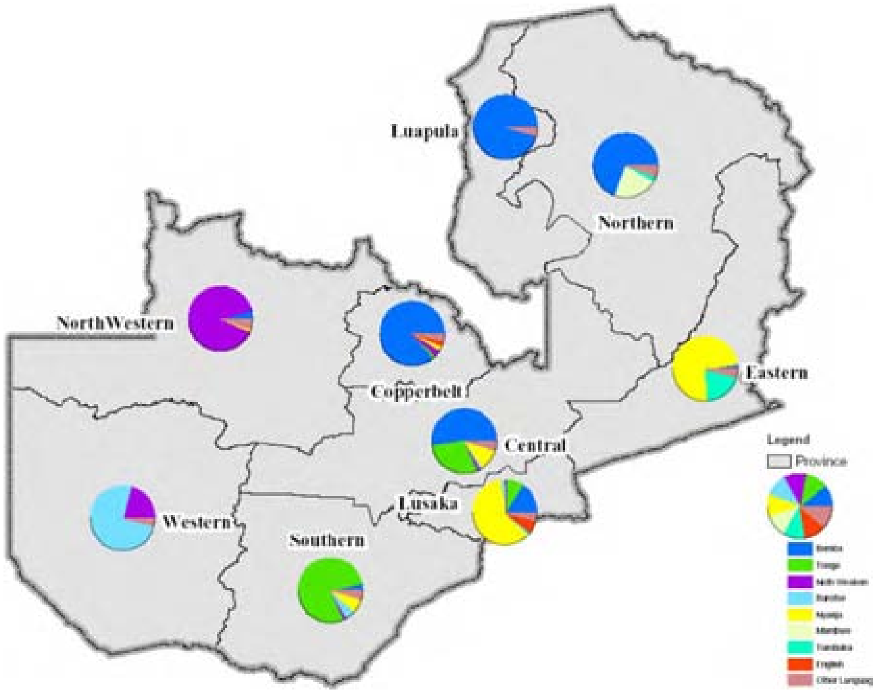
According to the National Census in 2000, almost all Zambians are ethnically African as shown in Table A. 7.

Table A. 7 Ethnic groups in Zambia

Residence/Sex		Ethnic Group					
		African	American	Asian	European	Other	Total
Zambia	Male	4,572,026	691	6,272	3,462	11,839	4,594,290
	Female	4,722,128	507	5,576	2,720	12,204	4,743,135
	Both Sexes	9,294,154	1,198	11,848	6,182	24,043	9,337,425
Percent of total population		99.54	0.01	0.13	0.07	0.26	100
Rural	Male	2,921,867	227	343	1,036	8,078	2,931,551
	Female	3,049,023	160	270	825	8,527	3,058,805
	Both Sexes	5,970,890	387	613	1,861	16,605	5,990,356
Percent of total population		99.68	0.01	0.01	0.03	0.28	100
Urban	Male	1,650,159	464	5,929	2,426	3,761	1,662,739
	Female	1,673,105	347	5,306	1,895	3,677	1,684,330
	Both Sexes	3,323,264	811	11,235	4,321	7,438	3,347,069
Percent of total population		99.29	0.02	0.34	0.13	0.22	100

(Source) 2000 Census of Population and Housing

Moreover, Zambia's Africans are divided into a total of 73 tribes, the main ones being Tonga, Nyanja-Chewa, Bemba, and Lunda. Figure A. 3 shows the distribution of tribes.



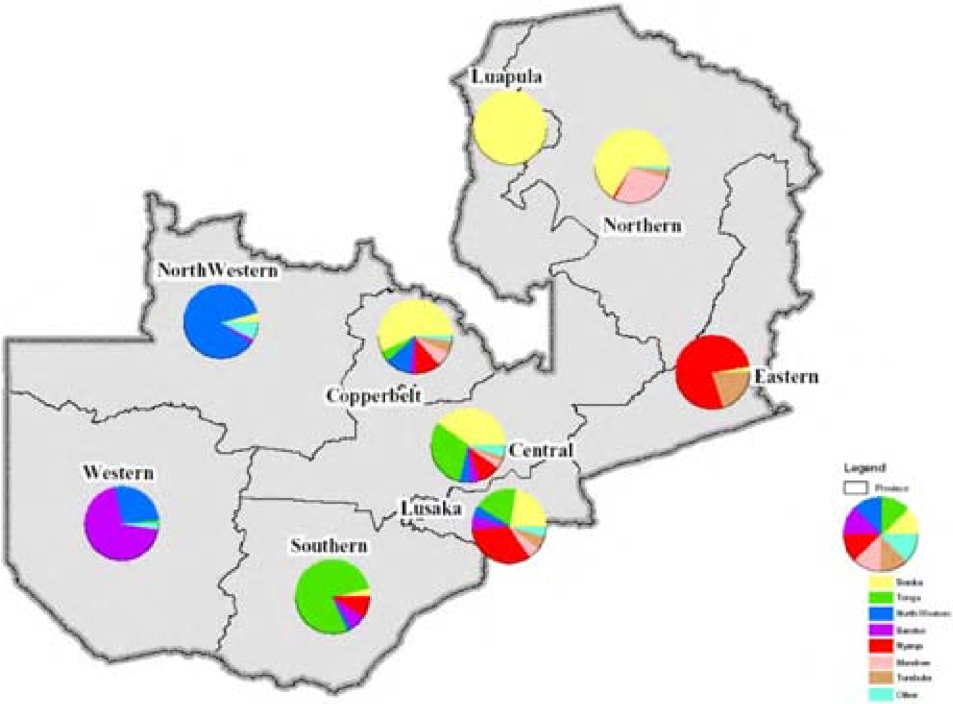
(Source) 2000 Census of Population and Housing

Figure A. 3 Ethnic Groups in Zambia

(2) Languages

The official language of Zambia is the English language, and the official documents such as laws and regulations, government documents are described in English.

On the other hand, daily conversation is generally conducted in native tribal languages, especially in rural areas. There are seven major languages of daily conversation (i.e., Bemba, Kaonde, Lozi, Lunda, Luvale, Nyanja, and Tonga). Bemba is spoken mainly in the provinces of Northern, Luapula, Copperbelt, and Central, and the Kaonde and Lunda languages, in North-Western Province. Lozi, Nyanja, and Tonga are spoken in Western, Eastern and Lusaka, and Southern provinces, respectively. Figure A. **4** shows the distribution of native languages in Zambia.



(Source) 2000 Census of Population and Housing

Figure A. 4 Native Languages in Zambia

(3) Religions

A large share of the population is occupied by Roman Catholics, but a variety of traditional religions are prevalent in rural areas and there are some Muslim and Hindu in the country.

A.4 Politics

(1) Government

Zambia is a constitutional republic with a president, who is both the head of state and the chief of the executive branch. National ministers are appointed by the president from the membership of the national assembly.

The president is directly elected by the citizens and serves a term of five years.

Mr. Rupiah Banda, the current president, was vice-president under the preceding administration of Mr. Levy Mwanawasa. On August 19, 2008, he began to act as president in place of Mr. Mwanawasa, who had become unable to discharge his duties because of illness. He was officially chosen to serve as the fourth president as a result of the special election held on October 30, 2008 after Mr. Mwanawasa's death. The next presidential election is scheduled to be held in 2011, when the term of the ex-president expires.

Table A. 8 shows the results of the presidential election last year.

Table A. 8 Presidential Election (October 2008)

Candidate	Percent of vote	Party
Rupiah Banda	40.1	MMD: Movement for Multiparty Democracy
Michael Sata	38.1	PF: Patriotic Front
Hakainde Hichilema	19.7	UPND: United Party for National Development
Godfrey Miyanda	0.8	HP: Heritage Party
Other	1.3	

(2) National Assembly

Zambia has a unicameral national assembly with a quorum of 158 seats. Of these, 150 seats are filled by direct election by the citizenry, and the remaining eight, by presidential appointment. Members of the national assembly serve a term of five years.

Following its independence in 1964, Zambia was long governed by a single party, i.e., the United Independence Party (UNIP). Partly due to pressure from the international community in favor of a multiparty arrangement, it enacted a new constitution recognizing the existence of different political parties in 1990 and held its first elections under the new order in 1991.

The current ruling party is the Movement for Multiparty Democracy (MMD), which was victorious in the general election held in September 2006. The list of opposition parties includes the Patriotic Front (PF) and the United Party for National Development (UPND). Table A. 9 shows the number of seats held by each party in the national assembly.

Table A. 9 Outcome of Generation Election (September 28, 2006)

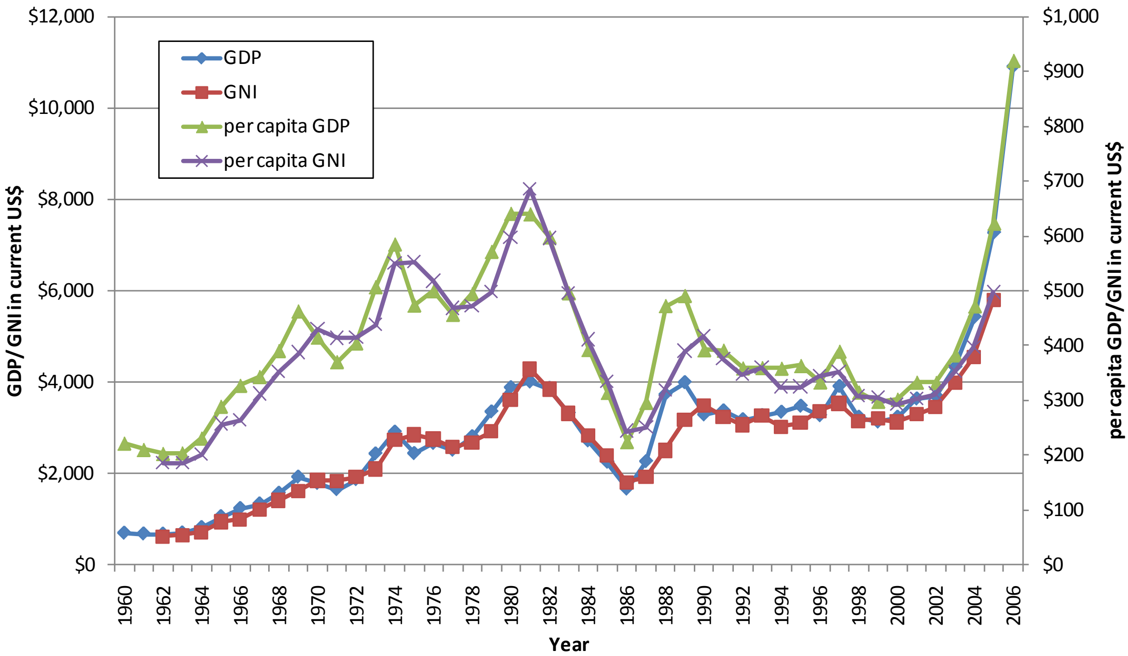
Party	Number of seats
Movement for Multiparty Democracy (MMD)	72
Patriotic Front (PF)	44
United Democratic Alliance (UDA)	27
United Liberal Party (ULP)	2
National Democratic Focus (NDF)	1
independents	2
not determined	2
Total	150

A.5 Economy

Zambia's economy has been characterized since the colonial days, as monoculture depending on copper production which holds 60 % of the total export. Therefore the fluctuation of copper production and its international price have big influence on the economy.

The ex-government advocated the industrial restructuring focusing on the development of agriculture and tourism as one of the top priority policies, in order to overcome such economic structure.

In recent years, Zambia's economy has experienced strong growth, with real GDP growth in 2005-08 about 6% per year (see Figure A. 5). Privatization of government-owned copper mines in the 1990s relieved the government from covering mammoth losses generated by the industry and greatly improved the chances for copper mining to return to profitability and spur economic growth. Copper output has increased steadily since 2004, due to higher copper prices and foreign investment. In 2005, Zambia qualified for debt relief under the Highly Indebted Poor Country Initiative, consisting of approximately USD 6 billion in debt relief. Zambia experienced a bumper harvest in 2007, which helped to boost GDP and agricultural exports and contain inflation. Although poverty continues to be significant problem in Zambia, its economy has strengthened, featuring single-digit inflation, a relatively stable currency, decreasing interest rates, and increasing levels of trade. The decline in world commodity prices and demand will hurt GDP growth in 2009, and elections and campaign promises are likely to weaken Zambia's improved fiscal stance.



(Source) "World Development Indicators database", World Bank

Figure A. 5 Trend of GDP and GNI in Zambia

Table A. 10 outlines main indicators of Zambian economy.

Table A. 10 Principal indicators of Zambia Economy

GDP:		2008 est.	2007	2006
- purchasing power parity	billion $	17.39	16.43	15.55
- official exchange rate	billion $	15.23 (2008 est.)		
- real growth rate	%	5.8	5.7 (est.)	6.2 (est.)
- per capita (PPP)	US$	1,500	1,400 (est.)	1,400 (est.)
- composition by sector	%	- agriculture: 16.7 - industry: 26.0 - services: 57.3 (2008 est.)		
Labor force:		5,093 million (2008 est.)		
- by occupation	%	- agriculture: 85 - industry: 6 - services: 9 (2004)		
- Unemployment rate	%	50 (2000 est.)		
Household income or consumption by percentage share:		- lowest 10 %: 1.2 - highest 10 %: 38.8 (2004)		
Gini index (distribution of family income):		50.8 (2004)		
Investment (gross fixed):		26% of GDP (2008 est.)		
Budget:	million $	- revenues: 3,777 - expenditures: 4,104 (2008 est.)		
Public debt:		25.7 % of GDP (2008 est.)		
Inflation rate (consumer prices):		11.8 % (2008 est.)		
Central bank discount rate:		11.73 % (Dec. 31, 2007)		
Commercial bank prime lending rate:		18.89 % (Dec. 31, 2007)		
Stock of money:		$995.8 million (Dec. 31, 2007)		
Stock of quasi money:		$1,709 million (Dec. 31, 2007)		
Stock of domestic credit:		$1,968 million (Dec. 31, 2007)		
Market value of publicly traded shares:		$2,346 million (Dec. 31, 2007)		
Agriculture products:		corn, sorghum, rice, peanuts, sunflower seed, vegetables, flowers, tobacco, cotton, sugarcane, cassava (tapioca), coffee; cattle, goats, pigs, poultry, milk, eggs, hides		
Industries:		copper mining and processing, construction, foodstuffs, beverages, chemicals, textiles, fertilizer, horticulture		
Industrial production growth rate:		7 % (2008 est.)		
Electricity:				
- production	GWh	9,289 (2006 est.)		
- consumption	GWh	8,625 (2006 est.)		
- exports	GWh	255 (2006)		
- imports	GWh	68 (2007 est.)		
Oil:				
- production	bbl/day	150 (2007 est.)		
- consumption	bbl/day	14,760 (2006 est.)		
- exports	bbl/day	190.6 (2005)		
- imports	bbl/day	13,810 (2005)		
Natural gas				
- production	cu m	0 (2007 est.)		
- consumption	cu m	0 (2007 est.)		
- exports	cu m	0 (2007 est.)		
- imports	cu m	0 (2007 est.)		
Current account balance		-$478 million (2008 est.)		

<table>
<tr><td colspan="2">Exports:</td><td colspan="5">$5,632 million FOB (2008 est.)</td></tr>
<tr><td colspan="2">- commodities:</td><td colspan="5">copper/cobalt 64%, cobalt, electricity; tobacco, flowers, cotton</td></tr>
<tr><td colspan="2">- partners:</td><td colspan="5">Switzerland 41.8%, South Africa 12%, Thailand 5.9%, Democratic Republic of the Congo 5.3%, Egypt 5%, Saudi Arabia 4.7%, China 4.1% (2007)</td></tr>
<tr><td colspan="2">Imports:</td><td colspan="5">$4,423 million FOB (2008 est.)</td></tr>
<tr><td colspan="2">- commodities:</td><td colspan="5">machinery, transportation equipment, petroleum products, electricity, fertilizer; foodstuffs, clothing</td></tr>
<tr><td colspan="2">- partners:</td><td colspan="5">South Africa 47.4%, UAE 6.3%, China 6%, India 4.1%, UK 4% (2007)</td></tr>
<tr><td colspan="2">Reserves of foreign exchange and gold:</td><td colspan="5">$1.35 billion (Dec. 31, 2008 est.)</td></tr>
<tr><td colspan="2">Debt - external:</td><td colspan="5">$2.913 billion (Dec. 31, 2008 est.)</td></tr>
<tr><td rowspan="2">Exchange rates:
Zambian kwacha (ZMK) per US dollar</td><td rowspan="2">ZMK/$</td><td>2008 est.</td><td>2007</td><td>2006</td><td>2005</td><td>2004</td></tr>
<tr><td>3,512.9</td><td>3,990.2</td><td>3,601.5</td><td>4,463.5</td><td>4,778.9</td></tr>
</table>

(Source) CIA “The World Fact Book

A.6 Communication and transportation

Although Zambia is a relatively well-watered country as its abundant hydropower generation but is mainly flat, meaning there are many navigable rivers, lakes and channels through swamps, which together reach a large proportion of the rural population, none of the major urban centers are located on usable waterways. Railways and road transportation are main communication and transportation means. The outline of railways and roads in Zambia are stated in the following.

A.6.1 Railways

Zambian railway system consists of mainly two systems indicated in Figure A. 6; the Zambia Railways limited (ZRL) system running from north to south across the central land area, which connects Zimbabwe and the Democratic Republic of the Congo, and the TAZARA Railways system running Kapiri-Mposhi in the Central Province to Dar es Salaam in Tanzania.

The administration for railways is under the Ministry of Communication and Transportation (MCT), which has the departments of Civil Aviation, Communications, Meteorology, Road Transport, Maritime and Inland Water Transport, and Planning, but no department for railways. The Safety and Compliance section has the responsibility for railways administration.

(Source) Made by the Study Team based on UN, 2004.

Figure A. 6 Railway network in Zambia

(1) Zambia Railways

Southern African region has most developed regional railway network in the African continent, since railway construction was promoted in the colonial age as the mean of transportation to take out of mineral resources of inland countries to ports.

In Zambia, railway business was started as a part of Rhodesian Railways. The railway system expanded to Livingstone in 1905, Broken Hill (present Kabwe) in 1906, Ndola in 1909 and finally connected to Sakania in Congo.

In the mid 1960s spurred by the Rhodesian UDI crisis, the newly-independent Zambia split its railways off from Rhodesia Railways, and Zambia Railways came into being.

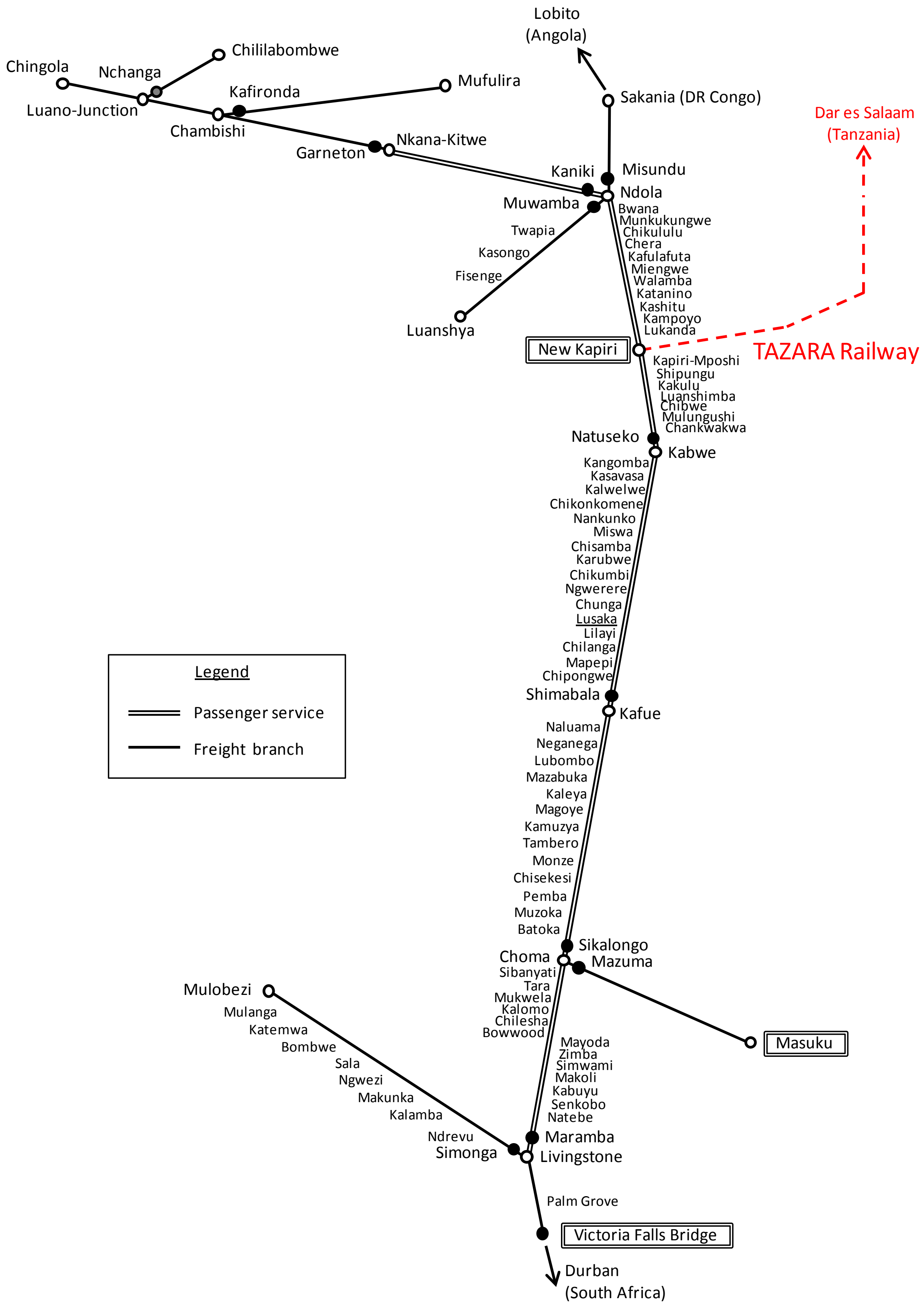
Aging of the facility due to lack of investment was problematic in Zambia Railways as is the case with other state enterprises such as electricity and mining industries, so that the privatization of Zambia Railways was conducted by the transfer of the concession to private enterprise with the support from the World Bank in February 2003. In other words, while the assets such as land, railroad, station house etc. were still owned and managed by Zambia Railways, operation and service were conducted by Railway Systems of Zambia limited (RSZ).

RSZ is a subsidiary of New Limpopo Project Investment (Pvt) Ltd. (NLPI) registered in

Mauritius. NLPI is a substantially South African investment company established to participate in railway projects jointly with Spoornet which is a subsidiary in railway division of Transnet (the transport corporation of South Africa), which large financial institutions in South Africa such as Nedbank Limited, Sanlam Life Insurance Limited and Old Mutual Life Assurance Company (SA) Limited invested in. NLPI has also invested in the New Limpopo Bridge Projects Limited (NLB) registered in Zimbabwe which built and owned the toll bridge for locomotives and automobiles connecting between South Africa and Zimbabwe by the first BOT scheme in Africa. NLPI made a provision of US$40 million for the rehabilitation of Zambia Railways. The World Bank funded an additional investment of approximately US$30 million to finance Zambia Railways staff retrenchment packages, locomotive rehabilitation and other related projects.

As shown in Figure A. 7, Zambia Railways comprises 847 km of trunk line with passenger service from Kitwe to Livingstone and other many freight branch lines. Chamishi- Mufulira, Nchanga- Chingola, Nchanga- Chililabombwe, Ndola- Luanshya lines in the Copperbelt Province are all for exclusive use of copper mines. Choma- Masuku line is for Maamba Collieries and Livingstone- Mulobezi line for lumber business. The Concession for RSZ will operate for a period of 20 years for freight service between Kitwe and Livingstone.

Internationally, Zambia Railways connects to Sakania in the Democratic Republic of the Congo through Ndola in the Copperbelt Province, and finally to Lobito Bay in Angola (details are described later). Moreover, ZR connects to Durban in South Africa through Livingstone and Victoria Falls Bridge via Bulawayo in Zimbabwe, and to Dar es Salaam from New Kapiri Mukushi through TAZARA Railways. These international corridors were put together in A.6.3.



(Source) http://www.railtracker.org/RailAFFILIATES/Railways/ZR/zrrailnt.htm

Figure A. 7 Zambia Railways diagram

(2) TAZARA Railway

After World War I, Tanganyika (then German East Africa) was handed over to Britain for administration as a League of Nations Mandate. A railway was envisioned from Northern Rhodesia (later Zambia) to Tanganyika as a part of Cape- Cairo railway. However, the plans lay dormant was not economically justified.

Only a year after Zambia's independence, Rhodesia's white-supremacist government issued its Unilateral Declaration of Independence from Britain, threatening Zambia's trade routes. President Nyerere of Tanzania and President Kaunda of Zambia pursued different avenues for the construction of an alternative rail route.

On September 6, 1967, an agreement was signed in Beijing by the three nations. China committed itself to building a railroad between Tanzania and Zambia, supplying an interest-free loan of $ 400 million to be repaid over 30 years. Construction was begun in 1970 and operation commenced six years later.

The line starts at the port of Dar-es-Salaam crossing Tanzania in a south-west direction and enters Zambia, and links to Zambia Railways at Kapiri Mposhi. Total length is 1,859 kilometers including 750 km in Tanzania. The gauge is 3 ft 6 in (1,067 mm) to match Zambia Railways. There was originally no connection with the 1,000 mm (3 ft 3⅜ in) of Tanzania Railways Corporation (TRC) system at the port of Dar-es-Salaam.

The operation and management has been conducted by the Tanzania Zambia Railway Authority (TAZARA) jointly invested by the governments of Tanzania and Zambia. However, as is the case with ZR, the deterioration of transportation ability due to aging of facility and equipment, and lack of capital investment is so serious that the privatization of TAZARA is being investigated.

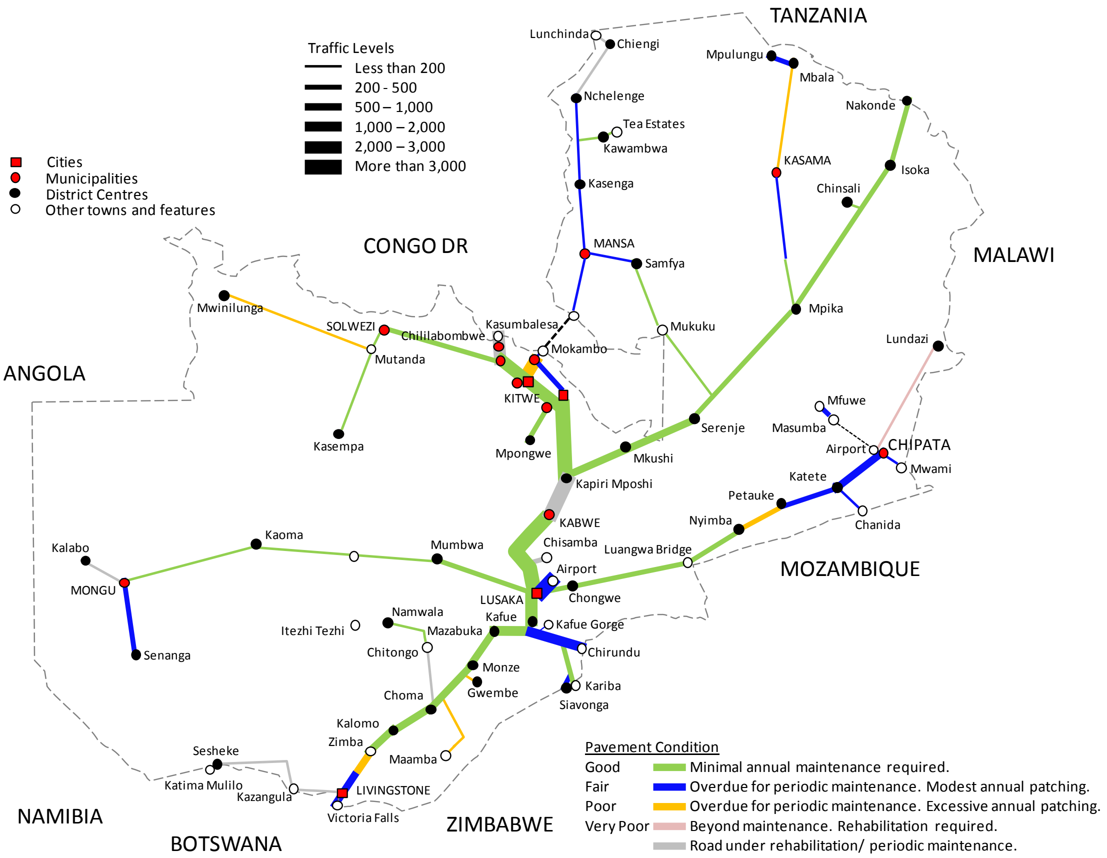
A.6.2 Roads

Before the establishment of Public Road Act in 2002, respective ministries such as Ministry of Works and Supply, Ministry of Local Government and Housing, Ministry of Tourism, Environment and Natural Resources, Ministry of Communication and Transportation, Ministry of Agriculture, Ministry of Justice and Ministry of Finance and National Planning controlled the agencies concerned with road. The Public Road Act systematized the road administration with three agencies by objective; Road Development Agency (RDA) responsible for road construction and maintenance, National Road Fund Agency (NRFA) for finance and budget and Road Transport and Safety Agency (RTSA) responsible for road safety and licencing.

The ministries related to road administration in the past are involved in the road policies organizing the National Roads Board (NRB) which are held twice a year.

According to NRFA, Zambia has total length 91,440 km of roads including paved 20,117 km (trunk main and district 6,779 km) and unpaved 71,323 km.

The trunk main and district paved road network are indicated in Figure A. 8.



(Source) Made by the Study Team after NRFA web site (http://www.nrfa.org.zm/Road%20Network.pdf)

Figure A. 8 Trunk main and district paved road network in Zambia

A.6.3 International corridors

The securement of international corridors is a lifeline to export mineral resources for landlocked Zambia. For power sector, it is quite important to transport equipment and import fuel.

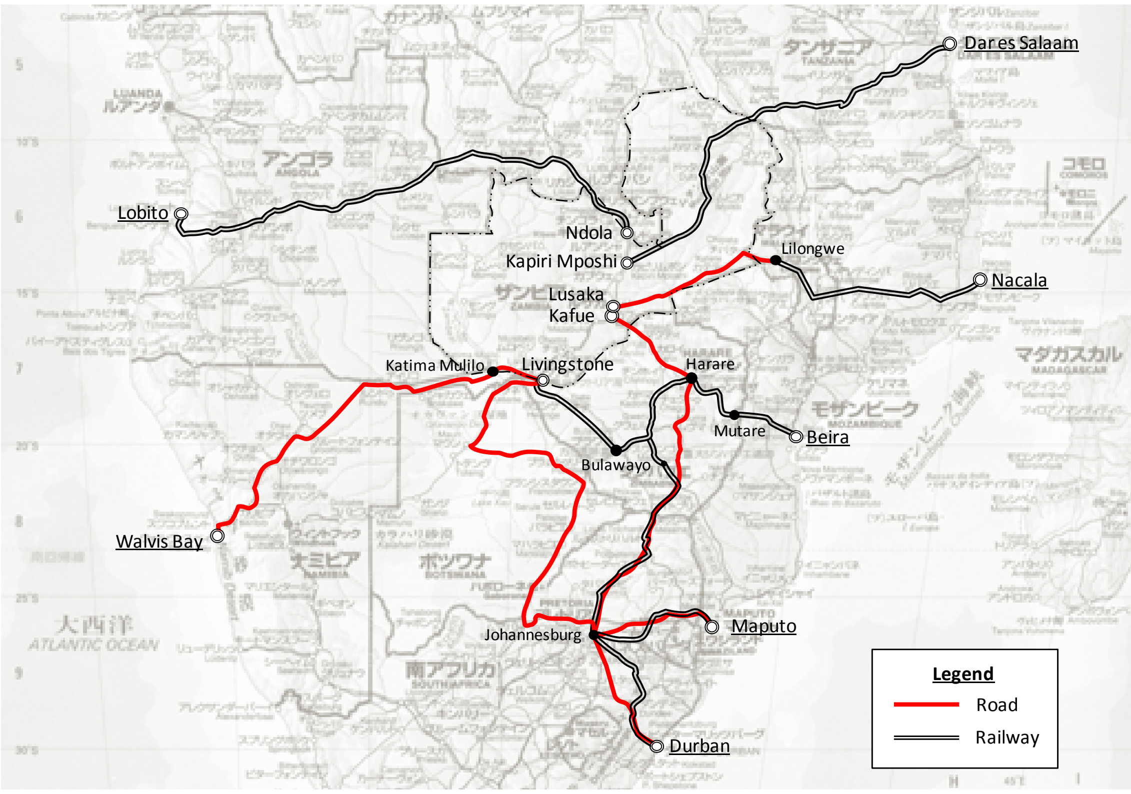
At present, there are seven routes[1] as principal corridors for Zambia indicated in Table A. 11 and Figure A. 9.

[1] However, Lobito- Luau route (in Benguela Railway) has been out of service since 1970s due to deterioration of facilities by the aftermath of civil war. The Zambia and Angola governments hold negotiations on reopening of the railway in 2005.

Table A. 11　　　Principal international corridors in Zambia

	Corridor	Destination	Route
1	**Southern**	Durban Port (SA)	Johannesburg, SA via Zimbabwe (Road or Rail)
			Botswana (Road)
2	**Maputo**	Maputo Port (Mozambique)	Johannesburg, SA (Road or Rail)
3	**Walvis Bay**	Walvis Bay Port (Namibia)	Livingstone/ Sesheke/ Katima Mulilo (Road)
4	**Beira**	Beira (Mozambique)	Harare (Road), Mutare (Rail)
			Bulawayo (Rail), Mutare (Rail)
5	**Nacala**	Nacala (Mozambique)	Lilongwe (Road), Nacala (Rail)
6	**Tazara**	Dar es Salaam (Tanzania)	Kapiri Mposhi (Road or Rail)
7	**Lobito**	Lobito Bay (Angola)	DR Congo (Rail)

(Source) Made by the Study Team based on "Regional Transport Infrastructure Development in Southern Africa", JBICI review, 2000. etc.



(Source) Made by the Study Team based on "Regional Transport Infrastructure Development in Southern Africa", JBICI review, 2000. etc.

Figure A. 9　　　Principal international corridors in Zambia

A.7　　Surrounding countries

As described above, Zambia is a land-locked country bounded by eight countries. The southern African region, in which it lies, is advocating economic integration and a common market, and is making efforts to deepen regional partnership, as exemplified by establishment of the Southern African Development Community (SADC). The SADC's objectives encompass promotion of economic growth, mitigation of poverty, regional integration, maintenance and furtherance of peace and safety, encouragement of autonomous development, coordination of international and intraregional strategy and planning, protection and effective use of regional resources, and reinforcement of the region's historical, social, and cultural ties of partnership. Japan, too, began making donations to it in 1995 and continues to provide it with assistance in such forms as the holding of seminars and dispatch of JICA development experts (to serve as advisors for regional development plans).

The SADC has a membership of 14 countries (Tanzania, Zambia, Botswana, Mozambique, Angola, Zimbabwe, Lesotho, Swaziland, Malawi, Namibia, South Africa, Mauritius, the DRC, and Madagascar). The electric power enterprises in all 12 other than Madagascar and Mauritius, which are island-countries, are members of the Southern African Power Pool (SAPP), an ancillary organ of the SADC. Table A. 12 outlines the SAPP member countries.

Details on the SAPP itself will be stated in Section 4.4.

Table A. 12 Outlines of SAPP countries

	Items		Angola	Botswana	DR Congo	Lesotho	Malawi	Mozambique	Namibia	South Africa	Swaziland	Tanzania	Zambia	Zimbabwe	Remarks
1	Population		12,799,293	1,990,876	68,692,542	2,130,819	14,268,711	21,669,278	2,108,665	49,052,489	1,123,913	41,048,532	11,862,740	11,392,629	July 09 est.
2	Population growth ratio	%	2.095	1.937	3.208	0.116	2.388	1.791	0.95	0.281	-0.459	2.04	1.631	1.53	
3	Capital		Luanda	Gaborone	Kinshasa	Maseru	Lilongwe	Maputo	Windhoek	Pretoria	Mbabane	Dar es-Salaam	Lusaka	Harare	
4	Time difference		UTC+1	UTC+2	UTC+1	UTC+2	UTC+2	UTC+2	UTC+1	UTC+2	UTC+2	UTC+3	UTC+2	UTC+2	
5	Land area	sq.km	1,246,700	600,370	2,345,410	30,355	118,480	801,590	825,418	1,219,912	17,363	945,087	752,614	390,580	
6	Land boundaries	km	5,198	4,013	10,730	909	2,881	4,571	3,936	4,862	535	3,861	5,664	3,066	
7	Coast line	km	1,600	0	37	0	0	2,470	1,572	2,798	0	1,424	0	0	
8	Independence from		11-Nov-75 Portugal	30-Sep-66 UK	30-Jun-60 Belgium	4-Oct-66 UK	6-Jul-64 UK	25-Jun-75 Portugal	21-Mar-90 South African mandate	31-May-10 British colonies	6-Sep-68 UK	26-Apr-64 UK	24-Oct-64 UK	18-Apr-80 UK	
9	Government type		multiparty presidential regime	parliamentary republic	republic	parliamentary constitutional monarchy	multiparty democracy	republic	republic	republic	monarchy	republic	republic	parliamentary democracy	
10	Official language		Portuguese	English	French	English	Chichewa	Portuguese	English	--	English	Swahili	English	English	
11	GDP (PPP)	bln US$	110.3	26.04	21.05	3.37	11.56	18.95	11.23	489.7	5.703	54.26	17.39	1.959	2008 est.
12	GDP (official ex. rate)	bln US$	95.95	13.81	12.96	1.652	4.082	9.788	7.781	300.4	2.968	20.63	15.23	4.548	2008 est.
13	real GDP growth ratio	%	13.2	3.2	8	6.8	6.5	6.5	3.3	2.8	2.7	7.1	5.8	-12.6	2008 est.
14	GDP per capita (PPP)	US$	8,800	13,300	300	1,600	800	900	5,400	10,000	5,100	1,300	1,500	200	2008 est.
15	Inflation rate (consumer price)		12.5	12.5	16.7	10	9	11.2	10.3	11.3	12.7	9.3	11.8	11.2 million	2008 est.
16	Central Bank discount rate	%	19.57	14.5	5.25	12.82	15	9.95	10.5	11	11	16.4	11.73	975	31-Dec-07
17	Commercial bank prime rate	%	17.7	16.22	NA	14.13	27.72	19.52	12.88	13.17	13.17	16.03	18.89	578.96	31-Dec-07
18	Local currency		Kwanza AOA	Pula BWP	Congolese Francs CDF	Maloti LSL	Malawian Kwacha MWK	Metical (Meticais) MZM	Namibian Dollars NAD	Rand ZAR	Lilangeni (Emalangeni) SZL	Tanzanian Shilling TZS	Zambian Kwacha ZMK	Zimbabwean Dollar ZWD	
19	Exchange rate	LC/US$	75.023	6.7907	464.69	7.75	142.41	24.125	7.75	7.9576	7.75	1,178.10	3,512.9	30,000	2008 est.

Note) Exchange rates of Congolese Francs and Zimbabwe dollar are the values in 2007.

(Source) Compiled by JICA Study Team excerpting from CIA "The World Fact Book

Appendix B Energy policies and primary energy resources

B.1 Energy policies

B.1.1 Socio-economic policies

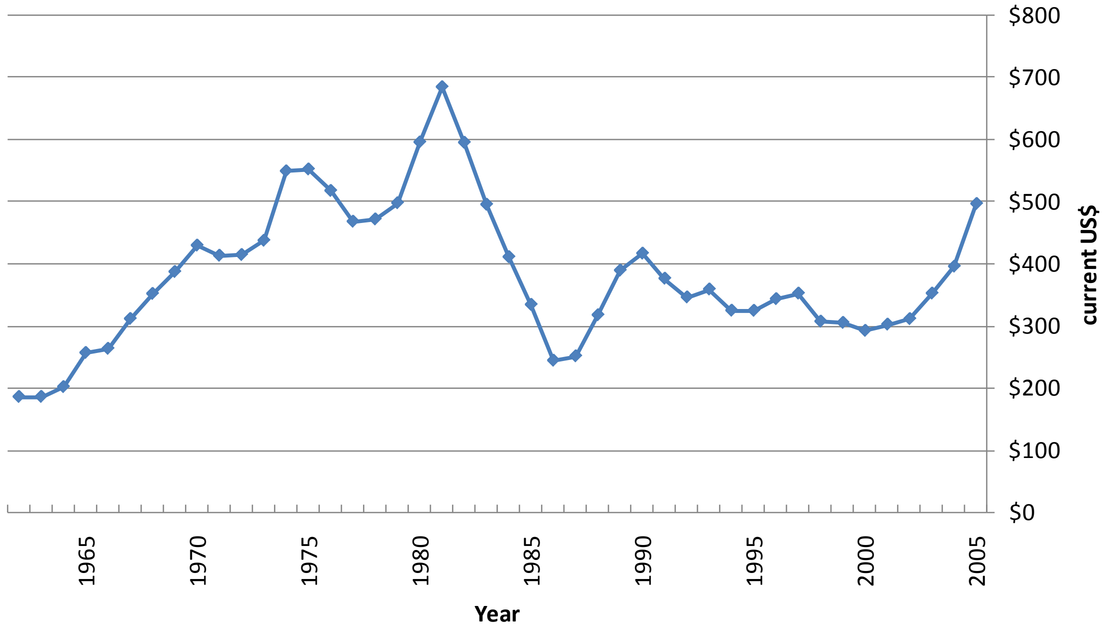
(3) Vision 2030

The National Long Term Vision 2030 (Vision 2030) is Zambia's first ever written long-term plan, expressing Zambian people's vision to become "A Prosperous Middle Income Nation by 2030".

World economies are divided according to 2005 GNI per capita, calculated using the World Bank Atlas method as follows:

-	Low Income countries:	less than $ 875,
-	Lower Middle Income countries:	between $ 876 and $ 3,465,
-	Upper Middle Income countries:	between $ 3,466 and $ 10,725, and
-	High Income countries:	$10,726 or more.

Figure B.1 shows the past trend of Gross National Income (GNI) per capita of Zambia over the year 1962 to 2005.



(Source) "World Development Indicators database", World Bank

Figure B. 1 Trend of per capita GNI (1962-2005)

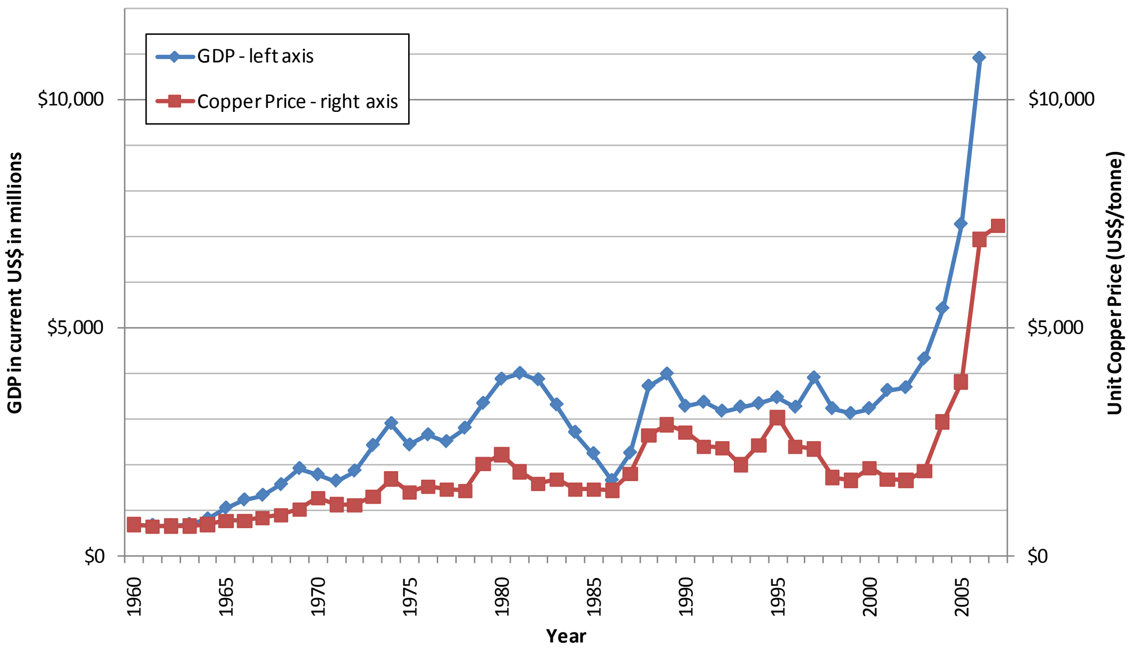
At the independence in 1964, Zambia's GNI stood then at US$ 200 in terms of current US$, and remained higher than those of Botswana, Egypt and Thailand, until the late 1970's or early 1980's, but in 2001 said countries recorded higher GNI per capita and gained the middle-income status while Zambia's GNI per capita remained $ 320 (see Table B. 1).

Table B. 1 Comparative GNI per capita for Middle-Income Economies

	1964	1974	1984	1994	2001	# times larger than 1964
Botswana	90	430	1,090	2,950	3,100	34.4
Egypt, Arab. Rep.	160	300	600	880	1,530	9.6
Gabon	350	1,880	4,450	4,140	3,160	9.0
Malaysia	310	790	1,980	3,580	3,330	10.7
Panama	510	1,060	2,130	2,910	3,260	6.4
South Africa	500	1,420	2,490	3,610	2,820	5.6
Thailand	130	330	800	2,410	1,940	14.9
Zambia	200	580	440	350	320	1.6

(Source) the Vision 2030

Such long-term slow growth or economic slump in Zambia may be caused principally by the economic structure heavy dependent on copper export, accounted for an average of 67 percent of annual total export receipt between 2002 and 2005. Figure B. 2 shows the trend of Zambian GDP and international copper prices between 1960 and 2006.



(Source) "World Development Indicators database", World Bank
USGS web site (http://minerals.usgs.gov/)

Figure B. 2 Trend of GDP and copper price (1960-2006)

At all events, the Vision highlights three scenarios outlining development options, namely the baseline, the preferred and the optimistic as shown in Table B. 2 in order to become a middle income nation by 2030. The baseline scenario which assumes 6 percent real growth and a constant population growth of 2.9 percent per annum over the period 2006 to 2030, raises GNI per capita to $ 676, but misses the target. On the other hand, the preferred scenario and the optimistic scenario which expect higher economic growth ratio raises GNI per capita to $ 1,639 and $ 2,185 respectively and could propel Zambia to middle income status. However, these scenarios are premised on the fact that few countries have achieved and maintained real economic growth rates in excess of 6 percent or more over a quarterly century. Finally, the Vision 2030 throws out the optimistic scenario since such a high level of sustained economic growth performance over a 25 year period is too ambitious and highly unattainable.

Table B. 2 Economic growth scenarios in Vision 2030

Scenario	Real growth ratio				Population growth ratio	Per capita GDP in 2030
	2006-10	2011-15	2016-20	2021-30		
Baseline	6 %				2.9 %	$ 676
	(Ave. 6 %)				(Ave. 2.9 %)	
Preferred	**6 %**	**8 %**	**9 %**	**10 %**	**2.9 %→0.8 %**	**$ 1,639**
	(Ave. 8.59 %)				**(Ave. 1.85 %)**	
Optimistic	6 %	6 % (2011) →14 % (2030)			2.9 %→0.8 %	$ 2,185
	(Ave. 9.17 %)				(Ave. 1.85 %)	

(Source) Made by Study team based on the Vision 2030.

In addition to the economic growth scenarios, to achieve middle-income status, Zambia's socio-economic development objectives are described as Table B. 3

Table B. 3 Socio-economic development objectives in Vision 2030

Items	2006 to 2030	Status quo	Remarks
Real economic growth ratio	6 - 10 %	6 %	In 2007 by CIA World Fact Book Zambia
Inflation rate	5 %	8 %	In 2007 by CIA World Fact Book Zambia
Annual population growth rate	Less than 1.0 %	2.9 %	As of 2005, by Vision 2030
National poverty head count[2]	Less than 20 %	51 %	As of 2004 by the MDGs Progress Report, 2008
Gini coefficient	Less than 40	53	Vision 2030
Access to safe potable water	100 %	40 %	As of 2006 by the MDGs Progress Report, 2008
Access to improved sanitation		36.1 %	

(Source) Made by Study team based on the Vision 2030, MDGs progress report, 2008 and CIA World Fact Book Zambia.

The Vision 2030 also enshrined sector and targets/goals, and those of energy sector were described as follows:

(Sector vision)

Universal access to clean, reliable and affordable energy at the lowest total economic, financial, social and environmental cost consistent with national development goals by 2030.

2 Incidence of extreme poverty as living on less than $1 per day

(Targets/goals)

i. Abundant and reliable supply of affordable energy to both urban and rural areas;
ii. Increased renewable alternative sources of energy;
iii. Export led energy industry; and
iv. Reduce the share of wood fuel to 40 percent by 2030.

(4) Fifth National Development Plan (FNDP)

From independence in 1964, Zambia implemented three national development plans. But, there was no national plan since 1991, the abolition of the Fourth National Development Plan (1989-1993) in preference for an open market system. One of the important lessons learnt from the 1990s was the realization that even in a liberalized economy, development planning is necessary for guiding priority setting and resource allocation. The absence of planning tends to concentrate on short-term needs representing narrow sectional interests thus denying the country the opportunity to attain broad based socio-economic development.

In this background, the Fifth National Development Plan (2006-2010) was formulated in December 2006, succeeding the Transitional National Development Plan (2002).

The Vision 2030 articulates that the Vision will be operationalized through the implementation of five national development plans, beginning with the FNDP covering the period 2006-2010.

The FNDP describes not only the national socio-economic development plan but also review of past performance, policies and key reforms, vision and goals, programmes, objectives and strategies, and implementation, monitoring and evaluation of each sector.

According to the FNDP, the projects in the energy sector to be implemented during the FNDP period (2006-2010) through public-private partnerships, the Government or the private sector include those listed below:

a) Kafue Gorge Lower Power Station with the potential to generate 750 MW. The project is anticipated to be developed through the public-private partnership model;

b) Kariba North Bank Extension, estimated at 320 MW;

c) Itezhi-Tezhi Hydropower project with a capacity of 120 MW. Additional to this is the construction of a 200 km 220 kV transmission line from Itezhi-Tezhi to Choma (Muzuma), which is the nearest point of inter-connection to the national grid;

d) The Zambia-Tanzania-Kenya Inter-connector project involving the construction of a total of 700 km of 330 kV transmission line, 600 km on the Zambian side and about 100 km on the Tanzanian side. In addition, 200 km of 330 kV transmission line will be built from Arusha to Nairobi. The proposed line will be able to supply an estimated load of up to 200 MW of power in Phase I. In Phase II another 200 MW will be exported to the East African market. Private and public investors are expected to develop the project;

e) The Zambia-Democratic Republic of Congo Inter-connector is being developed by Copperbelt Energy Corporation (CEC) and SNEL. This will enable power transfers of up to 500 MW from Congo DR to the Southern African market. A 200 km 330 kV line between Luano and Solwezi was commissioned by ZESCO in 2004 to supply power to Kansanshi Copper Mines. A further 70 km of 330 kV line will be constructed to supply power to Lumwana Mine and will be extended to Kolwezi in Congo DR;

f) Electrification of farm blocks and other social and health institutions;

g) Development of bio-fuels and other renewable energy programmes that aim to work towards the integration of the use of renewable sources of energy in the provision of energy services to communities;

h) Implementation of energy efficiency and conservation measures, including improved household and industry fuel combustion technologies;

i) Implementation of Phase II of the Zambia-Namibia 220 kV Inter-connector from Victoria Falls to Katima Mulilo;

j) Hwange-Livingstone 330 kV Inter-connector (Zimbabwe-Zambia). The inter-connector is meant to decongest the Insukamini-Phokoje-Matimba 400 kV line;

k) The Kalungwishi Hydro Power Scheme (200 MW) to supply the northern part of the country to stabilise and increase the reliability of the National Grid. All major power stations are located in the Southern and Central parts of the country. The scheme would also be strategic to the regional power supply system linking to the Congo DR and Tanzania;

l) Development of the Lunsemfwa Lower Hydro Power Scheme (55 MW) to support mining and agriculture in the Central and Copperbelt provinces; and

m) Development of both mini/micro and other hydro electric potential not captured above by both public and private sectors.

In the FNDP, the vision and the goal of energy sector are described as below:

The vision is: Universal access to clean, reliable and affordable energy at the lowest total economic, financial, social and environmental cost consistent with national development goals by 2030.

The goal is: To ensure availability and accessibility to adequate and reliable supply of energy from various sources at the lowest total economic, social and environmental cost consistent with national development goals of sustained growth, employment generation and poverty reduction.

The FNDP indicates not the specific programmes of the each sub-sector, but just the general programmes and objectives as shown in Table B. 4.

Table B. 4 Energy sector programmes in FNDP

	Programmes	Objectives
1	Energy Sector Reform	To strengthen the institutional, legal and policy framework in order to ensure effective development, management and provision of quality energy services
2	**Electricity Generation and Transmission Line Development**	**To increase generation capacity, accessibility (through transmission lines) and trade of electricity**
3	Strategic Petroleum Reserves	To ensure security of supply of petroleum products in the country
4	**Rural Electrification**	**To increase electrification levels in order to increase access for social economic development in rural communities**
5	Bio-Fuel Development	To facilitate the development of biofuel industry
6	Management of Petroleum Sub-sector and Rehabilitation of Infrastructure	To enhance an enabling environment for stable and increased supply and security of supply of petroleum
7	Hydrocarbon Exploration	To explore for hydrocarbon resources in order to increase security of supply
8	Energy Efficiency and Conservation	To promote energy efficiency and conservation
9	Renewable and Alternative Energy Development and Promotion	To provide and disseminate up to date information on renewable and alternative energy resources for effective planning and awareness, development, management and utilisation
10	Creation of Energy Development Fund	To create opportunities for different types of energy projects
11	Promotion of Improved Charcoal Production Technology	To promote the efficient production of charcoal in order to create an opportunity for improved charcoal production technology
12	Gender and HIV and AIDS Mainstreaming	To ensure that gender and HIV and AIDS are mainstreamed in all the energy programmes or project preparation and implementation
13	General Administration and Organization	To effectively manage and develop human resources for efficient performance of the sector
		To undertake and coordinate the planning, monitoring and evaluation of energy sector programmes and projects in order to ensure their effective implementation

(Source) The Fifth National Development Plan 2006-2010, Dec. 2006

Table B. 5 is also presented in the FNDP to indicate the investment plan of the energy sector during the FNDP period 2006-2010.

Table B. 5 Energy Sector Investment plan 2006-2010[3]

(Unit: Kwacha in billions)

Order of Priority		Programme	2006			2007			2008			2009			2010			Grand Total		
			GRZ	Donors	Total	GRZ	Donors	Total	GRZ	Donors	Total	GRZ	Donors	Total	GRZ	Donors	Total	Total	GRZ	Donor
Core FNDP Programs	1	Energy Sector Reform	0.00	3.00	3.00	1.00	1.30	2.30	0.30	0.20	0.50	0.20	0.20	0.40	0.30	0.20	0.50	6.70	1.80	4.90
	2	Electricity Generation and Transmission Line Development	0.00	12.80	12.80	3.40	9.60	13.00	4.30	8.00	12.30	10.20	25.00	35.20	10.30	25.00	35.30	108.60	28.20	80.40
	3	Strategic Petroleum Reserves	0.09		0.09	4.50	5.00	9.50	7.00	7.50	14.50	13.20	8.00	21.20	10.00	10.00	20.00	65.29	34.79	30.50
	4	Rural Electrification	11.77	4.00	15.77	13.20	20.00	33.20	15.00	28.00	43.00	23.00	35.00	58.00	25.00	10.00	35.00	184.97	87.97	97.00
	5	Bio-Fuels Development	0.40		0.40	1.50	5.00	6.50	2.90	4.00	6.90	3.00	5.00	8.00	2.00	5.00	7.00	28.80	9.80	19.00
	6	Management of the Petroleum Sector and Rehabilitation of Infrastructure	0.30	1.60	1.90	46.40	0.50	46.90	4.10	2.00	6.10	7.20	5.00	12.20	8.80	0.50	9.30	76.40	66.80	9.60
	7	Petroleum Exploration	0.60	0.96	1.56	1.00	5.00	6.00	2.00	5.00	7.00	3.00	5.00	8.00	3.00	5.00	8.00	30.56	9.60	20.96
		Sub-total	13.16	22.36	35.52	71.00	46.40	117.40	35.60	54.70	90.30	59.80	83.20	143.00	59.40	55.70	115.10	501.32	238.96	262.36
None-core FNDP Programs	1	Energy Efficiency and Conservation	0.09	0.64	0.73	0.30	2.00	2.30	2.00	1.50	3.50	3.00	1.50	4.50	3.00	1.50	4.50	15.53	8.39	7.14
	2	Renewable and Alternative Energy Development and Promotion	2.26	0.00	2.26	2.50	2.50	5.00	2.20	3.80	6.00	3.10	4.00	7.10	6.50	4.00	10.50	30.86	16.56	14.30
	3	Establishment and Operation of an Energy Development Fund	0.00	0.00	0.00	1.00	1.00	2.00	1.00	1.30	2.30	2.00	2.00	4.00	2.00	2.00	4.00	12.30	6.00	6.30
	4	Improved Charcoal Production Technology	0.00	0.00	0.00	0.10	0.20	0.30	0.30	0.20	0.50	0.50	0.20	0.70	0.50	0.20	0.70	2.20	1.40	0.80
	5	General Administration and Organisation	1.16	0.00	1.16	1.50	0.00	1.50	1.60	0.00	1.60	1.90	0.00	1.90	2.00	0.00	2.00	8.16	8.16	0.00
	6	Personnel Emoluments	3.87	0.00	3.87	4.56	0.00	4.56	5.06		5.06	5.50		5.50	6.01	0.00	6.01	25.00	25.00	0.00
		Sub-total	7.38	0.64	8.02	9.96	5.70	15.66	12.20	6.80	18.96	16.00	7.70	23.70	20.01	7.70	27.71	94.00	65.50	28.54
Grand Total			**20.50**	**23.00**	**43.50**	**80.96**	**52.10**	**133.06**	**47.76**	**61.50**	**109.26**	**75.80**	**90.90**	**166.70**	**79.41**	**63.40**	**142.81**	**595.40**	**304.47**	**290.90**

(Source) The Fifth National Development Plan 2006-2010, Dec. 2006

[3] According to DOE, the applicable exchange rate was "US$1=ZMK4,500"

B.1.2 Energy policies

(1) National Energy Policy (NEP)

The first National Energy Policy was formulated in 1994 to seek the promotion of optimal supply and utilization of energy, especially indigenous energy forms for socio-economic development in a safe and healthy environment. While the essence of the 1994 Energy Policy objectives remains valid, the New National Energy Policy was formulated in 2008 reflecting the changes of social, political, environmental and economic situation.

The NEP has taken account of the objectives of the Vision 2030 and the formulation and implementation of the policy is expected to yield the following:

- Increased access to modern energy, particularly in rural areas through various energy options forms;
- Integrated development that will promote the cross-sectoral linkages between the energy sector and other key social and economic sectors such as agriculture, trade and industry, transport, information and communications technology, health and education, etc;
- Security of supply of energy;
- Efficient production and utilization of energy;
- Minimization of the negative environmental and health effects of energy production, transportation and use;
- Reduced dependence on imported petroleum and switch to locally available energy countries and international organizations;
- Cost reflective pricing mechanisms; and,
- Increased utilization of renewable energy.

Regarding electricity sub-sector, sector objective is articulated as:

- The policy seeks to expand generation and transmission capacity and also increase access to electricity.

Consequently, the policy measures and strategies to achieve the above objectives are highlighted as Table B. 6.

Table B. 6 Electricity sub-sector policy measures and strategies

a)	**Increase generation and transmission capacity for local and regional markets by:** i) Encouraging the development of identified potential hydro sites through transparent mechanisms, taking cognizance of the public interest; ii) Promoting new sources of power generation including coal powered plants, co-generation and gasification; iii) Promoting local and foreign investment; iv) Promoting private sector involvement in generation and transmission; v) Encouraging the need for developing diversity in generation and transmission; vi) Promoting the need for increased interconnection with neighbouring states in accordance with NEPAD and SADC objectives to achieve regional optimization; vii) Adopting an open-access transmission regime; viii) Developing a policy framework for transmission pricing keeping in mind the objectives of open access and increased export and trade; ix) Adopting cost reflective tariffs; and x) Developing and implementing a licensing regime that is compatible with an open access regime.
b)	**Improve accessibility and service delivery to households, Small & Medium Scale Entrepreneurs (SMEs) through:** i) Enacting appropriate legislation for public and private sector investment and participation in the power sector; ii) Application of smart subsidy mechanisms (transparent, targeted, practical and benefit-based subsidies); and iii) Developing isolated grid systems with cost reflective tariffs.
c)	**Improve accessibility and service delivery to agriculture, tourism, manufacturing, mining and other commercial activities by:** i) Reinforcing and rehabilitating the distribution system in order to enhance quality of supply, increase efficiency and reduce cost; ii) Providing electricity to farm blocks, new mines and other industrial consumers; iii) Promoting the use of electricity for irrigation where it is economically feasible and in agro processing; and iv) Providing electricity access to social services like schools and health centres.
d)	**Improve Legislation and institutional framework through:** i) Reviewing/enacting appropriate legislation for investment in the power sector; and ii) Strengthening the capacity of institutions in the energy sector.
e)	**Enhance collaboration between industry, learning and training institutions through:** i) Upgrading the testing, training and research infrastructure in line with technological developments in the electricity sub-sector; ii) Building capacity of people involved in the energy sector; and iii) Promoting knowledge transfer of new technology and practices.

(source) National Energy Policy 2008

(2) National Energy Strategy

The National Energy Strategy: 2008-2030 (NES) was drafted by DOE/MEWD in January, 2008, but yet not finalized. However, there are specific goals and strategies for each sub-sector in energy sector. The goals and strategies for electricity sub-sector are shown in Table B. 7.

Table B. 7 Electricity sub-sector goals and strategies

Electricity Sub-sector	
Goal 1	**Attaining the targets of national access rates of 90 % in the urban areas and 51 % in the rural areas**
- Promote investment in new power generation facilities; - Reform the electricity industry; - Develop the electricity generation and transmission lines infrastructure; - Develop the interconnection with over 40,000 MW potential at Inga in DRC and be the transmission network of choice for interconnections to the Southern African, and East African sub-regions; - Implement the Rural Electrification Master Plan; - Promote Energy Efficiency and Conservation; - Improve the efficiency of the electricity industry and making it attractive to new investment.	
Goal 2	**Enhancing the Security of Supply**
- Diversify the sources of Zambia's electricity including consideration of a coal-fired thermal power station of 500 MW to be built by 2018; - Develop capacity for nuclear technology for power generation and feasible options for Zambia; - Promote energy conservation and efficiency and the conservation.	
Goal 3	**Achieve cost reflective tariffs for the electricity industry**
- Establish a more efficient and more transparent electricity industry; - Offer tariff and fiscal incentives to prospective investors in generation and transmission based on Cost of Service Studies; - Manage tariffs to discourage wasteful practices among customers; - Re-examine a possible reorganization of distribution and supply management and adopt the best opportunities for high performance gains.	
Goal 4	**Expand electricity generation capacity and choices**
- Develop and implement sites of major hydro potentials starting with Kafue Gorge Lower (KGL); others are the Itezhi-tezhi (ITT) and the Kariba North Extension (KNE).	
Goal 5	**Reinforce and extend transmission lines**
- Implementing the interconnection to Tanzania and make the East African region an important destination for electricity exports owing to an enduring power deficit in that region; - Enhance the transfer capacities of the interconnections with the Democratic Republic of Congo, together with reinforcement of the national transmission network to enable more of the power from the DRC to be availed to Zambia and the rest of the region; - Provide additional interconnection to Namibia raise the transfer capacity to that country and thereon to Botswana and introduce alternative routes for Zambia's imports, thereby enhancing the securities of supply.	

(Source) National Energy Strategy: 2008-2030 (Zero Draft)

B.2 Current energy balance in Zambia

According to IEA (International Energy Agency), the energy balance in Zambia is shown as Table B. 8.

Table B. 8 Energy Balance in Zambia in 2006

(Unit: kilo tonnes of oil equivalent)

SUPPLY and CONSUMPTION	Coal and Peat	Crude Oil	Petroleum Products	Hydro	Combustible Renewables and Waste	Electricity	Total*
Production	144	0	0	802	5,717	0	6,663
Imports	0	594	145	0		0	739
Exports	-7	0	-13	0	0	-22	-42
International Marine Bunkers**	0	0	0	0	0	0	0
Stock Changes	-36	0	-15	0	0	0	-51
Total Primary Energy Supply	**101**	**594**	**117**	**802**	**5,717**	**-22**	**7,309**
Transfers	0	0	0	0	0	0	0
Statistical Differences	0	0	0	0	0	0	0
Electricity Plants	-8	0	-10	-802	0	807	-14
CHP Plants[4]	0	0	0	0	0	0	0
Heat Plants	0	0	0	0	0	0	0
Gas Works	0	0	0	0	0	0	0
Petroleum Refineries	0	-594	562	0	0	0	-31
Coal Transformation	0	0	0	0	0	0	0
Liquefaction Plants	0	0	0	0	0	0	0
Other Transformation	0	0	0	0	-1,365	0	-1,365
Own Use	0	0	-23	0	0	-19	-42
Distribution Losses	0	0	0	0	0	-51	-51
Total Fuel Consumption	**93**	**0**	**646**	**0**	**4,352**	**715**	**5,806**
Industry sector	84	0	175	0	654	503	1,417
Transport sector	0	0	379	0	0	1	379
Other sectors	8	0	58	0	3,698	211	3,976
Residential	0	0	14	0	3,698	139	3,851
Commercial and Public Services	0	0	36	0	0	57	93
Agriculture / Forestry	0	0	8	0	0	8	16
Fishing	0	0	0	0	0	0	0
Non-Specified	8	0	0	0	0	8	16
Non-Energy Use	0	0	34	0	0	0	34

* Totals may not add up due to rounding.

** International marine bunkers are not subtracted out of the total primary energy supply for world totals.

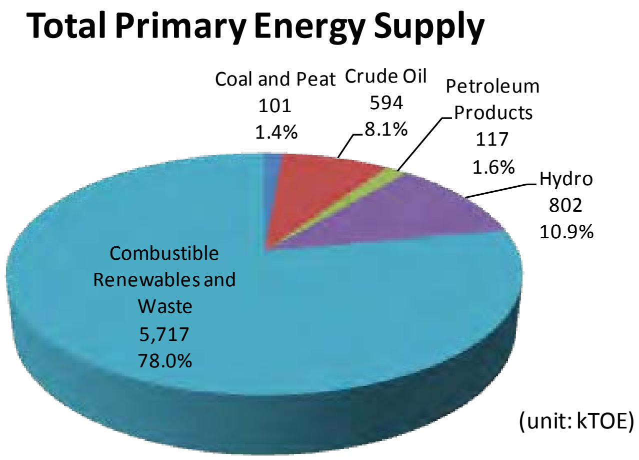
(Source) International Energy Agency, 2006

From the view point of primary energy supply, the self-sufficiency ratio of energy[5] is remarkably high as much as 91.2 percent. However, non-commercial energy which corresponds to combustible renewables and wastes occupies in Zambia, occupies 78.0 percent

[4] Combined Heat and Power Plants

[5] (Energy Production)/ (Energy Supply)

of the total supply, and except the non-commercial energy the ratio falls to 12.9 percent. As to commercial energy, domestic hydropower (10.9 percent), crude oil and petroleum products all imported (9.7 percent) and domestic coal (1.4 %) are counted.



(Source) International Energy Agency, 2006

Figure B. 3 Primary Energy Supply in Zambia

In addition, domestic energy supply per unit GDP, 1.684 TOE/US$ is quite high along with the Democratic Republic of Congo, Zimbabwe, Tanzania, Mozambique in the Southern African region, which indicates that the energy efficiency[6] in Zambia is extremely low. The salient indices on primary energy in Southern African countries, BRICs countries and G7 countries are shown in Table B. 9 for comparison.

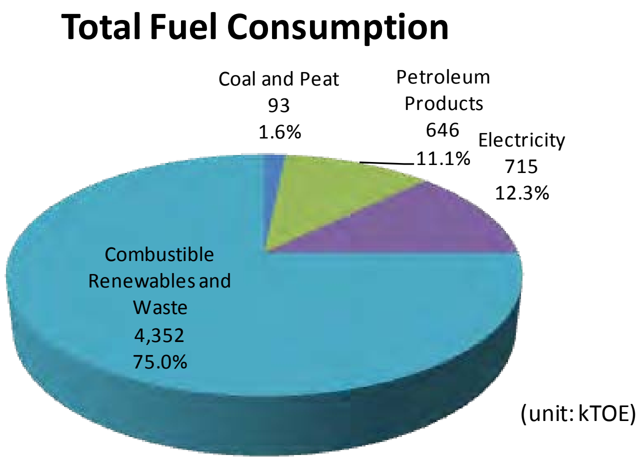
[6] (Energy Supply)/(real GDP)

Table B. 9 Primary energy supply in Zambia and other countries (year 2006)

	Population (million)	GDP (billion $)	GDP per capita US$	Energy Production (MToE)	Energy Self-sufficiency* (%)	excl. combustible waste (%)	Net Imports (MToE)	TPES (MToE)	TPE per capita (ToE)	TPE/GDP (TOE/$)
(SAPP countries)**										
1 Zambia	11.70	4.34	371	6.663	91.2%	12.9%	0.697	7.309	0.625	1.684
2 Angola	16.56	17.11	1,033	79.158	771.2%	707.3%	-68.269	10.264	0.620	0.600
3 Botswana	1.86	8.39	4,511	1.075	54.9%	31.7%	0.883	1.959	1.053	0.233
4 Congo, DR	60.64	5.51	91	17.822	101.8%	9.4%	-1.052	17.513	0.289	3.178
5 Mozambique	20.97	6.18	295	10.698	121.5%	39.9%	-3.309	8.804	0.420	1.425
6 Namibia	2.05	4.46	2,176	0.317	21.5%	8.8%	1.162	1.476	0.720	0.331
7 South Africa	47.39	168.81	3,562	158.676	122.2%	111.6%	-26.236	129.815	2.739	0.769
8 Tanzania	39.46	13.20	335	19.427	93.4%	2.3%	1.400	20.805	0.527	1.576
9 Zimbabwe	13.23	5.35	404	8.759	91.4%	28.2%	0.816	9.578	0.724	1.790
(Emerging countries)										
China, PR	1,311.80	2,092.15	1,595	1,749.290	93.1%	81.1%	135.878	1,878.744	1.432	0.898
Brazil	189.32	765.13	4,041	206.717	92.2%	61.7%	51.087	224.129	1.184	0.293
India	1,109.81	703.33	634	435.640	77.0%	48.7%	134.831	565.820	0.510	0.804
Russia	142.50	373.20	2,619	1,219.975	180.4%	179.3%	-531.121	676.196	4.745	1.812
(G7 countries)										
USA	299.83	11,265.20	37,572	1,654.226	71.3%		730.441	2,320.696	7.740	0.206
Japan	127.76	5,087.10	39,818	101.066	19.2%		431.108	527.560	4.129	0.104
Germany	82.37	2,011.20	24,417	136.757	39.2%		215.559	348.559	4.232	0.173
UK	60.53	1,684.70	27,832	186.623	80.7%		49.155	231.126	3.818	0.137
France	63.20	1,468.30	23,233	137.021	50.3%		140.223	272.666	4.314	0.186
Italy	58.86	1,157.00	19,657	27.427	14.9%		163.194	184.169	3.129	0.159
Canada	32.62	844.60	25,892	411.742	152.6%		-141.826	269.744	8.269	0.319

* Including nuclear energy among domestic energy production.
** Data in Malawi, Lesotho and Swaziland are not available.
(Source) "Energy Balances of non-OECD Countries, IEA, 2006"
"Energy Balances of OECD Countries, IEA, 2006"

On the other hand, from consumption side, combustible waste holds 75% of the final energy consumption, and electricity (12.3%), oil products (11.1%), coal (1.6%) follow. The other energy consumption such as gas, geothermal, solar counts nil or negligible.



(Source) International Energy Agency, 2006

Figure B. 4 Final Energy Consumption in 2006

Amidst the actual picture of the energy situation in Zambia indicated above, the government declared that heavy dependence on wood fuels should be grown out in the light of environmental sustainability, health implication, poverty reduction and gender equity. The Vision 2030 stated targets the reduction of wood fuel share to 40 percent by 2030.

B.2.1 Coal

The supply and consumption of coal is limited to bituminous coal in Zambia, and details are indicated in Table B. 10.

From the supply side, while 244,000 tonnes of coal were produced domestically, 12,000 tonnes were exported, 61,000 tonnes were stocked and finally 171,000 tonnes were supplied for domestic use. Most of the domestic supply of 157,000 tonnes is for industrial use, and consumed in copper mining, cement production, breweries etc.

Coal resources are found in various sites in Zambia detailed in Clause B.3.1, but the actual development and production of coal is limited in the mid-Zambezi Valley in the Southern Province. At present, two mining companies, both situated in Maamba the Southern Province; Maamba Collieries Limited (MCL) and Collum Coal Mines Limited, are operating in Zambia.

Table B. 10 Coal supply and consumption in 2006

(Unit: kilo-tonnes)

	Bituminous Coal
Production	244
From Other Sources	0
Imports	0
Exports	-12
Stock Changes	-61
Domestic Supply	171
Statistical Differences	0
Total Transformation	14
Electricity Plants	14
CHP Plants	0
Heat Plants	0
Other Transformation	0
Energy Sector	0
Distribution Losses	0
Total Final Consumption	157
Industry	143
Transport	0
Residential	0
Commercial and Public Services	0
Agriculture / Forestry	0
Fishing	0
Other Non-Specified	14
Non-Energy Use	0

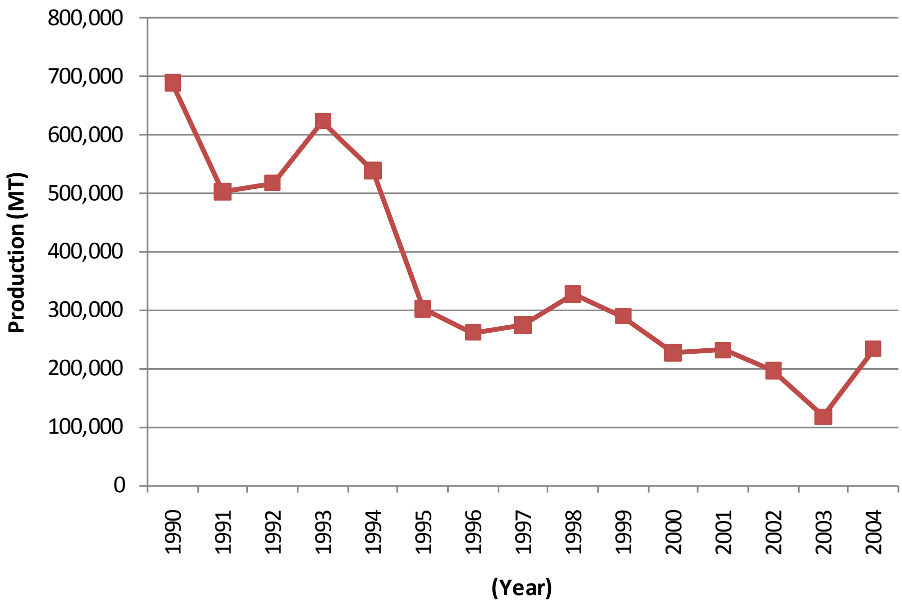
(Source) International Energy Agency, 2006

(3) Maamba Collieries Limited (MCL)

MCL, located in Maamba town 352 km from Lusaka, is the largest and main producer of coal in Zambia, and has been operating in the Siankondobo Coalfield since 1969. The main facilities available at MCL mining operations include the Coal Preparation Plant (CPP), water treatment plant, pump station, weigh bridges, engineering workshops, and other support infrastructure. There are two open cast mines operating in the Kanzize and Izuma basins with an annual capacity to produce between 600,000 and 800,000 metric tonnes of saleable coal, depending on demand and other constraints.

The CPP has a rated capacity to wash about 700,000 to 800,000 metric tonnes of coal per year while the ropeway has the capacity to transport between 600,000 to 700,000 metric tonnes to Masuku Railway Terminal per annum. Both however require some refurbishment to achieve the said capacities.

Historically, production was maintained at a level of about 500,000 tonnes per annum, but this slumped since 1995 due to historical under capitalization as shown in Figure B. 5 and Table B. 11.



(Source) Environment Statistics in Zambia: Energy Statistics, CSO

Figure B. 5 Coal production of MCL (raw coal: 1990-2004)

Table B. 11 Coal production of MCL (processed coal)

(unit: metric tonnes)

	2004	2005	2006	2007
Domestic sales	108,297	140,425	57,862	13,346
Exports	11,018	10,018	5,906	169
Total	119,315	150,443	63,768	13,515

(Source) Energy Regulation Board: Energy Sector Report, 2007

MCL was incorporated as a limited company in 1971 under the ownership of the government through the Zambia Industrial and Mining Corporation Limited (ZIMCO) which had once more than 130 companies including ZCCM. After the dissolution of ZIMCO in 1995, MCL was once privatized in 1999 with the support of Zambia Privatisation Agency (ZPA), taken over by a South African company, Benicon. The new owner struggled to keep production because of under-capitalisation and equipment problems and finally cease its operation and the mine was readvertisesd for sale. In a bid to revamp operations at the coal mine, the government decided to transfer the company to the ZCCM- Investment Holdings (ZCCM-IH). ZCCM-IH is expected to recapitalize and rehabilitate the mine with the assistance of an equity partner and in 2007 acquired 100 percent of share in the mine.

According to the recent press releases in 2009, a Singapore company named Nava Bharat started negotiation with ZCCM-IH on revamping the operations of the mine and construction of a thermal power plant at the mine-mouth.

(4) Collum Coal Mines Limited

Collum Coal Mines started its operations by a Chinese capital in 2002, and mines coal from the previously abandoned Nkandabwe coal mine. It has reserves of well over 12 million tonnes. The mine was abandoned in the past due to water control problems and complex geology and hydrogeological conditions.

Initially the mine could only produce 40,000 metric tonnes per annum of coal. With increased investment, the mine is now able to produce up to 10,000 metric tonnes per month. The mine projects its production levels will increase to 40,000 metric tonnes per month by 2007.

Collum continues to play a significant role in supplementing MCL's efforts and mostly supplies Chilanga Cement, Konkola Copper Mines, Nitrogen Chemicals with a few exports to Congo DR.

B.2.2 Crude oil and petroleum products

Zambia imports all its petroleum requirements, which contribute to about 10 percent of the national energy requirement.

The current infrastructure for import and processing includes the 1,704 kilometers TAZAMA (Tanzania- Zambia- Mafuta) pipeline from TIPER in Dar es-Salaam port to INDENI refinery in Ndola. The TAZAMA pipeline has a capacity to pump 1,100,000 metric tonnes of crude oil per year feeding into the INDENI oil refinery, and is owned and operated by Tazama Pipeline Limited which is jointly owned by the Governments of Zambia (66.7 percent) and Tanzania (33.3 percent).

(Source) Country analysis overview, EIA

Figure B. 6 TAZAMA Pipeline

Table B. 12 shows that 582 thousand tonnes of crude oil and 134 thousand tonnes of petroleum products were imported, and that all of crude oil were refined to petroleum products such as motor gasoline, jet kerosene, diesel oil etc. in the domestic refineries in 2006.

Table B. 12 Supply and consumption of oil products in 2006

(Unit: kilo-tonnes)

	Crude Oil	LPG	Motor Gasoline	Aviation Gasoline	Jet Kerosene	Other Kerosene	Gas/ Diesel	Residual Fuel Oil
Production	0	3	126	0	29	28	239	85
From Other Sources	0	0	0	0	0	0	0	0
Imports	582	0	46	3	22	0	63	0
Exports	0	0	0	0	0	-13	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0
Stock Changes	0	0	0	0	0	0	0	-15
Domestic Supply	582	3	172	3	51	15	302	70
Transfers	0	0	0	0	0	0	0	0
Statistical Differences	0	0	0	0	0	0	0	0
Total Transformation	582	0	0	0	0	0	7	3
Electricity Plants	0	0	0	0	0	0	7	3
CHP Plants	0	0	0	0	0	0	0	0
Heat Plants	0	0	0	0	0	0	0	0
Petroleum Refineries	582	0	0	0	0	0	0	0
Other Transformation	0	0	0	0	0	0	0	0
Energy Sector	0	0	0	0	0	0	0	6
Distribution Losses	0	0	0	0	0	0	0	0
Total Final Consumption	0	3	172	3	51	15	295	61
Industry	0	3	7	0	0	1	102	61
Transport	0	0	159	3	51	0	156	0
Residential	0	0	0	0	0	14	0	0
Commercial and Public Services	0	0	5	0	0	0	30	0
Agriculture / Forestry	0	0	1	0	0	0	7	0
Fishing	0	0	0	0	0	0	0	0
Other Non-Specified	0	0	0	0	0	0	0	0
Non-Energy Use	0	0	0	0	0	0	0	0

(Source) International Energy Agency, 2006

Reviewing the consumption, motor gasoline and diesel oil are the main petroleum products consumed in Zambia, of which diesel comprises nearly half and motor gasoline 28.7 percent of the total petroleum products (see Figure B. 7).

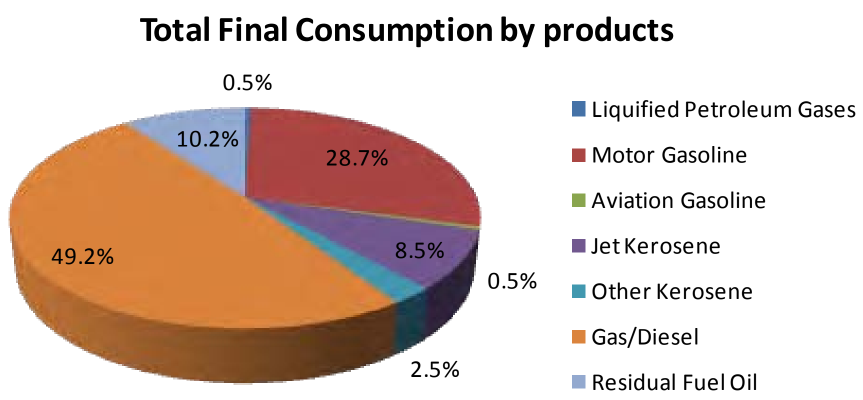


Figure B. 7 Petroleum consumption by product

Regarding consumption by sectors, most of the petroleum products are consumed by transport and industry sector as shown in Figure B. 8. Non-energy use of petroleum including petro-chemical consumption was reported in Zambia.

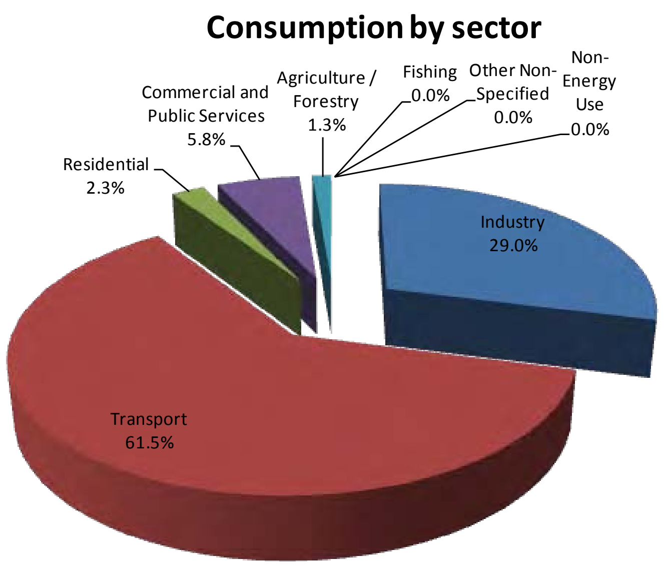


Figure B. 8 Petroleum consumption by sector

B.2.3 Electricity

As the current situation of electricity is detailed in the Section 4.3, almost all the electricity in Zambia is produced by hydropower as shown in Table B. 13.

Table B. 13 Electricity supply and consumption in 2006

(Unit: GWh)

	Electricity	
Production from:	(GWh)	(%)
- coal	19	0.2%
- oil	37	0.4%
- gas	0	0.0%
- biomass	0	0.0%
- waste	0	0.0%
- nuclear	0	0.0%
- hydro	9,329	99.4%
- geothermal	0	0.0%
- solar PV	0	0.0%
- solar thermal	0	0.0%
- wind	0	0.0%
- tide	0	0.0%
- other sources	0	0.0%
Total Production	9,385	100 %
Imports	0	
Exports	-255	
Domestic Supply	9,130	
Statistical Differences	0	
Total Transformation*	0	
Electricity Plants	0	
Heat Plants	0	
Energy Sector**	222	
Distribution Losses	596	6.5%
Total Final Consumption	8,312	
Industry	5,851	70.4%
Transport	6	0.1%
Residential	1,612	19.4%
Commercial and Public Services	664	8.0%
Agriculture / Forestry	89	1.1%
Fishing	0	0.0%
Other Non-Specified	90	1.1%

* Transformation sector includes electricity used by heat pumps and electricity used by electric boilers.

** Energy Sector also includes own use by plant and electricity used for pumped storage.

(Source) International Energy Agency, 2006

As shown in Figure B. 9, most of electricity is consumed by the industry sector, especially mining industry, while residential consumption remains less than 20 percent.

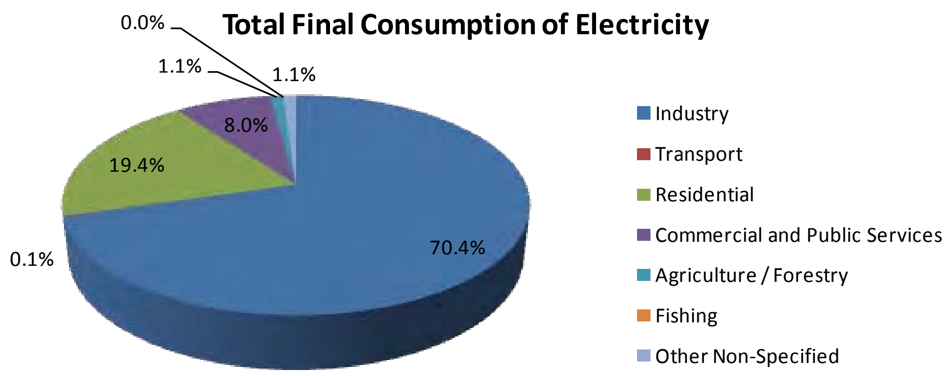


Figure B. 9 Total final consumption of electricity by sector

Low level of access to electricity, especially in the rural area is one of the major concerns for the national socio-economic development. In 2007, the access rate in rural areas is approximately 3 percent while that in urban areas is 47 percent. The Rural Electrification Master Plan (REMP) targets the future electrification ratio as Table B. 14.

Table B. 14 Electrification targets in REMP

Year	Urban	Rural	Average
2009	53	9.2	26
2015	64	28	42
2020	72	38	51
2025	81	45	59
2030	90	51	66

(Source) National Energy Strategy: 2008-2030 (Zero Draft)

B.2.4 Renewable Energy

According to the statistics of IEA in 2006, neither electricity nor heat use of renewable energy is counted, and the supply and consumption of renewable energy resources; municipal waste, industrial waste, biogas liquid bio fuels, geothermal, and solar thermal, other than primary solid biomass, are nil or negligible.

As stated above, wood fuel (i.e. fuel woods and charcoal) is primary solid biomass produced and consumed in Zambia. Most of wood fuel is consumed by residential for cooking and heating.

Table B. 15 Renewable Energy supply and consumption in 2006

(Unit: TJ)

	Primary Solid Biomass*
Production	239,396
Imports	0
Exports	0
Stock Changes	0
Domestic Supply	239,396
Statistical Differences and Transfers	0
Total Transformation	86,034
Electricity Plants	0
CHP Plants	0
Heat Plants	0
Other Transformation	86,034
Energy Sector	0
Distribution Losses	0
Total Final Consumption	153,362
Industry	26,181
Transport	0
Residential	127,181
Commercial and Public Services	0
Agriculture/ Forestry	0
Fishing	0
Other Non-Specified	0
Non-Energy Use	0

* Primary Solid Biomass: data are also available for charcoal
(Source) International Energy Agency, 2006

B.3 Primary energy potential in Zambia

B.3.1 Coal

(1) Coal resources in Africa

As the African continent has abundant mineral resources such as gold, diamond, copper, manganese, ironstone, bauxite, phosphate rock, uranium, etc., generally regarding energy resources, the northern part is known for oil production and the southern part for coal production.

Principal coal mines in Africa are concentrated in the Southern and South-eastern part. Smaller mines are found here and there in the Northern part, the west coast and the island of Madagascar. All of good quality bituminous coal in Africa occurs within the Ecca series in the Karoo system. As indicated in Figure B. 10, coal mines are found exclusively in the South Africa, Swaziland, Zimbabwe, Zambia, Botswana, Mozambique, Malawi, Tanzania, Madagascar, Congo DR etc. and the coal bearing Karoo sediments (upper Carboniferous – Triassic) distributes in these countries. On the other hand, smaller coal mines in Cretaceous and Tertiary are found in Nigeria, Morocco, Algeria, Libya, Sudan and Ethiopia.

(Source) GSJ Monthly Bulletin Vol. 26- No. 2, 1974

Figure B. 10 Distribution of coal mines in Africa

The World Energy Council (WEC) estimated the proved recoverable coal reserves in the African countries as Table B. 16. According to WEC, while the reserve in the Republic of South Africa comprises 97.1 percent of that in total Africa (11.1 percent in the world), that in Zambia is just 10 million tonnes. BP statistics also estimated the proved reserves of anthracite and bituminous coals in the whole Africa at the end of 2008 as 31,893 million tonnes, of which 30,408 million tonnes are in the South Africa, 502 million tonnes in Zimbabwe, and 929 million tonnes in other African countries.

Table B. 16 Proved recoverable coal reserves at end of 2005

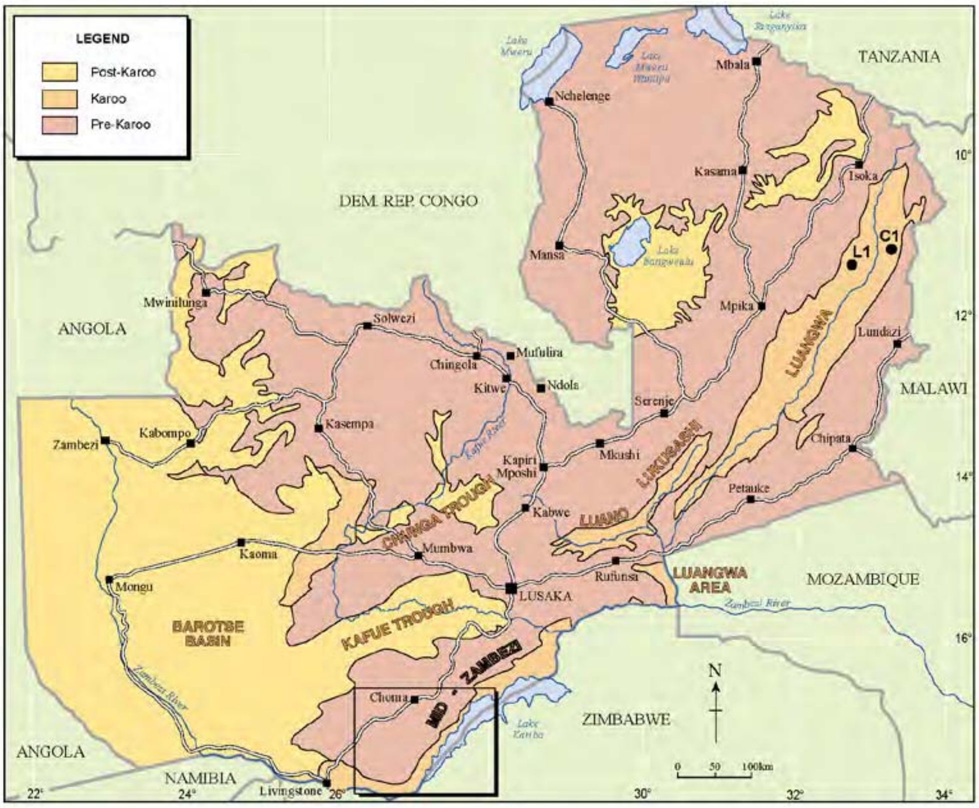
(unit: million tonnes)

	Country	Bituminous including Anthracite	Sub-bituminous	Lignite	Total
1	Algeria	59	-	-	59
2	Botswana	40	-	-	40
3	Central African Republic	-	-	3	3
4	DR Congo	88	-	-	88
5	Egypt	21	-	-	21
6	Malawi		2	-	2
7	Morocco	N.A	-	-	-
8	Mozambique	212	-	-	212
9	Niger	70	-	-	70
10	Nigeria	21	169	-	190
11	South Africa	48,000	-	-	48,000
12	Swaziland	208	-	-	208
13	Tanzania	200	-	-	200
14	Zambia	10	-	-	10
15	Zimbabwe	502	-	-	502
	Total Africa	**49,431**	**171**	**3**	**49,605**

(Source) "Survey of Energy Resources 2007", World Energy Council

(2) Coal resources in Zambia

Coal is found in a number of localities in Zambia and significant deposits have been discovered and mined in the mid-Zambezi Valley area. The coal seams occur exclusively within the Gwembe Formation, a sequence of sandstones, coal and carbonaceous and silty mudstones of the Lower Karoo Group. In addition to the mid-Zambezi Valley, potentially coal-bearing Karoo sediments occur in four other areas of Zambia – Luangwa Area, the Luangwa Valley, the Luano and Lukusashi Valleys and the Western Zambia Trough System (Chunga and Kafue Troughs and Barotse Basin) as shown in Figure B. 11.



(Source) "Investment Opportunities in Mining Industry", MMMD, 1998.

Figure B. 11 Distribution of Karoo rocks in Zambia

As for the quality of coal in Zambia, ash contents are high and calorific values are low compared with Wankie Coalfield in Zimbabwe and Witbank Coalfield in South Africa, as seen in Table B. 17.

Table B. 17 Analyses of Zambian coals

Area	H_2O %	Ash %	Volatile %	Fixed C %	S %	Calorific Value kCal/kg	No. of Analyses
Zambia							
Mid Zambezi							
- Nkandabwe	2.1	23.5	22.2	53.3	1.5	5,943	1,210
- Maamba	1.8	21.4	19.0	57.9	2.21	6,233	1,625
- Sinakumbe	2.3	22.3	18.2	56.8	1.21	5,996	50
- Mulungwa	1.6	23.3	17.9	57.1	0.77	6,056	50
Western Province	7.3	17.6	29.0	46.1	2.13	5,720	
Luangwa Valley	8.0	16.4	30.4	45.7	0.46	5,744	
Zimbabwe							
Wankie	0.76	9.8	23.8	65.7		7,534	
South Africa							
Witbank	2.3	13.0	28.5	56.2	1.06	6,833	

(Source) The Geology and Mineral Resources of Zambia Memoir No.6, Geological Survey of Zambia, 2001.

According to the coal classification by ASTM (American Society for Testing and Materials) shown in Table B. **18**, the Zambian coals are classified in lower bituminous coal to subbituminous coal, whereas Wankie coal in Zimbabwe and Witbank in the South Africa are in bituminous coal.

Table B. 18 Coal classification by (ASTM standard)

rank and group	fixed carbon percentage (dry, mineral-matter-free basis)		Volatile matter percentage dry, mineral-matter-free basis)		caloric value (moist, mineral-matter-free basis)[1]				agglomerating character
					Btu/lb		kcal/kg		
	equal to or greater than	less than	equal to or greater than	less than	equal to or greater than	less than	equal to or greater than	less than	
Anthracitic									
meta-anthracite	98	***	***	2	***	***	***	***	
anthracite	92	98	2	8	***	***	***	***	Non-agglomerating
semianthracite[2]	86	92	8	14	***	***	***	***	
Bituminous									
low-volatile bituminous	78	86	14	22	***	***	***	***	
medium-volatile bituminous	69	78	22	31	***	***	***	***	
high-volatile A bituminous	***	69	31	***	14,000 [3]	***	7,780	***	commonly agglomerating[4]
high-volatile A bituminous	***	***	***	***	13,000 [3]	14,000	7,220	7,780	
high-volatile A bituminous	***	***	***	***	11,500	13,000	6,390	7,220	
					10,500	11,500	5,830	6,390	agglomerating
Subbituminous									
subbituminous A	***	***	***	***	10,500	11,500	5,830	6,390	
subbituminous B	***	***	***	***	9,500	10,500	5,280	5,830	
subbituminous C	***	***	***	***	8,300	9,500	4,610	5,280	Non-agglomerating
Lignitic									
lignite A	***	***	***	***	6,300	8,300	3,500	4,610	
lignite B	***	***	***	***	***	6,300	***	3,500	

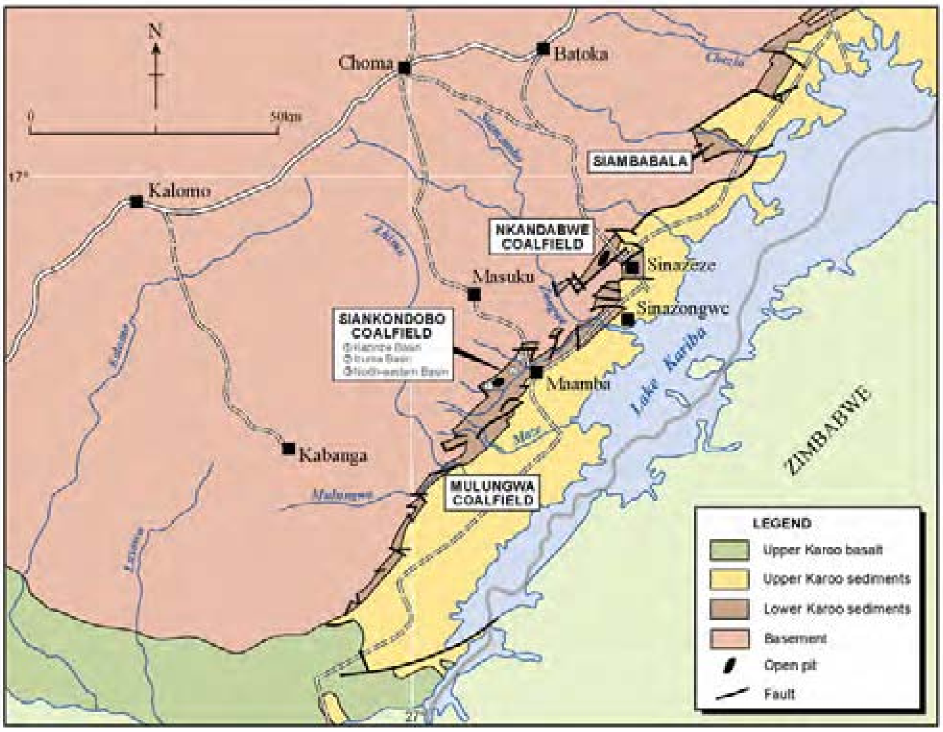
1) Moist coal contains natural inherent moisture but does not include visible water on the surface.
2) If agglomerating, classify in low-volatile group of the bituminous rank.
3) Coals having 69 percent or more fixed carbon on the dry, mineral-matter-free basis are classified by fixed carbon, regardless of caloric value.
4) There may be nonagglomerating varieties in these groups of the bituminous rank; there are also notable exceptions in the high-volatile C bituminous group.

(Source) 2000 Annual Book of ASTM Standards, section 5, volume 5.06.

The followings are the summary of five areas where Karoo system is distributed compiled by MMMD.

i) Mid Zambezi Valley

Karoo rocks occupy the full length of the mid-Zambezi Valley, extending continuously from the south-west end of Lake Kariba to the Kafue Gorge in the north-east. The sequence occupies a series of fault-controlled basins within Precambrian terrain but in some cases there is evidence for unconformable onlap of the sediments on to the basement rocks. Current production and future potential focuses mostly on the central and southern part of the mid-Zambezi Valley, notably the Siankondobo, Mulungwa and Nkandabwe Coalfields (see Figure B. 12).



(Source) Investment Opportunities in Mining Industry, MMMD, 1998

Figure B. 12 Distribution of coal mines in Mid Zambezi Valley

The overall thickness of the main seam member in the mid-Zambezi Valley varies from 1-15 m between the individual coal basins as shown in Table B. **19**

Table B. 19 Thickness of main seam member in mid-Zambezi Valley

Coalfield	Average thickness (m)	Maximum thickness (m)
Nkandabwe	3.7	7.0
Siankondobo, Kazinze sub-basin	6.0	15.0
Siankondobo, Izuma sub-basin	4.3	6.7
Maze- Sinakumbe	3.7	7.0
Mulungwa	7.0	9.0

(Source) The Geology and Mineral Resources of Zambia Memoir No.6, Geological Survey of Zambia, 2001.

At the end of 1996, the only major proven reserves of bituminous coal were those defined and owned by Maamba Collieries – specifically 13 million tonnes of open-pit and 14 million tonnes of underground coal in the Izuma basin and 30 million tonnes of open-pit and 20 million tonnes of underground coal in the Kazinze basin.

ii) Luangwa Area

This area borders the southern part of the Luangwa River in Zambia and is an eastern extension of the Mid-Zambezi Valley, separated from it by the basement gneisses exposed in the Mpata Gorge. The Karoo succession here is poorly known due to limited exposure, and carbonaceous units were not found during reconnaissance investigations undertaken by the Geological Survey in 1983. However, coal measures have been recorded immediately to the south of the area in Zimbabwe and so the area may merit further evaluation.

iii) Luangwa Valley

This area has the largest and most continuous exposure of Karoo rocks in Zambia which occupies the NE-trending rift valley over a distance of 560 km. In the main part of the Luangwa Valley, Lower Karoo rocks are exposed discontinuously along the western and eastern margins of the rift valley. Shaley coal horizons up to 0.6m thick are exposed in the southern extremity of the valley, suggesting some potential, but the northern strike-extension of the Lower Karoo sequence is within the South Luangwa National Park where exploitation would be unlikely to be permitted.

iv) Luano and Lukusashi Valleys

The area has not been explored exhaustively. However, lignitic coals outcrop in the central and northern parts of the Lukusashi Valley, with seams up to 2 m in thickness of interbedded lignitic coal and carbonaceous mudstone reported. The poor quality of the coal and the effects of faulting have reportedly discouraged further exploration.

v) Western Zambia Trough System

The trough system comprises the Barotse Basin, which underlies most of the Western Province and the north-western part of the North Western Province and two linear troughs – the Chunga trough extending from Kahare to the “Hot Springs Coalfield” and the Kafue trough, extending ENE from Mulobezi to Kafue.

There are some drillholes penetrated the Lower Karoo to intersect coal measures in these areas. However, quality of the coal proved to be low and the volumes available for extraction too small to be viable. Four additional holes drilled progressively westwards from Lubaba to Mulobezi revealed sandstone-mudstone sequences of Karoo age but neither coal measures nor basement were intersected. Consequently further exploration is warranted.

B.3.2 Petroleum

Two companies, Placid Oil Company, Zambia and Mobil, have undertaken exploration for oil in Zambia but with negative, albeit inconclusive results. The Phanerozoic geology of Zambia offers a number of pointers to the potential for oil. The Barotse Basin of western Zambia contains Karoo (Carboniferous- Triassic) sediments below a thin, possibly Tertiary, cover.

B.3.3 Natural Gas

As for natural gas, commercially feasible deposit has never been confirmed so far, although inquiry is performed together with oil by GSD (Geological Survey Department) under MMMD. The potential for coal bed methane (CBM) in the Lower Karoo coal measures of Zambia has yet to be investigated also.

B.3.4 Hydropower

Even though Zambia has abundant hydropower potential, it is not so much in the world and just ranked the eleventh in the African continent. Table B. 20 ranks the upper 15 countries in the African continent in terms of technically exploitable hydropower potential. The hydro potential in the Democratic Republic of the Congos (DR Congo) is prominent making up 42 %. Remarkably hydro potential in Africa is distributed uneven as the upper three countries occupy the two thirds of total hydro potential in Africa.

As for Zambia, per capital potential is 20 % bigger than the average of total Africa, but economically exploitable potential is below average. The amount of economically exploitable potential is nearly equal to the annual generation by the existing three hydropower stations; Kafue Gorge, Kariba North Bank and Victoria Falls. That is to say, economically exploitable hydro potential has already been developed in Zambia so far. On the other hand, technically exploitable hydro potential detailed in Clause 6.4.1 is close to the total amount of listed projects shown in Table 6.24. In conclusion, the hydro potential in Zambia is covered almost all with the existing facilities and the projects in hand.

Table B. 20 Exploitable Hydro Potential in African Continent

	Gross theoretical		Technically exploitable		Economically exploitable		Population
	(TWh/yr)	per capita (kWh/yr)	(TWh/yr)	per capita (kWh/yr)	(TWh/yr)	per capita (kWh/yr)	2007 (thsd)
1 DR Congo	1,397	22,388	774	12,404	419	6,715	62,399
2 Ethiopia	650	8,219	260	3,288	160	2,023	79,087
3 Madagascar	321	16,319	180	9,151	49	2,491	19,670
4 Cameroon	294	15,864	115	6,205	103	5,558	18,533
5 Gabon	190	142,857	76	57,143	33	24,812	1,330
6 Angola	150	8,814	65	3,819	65	3,819	17,019
7 Egypt (Arab Rep.)	125	1,656	50	663	50	663	75,467
8 Tanzania	47	1,162	40	989	13	322	40,432
9 Mozambique	95	4,445	38	1,778	32	1,497	21,372
10 Nigeria	43	291	32	216	30	203	147,983
11 Zambia	53	4,446	30	2,517	11	923	11,920
12 Guinea	26	2,772	19	2,026	19	2,026	9,380
13 Sudan	48	1,245	19	493	2	52	38,556
14 Zimbabwe	44	3,283	18	1,343			13,403
15 South Africa	73	1,534	14	294	5	105	47,588
Total Africa	3,884	4,145	1,852	1,976	1,007	1,075	937,121

(Source) Study Team from "Hydro Capability", WEC, 2007 and "World Development Indicators database," World Bank, 2008

The exploitable hydropower potential in the world is listed in Table B. 22 just for reference. Compared in terms of technically exploitable potential, that of Zambia is ranked 56th and less than that of Japan (20th). Moreover, per capita potential is 2,517 kWh p.a. and ranked 55th, which is fairly less compared to Bhutan (150,685 kWh), Lao PDR (10,751 kWh), Nepal (5,372 kWh), Canada (29,749 kWh) which are the countries actually exporting hydro energy. In this regards, Zambia can little afford to export hydro energy as busy to meet the domestic demand.

The specific hydropower potentials are stated as below.

(3) Conventional hydropower

The amount of rainfall in Zambia generally tends to increase as one proceeds further north. Although there is a dry season extending mainly for the months of June, July, and August, parts of North-Western, Luapula, and Northern provinces receive more than 1,300 millimeters of rain per year. Data for rainfall and river flow have been presented in the previous JICA study[7] (see Table B. 21).

Table B. 21 Rainfall data (yearly average levels, 1963 - 1992)

Name of station	East Longitude	South Latitude	Rainfall (mm)	Name of station	East Longitude	South Latitude	Rainfall (mm)
Chipata	32.58	13.57	980.4	Mansa	28.85	11.10	1179.2
Chipepo	27.88	16.80	776.5	Mbala	31.33	8.85	1202.4
Choma	27.07	16.85	770.7	Mfuwe	31.93	13.27	810.8
Isoka	32.63	10.17	1086.2	Misamfu	31.22	10.18	1330.7
Kabompo	24.20	13.60	1040.6	Mkushi	29.80	13.60	1178.4
Kabwe Met	28.48	14.42	901.4	Mongu	23.17	15.25	914.4
Kabwe Agro	28.50	14.40	878.2	Mpika	31.43	11.90	993.6
Kafironda	28.17	12.63	1274.8	Msekera	32.57	13.65	1010.3
Kafue	27.92	15.77	746.3	Mtmakulu	28.32	15.55	878.2
Kalabo	22.70	14.95	807.8	Mumbwa	27.07	14.98	820.6
Kaoma	24.80	14.80	904.5	Mwinilunga	24.43	11.75	1390.4
Kasama	31.13	10.22	1309.5	Ndola	28.66	13.00	1185.0
Kasempa	25.83	13.47	1155.4	Petauke	31.28	14.25	967.8
Kawambwa	29.25	9.80	1361.9	Samfya	29.32	11.21	1478.7
Livingstone	25.82	17.82	637.1	Senanga	23.27	16.12	727.0
Lundazi	33.20	12.28	874.2	Serenja	30.22	13.23	1058.7
Lusaka Hq	28.32	15.42	821.5	Sesheke	24.30	17.47	627.7
Lusaka Airport	28.43	15.32	934.0	Solwezi	26.38	12.18	1341.9
Lusitu	28.82	16.18	534.7	Zambezi	23.12	13.53	1022.3
Magoye	27.63	16.13	715.1				

(Source) JICA" Development Study for the Rural Electrification Plan in Zambia", (2008)

Topographically, Zambia is characterized by mountainous zones in the north, with high elevations in North-Western, Luapula, and Northern provinces. The elevation of the vicinity of the Zambezi River downstream of Lake Kariba and of the Luangwa River, which flows through the eastern part of the country, is less than 600 meters. As the rest of Zambia lies at an elevation of about 1,000 meters, there is a big difference from those near the aforementioned two rivers. Furthermore, there is a watershed in Northern Province, such that rivers in Luapula and Northern provinces flow into the DRC. Those in other provinces flow southward and ultimately into the Zambezi. Estimating the hydropower potential as far as topography is concerned from this basic information, the chief candidates would be 1) the Muchinga Escarpment extending from the watershed in Luapula and Northern provinces to the Luangwa River, and 2) the downstream areas of the Zambezi, whose catchment area encompasses most of Zambia, and the Kafue River (its tributary).

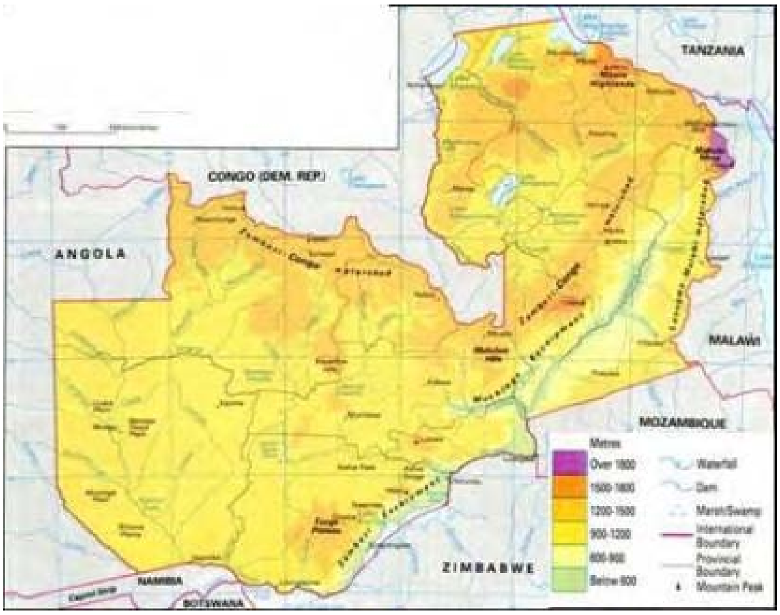
[7] "Development Study for the Rural Electrification Plan in Zambia", Japan International Cooperation Agency (JICA), 2008

Table B. 22 World exploitable hydropower (top 100 countries)

Rank	by per capita	Country	Gross theoretical (TWh/year)	Gross theoretical per capita (kWh/yr)	Technically exploitable (TWh/year)	Technically exploitable per capita (kWh/yr)	Economically exploitable (TWh/year)	Economically exploitable per capita (kWh/yr)	Population 2007 (thousand)
1	64	China	6,083	4,608	2,474	1,874	1,753	1,328	1,319,983
2	33	United States of America	4,485	14,870	1,752	5,809	501	1,661	301,621
3	17	Russian Federation	2,295	16,204	1,670	11,791	852	6,015	141,636
4	29	Brazil	3,040	15,866	1,488	7,766	811	4,233	191,601
5	9	Canada	2,216	67,200	981	29,749	536	16,254	32,976
6	16	Congo (Democratic Rep.)	1,397	22,388	774	12,404	419	6,715	62,399
7	97	India	2,638	2,348	660	588	600	534	1,123,319
8	67	Indonesia	2,147	9,516	402	1,782	40	177	225,630
9	14	Peru	1,577	56,527	395	14,159	260	9,320	27,898
10	6	Tajikistan	527	78,190	264	39,169	264	39,169	6,740
11	48	Ethiopia	650	8,219	260	3,288	160	2,023	79,087
12	26	Venezuela	320	11,650	246	8,956	130	4,733	27,467
13	77	Pakistan	480	2,956	219	1,349			162,389
14	51	Turkey	433	5,860	216	2,923	130	1,759	73,888
15	42	Colombia	1,000	21,684	200	4,337	140	3,036	46,117
16	5	Norway	560	118,921	200	42,472	187	39,711	4,709
17	24	Madagascar	321	16,319	180	9,151	49	2,491	19,670
18	21	Chile	227	13,679	162	9,762			16,595
19	35	Nepal	733	26,078	151	5,372	15	534	28,108
20	83	Japan	718	5,619	136	1,064	114	892	127,771
21	20	Ecuador	167	12,519	134	10,045	106	7,946	13,340
22	47	Argentina	354	8,961	130	3,291			39,503
23	52	Myanmar	342	7,011	130	2,665			48,783
24	15	Bolivia	178	18,701	126	13,238	50	5,253	9,518
25	39	Malaysia	230	8,663	123	4,633			26,550
26	76	Viet Nam	300	3,524	123	1,445	78	916	85,140
27	1	Greenland	800	14,035,088	120	2,105,263			57
28	31	Cameroon	294	15,864	115	6,205	103	5,558	18,533
29	13	Paraguay	130	21,242	106	17,320	101	16,503	6,120
30	70	Italy	340	5,726	105	1,768	65	1,095	59,375
31	74	France	270	4,376	100	1,621	70	1,134	61,707
32	18	Sweden	130	14,211	100	10,931	85	9,292	9,148
33	37	Australia	265	12,609	100	4,758	30	1,427	21,017
34	3	Bhutan	263	400,304	99	150,685	56	85,236	657
35	11	Kyrgyzstan	163	31,089	99	18,882	55	10,490	5,243
36	23	Iraq	225	23,639	90	9,456	50	5,253	9,518
37	12	Georgia	180	40,946	80	18,198	40	9,099	4,396
38	4	Gabon	190	142,857	76	57,143	33	24,812	1,330
39	25	Austria	150	18,040	75	9,020	56	6,735	8,315
40	69	Iran (Islamic Rep.)	176	4,455	70	1,772			39,503
41	75	Spain	150	3,342	66	1,471	32	713	44,879
42	45	Angola	150	8,814	65	3,819	65	3,819	17,019
43	2	Iceland	184	591,640	64	205,788	40	128,617	311
44	19	Laos	232	39,590	63	10,751			5,860
45	44	Kazakhstan	170	10,981	62	4,005	29	1,873	15,481
46	95	Egypt (Arab Rep.)	125	1,656	50	663	50	663	75,467
47	102	Mexico	135	1,282	49	465	32	304	105,281
48	30	Papua New Guinea	175	27,672	49	7,748	15	2,372	6,324
49	22	Costa Rica	223	49,978	43	9,637	20	4,482	4,462
50	34	Switzerland	125	16,556	43	5,695	41	5,430	7,550

Rank	by per capita	Country	Gross theoretical (TWh/yr)	Gross theoretical per capita (kWh/yr)	Technically exploitable (TWh/yr)	Technically exploitable per capita (kWh/yr)	Economically exploitable (TWh/yr)	Economically exploitable per capita (kWh/yr)	Population 2007 (thousand)
51	87	Tanzania	47	1,162	40	989	13	322	40,432
52	68	Mozambique	95	4,445	38	1,778	32	1,497	21,372
53	27	New Zealand	46	10,880	37	8,751	24	5,676	4,228
54	73	Romania	70	3,249	35	1,624	25	1,160	21,547
55	121	Nigeria	43	291	32	216	30	203	147,983
56	55	Zambia	53	4,446	30	2,517	11	923	11,920
57	59	Cambodia	88	6,092	30	2,077	5	346	14,446
58	85	Uzbekistan	88	3,275	27	1,005	15	558	26,868
59	7	Guyana	64	86,604	26	35,183	26	35,183	739
60	98	Korea (Republic)	52	1,072	26	536	19	392	48,530
61	113	Germany	120	1,459	25	304	20	243	82,268
62	57	Portugal	32	3,017	25	2,357	20	1,885	10,608
63	8	Cyprus	59	74,968	24	30,496			787
64	32	Bosnia-Herzogovina	70	17,825	24	6,112	19	4,838	3,927
65	99	Ukraine	45	970	24	517	17	367	46,383
66	41	Finland	48	9,075	23	4,349	14	2,647	5,289
67	72	Guatemala	54	4,046	22	1,648			13,348
68	28	Mongolia	56	21,440	22	8,423			2,612
69	120	Philippines	47	535	20	228	18	205	87,892
70	--	Taiwan, China	103	--	20	--	12	--	--
71	61	Guinea	26	2,772	19	2,026	19	2,026	9,380
72	100	Sudan	48	1,245	19	493	2	52	38,556
73	54	Serbia	37	5,009	19	2,572	18	2,437	7,386
74	78	Zimbabwe	44	3,283	18	1,343			13,403
75	65	Azerbaijan	44	5,134	16	1,867	7	817	8,571
76	116	Thailand	41	642	16	251	15	235	63,832
77	38	Albania	40	12,575	15	4,715	6	1,886	3,181
78	63	Bulgaria	27	3,533	15	1,963	12	1,570	7,642
79	79	Greece	80	7,147	15	1,340	12	1,072	11,193
80	114	South Africa	73	1,534	14	294	5	105	47,588
81	108	Poland	23	604	14	368	7	184	38,061
82	104	Uganda	18	582	13	420			30,930
83	10	Surinam	32	69,869	13	28,384			458
84	96	Côte d'Ivoire	46	2,387	12	623	6	311	19,268
85	46	Panama	26	7,782	12	3,592	12	3,592	3,341
86	101	Ghana	26	1,108	11	469			23,462
87	50	Liberia	28	7,461	11	2,931			3,753
88	53	Congo (Rep.)	50	13,273	10	2,655			3,767
89	36	Namibia	25	12,054	10	4,822	2	964	2,074
90	66	Nicaragua	33	5,888	10	1,784	7	1,249	5,605
91	49	Uruguay	32	9,641	10	3,013			3,319
92	117	Kenya	24	639	9	240			37,531
93	89	Dominican Republic	50	5,127	9	923	6	615	9,752
94	60	Croatia	20	4,507	9	2,028	8	1,803	4,438
95	40	Slovenia	19	9,415	9	4,460	7	3,469	2,018
96	92	Hungary	10	994	8	796	4	398	10,056
97	81	Sierra Leone	11	1,881	7	1,197			5,848
98	88	Honduras	16	2,256	7	987			7,091
99	58	Armenia	22	7,331	7	2,333	4	1,333	3,001
100	109	Sri Lanka	18	902	7	351	7	351	19,945

(Source) Compiled by JICA Study Team based on “Hydro Capability”, WEC, 2007 and ”World Development Indicators database,” World Bank, 2008



(Source) Basic Education Atlas of Zambia

Figure B. 13 Outline topographical map of Zambia

In a previous study, it was reported that Zambia had a hydropower potential of about 6,000 megawatts. Thus far, however, only about 1,800 megawatts of this potential have been developed. Numerous plans for additional hydropower development have been studied. There have already been studies for selection of promising new sites in the aforementioned area of hydropower potential. This study shall present plans for hydropower development found to be possible by previous studies. Because the objective is to prepare a master plan, it shall take up only projects with a capacity of at least 30 megawatts.

The Zambezi River forms Zambia's border with Zimbabwe. It is the fourth-longest river in Africa, trailing the Nile, Congo, and Niger rivers. It has a total length of about 2,750 kilometers, and flows through Mozambique into the Indian Ocean. In the 1960s, the Kariba Hydropower Station was constructed on the Zambezi. The reservoir created by the Kariba Dam is widely known as one of the biggest man-made lakes in the world. The Zambezi River is famed for Victoria Falls, which is regarded as one of the world's three biggest waterfalls. The candidate hydropower sites on the main channel of the Zambezi studied to date include Batoka Gorge, Devil's Gorge, and Mpata Gorge, but there has been no concrete progress since the 1993 study[8].

The Kafue River, which is the biggest tributary of the Zambezi, underwent development in the 1970s. Along with the construction of the current Kafue Gorge Hydropower Station, the Itezhi Tezhi dam was built about 230 kilometers upstream and formed a reservoir with a capacity of 6 billion cubic meters. This reservoir levels the flow of the Kafue, which varies with the season (wet versus dry) and contributes to the efficient operation of the Kafue Gorge Hydropower Station. At present, a plan is moving ahead for construction of a power plant on

[8] "Bakota Gorge Hydro Electric Scheme Feasibility Report", Zambezi River Authority (ZRA), 1993.

the Itezhi Tezhi reservoir. There is also a promising development site downstream of the Kafue Gorge plant. With the actualization of these projects, the Kafue River would be developed as an entire river system, and this would enable even more effective use of Zambia's water resources.

Studies are also being made of candidate sites for development on the Luapula River, which forms the boundary with the DRC north of Zambia, and the Kalungwishi River, which flows into Lake Mweru in Northern Province. To the west of South Luangwa National Park spreads a mountains district that forms the watershed and contains the Muchinga Escarpment affording a head of about 500 meters. There are good prospects for hydropower development in this area, and several plans to this end have been confirmed. The previous JICA study found comparatively many candidate sites for mini-hydropower development in North-Western Province. The study team also confirmed the existence of plans for development on a capacity scale of at least 30 MW with a view to supply to a mining company.

The promising projects specified by the existing study are located in areas with a high hydropower potential. In terms of physical distribution, they may be divided into the following major categories: the main channel of the Zambezi River; the Kafue River, the biggest tributary of the Zambezi; the border with the DRC and the northern region; and the hilly region containing the Muchinga Escarpment to the west of South Luangwa National Park.

Table B. 23 Hydropower potential (table of hydropower projects)

River	Province	Project	Capacity(MW)	Remarks
Zambezi	Southern	Kariba North Bank (Existing)	600（720）*[1]	Zimbabwe Border
	Southern	Victoria Falls (Existing)	108	
	Southern	Kariba North Bank Expansion	360	
	Lusaka	Mpata Gorge	600(1,200) *[2]	
	Southern	Devil’s Gorge	800(1,600) *[2]	
	Southern	Batoka Gorge	800(1,600) *[2]	
Kafue	Lusaka	Kafue Gorge (Existing)	900 (990) *[1]	
	Southern	Itezhi Tezhi	120	
	Lusaka	Kafue Gorge Lower	750	
Luapula	Luapula	Mumbotuta Fall - Site CX	 301	DR Congo Border
	Luapula	Mambilia Fall - Site II - Site I	 202 124	
Kalungwisi	Luapula &Northern	Kabwleume Falls Kundabwika Falls	62 101	
Others	Central	Lusiwasi Expansion	50	West mountain area of the South Luangwa national park
	Northern	Mutinondo	40	
	Northern	Luchenene	30	
	Central	Lunsemfwa	55	
	Central	Mkushi	65	
	North Western	Kabompo	34	
		Total	6,312 (1,818 Existing）	

*[1] Up-rate due to the rehabilitation project
*[2] Fifty - fifty with Zimbabwe

(4) Small scale hydropower

Zambia has a number of potential sites on small rivers suitable for local small-scale power generation. The most promising sites for such development are in the North-Western and Northern parts of the country, thanks to the topography of the terrain, the geology of the ground and high annual rainfall.

Based on the studies on rivers with sufficient perennial flows, the hydropower potential for some sites has been listed in the National Energy Policy as indicated in Table B. 24.

Acknowledging such small scale hydropower generation is effective for electrification of remote areas, the listed potential is too small to take account in the master plan study.

Table B. 24 Small scale hydro potential in Zambia

No.	River Basin	Site	River	Capacity, kW
1	Zambezi	Zambezi falls	Zambezi	to be determined
2	Zambezi	Chavuma falls	Zambezi	10 - 20,000
3	Zambezi	Sachibondo	Luakela	600
4	Zambezi	Mwinilunga	West Lunga	2,500
5	Zambezi	Kapembe	Kabompo	to be determined
6	Zambezi	Chikata falls	Kabompo	3,000
7	Kafue	Kasempa	Lufupa	230
8	Kafue	Mutanda	Lunga	400
9	Kafue	Kelongwa	Lunga	to be determined
10	Chambeshi	Chandaweyaya	Chambeshi	to be determined
11	Chambeshi	Mbesuma ferry	Chambeshi	to be determined
12	Chambeshi	Shiwang'andu	Manshya	1,000

(Source) National Energy Policy, 2008, originally from CEEEZ Limited, 2004

B.3.5 Renewable energy

Renewable energy sources of energy that are available in Zambia and have the potential to be exploited on a wider scale are solar, wind and biogas. The National Energy Policy enshrined the potential of renewable energy sources as Table B. 25.

Table B. 25 Availability and utilization of renewable energy sources

Renewable Energy Source	Opportunities/ Use	Resource Availability	Potential Energy Output
Solar	Thermal (water heating), Electricity (water pumping, lighting, refrigeration)	6-8 sunshine hours per day	5.5 $kWh/m^2/day$ (modest potential especially for limited irrigation)
Wind	Electricity, Mechanical (water pumping)	Average 3 m/s	Good potential, especially for irrigation
Micro-hydro	Small grids for electricity supply	Reasonably extensive	Requires elaboration and quantification
Biomass (combustion and gasification)	Electricity generation	Agro wastes Forest wastes Sawmill wastes	Requires elaboration and quantification
Biomass (biomethanation)	Electricity generation Heating and cooking	Animal waste Municipal and Industrial waste Waste water	Potential requires elaboration
Biomass (extraction, processing for transport)	Ethanol for blending with gasoline to replace lead as octane enhancer Biodiesel for stationary engines	Sugarcane Sweet sorghum Jetropha	Requires elaboration and quantification
Biomass (for household energy)	Improved charcoal production Improved biomass stove	Sawmill wastes and indigenous trees from sustainable forest management	Reasonably extensive
Geothermal	Electricity generation	Hot springs	Requires elaboration and quantification

(Source) National Energy Policy, 2008

Renewable energy sources are expected to be utilized instead of wood fuel as presented in the policy documents mentioned in Section B.1. Table B. 26 is the goals and objectives of the renewable energy development indicated the National Energy Strategy 2008-2030 (Zero draft).

Table B. 26 Renewable energy goals and objectives

Energy source	Goal	Objective
Solar	To contribute 100 MW towards water heating energy needs	Solar to be the major source of energy for water heating
	To install at least 500,000 solar PV systems country wide	To make solar energy the main source of energy especially for areas that off the power grid such as rural households, health centres and schools
	Establish solar farms outputting at least 100 MW	To increase solar energy contribution to the total national energy needs and mitigate power deficit
	To switch 50% of heating and drying processes to solar	To encourage use of solar energy for most agricultural and industrial heating and drying processes such as food processing, curing of tobacco, timber drying etc.
Wind	To produce at least 1 MW	To exploit wind energy potential for electricity generation and water pumping
Geothermal	To develop at least 50% of all viable geothermal sites	To exploit geothermal potentials for generation of electricity

(Source) National Energy Strategy: 2008-2030 (Zero Draft)

Information on available renewable energy resources and technologies elaborated in the National Energy Policy is follows:

(5) Solar

The Zambia Meteorological Department (ZMD) under the Ministry of Communication and Transport, gathers data on solar energy from nine stations spread across the country. The data shown in Table B. 27 shows that the sunshine hours range between 2,600 – 3,000 hours per year and the annual solar isolation is about 5.6 kilowatt hours per square meter (kWh/ sq.m) per day. The energy from the sun is at its peak between October and November.

Solar energy is well distributed across the country. With over half of Zambia's population living in rural areas, this energy is especially advantageous as the conventional sources of energy particularly grid electricity is expensive and difficult to supply. Solar photovoltaics (PVs) provide suitable alternative electricity in rural areas. However, despite the abundance of energy the relatively high initial cost of installation is a barrier to the widespread use of this technology. MEWD through DOE has embarked on a project, the Solar Energy Project to provide electricity to rural institutions for educational and medical purposes. The project is funded by SIDA and so far a total of 400 systems have been installed and distributed.

Table B. 27 Average Annual Isolation

Location	Global Radiation/ day (kWh/m^2)	Sunshine hours/ year
Chipata	7.6	2,774
Kabwe	8.8	3,212
Kasama	7.9	2,884
Livingstone	8.9	3,249
Lusaka	8.2	2,993
Mansa	6.4	2,336
Mongu	8.8	3,212
Ndola	8.0	2,920
Solwezi	7.6	2,774

(6) Wind

ZMD also collects data on wind. Wind data shown in Table B. 28 is recorded at 10 m heights above the ground and wind speeds vary between 0.1 and 3.5 meters per second (m/s). The annual average is 2.5 m/s. The use of wind energy in Zambia is basically limited to water pumping and little has been done to develop this technology further. However, recent developments provide great opportunities of exploiting this source of energy.

Table B. 28 Annual Average Wind Speed

Location	Annual Average Wind Speed (m/s)	Range between Months (m/s)
Lusaka	3.50	2.00 - 4.00
Ndola	2.30	1.60 - 3.45
Kasama	2.50	1.95 - 3.60
Chipata	2.30	1.50 - 3.30
Mansa	1.90	1.15 - 3.45
Livingstone	1.60	1.40 - 2.15
Kabwe	2.70	1.85 - 3.65

(7) Bio gas

Bio gas (methane gas) which is produced from a process of microbiological breakdown of animal waste, is well-established fuel for cooking in a number of countries such as China and India. In Zambia, the production and use of biogas is relatively new and is being spearheaded by the National Institute for Scientific and Industrial Research (NISIR). NISIR currently runs biogas digesters that use animal waste for cooking purposes in Lusaka, Monze, Kasisi, Lealui, Pemba, Chisamba, Maamba, Mukondi and Kabwe.

(8) Geothermal

Zambia has more than eighty hot springs. The earliest publications on Zambian hot springs date as far as 1889 and from 1950's a number of institutions and individuals have investigated the occurrence of hot springs to various degree, including the Geological Survey of Zambia and Department of Water Affairs. However, little has been done to utilize the hot springs efficiently for industrial and energy purposes.

Currently, there is no electricity generation at the identified geothermal sites.

B.3.6 Nuclear power

Zambia is a member country of the International Atomic Energy Agency (IAEA) and has already ratified the Nuclear Non-Proliferation Treaty (NPT) of UN. In this way, it is internationally accepted that Zambia committed peaceful use of nuclear power.

On the other hand, Zambia has no specific development plan while it has Uranium resources in its territory. In the National Energy Policy 2008 (NEP 2008), though there are some strategies on nuclear development as following, but those are not specified.

- Supporting investigations into the use of Uranium as an electricity generating source;
- Promoting the exploitation and use of Uranium for social and developmental activities;
- Developing separate legislation on the exploration and utilization of Uranium; and
- Attracting local and foreign investment.

Nuclear generation has already been introduced in the 32 counties/ regions[9] in the world as shown in Table B. 29[10] and becomes spotlighted again owing to recent fossil fuel price hike and necessity as a countermeasure against global warming.

For instance, new installation of NPPs has never seen in the United States since 1973 under the influence of TMI accident in 1979 and the number of operating NPPs was decreased from its peak of 111 reactors. The US government revised the Energy Policy Act of 2005 which prescribes the favorable treatment for promotion of NPPs. As of January 2009, 28 nuclear projects are under planning or construction in the United States. Italy is reconsidering installation of NPPs, which once abolished all the nuclear projects including then existing and operating ones with the Chernobyl Accident.

Table B. 30 shows the trend of nuclear energy development in the countries where NPPs have not yet been introduced.

Table B. 29 shows the fact that among the 32 countries operating NPPs, only two countries (India and Pakistan) are classified as Low Income countries, three countries (PR China, Ukraine and Iran) as Lower Middle Income countries and the rest as Upper Middle or High Income countries. However, as shown in Table B. 30, even Low Income countries, mainly the south-east Asian countries are discussing to introduce NPPs. In Africa, Egypt, Libya, Algeria, Tunisia, Morocco, Nigeria, Ghana and Namibia are taking some action for introduction of nuclear energy.

Nuclear power generation needs wide national consensus because of its potential risk, so that strong commitment of the government seems to be essential. In this sense, Zambia has not yet prepared for introduction of nuclear energy, compared with the countries shown in Table B. 30.

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9 Iran started NPP operation in February 2009.

10 Colors in the table are accordance with the classification of national income defined by the World Bank. (i.e. blue: high income, green: upper middle income, purple: lower middle income, red: low income).

Table B. 29 Nuclear Power Generation in the World

	Country	Stage						Total		Type of Reactor												Total		GDP	GDP	Population
		Operation		Construction		Plan				PWR		BWR		HWR		LWGR		GCR/ AGR		FR				per capita	2007	2007
		(MW)	Nos	(MW)	Nos	(MW)	Nos	(MW)	Nos	(MW)	Nos	(MW)	Nos	(MW)	Nos	(MW)	Nos	(MW)	Nos	(MW)	Nos	(MW)	Nos	US$	million $	thousand
1	USA	106,061	104			1,200	1	107,261	105	71,936	70	35,325	35									107,261	105	45,790	13,811,200	301,621
2	France	66,020	59	1,630	1			67,650	60	67,510	59									140	1	67,650	60	41,523	2,562,288	61,707
3	Japan	49,580	55	2,565	3	14,945	11	67,090	69	23,354	26	43,456	42							280	1	67,090	69	34,254	4,376,705	127,771
4	Russia	23,194	27	6,154	8	5,500	5	34,848	40	21,448	26					12,000	12			1,400	2	34,848	40	9,115	1,291,011	141,636
5	Germany	21,371	17					21,371	17	14,723	11	6,648	6									21,371	17	40,079	3,297,233	82,268
6	South Korea (ROK)	17,716	20	6,800	6	2,800	2	27,316	28	24,537	24			2,779	4							27,316	28	19,983	969,795	48,530
7	Ukraine	13,835	15	2,000	2			15,835	17	15,835	17											15,835	17	3,029	140,484	46,383
8	Canada	13,425	18					13,425	18					13,425	18							13,425	18	40,222	1,326,376	32,976
9	UK	11,952	19					11,952	19	1,250	1							10,702	18			11,952	19	44,693	2,727,806	61,034
10	Sweden	9,384	10					9,384	10	2,928	3											2,928	3	48,584	444,443	9,148
11	PRC	9,118	11	7,900	8	8,000	8	25,018	27	23,578	25	6,456	7									30,034	32	2,485	3,280,053	1,319,983
12	Spain	7,727	8					7,727	8	6,169	6			1,440	2							7,609	8	31,846	1,429,226	44,879
13	Belgium	6,117	7					6,117	7	6,117	7	1,558	2									7,675	9	42,213	448,560	10,626
14	ROC	5,164	6	2,700	2			7,864	8	1,902	2											1,902	2	--	--	--
15	India	4,120	17	3,160	6	6,800	8	14,080	31	2,000	2	5,962	6									7,962	8	1,042	1,170,968	1,123,319
16	Czech	3,860	6					3,860	6	3,860	6	320	2	7,260	22					500	1	11,940	31	16,271	168,142	10,334
17	Switzerland	3,372	5					3,372	5	1,780	3											1,780	3	55,035	415,516	7,550
18	Finland	2,800	4	1,700	1			4,500	5	2,720	3	1,592	2									4,312	5	46,515	246,020	5,289
19	Slovak	2,200	5					2,200	5	2,200	5	1,780	2									3,980	7	13,887	74,932	5,396
20	Brazil	2,007	2			1,350	1	3,357	3	3,357	3											3,357	3	6,859	1,314,170	191,601
21	Bulgaria	2,000	2			2,000	2	4,000	4	4,000	4											4,000	4	5,175	39,549	7,642
22	Hungary	1,940	4					1,940	4	1,940	4											1,940	4	13,741	138,182	10,056
23	South Africa	1,890	2			110	2	2,000	4	1,890	2											1,890	2	5,833	277,581	47,588
24	Lithuania	1,500	1					1,500	1									110	1			110	1	11,353	38,328	3,376
25	Romania	1,412	2	2,118	3			3,530	5							1,500	1					1,500	1	7,703	165,980	21,547
26	Mexico	1,364	2					1,364	2					3,530	5							3,530	5	8,486	893,364	105,281
27	Argentine	1,005	2	745	1			1,750	3			1,364	2									1,364	2	6,641	262,331	39,503
28	Slovenia	727	1					727	1	727	1			1,750	3							2,477	4	22,523	45,451	2,018
29	Netherlands	510	1					510	1	510	1											510	1	46,041	754,203	16,381
30	Pakistan	462	2	300	1			762	3	625	2											625	2	884	143,597	162,389
31	Armenia	408	1					408	1	408	1			137	1							545	2	3,058	9,177	3,001
32	Iran			1,000	1	360	1	1,360	2	1,360	2											1,360	2	3,815	270,937	71,021
33	Indonesia					4,000	4	4,000	4	4,000	4											4,000	4	1,918	432,817	225,630
34	Egypt					1,872	2	1,872	2	1,872	2											1,872	2	1,697	128,095	75,467
35	Israel					664	1	664	1	664	1											664	1	22,563	161,822	7,172
36	Turkey					N/A	3	0	3	N/A	3											0	3	8,893	657,091	73,888
37	Kazakhstan					N/A	1	0	1	N/A	1											0	1	6,708	103,840	15,481
38	Viet Nam					N/A	1	0	1	N/A	1											0	1	836	71,216	85,140
		392,241	435	38,772	43	49,601	53	480,614	531	315,200	328	104,461	106	30,321	55	13,500	13	10,812	19	2,320	5	476,614	526	--	--	--

(Source) Trend of the World Nuclear Energy Development 2007/2008

Table B. 30 Trend of the World Nuclear Energy Development

Region	Country	Status
Europe	Italy	- Total abolition of NPPs (including then operating plants) by the referendum, triggered by Chernobyl accident. - Electric utility ENEL is negotiating with EDF on participation in the new installation of NPP planned by EDF.
	Poland	- Under discussion on the participation in the construction plan of alternative of Ignalina #2 NPP in Lithuania (joint construction with Baltic States). - Jan. 2009, the Prime Minister declared the construction of two NPPs in the country. (Commencement of Unit #1targeted by 2020)
Asia	Indonesia	- Construction of Muria NPP (2 x 1,000 MW) located in mid Jawa was decided, targeting commercial operation in 2016- 2017. - Jul. 2007, signing on MOU for F/S on construction of two units with Korean KHNP.
	Vietnam	- Jan. 2006, Prime Minister approved "Long-term strategy on peaceful use of Nuclear power up to 2020" - Apr. 2008, the Government decided the installation of 4,000 MW NPPs (1,000 MW x 4 units) by 2020. (2 units x 2 sites in Ninh Thuận Province)
	Thailand	- Introduction of NPP was revived in PDP on Nov. 2006, owing to high demand growth (7%, 20 years ahead). - June 2007, energy ministry announced NPP plan with 4,000 MW capacity (commencement of work in 2014, commercial operation in 2020).
	Bangladesh	- Since 1963, nuclear development plan at Roopur site has been discussed several times. - In 2007, BAEC proposed Roopur project (2units, 500 MW up to 2015). - Apr. 2005, conclusion of agreement on NPP with China (exploration of nuclear material and construction of NPP). - Apr. 2008, the government expressed the intention to cooperate with China, on construction of NPP. (Russia and Korea also show interest.)
	Philippines	- Construction of Batan NPP (620 MW) was completed in 1984, but abolishment started before nuclear fuel loading for fear of question on contract and safety. - National Energy Policy in 2008, referred to the necessity of introduction of 600 MW class NPP. (commission in 2025.) - In 2008, IAEA mission surveyed the Batan NPP, and advised that Batan could be operated economically and safely with some renovation. - Dec. 2008, the government commissioned Korean KEPCO to conduct a F/S on operation of NPP.
	Malaysia	- Jul. 2008, the government ordered state utility TNB to establish NPP F/S task force. - Sep. 2008, the government set the target of nuclear development in year 2023.
	Mongolia	- Closer relation with Russia (signing on agreement : F/S on NPP, development of uranium resources)
CIS	Azerbaijan	- Plan to construct 1,000 -1,500 MW class NPP
	Georgia	- Discussion on NPP construction as to support the energy security.
	Kazakhstan	- 1973- 1999: Operation of Fast Reactor BN-350 (along the Caspian Sea) (for generation and desalination) - Promotion of NPPs (southern , western and rural area) - F/S for NPP will be completed by 2009. (unit 1: to be commissioned by 2016). - World second largest uranium possession (third largest producer of uranium, targeting world No. 1 by 2010).
	Belarus	- Plan to construct two units of NPP (1st unit: 2016, 2nd unit 2018)
Oceania	Australia	- Start discussion on the possibility of future introduction of NPP to reduce CO2 emission. - End of 2006, task force established by the prime minister reported "if carbon tax is introduced, nuclear energy will have competitiveness, and the first unit will be operated within 15 years. In 2050, one-third of power demand will be possibly supplied by nuclear energy."
Middle-east & North Africa	Turkey	- Continuous study and planning on construction of NPP since 1970's. (several disruption by economic reason). - Aug. 2006, the government announced construction plan of three units of NPP with capacity of 4,500 MW (start operation: 2012-2015). - Mar. 2008, TAEK offered international bidding and only Russian responded.

Region	Country	Status
	Iran	- Feb. 2009, the first NPP was commenced by Russian support.
	GCC: Kuwait, Saudi Arabia, Bahrain, UAE, Qatar, Oman	- Dec. 2006, GCC announced its commencement of study on peaceful use of nuclear energy. - Feb. 2007, GCC & IAEA agreed cooperation on F/S on nuclear generation and desalination. - Apr. 2008, UAE announced its own nuclear comprehensive policy (5,000 MW of NPPs by 2020). - ENEC of UAE concluded contract on management of introduction plan of NPPs with US CH2M Hill. - Jordan expressed the target of operation of NPPs by 2015 (share of NPP: 30 % in 2030's).
	Jordan	- May 2008, started discussion on the possibility of NPP construction with French AREVA.
	Egypt	- Oct. 2006, energy minister announced 1,000 MW class reactor by 2015. - Dec. 2008, energy ministry concluded contract on technical service of NPP with US Bechtel. - Conclusion of agreement on nuclear development with Russia, China etc.
	Libya	- In 2006, conclusion of agreement for NPP with France. - Mid 2007, conclusion of MOU on construction of NPP for desalination.
	Algeria	- Jan. 2007, signing on agreement for study of NPP with Russia (US, France, China)
	Tunisia	- Dec. 2006, signing on MOU on nuclear energy & desalination with France.
	Morocco	- Movement of Russia, China and France for desalination and NPP.
Africa	Nigeria	- In 2008, Ministry of Science & Technology reconfirmed the promotion plan of NPP (5,000 MW up to 2017)
	Ghana	- May 2008, expressed NPP development plan (400 MW up to 2018).
	Namibia	- Possession of 7% of world uranium deposit. - Government committed power supply policy by nuclear power.
Latin America	Venezuela	- End of 2008, the president expressed the introduction of NPP with the aid of Russia (Nov. 2008, conclusion of agreement for NPP)
	Chile	- Feb. 2007, DOE announced commencement of development study for NPP (already talked with AREVA). - Nov. 2007, the president indicated the study for NPP options (next government will decide the introduction of NPP).

(Source) excerpts from "Japan Atomic Industrial Forum Inc, 2009"

B.3.7 Conclusion

As seen above, primary energy for power generation in Zambia is not abundant compared with the surrounding countries and the world.

- Hydropower: Economically exploitable potential has already been developed and technically exploitable potential is covered by listed projects[11].
- Coal: Production ability at Maamba is 800,000 tonnes per year and the rest of domestic use 200,000 tonnes can be utilized for power generation which is corresponding to 200 MW class thermal power station. However, coal production at Maamba currently has reduced remarkably as shown in Figure B. 5 and Table B. 11 due to deterioration of production facilities.
- Renewable energy: Solar energy has been introduced in the form of SHS systems for rural electrification. It will take long time for other renewable energy sources such as wind, bio gas, geothermal to be introduced as these are still in the stage of survey, study or investigation.

[11] According to WEC, the original data source, "Economically exploitable capability" is defined as "the amount of the gross theoretical capability that can be exploited within the limits of current technology under present and expected local economic conditions. The figures may or may not exclude economic potential that would be unacceptable for social or environmental reasons."

- Nuclear energy: Along with technical constraint, introduction of nuclear energy needs strong political commitment to gain the national consensus. The existing policy documents states that study and investigations will be continued, but there is no specific development plan or political commitment so far.

Appendix C Current status of power sector

C.1 History of power industry in Zambia

Electricity supply in the present Zambia originated in 1906 when a small thermal power station was built in Livingstone to serve a section of the town in 1906 as a form of regional supply. After that, along with the activated copper mines development, electricity supply was spread mainly in the mining area. Electricity of those days was generated by thermal power and the first hydropower was developed in Victoria Falls in 1938.

In the early part of the last century, power development was mainly associated with copper mines, hence several independent thermal stations were constructed. This meant that a number of local authorities distributed electricity in their own districts obtaining their supplies in the main from existing power stations. For instance, Livingstone local authorities bought power from the Victoria Falls Electricity Board while Kabwe and the Copperbelt authorities purchased power from the mining companies.

The first initiative to coordinate power generation was taken in the early 1950s when at least four stations with a combined 120 MW capacity were connected to a central switching station at Kitwe. The next major development was the construction of 220kV transmission line in 1956 to connect the Copperbelt power systems with a transmission system in the Shaba Province of the Congo to enable the load growth in the mines to be satisfied by imported hydroelectric power.

The most significant development in the electricity supply situation took place between 1956 and 1962 when the Kariba dam and consequently the Kariba South Bank Power Station were constructed. The Kariba South Bank Power Station was owned and operated by Central Africa Power Corporation (CAPCO) which, in turn, was jointly owned by the governments of the Southern and the Northern Rhodesia (presently Zimbabwe and Zambia).

This development, necessitated the transmission of power lines of 330kV to the Copperbelt mines in the north of Northern Rhodesia (Zambia). Intermediate substations at Leopards Hill and Kabwe were also erected. There were also a number of bulk supply centers in Rhodesia giving the 330kV system a total length of 2,700 kilometers.

The next major step in making hydroelectric power potential abundant in Central Africa was taken with the construction of Kafue Gorge Power Station to be an alternative to the Kariba scheme. Soon after independence in 1964, the Government of Zambia revived the project and preliminary work began in July 1967. The first generating unit was commissioned in 1971 and the project was completed in 1973. The project had an initial capacity of 600 MW using four units but this was later increased to six units with an installed capacity of 900 MW. Connection to the grid was provided through 330kV lines to Leopards Hill Substation adjacent to Lusaka.

Around the same time, expansion of Victoria Falls Power Station was conducted. Station B with the capacity of 60 MW was constructed in 1969 and Station C with 40 MW in 1972. Finally, total capacity of Victoria Falls became 108 MW with three power stations.

The Government of Zambia established Kariba North Bank Company Limited (KNBC) in 1969 to revive the Kariba project phase II. In 1976, Kariba North Bank came into operation.

Zambia Electricity Supply Corporation (ZESCO) was established in 1969 as a vertically integrated electric utility to promote intensively electric power industry I unify electricity companies of Zambia vertically, and has since merged and acquired distribution and generation businesses dispersed in Zambia.

C.2 Organization

C.2.1 Administration

The official authority in charge of the power sector in Zambia is the Ministry of Energy and Water Development (MEWD). Headed by the Minister, who is a member of Parliament (MP), and Permanent Secretary, the MEWD has jurisdiction over the energy and resource sectors, and consists of the following four departments:

- Human Resource and Administration;
- Energy:
- Water Affairs; and,
- Planning and Information.

After Zambia instated a multiparty system in 1991, the reins of government passed to the MMD as it replaced the UNIP, which had been the sole party after independence, as the ruling party. The MMD administration reorganized the administrative machinery to improve and streamline public services. Whereas the Energy Department had previously been arrayed under the Ministry of Power, Transport and Communications (MPTC), and the Water Affairs Department, under the Ministry of Water, Land and Natural Resources (MWLN), the reorganization led to institution of the MEWD as a new ministry comprising these two departments. It was followed in 1993 by a reorganization of the MEWD under a program of administrative reform (the Public Service Reform Programme; PSRP), which led to addition of the Human Resource and Administration Department and Planning and Information Department to the MEWD.

Under MEWD, government organizations related to electricity; DOE, OPPPI, REA and others are deployed.

(1) Department of Energy (DOE)

Within the MEWD, the DOE has jurisdiction over the energy sector, which is managing the following subsectors:

- Electricity;
- Petroleum;
- Coal;
- Wood fuel (i.e., firewood and charcoal); and
- New and Renewable Sources of Energy (NRSE), such as solar, wind and biogas.

The functions of the DOE are as follows.

- To develop, articulate and implement Policy on Energy;
- To formulate programmes for the development of the Energy sector;
- Ensure that there are efficient and reliable supplies of energy for socio-economic development;
- To integrate the Energy sector into the national and regional development strategies; and
- To regulate the Energy sector through appropriate legislation including the development of new laws and bye-laws.

The DOE also has jurisdiction over the following energy-related governmental institutions and statutory bodies:

- TAZAMA Pipelines Limited;
- INDENI Petroleum Refinery Company Limited;
- ZESCO Limited;
- Zambezi River Authority; and,
- Energy Regulation Board.

Figure C. 2 presents a chart of the DOE organization. Under the Department Director are 33 executive posts to be filled by personnel who have a bachelor's degree at least. As shown in Figure C. 2, however, only 15 of these posts have been filled; the remainders are empty. There are four major lines: Renewable Energy and Energy Management, Energy Exploration, Power Systems, and Electrification. The Energy Exploration line has only one staff member.

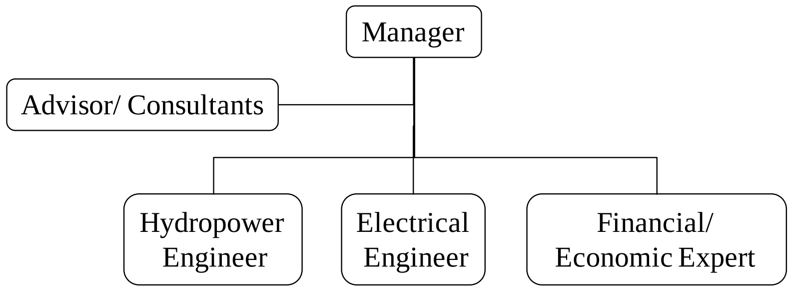
On the other hand, upstream exploration and development of mineral resources including energy resources of coal and oil is the jurisdiction of the Ministry of Mines and Minerals Development (MMMD).

(2) Office for Promoting Private Power Investments (OPPPI)

Promulgated in 1994, the National Energy Policy (NEP) posted the participation of private capital in hydropower development as an agendum alongside the promotion of electrification and higher efficiency in power enterprises in the power subsector. It was followed by adoption of the Framework and Package of Incentives (FPI) for Hydropower Generation and Transmission Development in 1998 and inauguration of the OPPPI under the MEWD as the organization to implement the FPI in October 1999.

The FPI sets forth the system of privileges and framework for incentives to encourage private investment in the power subsector. The OPPPI was instituted for the purpose of a "one-stop" operation, i.e., simplification of procedures and legislative requirements related to authorization and issuance of licenses to power sector investors. In other words, its role lies in acting on behalf of the national government in soliciting and assessing project proposals, negotiating contracts, and issuing development concessions while coordinating matters with the other concerned institutions.

Figure C. 1 presents a chart of the OPPPI organization.



(Source) http://www.opppi.gov.zm

Figure C. 1 Organization of OPPPI

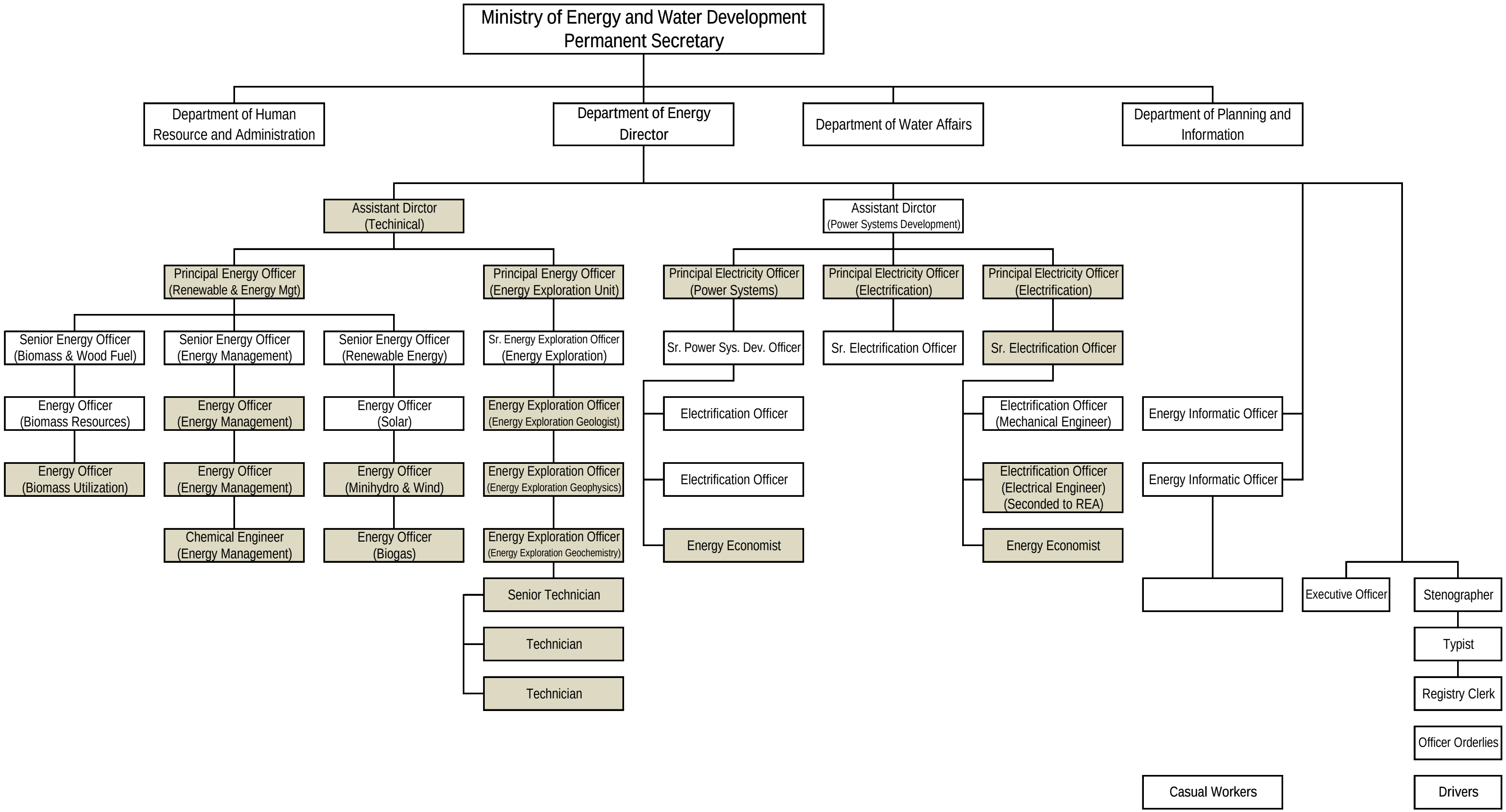
(3) Rural Electrification Agency

The REA was established under the MEWD on the basis of the Rural Electrification Act, which was promulgated in December 2003.

Rural electrification programme in Zambia has been promoted by screening project sites proposed by local governments, based on "Guidelines on Selecting of Rural Electrification Projects for Funding by Government, 1995". The government fund to rural electrification is diverted from Rural Electrification Fund (REF) financing from taxes and duties imposed on retail selling tariff of ZESCO.

Main functions of REA are as follows:

- Administering and managing the rural electrification fund (REF);
- Developing and implementing the Rural Electrification Master Plan;
- Mobilizing funds to support rural electrification;
- Encouraging private sector participation in rural electrification through provision of smart subsidies;
- Competitive bidding and community mobilization;
- Financing project preparation studies for rural electrification;
- Recommending to government suitable policies aimed at enhancing access to electricity by the rural communities.



Note) Halftone boxes mean vacancy.

(Source) JICA Study Team

Figure C. 2 Organization of DOE

(4) Zambezi River Authority (ZRA)

The Zambezi river basin covers an area of almost 1.4 million square kilometers within the territory of eight nations (Table C. 1), and a long stretch of the river itself constitutes the border between Zambia and Zimbabwe. Conflicts over the use of water resources in a river basin may arise between riparian states or other interest organizations, and one way to reduce the threat of conflict and promote equitable water sharing is to establish international commissions. So far, the water supplies from the Zambezi river basin has been sufficient to cover the needs for agriculture, industry and domestic use, but in the future, supplies may not meet the needs from a developing industry and growing populations. To minimize the risk of potential conflicts, a Water Sector was created within the existing Southern African Development Community (SADC). Initiatives are being carried out in conjunction with the Zambezi River Authority (ZRA) to monitor the use of shared water resources and to promote integrated water resource management around the Kariba reservoir.

Table C. 1 Riparian Countries in Zambezi basin

No.	Country	Area within basin (sq. km)	Part of basin area
1	Zambia	576,900	41.7%
2	Angola	254,600	18.4%
3	Zimbabwe	215,500	15.6%
4	Mozambique	163,500	11.8%
5	Malawi	110,400	8.0%
6	Tanzania	27,200	2.0%
7	Botswana	18,900	1.4%
8	Namibia	17,200	1.2%
		1,384,200	100.0%

Historically, development of the Zambezi river has been conducted jointly by the two governments of Zambia (ex- Northern Rhodesia) and Zimbabwe (ex-Southern Rhodesia).

In May 1956 the Federal Power Board was established. The new Board was vested with the construction of new dams and power stations along the Zambezi River. At the same time a hydrological data collection organization was founded. In 1963, the Federal Power Board was dissolved and the Central African Power Corporation (CAPCO) as a single system under joint ownership of the two Governments of Northern and Southern Rhodesia was established. The CAPCO took over the liabilities of the Federal Power Board. Four ministers, two of each Government, regulated the conduct of the CAPCO. In 1964, Zambia became independent and in 1980 also Zimbabwe became independent. On the first day of October in 1987 the Zambezi River Authority (ZRA) was founded, replacing the CAPCO.

The governments of Zambia and Zimbabwe jointly own the ZRA in equal proportions and a Council of four Ministers, two of each State heads the ZRA. The Ministers are holding the portfolios of Energy on the one hand and Finance on the other hand. Currently the ZRA is financed through direct disbursement from the two countries. However, with the prevailing privatization, the ZRA is working out a mechanism to raise finances through tariffs and fees for services provided. For example the electricity utilities have to pay for the water used in power generation. The concept of water banking is in discussion, and how this can be applied at Kariba with the two national electricity utilities. A financial autonomy of the ZRA would be the final goal. The functions of ZRA cover a broad field:

- Operate, monitor and maintain the Kariba Dam Complex,
- Investigate the desirability of constructing new dams on the Zambezi River and make recommendations thereon,
- Construct, operate, monitor and maintain any other dams of the Zambezi River,
- Collect, accumulate and process hydrological and environmental data of the Zambezi River for the better performance of the functions and for any other purpose beneficial to the contracting States,
- Regulate the water level in the Kariba reservoir and in any other reservoir owned by the Authority,
- Make recommendations, which will ensure the effective and efficient use of the waters and other resources of the Zambezi River.

The ZRA is a bi-national organization managing an international shared water resource. It operates a total of 12 telemetry and hydrographical stations where water levels are monitored daily. Flow measurements are carried out at seven of these stations. The hydrometric network is used for day-today operations of the Kariba reservoir, the management of power generation, and the flood control and drought analysis.

Since 1994, the ZRA has been aggressively addressing environmental concerns in the Zambezi River and Kariba Lake, focused on monitoring water quality and water resources for hydropower.

ZRA has also the responsibilities for development of future projects (Batoka Gorge, Devil's Gorge and Mpata Gorge) of the Zambezi detailed in Clause 6.4.1.

C.2.2 Regulation

The Energy Regulation Board (ERB) was established by law as a statutory body and commenced operations in January 1997, following issuance of Statutory Instrument No. 6 of 1997, under the Energy Regulation Act (commencement) order of 27th January 1997. The ERB’s primary objective is to regulate the provisions of energy services to consumers. The Energy Regulation Act gives the ERB sole responsibility to issue licenses to energy undertakings. The ERB has since then regulated utilities in the energy sector offering services such as electricity, fossil fuels, solar, coal and other renewable forms of energy.

Currently, ERB has six departments:

- Legal and Secretarial Services;
- Economic Regulation;
- Infrastructure and Operations Regulation;

- Finance and Administration;
- Consumers and Public Affairs; and
- Information and Communication Technology.

As for electricity sub-sector, ERB has the following main functions:

- License for generation, transmission, distribution, supply of electricity (currently five undertakings licensed in the electricity sub-sector);
- License for manufacture, supply, installation and maintenance of solar energy systems (currently 22 in renewable energy sub-sector);
- Electricity tariff determination; and
- Complaints handling.

C.2.3 Utilities

Currently, electric utilities in Zambia are state-owned ZESCO, and private-owned CEC and LHPC. ZESCO is vertically integrated state power utility handling generation, transmission and distribution, while CEC is the specialized power supplier to the mines in the Copperbelt province and LHPC is the hydropower IPP selling power to ZESCO.

(1) ZESCO

Zambia Electricity Supply Corporation (ZESCO) was established based on the Companies Ordinance, 1969. Initially, ZESCO was based on its previous constituent undertakings shown in Table C. 2.

Table C. 2 Previous Constituent of initial ZESCO

Constituent	Business Outline
1. Central Electricity Corporation Limited (CEC)	Established in 1953 to supply electricity to Lusaka municipality. CEC expanded its distribution network into Chilanga, Kafue and Monza adjacent area to Lusaka. In 1963, CEC's network was connected to Kariba- Kitwe transmission line of CAPCO at Leopards Hill substation.
2. Northern Electricity Supply Corporation (NESCO)	Established in 1960 succeeding the rural electrification business in Mongu, Kasama, Mbala and Mansa, conducted by the Northern Rhodesia Government so far. NESCO purchased electricity from the Copperbelt Power Company (CPC) and expanded its distribution network in unelectrified areas in the Copperbelt province.
3. Victoria Falls Electricity Board	Established in 1951 to operate Victoria Falls Power Station commenced in 1938 which initial capacity was 8 MW. The Board extended the capacity of VFPS and succeeded the electricity supply to Choma and Kalomo in 1964.

In 1972, ZESCO took over several municipal undertakings to include Livingstone, Ndola, Kabwe, Luanshya, Mufulira, Kitwe and Chingola. The effect of these takeovers was to enlarge ZESCO's area of supply to cover the whole of Zambia except the Copperbelt mines which remained under the Copperbelt Power Company (CPC; present day CEC).

Zambia Electricity Supply Corporation Limited operated under the same name and style until the board, through a court order, dated 18th August 1988 moved a motion to have the corporation changed into a company limited by shares. The registration of incorporation was issued on 10th October 1988. In addition, Zambia Electricity Supply Corporation Limited was changed to simply "ZESCO Limited".

Currently, ZESCO has the following six directorates under the Managing Director (Chief executive):

- Human Resources,
- Finance,
- Customer Services,
- Generation and Transmission,
- Distribution and Supply,
- Engineering Department and
- Power Rehabilitation Project (PRP).

(2) Copperbelt Energy Corporation (CEC)

As mentioned in the Section C.**1**, electricity supply was commenced from its initial stage related to mining development in the Copperbelt area. In 1954, the Rhodesia-Congo Border Company was incorporated to transmit thermal and hydro power to mines on the Copperbelt. This company was renamed the Copperbelt Power Company after Zambia attained independence in 1964, and became the Power Division of Zambia Consolidated Copper Mines Limited (ZCCM), following the formation of ZCCM, in 1982.

In 1996, the Government of Zambia commenced the privatisation of ZCCM which entailed the sale of various ZCCM mining and power divisions to regional and international mining companies and investors. In 1997, a consortium comprising Cinergy, National Grid and a local Zambian management team was the successful bidder in the privatization of the Power Division of ZCCM. As part of the privatization transaction, the Power Division of ZCCM was incorporated in Zambia as CEC on 19 September 1997. In February 2006, Zam-En, acting through its wholly-owned subsidiary, Zambian Energy Corporation (Netherlands) BV, signed a sale and purchase agreement to acquire an indirect 77% shareholding in CEC from Cinergy and National Grid. Following receipt of all statutory approvals for the transaction from the Government of Zambia and its agencies, the acquisition was completed and the shares transferred in October 2006. Table C. 3 shows the shareholders of CEC and floating shares of CEC has been traded in Lusaka Stock Exchange (LuSE).

Table C. 3 Shareholders of CEC

Shareholder	% Holding
Zambian Energy Corporation	52.0
ZCCM-IH	20.0
Individual shareholders	15.8
African Life Financial Services Zambia Limited – managed funds	7.2
CEC Employees Share Ownership Plan	5.0

(Source) CEC website (http://www.cecinvestor.com)

The business of CEC has been fundamentally unchanged since its establishment which CEC supplies electricity purchased from power generation companies to mines and mining companies, not to residential demand in Copperbelt, which is obligation of ZESCO.

CEC purchases electricity from ZESCO under a Bulk Supply Agreement, which is effective until 2020. Under this agreement, tariffs are adjusted annually in accordance with the US's producer price index. CEC also earns revenue from the operation of its inter-connector with the DRC and from wheeling power through its system for distribution by ZESCO to its non-mining and township customers and industry within and outside of the Copperbelt. The rapid expansion of the mining activities on the Copperbelt, the long-term development of electricity trading within the SAPP, CEC's close proximity to DRC power, together with the ownership of the power system transmission assets in the Copperbelt Province, provide CEC with a strong base to participate in the future growth and evolution of the Zambian and regional power sectors.

As Table C. 4 shows the business outline of CEC, its power generation gas turbine facilities are not for conventional use but for emergencies. Therefore, CEC can be classified as transmission and distribution company in essential. Moreover, CEC is playing a part of international power trade with Democratic Republic of the Congos by wheeling electricity using its transmission system.

Table C. 4 CEC Business Outline

Main Facilities	
Generation	Gas Turbine 80 MW
Transmission	880 km（220kV, 66kV）
Substation	38 os.
Power Demand	540 MW
Wheeling	270 MW for ZESCO 210 MW for SNEL (DRC)

(3) Other private entrepreneurs

At present, Lunsemfwa Hydropower Company (LHPC) is the only IPP in Zambia, which owns and operates two hydropower stations in Lunsemfwa (18 MW) and Mulungshi (20 MW).

LHPC was established by privatization of ZCCM as well as CEC. LHPC started operation since December 2001, which stocks is owned by ESKOM of the South Africa (51 %) and the management of LHPC.

The government of Zambia is promoting private investment in power sector including foreign capital to secure the vast capital to develop power systems. TATA from India is one example planning to enter power sector in Zambia as mentioned later in detail.

Appendix D Case Study

D.1 Outline of Case Study

D.1.1 Objective

To heighten prospects for the master plan materialization, a case study is to be implemented on two sites selected in short list of the hydropower development projects. In case study the study team and counterparts check the contents of the report from the feasibility study and other reports already made and put obstacles and recommendations to execution in order through the field survey including the simple measurements and local people interviews.

In the technical aspect for the hydropower development, the study includes simple measurements utilizing a global positioning system (GPS) for the purpose of confirming the topographical data and checking the facility layout plans and head. It also embraces collection of data on river flow and a check of the prospective generated output.

In addition, studies on environmental and social impacts of case study projects are examined through concise surveys on ecological and socio-economic conditions in case study sites, consultations with local stakeholders including government agencies, representatives of farmers and NGOs, and interviews with chiefs and local residents. Based on the surveys and consultations, points to consider in environmental and social impacts are clarified.

D.1.2 Project Selection

The most possible project at the current situation should be focused on and in light of factors such as the possible of a future aid from donor institutions, and the study team and counterpart pick out projects for implementation of case studies such as those projects on the short list that entail a high degree of involvement by the counterpart institution. Excluding projects led by the private sector, this means that the chief candidates are the Kariba North Expansion, Itezhi Tezhi, Lusiwasi Expansion, and Kafue Gorge Lower projects. In the Kariba North Expansion Project, construction is already under way with Chinese assistance. In the Kafue Gorge Lower Project, the IFC is making preparations for a feasibility study, but the lack of roads affording access to the site would make it difficult to conduct a case study. For these reasons, upon consultation with the counterpart, it has been decided to execute case studies for the Itezhi Tezhi and Lusiwasi Expansion projects.

D.1.3 Methodology of Case Study

(1) Examination of Technical Feasibility

Examination of the technical feasibility of the Itezhi-Tezhi project puts focus on the calculation of potential electricity to be generated, and conducts literature reviews and check the hydrological data. The study team also conducts on-site investigation and examines the rough layout of planned facilities on topographic maps.

Calculation of the potential electricity to be generated was conducted as part of technical transfer. Practical training was provided to the counterpart so that they can understand the methodology for the calculation of the potential electricity to be generated for both reservoir type project (Itezhi-Tezhi) and run-of-river type (Lusiwasi Expansion), and acquire skills to calculate it by themselves.

Table D.1 demonstrates the methodology for the examination of technical aspect of the case study projects.

Table D.1 Methodology for Examination of Technical Aspects of Case Study

Category	Main study item/ Methodology
Literature review	- Check the specifications of the projects - Check the preconditions to calculate potential electricity to be generated
On-site investigation	- Access to the project site - River conditions - Rough measurements of project sites by utilizing GPS - Rough planning of the layout on topographic maps - Site survey in both upstream and downstream - On-site investigation of proposed dam site, etc.
Calculation of potential electricity to be generated	- Calculation of potential electricity to be generated by reservoir type projects - Calculation of potential electricity to be generated by run-off-river type projects - Verification of conditions - Sensitivity analysis

(Source) JICA Study Team

(2) Environmental and Social Considerations

Environmental and social impacts of Itezhi-Tezhi Project and Lusiwasi Expansion Project are studied as part of the case study. Potential environmental and social impacts are identified through literature reviews, on-site investigations on the planned project sites, and consultations with local governments and local representatives. Scoping on potential impacts for the detailed study is, then, conducted based on the identified impacts. Mitigation measures are also elaborated based on the scoping results.

Table D.2 shows the methodology for the Study on Environmental and Social Considerations.

Table D.2 Methodology for Study on Environmental and Social Considerations

Category	Main study item/ Methodology
Literature review	- Reports of similar projects including Environmental Impact Assessment reports - Area Management Plans and Land Use Plans of adjacent national parks and game management areas - District Development Plans and Situation Analysis Reports of related Districts
On-site investigation	- Identification of village distribution and land use status in the vicinity of construction sites - Simplified surveys on vegetations found around project sites - Interviews on wildlife with local residents etc.
Stakeholder consultations and interviews	- Consultations with District Development Coordination Committee - Interviews with traditional chiefs - Focused group interviews with local residents

(Source) JICA Study Team

The tasks necessary for the Study on Environmental and Social Considerations are subcontracted to a Zambia-based consulting firm[12]. Environmental and social information in this chapter largely depends on the outputs produced by the subcontractor unless otherwise specified.

D.1.4 Schedule of Case Study

The schedule of the case study is given in Table D.3.

Table D.3 Schedule of Case Study

No	Date			Activities
1	2 June	Tue		Move to Serenje, a town adjacent to the project site for Lusiwasi Expansion Project
2	3 June	Wed	AM	Meeting with Serenje District Commissioner Meeting with Chief Mailo
			PM	On-site investigation on the existing facilities of Lusiwasi Power Station (Water intake, Penstock)
3	4 June	Thu	AM	On-site investigation on the existing facilities of Lusiwasi Power Station (Power house)
			PM	On-site investigation on the proposed dam site/ Local stakeholder interview
4	5 June	Fri	AM	Meeting with District Development Coordinating Committee (participants: approximately 40 stakeholders)
			PM	On-site investigation on the existing reservoir and dam/ Local stakeholder interview
5	6 June	Sat		Back to Lusaka
6	7 June	Sun		Day-off
7	8 June	Mon		Move to Itezhi-Tezhi, a town where Itezhi-Tezhi project is planned
8	9 June	Tue	AM	Meeting with Itezhi-Tezhi District Commissioner Meeting with District Development Coordinating Committee (participants: approximately 40 stakeholders)
			PM	On-site investigation on the existing Itezhi Tezhi dam and reservoir, and proposed site for a power house
9	10 June	Wed	AM	Meeting with the Chief Kaingu
			PM	On-site investigation on the existing facilities related to Itezhi-Tezhi/ Local stakeholder interview
10	11 June	Thu		Training on hydroelectric engineering study/ Local stakeholder interview
11	12 June	Fri		Back to Lusaka

D.1.5 Participants in Case Study

Participants in the case study are listed in Table D.4.

[12] Subcontractor is the Freestop Enterprise, a Zambia-based consulting firm.

Table D.4 Participants in Case Study

Organization	Name	Title
Department of Energy	Patrick Mubanga (Mr.)	Senior Power Development Officer
	William Sinkala (Mr.)**	Electrification Officer
	Lufunda Muzeya (Mr.)**	Energy Economist
	Malama Chileshe (Mr.)**	
	Manice Nyirenda (Ms.)**	
Rural Electrification Authority	Naomi N.Sidono (Ms.)**	Community Mobilization Specialist
	Jacqueline H.Musonda (Ms.)**	Economic Specialist
ZESCO Limited	Martine Sinjala (Mr.)	Chief Civil Engineer
	Robam Musonda (Mr.)*	Environmental and Social Affairs Unit
	Bonje Muyunda (Ms.)**	Environmental and Social Affairs Unit
JICA Study Team	Takashi Aoki (Mr.)	Hydropower Planning
	Kenzo Ikeda (Mr.)	Environmental and Social Considerations
National Consultant Team	Shadreck Nsongela (Mr.)	Principal Environmental Consultant
	Nyambe Nyambe (Dr.)**	Senior Social Consultant
	Moses Chamfya (Mr.)	Social Consultant
	Richard Mulenga (Mr.)	GIS Specialist

Note: * Participants in Lusiwasi Expansion Project only

** Participants in Itezhi-Tezhi Project only

D.2 Itezhi-Tezhi Project

D.2.1 Examination of Technical Feasibility

(1) Implementation of the field study

i) Access

About 220 kilometer west from Lusaka on the main road leading to Kafue National Park is the junction with the road leading to the Itezhi-Tezhi district. The district lies about 117 kilometers to the south of this junction, and contains the Itezhi-Tezhi reservoir and the existing dam. Just downstream of the dam is the site of the planned power station. After the junction with main road, the road may be considered essentially unpaved in its current state. Although it was once paved, the pavement no longer retains its original condition in almost all sections. Within the Itezhi-Tezhi district, a few sections of some roads have pavement.

ii) Survey of the project site

(a) Dam body and incidental facilities

The project envisions use of the Itezhi-Tezhi dam and reservoir in their present condition, with no change in the pattern of discharge downstream. For this reason, there is thought to be basically no additional impact on downstream areas.

For intake facilities, plans call for use of a diversion tunnel built in the bank on the right side of the dam. There are two diversion tunnels, and one is to be used as the intake. The diversion tunnels are equipped with gates, and these would be operated by gantry crane (see Figure D.3).

The dam body has inspection galleries in the right bank and flood sluice, and measurements are taken of items including leakage water and uplift force. In interviews with maintenance engineer, the team was told that the dam height at the face subside by about 205 millimeters as a settling over the approximately 30 years since its construction. Although an assessment cannot be made on the strength of this figure alone, a subsidence of 205 millimeters over the period in question would be within the scope of acceptability. Calculation of the planned subsidence rate, amount of subsidence divided by dam height, based on the results of research in Japan yields a figure of about 0.35percent after a period of 30 years. Application of this rate in the case of Itezhi-Tezhi dam produces a subsidence of about 227 millimeters. The interview figure is lower than this. The reservoir also apparently has little sediment; the interviewees said the layer was about 115 millimeters thick.

Figure D.1 Itezhi-Tezhi dam downstream face (view from the right edge)

Figure D.2 Itezhi-Tezhi dam（View from the left bank upstream）

Table D.5 Main Features of the Itezhi Tezhi reservoir

Main Features	Characteristic	
Dam	Crest Length	1,800m
	Crest Width	9m
	Height	65m
	Earth and Rockfill	$10 \times 10^6 m^3$
Reservoir	Full Supply Level	1,030.5 masl
	Low Supply Level	1,006.0 masl
	Live Storage Capacity	$5.3 \times 10^9 m^3$
	Dead Storage Capacity	$0.7 \times 10^9 m^3$
	Surface Area at FSL	390 km^2
Spillway	Radial Gates	3 Gates
	Bulkhead Gate	1 Gates
	Width of Each Gate	15m x 12m
	Discharge Capacity	4,200 m^3/s
	Plunge Pool Depth	19.8 m
Emergency Spillway	Crest of Fuse Plug	1,033.0 masl
	Invert of Fuse Plug	1,025.0 masl
	Discharge Capacity	750 m^3/s
Outlet Diversion Tunnels	Left Tunnel Length	480 m
	Right Tunnel Length	550 m
	Cross Section Area	2 x 190 m^2
	4 Roller Gates	17m x 4m each
	1 Regulation Gate	4m x 7.5m
	Gate Discharge Capacity	350 m^3/s

(Source) ZESCO, ITT Office

Figure D.3 Gates of diversion tunnels (Future intake gate)

(b) Power station project site

The plan is to build an above-ground power station directly downstream of the existing dam on the right bank. The necessary space has been acquired, and markings have already been made on the site for locations of installation of the surge tank and generator (see Figure D.4, Figure D.5).

Figure D.4 Power station construction site

Figure D.5 Generator settling point

(c) Road improvement

The exiting road running for a distance of about 117 kilometers between the junction with the main road and the Itezhi-Tezhi district is positioned more as a public road serving the district than as one almost exclusively for the project, and the official authorities share the view that its improvement is basically a job for the government. Nevertheless, it is indispensable for the road to be improved before the project development, as the development schedule would be adversely affected if the improvement lags. At the very least, the road must immediately be conditioned to permit passage of heavy transport vehicles. The requisite arrangements and preparations must be made to this end.

(d) Construction of transmission lines

The construction of transmission lines is perceived as the responsibilities of ZESCO. Questioned on the subject, SPC personnel indicated that an agreement had been reached with ZESCO to incorporate reparations for the PPA in the event that transmission lines are not constructed in time for the start of power station operation.

(2) Study of the amount of generated output

1) Procedure (reservoir type)

Obtain the amount of generated output based on the reservoir rule curve.

A) Use flow data from the Hook observation station for the period from October 1978 to September 2007.

B) Rank the 30 intervening years in order, beginning with that with highest annual flow (see Table D.6).

C) In the case study, use the flow patterns of three representative years, and calculate the generated output in each. The representative years were as follows.

- High case (rich water case): 1979/80, Rank 3
- Middle case: 1997/98, Rank 15
- Low case (drought case): 1995/96, Rank 27

These three cases represent flows of 10, 50, and 90 percent, respectively. A calculation was made of the annual generated output in each case, and the average value for the three years (cases) was taken as the annual generated output.

D) Use the storage capacity curve to calculate the fluctuation in dam water level (see Table D.7 and Figure D.6).

E) Because the existing feasibility takes account of the amount of evaporation, apply the same approach in the case study and make a calculation with reference to the feasibility study report (see Table D.8).

F) Set specifications for the power station. In the case study, the team tentatively set the values noted below (see Table D.9), but made arrangements so that the counterpart personnel could modify these values as they saw fit and make calculations for cases they postulated.

G) Simulate power generation in accordance with rule curve (see Figure D.7), because the ITT reservoir operation is fixed.

H) Make adjustments (increase or decrease) in output so that values are in accordance with the reservoir rule curve. Take the output adjustment as the monthly setting.

I) Assume discharge from the flood sluice gate in the event of inflow in excess of the generation use level in times of full supply level.

J) Other calculation conditions

- Assure a discharge downstream of at least 30 cubic meters per second in normal times

Table D.6 Rank of an annual total flow volume

No.	Year	Annual Total Flow (million)	Rank	Representative Flow
1	1978/79	20,096	1	
2	1979/80	15,608	3	10% Flow
3	1980/81	15,951	2	
4	1981/82	7,730	14	
5	1982/83	6,825	19	
6	1983/84	5,979	23	
7	1984/85	10,756	6	
8	1985/86	11,466	5	
9	1986/87	7,422	16	
10	1987/88	8,533	11	
11	1988/89	8,110	13	
12	1989/90	5,717	25	
13	1990/91	6,627	21	
14	1991/92	2,607	30	
15	1992/93	10,422	7	
16	1993/94	7,125	17	
17	1994/95	3,370	29	
18	1995/96	5,434	27	90% Flow
19	1996/97	5,589	26	
20	1997/98	7,694	15	50% Flow
21	1998/99	9,857	8	
22	1999/00	6,093	22	
23	2000/01	14,541	4	
24	2001/02	5,774	24	
25	2002/03	6,965	18	
26	2003/04	6,708	20	
27	2004/05	4,097	28	
28	2005/06	8,138	12	
29	2006/07	9,440	10	
30	2007/08	9,853	9	

Table D.7 Relation between reservoir water level (elevation) and storage capacity

Elevation (masl)	Area (km^2)	Storage (mcm)	Elevation (masl)	Area (km^2)	Storage (mcm)
1,006	90	699	1,021	238	3,045
1,007	97	793	1,022	253	3,291
1,008	105	894	1,023	268	3,551
1,009	113	1,003	1,024	284	3,827
1,010	120	1,119	1,025	298	4,118
1,011	129	1,244	1,026	314	4,424
1,012	138	1,377	1,027	330	4,746
1,013	148	1,520	1,028	346	5,084
1,014	158	1,673	1,029	364	5,439
1,015	167	1,836	1,030	374	5,024
1,016	177	2,008	1,030	380	5,812
1,017	189	2,191	1,031	392	6,005
1,018	203	2,387	1,031	404	6,204
1,019	214	2,595	1,032	420	6,616
1,020	224	2,814	1,033	446	7,049

(Source) ZESCO

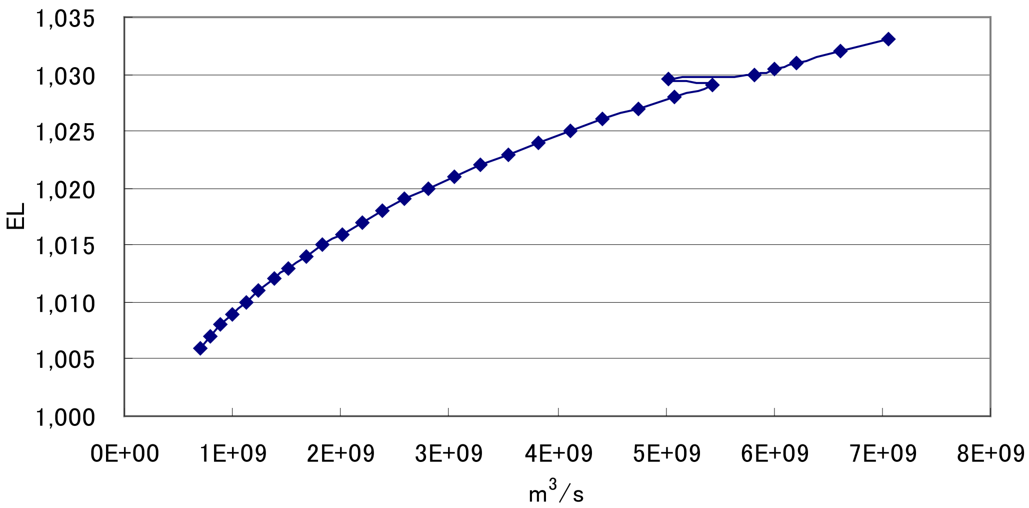


Figure D.6 Storage capacity curve of the ITT reservoir

Table D.8 Procedure of an evaporation calculation

1.Monthly Pan Evaporation Data (1979-2006 average)

(unit:mm)

	Oct.	Nov.	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	total
Average	295.9	155.8	8.1	-33.5	-33.2	64.8	168.3	175.4	164.7	179.5	229.6	282.7	1,658.1

2. Pan Coefficience

0.79

3. Lake Evaporation

Lake Evaporation=(Pan Coefficience) x (Pan evaporation)

(unit:mm)

	Oct.	Nov.	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	total
Average	233.8	123.1	6.4	-26.5	-26.2	51.2	133.0	138.6	130.1	141.8	181.4	223.3	1,309.9

4. Surface Area of the reservoir

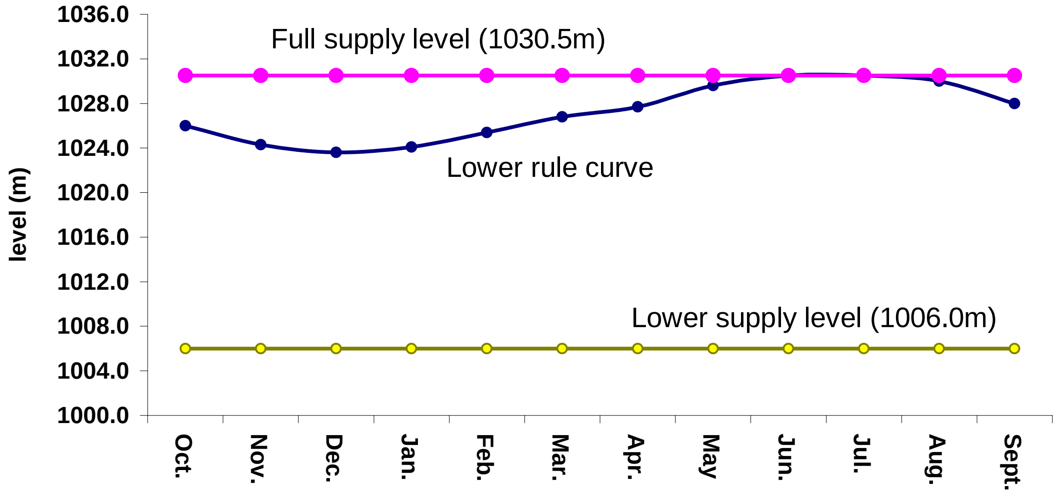
392 km2 (at the full supply level)

	Oct.	Nov.	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	total
Evap. (mm)	233.8	123.1	6.4	-26.5	-26.2	51.2	133.0	138.6	130.1	141.8	181.4	223.3	1309.9
days	31	30	31	31	28	31	30	31	30	31	31	30	365.0
m3/s	34.2	18.6	0.9	-3.9	-4.2	7.5	20.1	20.3	19.7	20.8	26.5	33.8	
total m3	91,634,312	48,248,144	2,508,408	-10,374,280	-10,281,376	20,067,264	52,119,144	54,317,872	51,004,296	55,587,560	71,102,528	87,546,536	513,480,408

(Source) Feasibility report for the Itezhi -Tezhi Hydro Electric Project (2x60MW)

Table D.9 Preconditions for generation calculation of ITT project

Item	Figure	Item	Figure
Start water level	1026.0 m.a.s.l	Combined efficiency	86.7%
Tailrace level	985.1 m.a.s.l	Head loss	1.3 m
Overflow level	1030.5	Transmission loss	2.0%
Max. discharge	306 m^3/s	Auxiliary	1.5%
Installed capacity	120,000 kW	Outage factor	0.97



(Source) ZESCO

Figure D.7 Rule curve of the ITT reservoir

2) Results

Calculation of the generated output based on the rule curve for the Itezhi- Tezhi reservoir yielded a figure of 616.8 gig watt-hours (GWh). This is on basically the same level as that of 611GWh in the existing feasibility study report (see Table D.10).

The simulated generation was controlled so that the reservoir was operated in accordance with the ZESCO rule curve. For middle and low case years, with 50 and 90 present flow, respectively, it was able to reproduce operation in line with the rule curve, but in high case years, with 10 present flow, the inflow into the reservoir was higher than the rule curve even at maximum output (see Figure D.8). At levels below full supply, it was assumed that water level would be controlled by means of the generation discharge.

Technical verifications were basically conducted with the counterpart. The study team transferred technology to the counterpart in areas such as checking of the generated output, confirmation of the reservoir operation (rule), and calculation of the generated output of reservoir type hydropower plants

Table D.10 Calculation results of the Generation Output of ITT project

Case	10% Flow	50% Flow	90% Flow	Average
Annual generation (GWh)	855.5	587.7	407.0	616.8

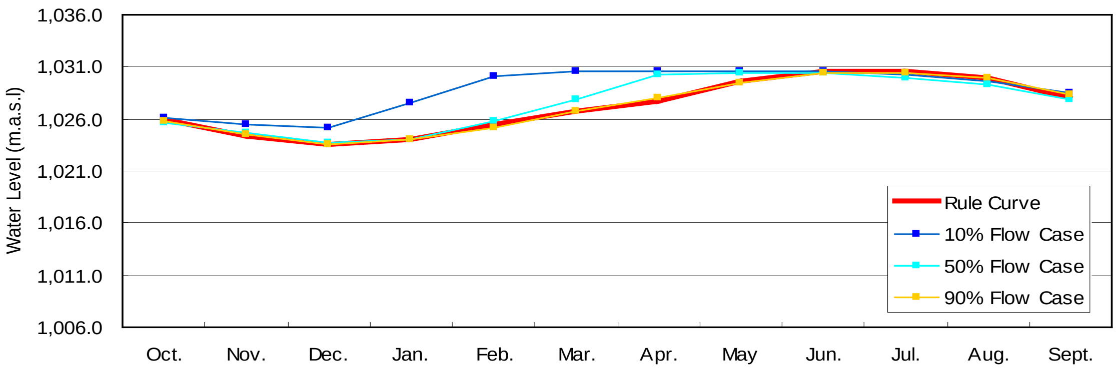


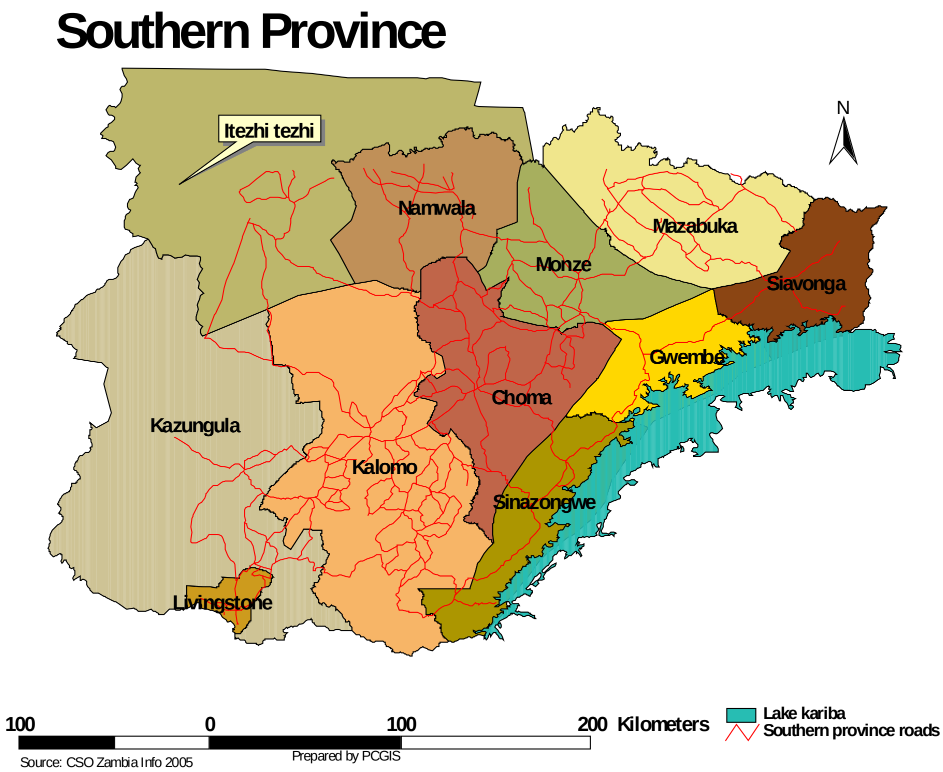
Figure D.8 Reservoir water level simulation of each year case

D.2.2 Environmental and Social Considerations

(3) Natural Conditions

1) Geographical conditions

Itezhi-Tezhi District is located in the northwest part of Southern Province, and between 15 to16 degrees south latitude and about 26 degrees east longitude. The district is in the upstream part of the Kafue Flats. It is approximately from 985 to 1,100 m above sea level, and the area is around 13,000 km^2. Figure D.9 demonstrates the overview of Southern Province and the location of Itezhi-Tezhi District.



(Source) Itezhi-Tezhi District Development Poverty Reduction Strategy 2007 – 2009

Figure D.9 Location of Itezhi-Tezhi District

2) Climatic Conditions

The climate of Itezhi-Tezhi District is largely characterized by three seasons, cool dry, hot dry and hot wet. The rainy season starts in late October or November, and ends in March or early April. From May to August is the cool dry season, and September and October are the hot dry season. Annual precipitation by month is given in Table D.11. The annual precipitation ranges from approximately 600 mm to 900 mm.

Table D.11 Annual Precipitation by Month in Itezhi-Tezhi District

(mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	144	103.3	156.7	5.6	0	0	0	0	0	9.1	98.3	142.2
2004	161.2	33.9	63.1	17.5	0	0	0	0	0	17.3	34.6	144.7
2005	167	204	130.5	1	0	0	0	0	0	0	172.1	277.2
2006	335.7	180.3	84.2	4.9	0	0	0	0	11.4	29.2	107.8	88.2
2007	340	125.7	99.1	0	5.7	0	0	0	0	0	70.5	342.9

(Source) ZESCO Hydro-meteorological Data Base, Itezhi-Tezhi

Table D.12 demonstrates mean monthly temperature of Itezhi-Tezhi. From October to January, the mean temperature is above 25 °C, and the hottest month is October with the highest temperature of 34.9 ^{o}C. The mean temperature from June to August is below 20 ^{o}C, and the mean lowest temperature of July is 6.8 ^{o}C.

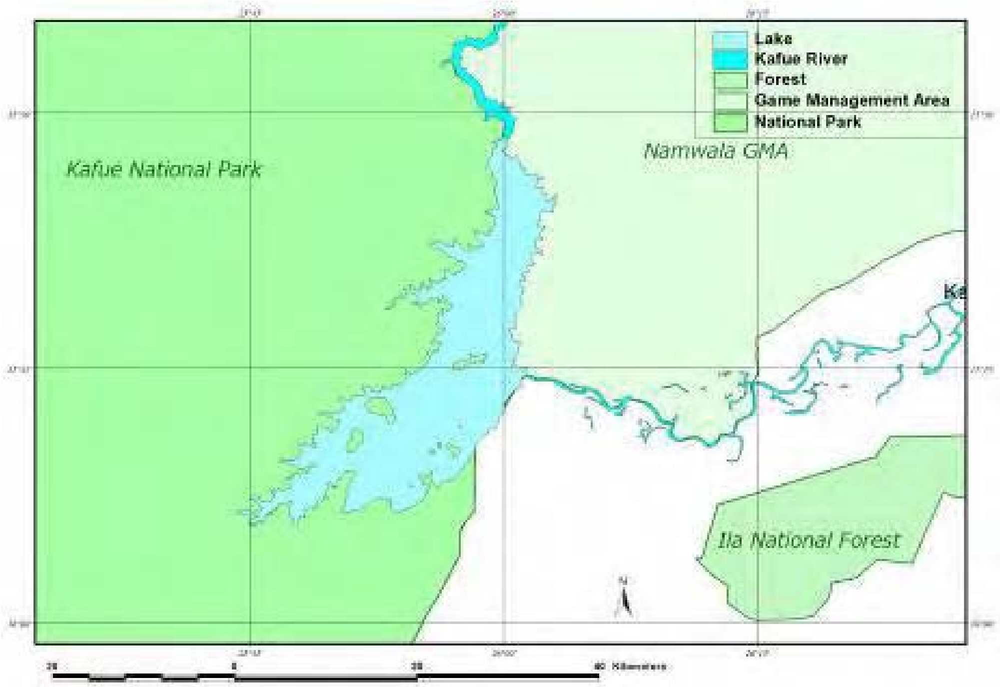
Table D.12 Mean Monthly Temperature of Itezhi-Tezhi from 1965 to 1997

Tempera-ture (^{o}C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	25.5	24.3	24.5	23.1	20.1	17.3	17.6	19.8	23.3	25.5	26.4	25.4
High	31.3	29.9	30.6	30.9	29.4	26.9	28.3	29.9	34.7	34.9	34.6	31.4
Low	19.7	18.6	18.3	15.3	10.7	7.7	6.8	9.6	11.8	16.0	18.1	19.4

(Source) Ngoma Research Station in the Kafue National Park-South cited in ZAWA 2008

3) Natural Environment

Itezhi-Tezhi Dam is located in or in the vicinity of the Kafue National Park. The Dam itself is not located in the national park, but there are Namwala Game Management Area and Ila National Forest around the Dam (Figure D.10).



(Source) Namwala 1:250,000 topographic maps - GRZ Survey Department

Figure D.10 Protected areas around the Itezhi-Tezhi Dam

The Kafue Flats, which is registered with the Ramsar Convention, stretches in the downstream of the Itezhi-Tezhi Dam. There are a number of protected areas such as Blue Lagoon National Park and Lochinvar National Park.

Vegetation around Lake Itezhi-Tezhi, Kafue National Park, and Namwala Game Management Area can be classified into five (5) types: 1) Dry deciduous forest; 2) Riparian woodland; 3) Open forest; 4) Termitaria vegetation; and 5) Grassland.

There are three (3) types of dry deciduous forest, i.e., Baikiaea, Secondary baikiaea, and

Ptelopsis. Baikiaea Forest characterizes the vegetation of this area, and is mainly found in the south and southwest of Lake Itezhi-Tezhi. In particular, tall tree species such as Baikiaea plurijuga, Pterocarps antunesii and Lonchocarpus nelsi, and short trees such as Baphia massaiensis obovata and Combretum celastroides are found. Secondary Baikiaea Forest distributes the southeast of the lake and the southeastern part of Kafue National Park. Tall tree species include Burkea Africana, Combretum callinum, Eythropleum africanum, Lonchocaipus capassa and Acacia giraffae. Pteleopsis Forest is observed in the southwest of Lake Itezhi-Tezhi and along Musa stream, a tributary flowing into the Lake. Dominant tall tree species include Pteleopsis mystifolia, Pteleopsis antunesis, Pteleopsis anisoptera, and Entandrophragma caudatum. Riparian Forest occurs along Kafue River and its perennial tributary and wetlands where water pools can be found in the dry season. The dominant tree species is Syzygium guineensedearu. Other species include Acacia albida, Albizia glaberrima, Diospyros mespiliformis, Homalium abdessammadii, and Syzygium cordatum. Riparian Forest plays an important role in the stability of river bank, and grazing by wildlife animals.

Open forest is categorized into three types: 1) Miombo Woodland; 2) Kalahari Woodland; and 3) Munga Woodland. In particular, Miombo Woodland covers the site where a power generation house is planned to be constructed. Miombo woodland is found in two forms around the Lake: 1) one dominated by Julbernardia paniculata on the north bank of the Kafue River; and the other dominated by Julbernardia globiflora on the south bank. Other tall tree species commonly found include Acacia goetzei spp. Microphylla, Hymenocardia acida, and Phyllanthus engleri. Kalahari Woodland is found on the south bank of the Kafue River, and the dominant species include Burkea Africana, Brachystegia spiciformis, Erythrophleum africanum, and Julbernardia paniculata. Mopane Woodland occurs in the Kafue Flats, and is sometimes the mixture of Munga Woodland. The main canopy consists of Acaci nigrescensya, Combretum imberb, Lannea stuhlmannii and Sterculia quinqueloba. Munga Woodland is open woodland of savanna type, and is characterized by Accacia and Albizia genus.

Termitaria widely spreads in Miombo and Munga Woodland. The flora of areas with many termite mounds is different from the other areas. In Miombo Woodland, Diospyros mespiliformis, Manikara mochisia and Mimusops zeyheri are featured, while Albizia amara, Lannea discolor and Markamia obtusifolia are distinctive in Munga Woodland.

Flora found around the project site are presented in Table D.13.

Table D.13 Flora Found in the Vicinity of the Site Where the Power House will be Constructed

No	Scientific name	Common name in English/ Local language	Family	Conservation status*1	Description of habitat
1	*Baphia massaiensis*	Jasmine pea	Fabaceae	*(Not listed)*	Terrestrial
2	*Brachystegia spiciformis*	Bean-pod tree	Fabaceae	*(Not listed)*	Terrestrial
3	*Canthium inerme*	Turkey-berry	Rubiaceae	*(Not listed)*	Terrestrial /Aquatic
4	*Carissa edulis*	Simple-spined num num	Caesalpiniaceae	*(Not listed)*	Terrestrial
5	*Cassia abbreviate*	Sjambokpod	Fabaceae	*(Not listed)*	Terrestrial /Aquatic
6	*Cassia singueana*	Winter cassia	Fabaceae	*(Not listed)*	Terrestrial
7	*Combretum collinum*	Bushwillow	Combretaceae	*(Not listed)*	Terrestrial
8	*Combretum zeyheri*	Large-fruited bushwillow	Combretaceae	*(Not listed)*	Terrestrial
9	*Croton megalobotrys*	Mutuatua	Euphorbiaceae	*(Not listed)*	Terrestrial
10	*Croton polytricus*		Euphorbiaceae	*(Not listed)*	Terrestrial
11	*Dalbergia melanoxylon*	African blackwood	Fabaceae	*(Not listed)*	Terrestrial
12	*Diospyros mespiliformis*	African ebony, jackal-berry	Ebenaceae	*(Not listed)*	Terrestrial
13	*Diplorhynchus condylocarpon*	Rhodesian rubber tree	Apocynaceae	*(Not listed)*	Terrestrial
14	*Feretia aeruginescens*	Munyansankula	Rubiaceae	*(Not listed)*	Terrestrial
15	*Friesodielsia obovata*	Monkey fingers	Annonaceae	*(Not listed)*	Terrestrial
16	*Haplocoelum foliolosum*	M'kalandja	Sapindaceae	*(Not listed)*	Terrestrial
17	*Julbernadia paniculata*	Mutondo	Leguminoceae	*(Not listed)*	Terrestrial
18	*Kraussia floribunda*	Rhino coffee	Rubiaceae	*(Not listed)*	Terrestrial
19	*Lannea stuhlmannii*	False maroela	Anacardiaceae	*(Not listed)*	Terrestrial
20	*Markhamia obtusifolia*	Golden bean tree	Bignoniaceae	*(Not listed)*	Terrestrial
21	*Ochna afzeli*	Musengu	Ochnaceae	*(Not listed)*	Terrestrial
22	*Parinari curatellifolia*	Mpundu	Chrysobalanaceae	*(Not listed)*	Terrestrial /Aquatic
23	*Paulinia pinnata*	Nistmal	Sapindaceae	*(Not listed)*	Terrestrial
24	*Phoenix reclinata*	Wild date palm	Arecaceae	*(Not listed)*	Terrestrial /Aquatic
25	*Pseudolachnostylis maprouneifolia*	Kudu berry	Euphorbiaceae	*(Not listed)*	Terrestrial
26	*Pteleopsis anisoptera*	Mwangula	Combretaceae	*(Not listed)*	Terrestrial
27	*Pterocarpus antunesii*	Mukambo	Fabaceae]	*(Not listed)*	Terrestrial
28	*Securinega virosa*	White-berry bush	Phyllanthaceae	*(Not listed)*	Terrestrial
29	*Strychnos lucens*		Strychnaceae	*(Not listed)*	Terrestrial
30	*Strychnos usambarensis*	Blue bitterberry	Strychnaceae	*(Not listed)*	Terrestrial
31	*Syzygium guineense*	Forest waterberry	Myrtaceae	*(Not listed)*	Terrestrial /Aquatic
32	*Thorny markania*		Rutaceae	*(Not listed)*	Terrestrial
33	*Vangueriopsis lanciflora*	Wild medlar	Rubiaceae	*(Not listed)*	Terrestrial

Note *1: Conservation status cited as per IUCN Red List category, i.e., “EX: Extinct”, “CR: Critically Endangered”, “EN: Endangered”, “VU: Vulnerable”, “LR/cd: Lower Risk / Conservation Dependent”, “NT or LR/nt: Near Threatened”, “DD: Data Deficient”, “LC or LR/lc: Least Concern” (IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <www.iucnredlist.org>. Downloaded on 19 August 2009.)

*2: Flora species sighted during site walkover on 9th and 10th July 2009.

Fauna is rich around the project site. Kafue National Park and Namwala Game Management Area, and the Lake Itezhi-Tezhi are considered to contribute to the rich fauna.

Major fauna found around the project site is given in Table D.14.

Table D.14 Fauna found in the vicinity of site where power house will be constructed

No	Scientific name	Common name in English/ Local language	Family	Conservation status*1	Description of habitat
1	Mammals				
1.1	*Kobus defassa*	Waterbuck	Bovidae	*(Not listed)*	Terrestrial
1.2	*Lepus victoriae*	African Savannah Hare	Leporidae	LC	Terrestrial
1.3	*Syncerus caffe*	Buffalo	Bovidae	*(Not listed)*	Terrestrial
1.4	*Kobus vardonii*	Puku	Bovidae	NT	Terrestrial
1.5		Warthog	Suidae	LC	Terrestrial
1.6	*Aepyceros melampus*	Impala	Bovidae	LC	Terrestrial
1.7	*Loxondotha Africana*	African Elephant	Elephantidae	*(Not listed)*	Terrestrial
1.8	*Papio ursinus*	Baboons	Cercopithecidae	*(Not listed)*	Terrestrial
1.9		Monkeys		*(Not listed)*	Terrestrial
1.10		Wilderbeest	Bovidae	*(Not listed)*	Terrestrial
1.11		Bushbuck	Bovidae	LC	Terrestrial
2	Amphibians				
2.1	*Hippopotamus amphibious*	Hippo	Hippopotamidae	EN	Terrestrial/Aquatic
2.2	*Crocodylus niloticus*	Crocodiles	Crocodylidae	VU	Aquatic/terrestrial
3	Reptiles				
3.1	*Varanus albigularis*	Monitor lizards	Varanidae	*(Not listed)*	Aquatic/terrestrial
4	Fish*3				
4.1	*Tilapia rendalli*	Red breasted Bream	Cichlidae	LC	Aquatic/ fresh water
4.2	*Labaeo cyndricus*	Mudsucker		*(Not listed)*	Aquatic/ fresh water
4.3	*Hepsetus odoe*	African Pike	Hepsetidae	*(Not listed)*	Aquatic/ fresh water
4.4	*Synodontis kafuensis*	Squeaker	Mochokidae	*(Not listed)*	Aquatic/ fresh water
4.5	*Scilbe intermendius*	Silver fish		*(Not listed)*	Aquatic/ fresh water
4.6	*Serranochromis robustu*	Yellow belly bream		*(Not listed)*	Aquatic/ fresh water
4.7	*Clarius spp*	Barbel fish		*(Not listed)*	Aquatic/ fresh water
4.8	*Barbus barbus*	Barbus	Cyprinidae	LC	Aquatic/ fresh water
4.9	*Limnothrissa miodon*	Kapenta (Lake Tanganyika sardine)	Clupeidae	LC	Aquatic/ fresh water
4.10	*Brycinus lateralis*	Strip tailed robber		*(Not listed)*	Aquatic/ fresh water

Note *1: Conservation status cited as per IUCN Red List category, i.e., “EX: Extinct”, “CR: Critically Endangered”, “EN: Endangered”, “VU: Vulnerable”, “LR/cd: Lower Risk / Conservation Dependent”, “NT or LR/nt: Near Threatened”, “DD: Data Deficient”, “LC or LR/lc: Least Concern” (IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <www.iucnredlist.org>. Downloaded on 19 August 2009.)

*2: Sighting of above fauna around the proposed power station project area reported by Christopher Kaoma, Acting Warden, Ngoma Sector, Kafue National Park, ZAWA during personal interview on 9th July 2009).

*3: Source of information on fish species found in Lake Itezhi-Tezhi and Kafue River is the Namwala Game Management Area Draft Land-Use Plan: 2008-2018 (ZAWA, 2008)

4) Air Quality and Noise

There is no data on air quality in Itezhi-Tezhi District. However, the air quality in the district is deemed to be good since there are no or few pollution sources and the traffic volume is also very limited. Similarly no sources of noise is observed and identified around the project area. Interviews with local residents have not identified any complaints about air pollution and noise.

5) Water Quality

There are data on water quality observed at the water intake and discharge of the

Itezhi-Tezhi Dam by ZESCO in 1999. The temperature is between 24 °C and 25 °C, and the dissolved oxygen ranges from 3.34 mg/l to 5.5 mg/l at the water intake, and from 7.7 mg/l to 8.5 mg/l at the water discharge.

Households in Itezhi-Tezhi town mainly rely on treated piped water supplied by ZESCO. Households around the Lake Itezhi-Tezhi use the lake water, while shallow wells and boreholes are the main sources of water for households in the other areas.

6) Hydrology

The Kafue River and its tributaries, together with the Lake Itezhi-Tezhi created by the dam, characterize the hydrology in Itezhi-Tezhi District. At the downstream of the Lake Itezhi-Tezhi, the Kafue Flats, a vast wetland stretching out about 200 km, is located.

The Kafue River has large seasonal fluctuations in water flows like the other rivers of Zambia. The water flow increases in the rainy season, and significantly decreases in the dry season. However, flooding of the Kafue Flats in the rainy season is alleviated while certain amount of water flows is observed even in the dry season, since water volume to be discharged to the Kafue Flats is controlled by the Itezhi-Tezhi Dam (Table D.15).

Table D.15 Monthly Water Flows of the Kafue River

Month	Average Water Flows (m^3/s)			
	2003		2007	
	Upstream	Downstream	Upstream	Downstream
Jan	213.308	114.387	335.123	223.568
Feb	303.319	168.596	948.239	837.204
Mar	518.672	130.987	1 026.655	844.094
Apr	636.927	102.137	617.990	500.980
May	413.310	331.124	266.767	158.358
Jun	184.441	164.964	119.344	95.023
Jul	115.059	221.007	83.801	100.019
Aug	85.734	217.127	63.994	144.487
Sep	59.957	179.450	41.250	158.277
Oct	36.357	153.194	24.148	153.702
Nov	32.981	122.580	24.406	192.097
Dec	61.053	101.303	90.736	187.006

(Source) ZESCO Hydro-meteorological Data Base, Itezhi-Tezhi

(4) Socio-Economic Conditions

1) Local Government and Social Institutions

There are 12 wards in Itezhi-Tezhi District. The Itezhi-Tezhi Dam and the site for the power house belong to Itezhi-Tezhi Ward. The site for the power house is close to the boundary between Itezhi-Tezhi Ward and Basanga Ward.

Itezhi-Tezhi District is traditionally divided into six (6) Chiefdoms: Chief Shimbinzhi; Chief Kaingu; Chief Chilyabufu; Chief Muwezwa; Chief Shezongo; and Chief Musungwa. The Chiefs who govern land close to the project site is Chief Kaingu and Chief Musungwa.

2) Population

The population of Itezhi-Tezhi District is 46,357 according to the Census carried out in 2000, and is the second least populated in Southern Province. Most of the population is rural. The number of households is 7,976, and average size of households is approximately six (6). Population density of the district is 4.7 persons per square kilometer, which are considered very low, taking into account that the average of Southern Province is 14.2 persons per square kilometer. Estimated population growth rate is 4 percent, larger than the national rate of 2.9 percent. The site for the power house belongs to Itezhi-Tezhi Ward and is next to Basanga Ward. The population of Itezhi-Tezhi Ward is around 3,000, and that of Basanga Ward is 4300.

The main tribe in the Itezhi-Tezhi District is the Ila. There are, however, many immigrants from other areas of the country. For instance, there are the Lozis engaging in fishing, and the Tongas who migrated from other areas of Southern Province to secure farming land.

3) Local Economy

The agriculture in Itezhi-Tezhi District is mainly subsistence agriculture. Main crops in the district are maize, and some cultivate sorghum, and millet. In Itezhi-Tezhi and Basanga Ward, produce of maize is the biggest, followed by cassava and groundnuts. According to the District Agriculture Coordinator, average agricultural field size is between 5 ha and 10 ha in the two wards.

Livestock production is an important livelihood means in Basanga Ward. Cattle herding is historically widespread in the Kafue Flats. Cattle provide power for draught and transportation, and are utilized for food sources such as meat and milk.

Fishing is one of the main economic activities in Itezhi-Tezhi District. Major fisheries are the Lake Itezhi-Tezhi and the Kafue Flats. Commonly exploited fish are species are the tilapia, bream or catfish. Fish is the main source of protein as well as means of cash income. Major markets for Itezhi-Tezhi fish are Mumbwa and Lusaka which are located 200 km and 300 km away respectively. Fishing industry is however not well established largely due to the poor road condition and poor storage infrastructure.

Itezhi-Tezhi District is endowed with rich forests which support local residents' livelihoods. Many residents utilize fuel wood for cooking, timber products for construction, grass and barks. Major tree species in forest of the district include Pterocarpus Angolensis, Guibourtia Coleosperma, Baikiaea Plurijuga, and Afzelia Quanzensis. Despite the district's abundant forest resources, forestry or wood-based industry is not well established in Itezhi-Tezhi District, and thus only primary forest products such as timber are sold in the market of Lusaka. In terms of non timber forest products (NTFP), fruits, nuts, mushroom, grass and leaves. The district has also more than 150 beekeepers to produce honey.

Itezhi-Tezhi District is within or adjacent to protected areas such as the Kafue National Park, Namwala Game Management Area, and Nkala Game Management Area. The tourism industry is now gradually developing such as the game tour and trophy hunting in the protected areas. In addition, the district has tourist attraction such as the Lake Itezhi-Tezhi and hot springs, and lodges are currently under construction for tourists. Although the tourism development is still underway, the potential of the district is considered high.

There are limited opportunities of employment to obtain cash income in Itezhi-Tezhi District. More than half of the employee work for government or parastatal enterprises including schools, clinics, government extension offices, and ZESCO. The other source of employment is NGOs. There are also small-scale commercial stores in the center of Itezhi-Tezhi town.

(5) Scoping Result

Potential environmental and social impacts of Itezhi-Tezhi Project are given in Table D.16. The scoping is conducted for the potential impacts of the Itezhi-Tezhi hydropower development project since the case study targeted the hydropower project.

Table D.16 Scoping Table for Potential Impacts of Itezhi-Tezhi Project

Impacts	Hydro	
	Construction	Operation
Involuntary Resettlement		
Impacts on Local Economy (employment and livelihood) and Land Use	C	
Impacts on Local Social Institutions such as Decision-making Institutions		
Impacts on the Livelihoods of Indigenous Peoples and Ethnic Minorities		
Local Conflict of Interests and Inequality		
Water Usage and Water Rights		
Sanitation and Infectious Diseases such as HIV / AIDS	B	
Cultural Heritage		
Topography and Geological Features		
Soil Erosion	B	
Local Hydrology and Groundwater		
Flora and Fauna, and Biodiversity	B	B
Landscape		
Global Warming		
Air Pollution		
Water Pollution	B	
Soil Contamination		
Waste	B	
Noise and Vibration		
Ground Subsidence		
Offensive Odor		
Bottom Sediment		
Accident and Safety	B	

[Legend] A: Significant impacts expected B: Certain impacts expected
C: Impacts unknown No Mark: Negligible impacts

The current environmental and socio-economic situations around the project site and the detailed potential impacts are presented below.

1) Involuntary Resettlement

The site for the power house is located immediate downstream of the existing dam, and no settlement is found around the site. In addition, the existing road can be utilized as the road for construction works. Involuntary resettlement is, therefore, not anticipated by the construction of new power generation facilities.

2) Impacts on Local Economy (employment and livelihood) and Land Use

There are no lands for economic use such as agricultural and forestry lands in the vicinity of the site for the power house. Impacts on local economy and land use are therefore not anticipated. However, the site is located along a road connecting downstream communities and Itezhi-Tezhi town, and thus, the passage on the road may be disturbed during construction works. Occurrence/nonoccurrence of such impacts is unclear at present since it relies on the details of the project plan. It is, therefore, necessary to confirm the project plan, including the construction methodologies and layout of construction materials, at the F/S and/or D/D phases, and to identify the existence/nonexistence of adverse impacts.

3) Impacts on Local Social Institutions such as Decision-making Institutions

The site for the power house is located immediate downstream of the existing dam, and no settlement is found around the site. Thus impacts on local social institutions are not anticipated in association with the construction of new power generation facilities.

4) Impacts on the Livelihoods of Indigenous Peoples and Ethnic Minorities

According to the District Commissioner, District Coordination Committee and local residents, no indigenous peoples and ethnic minorities are found in the vicinity of the site for the power house.

5) Local Conflict of Interests and Inequality

The construction of the power house will not cause local conflict of interests and inequality.

6) Water Usage and Water Rights

Water usage and water rights will not be affected since water discharge pattern of the existing dam will be maintained after the power generation starts.

7) Sanitation and Infectious Diseases such as HIV/ AIDS

Risks of HIV/ AIDS could temporarily increase as a result of inflow of construction workers into the project site. HIV-infection rate in Southern Province is estimated 14.5 %[13], and further spread of HIV infection is a matter of concern. The Ila people, the main tribe in Itezhi-Tezhi District, has the culture of succession of widows through sexual cleansing. Such cultural practice may contribute to the high incidence of STD including HIV/ AIDS.

[13] Based on the website of the Central Statistics Office (http://www.zamstats.gov.zm/)

8) Cultural Heritage

No cultural heritages are identified around the site for the power house through interviews with the District Commissioner, District Coordination Committee and local residents.

9) Topography and Geological Features

No valuable topographic and geological features are identified around the site for the power house.

10) Soil Erosion

Limited scale of soil erosion may occur due to construction works since the site for the power house is located at the base of a steep hill.

11) Local Hydrology and Groundwater

Local hydrology and groundwater will not be affected since water discharge pattern of the existing dam will be maintained after the power generation starts.

12) Flora and Fauna, and Biodiversity

The site for the power house is adjacent to Kafue National Park, Nkala Game Management Area, and Namwala Game Management Area. According to interviews with local residents, wildlife animals inhabiting in these areas are frequently found at the downstream of the existing dam. The spoor of African elephant was observed at approximately one kilometer downstream of the existing dam during on-site investigation. The construction of the new power house may affect such wildlife animals' behavior. In addition, the improvement of road infrastructure may increase the risk of poaching. In terms of vegetation, impacts will be limited though some trees on the site will be cleared.

13) Landscape

The site for the power house is located at the base of a steep hill. The project, therefore, will not affect local landscape due to such and inconspicuous location of the site.

14) Global Warming

The project aims to construct a new hydropower station, and thus will not contribute to global warming. The amount of greenhouse gases emitted by construction works is negligible.

15) Air Pollution

The project aims to construct a new hydropower station, and thus will not cause air pollution. There is no concern about accumulated air pollution since no air pollution sources such as industrial activities are found in Itezhi-Tezhi District, and the traffic volume is very limited in the district. Emission of air pollutants due to construction works is negligible.

16) Water Pollution

Construction works for the power house may cause water pollution of the Kafue River due to the inflow of muddy water into nearby rivers and streams.

17) Soil Contamination

Construction of the power house will not cause soil contamination.

18) Waste

Construction works will generate waste soils and other construction wastes.

19) Noise and Vibration

Construction works may cause limited noise and vibration, but they are negligible since there are no villages around the site for the power house.

20) Ground Subsidence

There is no possibility of ground subsidence.

21) Offensive Odor

There is no possibility of offensive odor.

22) Bottom Sediment

The project will utilize the existing Itezhi-Tezhi Dam, thus no additional bottom sediment is anticipated.

23) Accident and Safety

Accidents during construction works may take place. Vehicles for construction works may cause traffic accidents.

(6) Necessary Mitigation Measures

Mitigation measures necessary for the potential environmental and social impacts described in (3) are presented below.

1) Impacts on Local Economy (employment and livelihood) and Land Use

When formulating the plan of civil works, it is necessary to ensure smooth passage on the road between Itezhi-Tezhi Town and communities located at the downstream of the existing dam. If temporary disturbance of the passage is unavoidable, a diverting route shall be constructed. Local residents should also be informed of the work schedule and the diverting route.

2) Sanitation and Infectious Diseases such as HIV/ AIDS

Educational and promotion activities to prevent infectious diseases should be implemented for construction workers and local residents. In particular, educational activities for construction workers, including the distribution of condoms, are essential. In addition, it is effective to employ as many local workers as possible.

3) Soil Erosion

Measures against soil erosion should be taken during construction works. In particular, measures to stabilize soil such as re-vegetation should be taken for a hill behind the site for the power house.

4) Flora and Fauna, and Biodiversity

Tree cutting and vegetation removal associated with construction works shall be minimized. In particular, vegetation along Kafue River shall be strictly conserved. A re-vegetation program to restore removed vegetation shall be implemented after the completion of the works. The velocity limit of construction vehicles should be set to prevent traffic accidents with wildlife animals from the immediate downstream of the existing dam to the downstream areas where wildlife animals are frequently found.

Appearances and behaviors of wildlife animals coming from nearby protected areas shall be monitored. Any sort of actions that could affect wildlife animals, such as leaving food wastes around the construction site, shall be strictly prohibited. Construction workers shall be educated to avoid any form of harm to such wildlife animals. Anti-poaching campaign shall be implemented around the project site.

It is necessary to elaborate effective mitigation measures for wildlife protection, referring to the precedents of infrastructure development projects.

5) Water Pollution

It is necessary to take measures to prevent muddy water from flowing into Kafue River and other rivers such as the construction of small-scale temporary dams. Civil works that could cause such muddy water inflows should be implemented avoiding the rainy season and during rain.

6) Waste

Education and instruction to properly dispose of construction wastes such as waste soils shall be provided to construction workers.

7) Accident and Safety

Safety education and instruction shall be provided to construction workers to prevent accidents during construction works. Traffic safety education for construction workers and road traffic safety campaign should be implemented to ensure traffic safety.

(7) Stakeholder Consultations

Stakeholder consultation meetings are held in the vicinity of the site of Itezhi Tezhi project. The overview of the stakeholder meetings and points to consider for the future hydropower development projects are presented in Chapter 11.

(8) Environmental Management Plan and Monitoring

A project-specific environmental management plan needs to be properly formulated, and the effective implementation should be ensured. The framework of the plan is described in Chapter 11, thus this section presents items to be monitored for Itezhi Tezhi Project in particular (Table D.17).

Table D.17 Major Monitoring Items for Itezhi Tezhi Project

Item	Description
Impacts on local economy	- Occurrence/nonoccurrence of disturbance of the passage, and implementation status of mitigation measures such as the construction of diverting routes
Sanitation and Infectious Diseases such as HIV/ AIDS	- Understandings of construction workers about infectious diseases - Progress of the proposed mitigation measures such as the distribution of condoms
Soil Erosion	- Situation of soil erosion around the site for the power house. - Implementation status of soil stabilization measures such as re-vegetation
Flora and fauna, and biodiversity	- Changes in vegetation in the vicinity of the site for the power house, such as the number of indicator species - Implementation status of a re-vegetation program after the completion of civil works - Understandings of construction workers about anti-poaching - Progress of the other proposed mitigation measures and their effectiveness
Water Pollution	- Implementation status of water pollution measures and their effectiveness
Waste	- Appropriateness of the disposal of construction wastes
Safety measures	- Implementation of safety measures during construction works - Maintenance and inspection of facilities, and prevention of fire breaking
Mitigation Measures	- Implementation status of proposed mitigation measures and their effectiveness
Complaints	- Establishment of system for accepting complaints and records of complaints - Appropriateness of processing complaints

(Source) JICA Study Team

(9) Conclusions

Itezhi Tezhi project aims to add a new power generator to the existing dam and reservoir. Therefore, significant impacts such as involuntary resettlement and the submersion of valuable ecosystem are not anticipated. Water discharge pattern will be the same after power generation starts, and thus the impacts on downstream ecosystem will remain the same. It can therefore be concluded that no significant environmental and social impacts are anticipated in association with Itezhi Tezhi Project.

However, certain impacts such as the spread of infectious disease, and impacts on flora and fauna and biodiversity are anticipated. It is therefore critical to formulate an environmental management plan that can effectively address the issues, and to conduct monitoring activities. In addition, it is necessary for the project developer to acquire agreements from stakeholders such as project-affected-persons, chiefs and local governments through sufficient consultations prior to the project implementation.

D.3 Lusiwasi Expansion Project

D.3.1 Examination of Technical Feasibility

(1) Implementation of the field study

1) Access

About 60 kilometers northeast on the main road out of Serenje, the major city in the district, is the junction for the road leading to the ZESCO Lusiwasi Power Station. The entrance gate to the power station lies to the east, about 72 kilometers from the junction, and leads to the intake and head pond sites. The first 22 kilometers of road from the junction are paved, but the remaining 50 kilometers are unpaved. There is no road from the site of the intake and head pond to the power station; from the vicinity of the head pond site, there is an incline trolley along the pen stock. This trolley is the only mode of access to the power station. It travels for a distance of about 40 minutes when descending and 1 hour when ascending.

The dam site in the upstream scheme is reached by walking to the northeast from the aforementioned unpaved road leading to the Lusiwasi Power Station a little before crossing the Lusiwasi River. It is near the confluence of the Lusiwasi and Luangala rivers. There is no road, and the distance is about 2 kilometers.

2) Results of the project site survey

Table D.18 shows the results of simple measurements taken by Global Positioning System (GPS) to ascertain the location of major facilities related to the Lusiwasi Project as a first step.

Table D.18 Location of each site (Measuring result by GPS)

Facilities	Latitude	Longitude	Altitude (m)	Remarks
Upstream Scheme				
Dam Site	S13 11’23.8”	E31 01’46.5”	1,443	
Expansion project				
Intake	S13 19’19.5”	E31 01’16.6”	-	Same Existing
Head Pond	S13 19’88.3”	E31 00’97.8”	1,161	Same Existing
Power Station	S13 20’47.0”	E31 01’08.1”	661	Same Existing
Lusiwasi Reservoir	Existing			
Dam Site	S12 59’30.4”	E30 51’87.2”	1,563	
Overflow	S12 59’30.4”	E30 51’87.2”	1,562	
Upstream edge	S12 58’29.9”	E30 39’10.4”	1,567	Rail way

(a) Upstream scheme (Capacity: 10 MW)

<u>Dam site</u>

The project site is the point of confluence between the Lusiwasi River, which flows from the existing Lusiwasi reservoir, and the Luangala River (see Figure D.11). The construction of a reservoir at this point will enable effective use of the water resources in the Lusiwasi River system. There are also rocky hills in the area, and this suggests that the ground foundation may be considerably strong. As compared to ordinary dam sites, nevertheless, the terrain is flat (see Figure D.12), and this will make for a longer dam crest length. A rough calculation yielded a crest length of about 500 meters at a dam height of 10 meters.

In reports to date, the reservoir capacity was put at 70 million cubic meters. Actual construction of a reservoir with this capacity would enable use of the total annual flow of the Lusiwasi and Luangala rivers for power generation.

Figure D.11 Confluence of the Luangala and Lusiwasi rivers

Figure D.12 Dam site of the upper scheme

Intake and power station site

It is not necessary to install the intake facilities on the new reservoir. The dam site is flat, and it would be more economical to conduct the intake further downstream at a location offering head, which would also shorten the extended length required for the headrace. A look at topographical maps reveals that the power station location may possibly be pushed back to vicinity of the intake for the existing power station. Depending on the location, a direct connection of the tailrace in the upstream project and intake for the existing and additional facilities located downstream would another option.

(b) Expansion project (Capacity: 40MW)

Head

GPS measurement found that the head from the head pond of the existing facility and power station was about 500 meters.

Installation of the flushing gate

The existing dam (see Figure D.13) has a height of about 3 meters, with overflow across the entire breadth. It is not equipped with a flushing gate, and the intake is on the left bank. Because there is no flushing gate, the dam lacks mechanism for removal of sediment collecting behind it. Installation of a flushing gate near the intake would enable removal of sediment in the intake vicinity and reduction of sediment inflow into the headrace. It would be advisable to construct a flushing gate when building the intake for the expansion project facility in order to provide the dam with a function for sediment removal.

Figure D.13 Existing weir

Construction of a settling basin

The existing facility does not have a settling basin. Settling basins remove the sand entering with water from the intake by having it settle to their bottoms. The installation of a settling tank downstream of the intake would lessen erosion of the headrace and abrasion of turbines.

Headrace

For the purpose of assuring space for construction of the headrace, the option of expanding the current headrace will probably be preferred to that of building an additional one. If so, water will be unavailable and the existing power station will be taken out of operation during the period of construction.

Figure D.14 Existing headrace

Head pond

The head pond and the spillway must be enlarged to handle the increase in the amount of water use. There is sufficient space for the enlargement in the vicinity of the existing head pond.

Figure D.15 Existing head pond

Penstock

There are plans to install two additional pen stocks alongside the existing one.

Figure D.16　　Existing penstock

<u>Power house</u>

The power house is to be built next to the existing one. The requisite space can be procured. According to past reports, the turbine generator is to be of the horizontal pelton type, the same as in the existing power station, but the vertical pelton type is generally used with the head and amount of water use in question.

Figure D.17　　Existing power house

Figure D.18　　Existing turbine and generator

<u>Tailrace</u>

The tailrace of the existing power station has a small capacity, and a new one would have to be built.

Figure D.19 Existing tailrace

Incline trolley for transport of material and equipment

There is no road to the power station, which can be accessed only by using the incline trolley running along the pen stock from the head pond. This incline was also used in construction of the existing power station, and the plans for construction of the expansion project facilities are likewise premised on its use. As a result, the transport of material and equipment will be under constraints, and the construction will probably take longer than usual. Furthermore, there are apprehensions about the incline's deterioration, and regular use in the project must be preceded by inspection including confirmation of the live load and repair as necessary.

Decreased flow area

The section downstream from the existing dam to the existing power station is the decreased flow area.

Upon construction of the expansion project facilities, the period of decreased flow in this area will be longer than at present, because more river water will be diverted from the existing intake point to the headrace than heretofore. Without an environmental conservation flow, the section between the dam and the power station would be devoid of water almost half of the year if both the existing and new facilities are operated at maximum output. Downstream of the existing dam, there are no roads or houses, and use of river water for irrigation or other purposes has not been confirmed.

(c) Other matters

Road improvement

It is necessary to improve the existing road leading from the junction with the main road to the project site, which is same the existing power station, and to build a road to the dam site in the upstream scheme.

In the project for the new facilities, the unpaved road leading to the existing power station must be improved before the start of construction. It may also be noted that the road is bisected by the Lusiwasi River and seven other small rivers, with width of about two meters, over the section in question, and this situation must be corrected.

Figure D.20 Existing road to Lusiwasi site **Figure D.21 Lusiwasi river bridge**

<u>Establishment of flow gauging stations on the Luangala and Lusiwasi rivers</u>

The establishment of flow gauging stations on the Luangala and Lusiwasi rivers, which will flow into the new reservoir in the upstream scheme, will provide a grasp of the amount of reservoir inflow. On the Lusiwasi River, facilities are to be built to determine the amount of discharge from the Lusiwasi reservoir. Determination of the operational rule curve for the new reservoir based on the storage capacity curve for prepared at the time of construction of the new reservoir and past flow data will enable operation that makes effective use of water resources.

<u>Raising of the existing Lusiwasi reservoir dam</u>

The existing Lusiwasi reservoir dam is a small one of the rockfill type, with a maximum height of about 8 meters and crest length of about 313 meters. In the middle are a discharge pipe about 40 centimeters in diameter and five gates. The dam is also equipped with an 81-meter overflow.

Regarding the prospect of raising the height of the existing dam, calculations indicate that the entire annual river flow could be used to generate power in the new upstream scheme if the reservoir is equipped with a capacity of 70 million cubic meters, as envisioned in the current plan. For this reason, there would be little need for buildup for the purpose of power generation. It may also be noted that the existing reservoir is the source of water for the Lusiwasi River, and that the Tan-Zam railway line forms a dike at the backwater edge (see Figure D.24). Considering the impact on the railway line, the increase could be no more than two meters. An increase of two meters would require an extension of the crest length from both sides of the dam body edge by anywhere from several tens of meters to 100 meters, given the flatness of the dam site. There would consequently also be no topographical advantage.

Figure D.22　　Existing Lusiwasi dam　　**Figure D.23　Overflow part of the existing Lusiwasi dam**

Figure D.24　　Upstream edge of the Lusiwasi reservoir (Railway point)

Operation and maintenance of the existing facilities

The existing power station is equipped with four turbine generators, each with a capacity of 3MW, but two of them have been out of operation for a long time.　The facilities as a whole are decrepit, and delivery of a stable operation will require of the turbine and generator.

(2)　Study of the amount of generated output

1) Procedure (run- of – river type)

Obtain the generated output from the flow duration curve.

A)　Use daily flow data from the Masase observation station for the period from November 1965 to December 2008.

B)　Use the daily flow data for the 30 years for which there is no lack of data in chronological order to prepare a 30-year average flow curve.

C)　Calculate the amount of generated output from the average flow curve.

D)　Set the specifications for the power station.　In the case study, it tentatively set the values noted below (see Table D.19), but made arrangements so that the counterpart personnel could modify these values as they saw fit and make calculations for cases they envisioned.

Table D.19 Preconditions for generation calculation of Lusiwasi project

Item	Upper scheme	Expansion	Existing
Installed capacity	10,000 kW	40,000 kW	12,000 kW
Max. discharge	13.3 m^3/s	9.6 m^3/s	2.9 m^3/s
Effective head	90.0 m	500.0 m	509.2 m
Combined efficiency	85.0 %	85.0 %	85.0 %
Transmission loss	2.0%	2.0%	2.0%
Auxiliary	1.5%	1.5%	1.5%
Outage factor	0.97	0.97	0.97

E) Obtain the amount of generated output by calculating the output for each daily flow value on the flow duration curve, from the first to the 365^{th}, and adding up the results.

F) Calculation cases

a) Case of the expansion project facilities alone

b) Case of the existing power station alone

c) Case of both the existing facilities and the expansion project facilities

d) Case of upstream scheme alone

e) Case of generation with the amount of storage in the event that the amount of overflow is stored in the upstream scheme reservoir (Generation increasing effect of water storage)

f) Case of discharge of an environmental conservation flow, at rate of 1.0, 2.0 and 3.0 cubic meters per second, from the existing weir

2) Results

The calculation of generated output indicated that the additional facilities could be expected to generate 205.3 GWh per year (see Table D.20). The existing power station could presumably generate 92.8 GWh per year if its facilities were in good condition, but two of its four generators had been out of operation due to failure for a long time when the field survey was conducted.

The expansion project facilities calls for construction of an intake at the same place as the existing facility. The sum of the output from the existing and new facilities yields a combined annual generated output of 231.3 GWh.

The upstream scheme will construct an additional reservoir. There is a plan to give this reservoir a capacity of 70 million cubic meters. This would enable storage of the annual river flow that cannot be used by the power generation facilities in the downstream expansion facilities and the existing power station, i.e., the annual overflow of 47 million cubic meters. Operation of this reservoir would therefore make it possible to use the entire annual flow of the Lusiwasi River system to generate power.

The amount of storage in this upstream scheme reservoir translates into an annual generated output of 53.4 GWh. Effective operation of the upstream scheme reservoir would therefore enable effective use of the river system water resources for power generation and could increase the annual generated output by 53.4 GWh. For this purpose, it is important to install flow gauging facilities to determine the inflow into the reservoir and provide for proper operation of the reservoir by preparing a storage capacity curve and determining an operational rule curve like that for the Itezhi- Tezhi reservoir.

Next, let us consider the case of discharge of an environmental conservation flow from the location of the existing dam. Because Zambia does not have any explicit standards related to the amount of environmental conservation flow, the study team made a rough calculation of the decrease in generated output in the hypothetical case of discharge for environmental conservation flow. At a discharge of 1.0 cubic meter per second in normal operation, the annual output would be reduced by 27.1 GWh (see Table D.21).

Table D.20 Calculation results of the annual generation output by each case

	Generation output (GWh)	Overflow (m^3)	Plant factor (%)
a) Expansion PJ	205.3	71,062,563	62.4
b) Existing	92.8	174,404,339	94.0
c) Expansion +Existing	231.3	47,027,661	54.1
d) Upper scheme	42.7	41,671,351	52.0
e) Reservoir storage energy	53.4		

Table D.21 Annual generation calculation of the environmental conservation flow case

Environmental Flow	Generation output (GWh)	Overflow (m^3/s)	Plant factor (%)	Decrease (GWh)
Base Case				
c) Expansion +Existing	231.3	47,027,661	54.1	0
Case1 : 1.0 m^3/s	204.2	40,425,636	47.8	27.1
Case2 : 2.0 m^3/s	177.3	34,674,843	41.5	54.0
Case3 : 3.0 m^3/s	154.4	29,696,581	36.1	76.9

1.1.2 Environmental and Social Considerations

(1) Natural Conditions

1) Geographical Condition

Lusiwasi project site is located in Serenje District of Central Province. The district lies between 12 to 13 degrees south latitude and 29 to 31 degrees east longitude. It has an international boundary with the Democratic Republic of Congo. Its area is approximately 23,351 km^2. Lusiwasi is located approximately 100 km northeast of Serenje Town, the center of Serenje District.

2) Climatic Conditions

The climate of Serenje District is largely divided into three seasons, cool dry, hot dry and hot wet. Cool dray season starts in April and ends in August, and hot dry season is from

August to November. Rainy season is from November to April. Table D.22 demonstrates the precipitation of Serenje District. Average annual precipitation of past 30 years is 1,159 mm, and the annual precipitation in 2008 is over 1,300 mm. Annual precipitation of Lusiwasi is considered higher since Lusiwasi is adjacent to an area where an average annual precipitation is more than 1,200 mm.

Table D.22 Precipitation by Month in Serenje District

(mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	302.6	379.2	254.3	26.6	14.4	0.0	0.0	0.0	0.0	0.5	121.4	207.5
Average[*1]	262.0	274.0	156.0	41.0	4.0	0.0	0.0	0.0	0.0	15.0	109.0	298.0

Note 1: Monthly average precipitation from 1978 to 2008

(Source) Serenje Meteorological Station

Table D.23 shows mean maximum and minimum temperature by month. In October, mean maximum temperature is over 30 ^{o}C, but other months are less than 30 ^{o}C. On the other hand, from April to August, the mean minimum temperature is below 15 ^{o}C. The lowest is about 10 degrees, recorded 10.2 ^{o}C and 9.6 ^{o}C in June and July respectively.

Table D.23 Mean Monthly Temperature of Serenje District

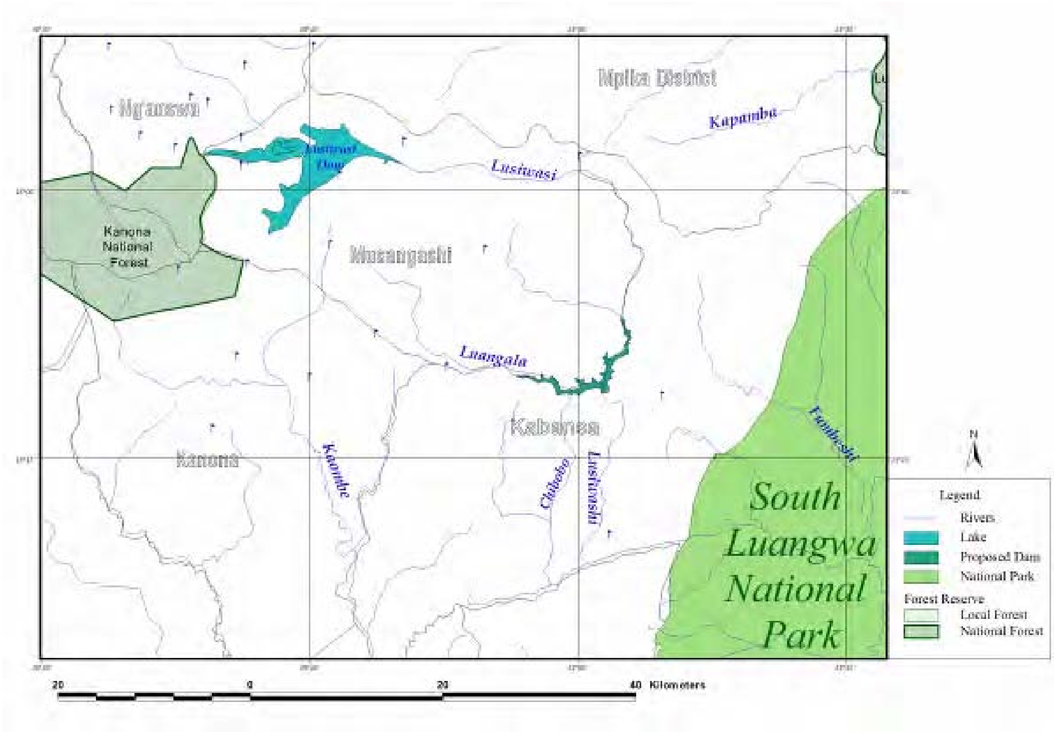
Temperature (^{o}C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Maximum	25.8	25.8	26.1	26.3	24.6	22.8	22.7	25.4	28.9	31.2	28.7	26.5
Mean Minimum	17.2	17.1	16.3	14.0	12.2	10.2	9.6	11.7	14.7	17.8	17.8	17.3

(Source) Serenje Meteorological Station

3) Natural Environment

The most distinctive topographic feature around Lusiwasi is Muchinga Escarpment. Its difference in height is 500 m, and the expansion of the existing Lusiwasi Power Station, which utilizes the difference for power generation, is a component of the Lusiwasi Expansion Project.

There is no protected area around the existing power station, but South Luangwa National Park is located at the downstream of the Lusiwasi River. The river flows down Muchinga Escarpment and then into the South Luangwa National Park, and joins the Luangwa River. Kanona National Forest Reserve is located about 45 km northeast of Serenje Town. There is the existing Lusiwasi Lake in the vicinity of the Kanona Reserve. A new reservoir is planned to be constructed at the confluence of the Lusiwasi and Luangala River, which is in the downstream of the existing Lusiwasi Lake (Figure D.25).



(Source) 1:50,000 topographic maps, Survey Department, Ministry of Lands

Figure D.25 Protected Areas around the Project Sites for the Lusiwasi Expansion Project

The proposed dam site and the area of existing Lusiwasi Power Station are mainly covered by Miombo woodland, a typical open forest in Zambia. Tree species belonging to the Brachystegia and Julbernardia genus are observed in and around the project sites. In Serenje District, there are also plantation forests mostly covered by Eucalyptus grandis and Pinus oocarpa.

Flora found in the vicinity of the existing Lusiwasi Power Station are given in Table D.24.

Table D.24 Flora Found in the Vicinity of the Project Site[*2]

No	Scientific name	Common name in English/ Local language	Family	Conservation status[*1]	Description of habitat
1	*Afzelia quanzensis*	Umusafwa	Caesalpiniaceae	*(Not listed)*	Terrestrial
2	*Albizia antunesiana*	Musase	Leguminosae	*(Not listed)*	Terrestrial
3	*Amblygonocarpus andongensis*	Umunye	Mimosaceae	*(Not listed)*	Terrestrial
4	*Anisophyllea boehmii*	Umufungo	Anisophylleaceae	*(Not listed)*	Terrestrial
5	*Bauhinia petersenia*	Umupo	Fabaceae	*(Not listed)*	Terrestrial
6	*Brachystegia boehmii*	Umusamba	Leguminosae-Caesalpinioideae	*(Not listed)*	Terrestrial
7	*Brachystegia bussei*	Mwansamasaka	Fabaceae	*(Not listed)*	Terrestrial
8	*Brachystegia floribunda*	Kasabwa, Chifwanga	Fabaceae	*(Not listed)*	Terrestrial
9	*Brachystegia spiciformis*	Umuputu (Bean-pod tree)	Brachystegia Spiciformis	*(Not listed)*	Terrestrial
10	*Bridelia micrantha*	Umushiminwanongo/ Ubukuku	Euphorbiaceae	*(Not listed)*	Riverine
11	*Burkea africana*	Icipangala	Leguminosae	*(Not listed)*	Terrestrial
12	*Chrysophyllum magalismontanum*	Umusambya	Sapotaceae	*(Not listed)*	Riverine
13	*Combretum molle/Combretum celastroides*	Umontamfumu	Combretaceae	*(Not listed)*	Terrestrial
14	*Cryptosepalum exfoliatum spp.pseudotaxus*	Umukuwe	Detarieae	*(Not listed)*	Terrestrial
15	*Dalbergia nitidula*	Akalongwe	Papillionaceae	*(Not listed)*	Terrestrial
16	*Diplorhynchus condylocarpon*	Umwenge	Apocynaceae	*(Not listed)*	Terrestrial
17	*Ekebergia benguelensis*	Mubundikwa	Meliaceae	*(Not listed)*	Terrestrial
18	*Erythrina abyssinica*	Nachisungu	Papillionaceae	*(Not listed)*	Terrestrial
19	*Faurea spp*	Saninga	Proteaceae	*(Not listed)*	Terrestrial
20	*Isoberlinia angolensis*	Umutobo	Leguminoceae-Caesalpiniaceae	*(Not listed)*	Terrestrial
21	*Julbernardia paniculata*	Mutondo	Leguminoceae	*(Not listed)*	Terrestrial
22	*Khaya nyasica*	Umululu	Meliaceae	*(Not listed)*	Terrestrial
23	*Lannea spp*	Kabumbu	Anacardiaceae	*(Not listed)*	Terrestrial
24	*Monotes spp*	Chimpampa	Dipterocarpoideae	*(Not listed)*	Terrestrial
25	*Oncoba spinosa*	Umusangwa	Flacourtiaceae	*(Not listed)*	Terrestrial
26	*Ozoroa reticulata*	Mabelemabele	Anacardiaceae	*(Not listed)*	Terrestrial
27	*Parinari curatellifolia*	Mupundu	Chrysobalanaceae	*(Not listed)*	Terrestrial
28	*Protea cynaroides*	Shinsashinsa	Proteaceae	*(Not listed)*	Terrestrial
29	*Pseudolachnostylis maproneufolia*	Umusolo (Kudu berry)	Euphorbiaceae	*(Not listed)*	Terrestrial
30	*Pterocarpus angolensis*	Mukwa/Umubanga	Fabaceae	*(Not listed)*	Terrestrial
31	*Raphia farinifera*	Ifibale	Arecaceae	*(Not listed)*	Riverine

No	Scientific name	Common name in English/ Local language	Family	Conservation status*1	Description of habitat
32	*Rauvolfia caffra*	Umubimbi	Apocynaceae	*(Not listed)*	Terrestrial
33	*Steganotaenia araliacea*	Nakundachabusha/ Umupeela	Apiaceae	*(Not listed)*	Riverine
34	*Strychnos spinosa*	Sansa	Loganiaceae	*(Not listed)*	Terrestrial
35	*Swartzia madagascariensis*	Umulundu	Leguminosae-Papilionoideae	*(Not listed)*	Terrestrial
36	*Syzygium cordatum*	Umukute	Myrtaceae	*(Not listed)*	Riverine
37	*Uapaca kirkiana*	Umusuku	Euphorbiacea	*(Not listed)*	Terrestrial
38	*Uapaca sansibarica/nitida*	Musokolobe	Euphorbiacea	*(Not listed)*	Terrestrial
39	*Videx doniana*	Akafifi	Labiatae	*(Not listed)*	Terrestrial

Note *1: Conservation status cited as per IUCN Red List category, i.e., "EX: Extinct", "CR: Critically Endangered", "EN: Endangered", "VU: Vulnerable", "LR/cd: Lower Risk / Conservation Dependent", "NT or LR/nt: Near Threatened", "DD: Data Deficient", "LC or LR/lc: Least Concern" (IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <www.iucnredlist.org>. Downloaded on 19 August 2009.)

*2: Flora species sighted during site walkover with Paul Bwale, Water Gauge Reader, ZESCO Limited, Peter Gondwe, former Area Ward Counsellor, Manix Mofya, Water Plant Attendant, ZESCO Limited, Harrison Munkanta, Security Officer, Zambia National Service (ZNS) and Venison Malikebbo, Water Plant Attendant, ZESCO Limited on 4th June 2009.

An open forest called miombo woodland is observed around the proposed dam site like the area of the Lusiwasi Power Station. However, the vegetation of the proposed dam site is less richer than that of the Lusiwasi Power Station, and secondary vegetation is frequently found since there are farming activities and settlements around the proposed dam site. Miombo woodland is also found along the Lusiwasi River.

Interviews with local residents revealed that the number of noticeable fauna such as large mammals is small. However, some indicate that fauna around the Lusiwasi Power Station is similar to that of South Luangwa National Park. Fauna commonly found in South Luangwa National Park are listed in Table D.25.

Table D.25 Fauna Commonly Found in South Luangwa National Park

Scientific name	Common name
Loxondotha Africana	Elephant
Aepyceros melampus	Impala
Syncerus caffe	Buffalo
Kobus vardonii	Puku
Equus buchelli	Zebra
Hippotragus equinus	Roan antelope
Kobus defassa	Water buck
Tragelaphus strepsiceros	Kudu
Redunca arundinum	Hartebeest
Giraffa camelopardalis	Thorncraft giraffe
Redunca arundinum	Reedbuck
Taurotagus oryx	Eland
Papio ursinus	Baboon
Cercopithecus aethiops	Vervet monkey
Panthera leo	Lion
F. (Panthera) pardus	Leopard
Acinonyx jubatus	Cheetah
Crocuta crocuta	Spotted hyena
Canis adustus	Side striped jackal
Lycaon pictus	Wild dong
Lepus victoriae	Hare (African Savannah Hare)
Atherurus africanus	Inungi (porcupine)
Potamochoerus porcus	Bush pig
Hippopotamus amphibious	Hippo
Crocodylus niloticus	Crocodiles
Varanus albugularis	Monitor lizards
Naja anchietae	Ngoshe (Cobra)
Bitis arietans	Icipili (Puff adder)
Python sebae	Insato/ Ulusato (Python)
Lepus victoriae	Hare (African Savannah Hare)

(Source) Website of ZAWA (http://www.zawa.org.zm/southl_luangwa.htm) accessed on 30 June 2009, and Interview with ZESCO Regional Office

Table D.26 demonstrates fauna found in the vicinity of the existing Lusiwasi Power Station and the proposed dam site.

Table D.26 Fauna Found in the Vicinity of the Project Site[*2]

No	Scientific name	Common name in English/Local language	Family	Conservation status[*1]	Description of habitat
1	Mammals				
1.1	Power Station Area				
1.1.1	*Kobus defassa*	Waterbuck	Bovidae	*(Not listed)*	Terrestrial
1.1.2	*Lepus victoriae*	African savannah hare	Leporidae	LR	Terrestrial
1.1.3	Atherurus africanus	African brush-tailed Porcupine	Hystricidae	LR	Terrestrial (along waterways and on termite mounds)
1.1.4	*Potamochoerus porcus*	Bush pig	Suidae	*(Not listed)*	Terrestrial
1.1.5	*Lycaon pictus*	Wild dog	Canidae	EN	Terrestrial
1.1.6	Thryonomys swinderianus	Greater cane rat	Thryonomyidae	LC	Terrestrial
1.2	New Dam Area				
1.2.1	*Aepyceros melampus*	Impala	Bovidae	LR	Terrestrial
1.2.2	Thryonomys swinderianus	Greater cane rat	Thryonomyidae	LC	Terrestrial
1.2.3	Thryonomys gregorianus	Lesser Cane rat	Thryonomyidae	LC	Terrestrial
2	Birds				
2.1	Power Station Area				
2.1.1	*Nectarinia senegalensis*	Sunbird	Nectariniidae	LC	Terrestrial
2.2	New Dam Area				
2.2.1	*Uraeginthus angolensis*	Blue-breasted waxbil	Estrildidae	LC	Terrestrial
2.2.2	*Pycnonotus barbatus*	Common bulbul	Pycnonotidae	LC	Terrestrial
3	Amphibians				
3.1	Power Station Area				
3.1.1	*Hippopotamus amphibiou*	Hippo	Hippopotamidae	EN	Terrestrial/Aquatic
3.1.2	*Crocodylus niloticus*	Crocodiles	Crocodylidae	VU	Aquatic
3.2	New Dam Area				
-	-	-	-	-	-
4	Reptiles				
4.1	Power Station Area				
4.1.1	*Varanus albugularis*	Monitor lizards	Varanidae	*(Not listed)*	
4.1.2	*Naja anchietae*	Cape Cobra	Elapidae	*(Not listed)*	Underground burrows
4.1.3	*Bitis arietans*	African puff Adder	Viperidae	VU	Underground burrows
4.1.4	*Python sebae*	Python	Elapiodae	*(Not listed)*	Underground burrows
4.1.5	*Dendroaspis polylepis*	Black mamba	Elapiodae	*(Not listed)*	Terrestrial/ burrows
4.1.6	*Lamprophis inornatus*	African house snake	Colubridae	*(Not listed)*	Underground burrows/crevices

No	Scientific name	Common name in English/Local language	Family	Conservation status[*1]	Description of habitat
4.2	New Dam Area				
4.2.1	*Lamprophis inornatus*	African house snake	Colubridae	*(Not listed)*	Underground burrows/crevices
4.2.2	*Python sebae*	Python	Elapiodae	*(Not listed)*	Underground burrows
4.2.3	*Naja anchietae*	Cape Cobra	Elapidae	*(Not listed)*	Underground burrows

Note *1: Conservation status cited as per IUCN Red List category, i.e., “EX: Extinct”, “CR: Critically Endangered”, “EN: Endangered”, “VU: Vulnerable”, “LR/cd: Lower Risk / Conservation Dependent”, “NT or LR/nt: Near Threatened”, “DD: Data Deficient”, “LC or LR/lc: Least Concern” (IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <www.iucnredlist.org>. Downloaded on 19 August 2009.)

*2: Sighting of above fauna in the area reported by Paul Bwale, Water Gauge Reader, ZESCO Limited, Peter Gondwe, former Area Ward Counsellor, Manix Mofya, Water Plant Attendant, ZESCO Limited, Harrison Munkanta, Security Officer, Zambia National Service (ZNS) and Venison Malikebbo, Water Plant Attendant, ZESCO Limited during personal interviews on 4th June 2009.

According to local residents, fish resources are relatively poor in the species and quantity in the Lusiwasi River, though some fish species such as bubble fish (Diodon holocanthus), red breasted bream (Tilapia rendalli) and Kapenta (Limnothrissa miodon) are found.

4) Air Quality and Noise

No data on air quality in Serenje District is available. The air quality is, however, considered good since there are no or few pollution sources such as factories, and in addition, the traffic volume is also very limited. Similarly no sources of noise is observed and identified around the project sites. Interviews with local residents have not identified any complaints about air pollution and noise.

5) Water Quality

There is no data on water quality of the Lusiwasi River and the Lake Lusiwasi. However, the water quality is considered good since no pollution sources except rural settlements are identified and the amount of discharged water is limited.

6) Hydrology

Serenje District has six (6) major rivers: 1) the Luombwa; 2) the Lukusashi; 3) the Kanbe; 4) the Lusiwasi; 5) the Mulembo; and the Luapula. The Lusiwasi Expansion Project is planned for the Lusiwasi River System. The Lusiwasi River flows into the South Luangwa National Park and joins the Luangwa River.

The proposed dam site is the confluence of the Lusiwasi River and the Luangala River, a tributary of the Lusiwasi. There is the existing Lake Lusiwasi at the upstream of the proposed dam site, and the Lake Lusiwasi regulates water flows into the existing Lusiwasi Power Station. There is a seasonal fluctuation in the Lusiwasi River, i.e., low in the dry season and high in the rainy season. Table D.27 demonstrates the seasonal changes in the Lusiwasi River.

Table D.27 Seasonal Water Levels for Lusiwasi River at Lusiwasi Power Station Road

Hydrological Year	2006/2007				2007/2008				2008/2009			
Day	1st	10th	20th	Average	1st	10th	20th	Average	1st	10th	20th	Average
October	1.011	0.921	1.012	0.981	1.015	1.085	0.731	0.9437	1.014	1.154	1.124	1.097
November	0.955	1.043	1.225	1.074	0.965	1.275	0.991	1.0770	1.041	1.234	1.034	1.103
December	1.222	1.401	1.795	1.473	0.925	1.693	2.195	1.6043	1.081	1.275	2.063	1.473
January	1.971	2.645	2.304	2.3067	2.395	3.045	2.532	2.657	1.421	1.404	1.765	1.530
February	2.531	2.265	2.045	2.2803	2.833	2.712	2.283	2.609	1.822	2.145	2.085	2.017
March	2.662	2.393	1.953	2.3360	2.495	2.321	2.391	2.402	2.155	2.295	2.763	2.404
April	1.785	1.713	1.705	1.7343	2.051	2.065	1.811	1.976	2.723	2.295	2.011	2.343
May	1.621	1.511	1.422	1.5180	1.731	1.631	1.582	1.648	1.842	1.811	1.664	1.772
June	1.375	1.345	1.291	1.3370	1.533	1.481	1.454	1.489				
July	1.263	1.262	1.225	1.2500	1.403	1.265	1.363	1.344				
August	1.162	1.135	1.095	1.1307	1.331	1.295	1.243	1.290				
September	1.022	0.992	1.145	1.0530	1.164	1.124	1.092	1.127				

(Source) ZESCO Lusiwasi Power Station

The Lusiwasi River is also the main source of household water for local residents. There is a ZESCO compound, the only major residence in the Lusiwasi area. In the compound, treated piped water from the Lusiwasi River is utilized. At the proposed dam site, there are several small-scale settlements whose major sources of water are, the river, wells and boreholes.

(2) Socio-Economic Conditions

1) Local Government and Social Institutions

Serenje District has 20 Wards. Serenje Town, the center of the district, belongs to Ibolelo Ward. The proposed dam site and the existing Lusiwasi Power Station where additional generation facilities will be installed are part of Serenje Ward. When a new dam is constructed, Mailo Ward may be affected by the reservoir water. The existing Lake Lusiwasi belongs to Mailo Ward.

There are several chiefdoms that are governed by traditional chiefs in Serenje District. The expansion of the existing power station and the construction of a new dam will be implemented on the land where Chief Serenje governs. On the other hand, the creation of a new reservoir may affect the land of Chief Mailo.

2) Population

According to the Census carried out in 2000, the population of Serenje District is 132,836. The population of Ibolelo Ward, Serenje Ward, and Mailo ward are 17,874 from 3,314 households, 3,488 from 579 households, and 7,510 from 1,363 households respectively. Average household size in Serenje District is about six (6). Population density is relatively higher along rivers and trunk roads, and the Lusiwasi Power Station. According to the

Lusiwasi Regional Health Center, population density of the project site called Chalyangwa area is about five (5) persons per square kilometers, which are considered very low, taking into account that the average of Central Province is 10.7 persons per square kilometer.

The main tribe of Serenje District is Lala, but Bisa and Bembas are also found.

3) Local Economy

Serenje District is considered suitable for agriculture since the district is endowed with good rainfall and fertile soils. Main crops include maize, cassava, sorghum, and millet. Serenje District Situational Analysis Report in 2005 states that there are 15,757 farmers in the district. The report identifies three (3) types of farmers: 1) commercial farmers; 2) emergent farmers; and 3) small scale or subsistence farmers. Most of famers in the district are classified as small scale or subsistence farmers by the report (Table D.28).

Table D.28 Types of Farmers in Serenje District

Type	Description
Commercial Farmers	Commercial farmers cultivate more than 10 hectares of agricultural land, and primarily engage in commercial agriculture to gain cash. They usually have a good capital base to invest in agricultural machineries and external inputs including fertilizers and pesticides. Eleven (11) commercial farmers as of 2005.
Emergent Framers	Emergent farmers have between 2 and 10 hectares of agricultural land. They engage in both for own consumption and for sale. Use of agricultural machineries is limited, but external inputs such as fertilizers and pesticides are moderately used. Fifty-one (51) farmers as of 2005.
Subsistence Farmers	Subsistence farmers cultivate less than 2 hectares, and do not use machineries but hand-tools. No or low external inputs such as fertilizers and pesticides are utilized. Almost agricultural produce is consumed by themselves. 15,695 farmers as of 2005.

(Source) Serenje District Situation Analysis Report (2005)

Many farmers cultivate agricultural lands along rivers. Chitemene system, or slash and burn system is considered to cause the degradation of forests and vegetation. Fruit plantation including mango, guava, paw paw and citrus fruits is only on small scale.

Serenje District has four fisheries, the Lake Lusiwasi, Lake Bangweulu, Luapula River, and Luangwa River. Fishing activities are also found in small streams and wetlands. Fisheries are dominated by artisanal fishers, and fishing is an important source of employment for the district. On the other hand, fishing villages face the risks of infectious diseases such as HIV/AIDS and cholera. Fish species exploited in the district include Bull dog (Gnathonemus macrolepidotus), Tiger fish (Hydrocynus vittatus), Nchenga (Alestes Imberi), Barbel catfish (Clarias Garipinus (mossambicus)), Silver/ barbell (Schilbe Mystus), Mbowa/Armoured catfish (Auchenoglanis occidentalis), Red breasted bream (Tilapia Rendarrii), Green Headed bream (Tilapia Macrochir), Banded bream (Tilapia Sparrmanii), Large mouth yellow belly bream (Serranochromis Spp), Mudsucker (Labeo Spps), Bottlenose/sheephead/conish jack (Mormyrus Spps), and Squeakers (Synodontis Spps). Main markets for these fish are in the line of the railway and Copperbelt Province. Most fishers are male, while fish traders are normally female.

There are three (3) national forests and three (3) local forests in Serenje District. Total areas of forest reserves are 112,082 hectares. The forests provide a variety of natural resources including timber, mushroom, honey, wild vegetables, edible tubers, and medicines to local communities. Charcoal and fuel wood production for energy are also found. Concerns about unsustainable exploitation of natural resources, including illegal harvesting, shifting cultivation and overgrazing, are growing. Eucalyptus is commonly planted in the district, but a variety of indigenous species are also found.

In Serenje District, industrial activities are very limited, though small-scale commercial activities are frequently observed. Household goods and agricultural produce are the main goods to be traded. For agricultural produce, maize, beans, tubes and other vegetables are traded. Livestock such as poultry, pigs and goats are also commonly traded. The main market is people of the district, but some traders come to the district from Lusaka and Copperbelt Province to purchase maize and beans.

There are few small-scale commercial shops around the project areas including the proposed dam site and the existing Lusiwasi Power Station. This may be attributed to scattered settlements and small population in the district. In addition, poor infrastructure conditions may also contribute to the underdevelopment of the project area.

(3) Scoping Result

Potential environmental and social impacts of the Lusiwasi Expansion Project are provided in Table D.29.

The current environmental and socio-economic situations around the project site and the detailed potential impacts are presented below.

Table D.29 Scoping Table for Potential Impacts of Lusiwasi Expansion Project

Impacts	Constru-ction	Operati-oin
Involuntary Resettlement	C	C
Impacts on Local Economy (employment and livelihood) and Land Use	B	B
Impacts on Local Social Institutions such as Decision-making Institutions		
Impacts on the Livelihoods of Indigenous Peoples and Ethnic Minorities		
Local Conflict of Interests and Inequality		
Water Usage and Water Rights	B	B
Sanitation and Infectious Diseases such as HIV / AIDS	B	
Cultural Heritage		
Topography and Geological Features		
Soil Erosion	B	
Local Hydrology and Groundwater	B	B
Flora and Fauna, and Biodiversity	A	A
Landscape	B	B
Global Warming		
Air Pollution		
Water Pollution	B	
Soil Contamination		
Waste	B	
Noise and Vibration	C	
Ground Subsidence	C	C
Offensive Odor		
Bottom Sediment		B
Accident and Safety	B	

[Legend] A: Significant impacts expected B: Certain impacts expected
C: Impacts unknown No Mark: Negligible impacts

1) Involuntary Resettlement

Construction works for the expansion of the Lusiwasi Power Station, such as the installment of additional power generation facilities, the expansion of headraces, and the construction of additional penstocks, are conducted within the site of the power station. Involuntary resettlement is, therefore, not expected.

On the other hand, minor-scale of involuntary resettlement may be anticipated for the proposed dam site. Although the possibility of involuntary resettlement is considered low since no settlements were found within the area that will be submerged during the on-site investigation, the occurrence/nonoccurrence is unclear at present. It is necessary to conduct detailed field survey on the occurrence/nonoccurrence of households to be affected and the number of such households when determining the details of project components.

Route for a road to be constructed for the proposed dam site is not yet determined. There is an unpaved and narrow road from the nearest trunk road to the vicinity of the proposed dam site, but the last few kilometers are footpath where vehicles cannot go through, and the footpath finally disappears. Along this road and footpath, no settlements are found, and thus involuntary resettlement is not anticipated at present. However, limited scale of involuntary resettlement may be necessary depending on the route. It is therefore necessary to conduct a line route survey at the F/S phase to confirm existence/nonexistence of households to be relocated and the scale prior to the determination of the route.

2) Impacts on Local Economy (employment and livelihood) and Land Use

No significant impacts are anticipated for the expansion of the existing Lusiwasi Power Station since there is no agricultural land and homesteads around the construction site. Certain impacts such as temporary block of road passage may be anticipated.

For the proposed dam site, there are scattered agricultural and grazing lands, and thus certain impacts are unavoidable due to the submersion of these lands.

In terms of road construction works, land acquisition of agricultural lands or restriction of land use may be necessary.

3) Impacts on Local Social Institutions such as Decision-making Institutions

Impacts on local social institutions are not anticipated in association with the expansion of the existing Lusiwasi Power Station.

Although scattered small-scale settlements are found at the proposed dam site, impacts on local social institutions are not anticipated at present. However, with respect to the proposed dam site, it is essential to obtain an agreement from Chief Serenje and Chief Mailo since the site is traditionally governed by the chiefs.

4) Impacts on the Livelihoods of Indigenous Peoples and Ethnic Minorities

According to the District Commissioner, District Coordination Committee and local residents, no indigenous peoples and ethnic minorities are found in the vicinity of the Lusiwasi Power Station and the proposed dam site.

5) Local Conflict of Interests and Inequality

The project will not cause local conflict of interests and inequality.

6) Water Usage and Water Rights

Water intake form the Lusiwasi River at the existing power station will increase, and as a result, the water decrease between the existing dams and existing power station will become severe. However, there is no possibility of impacts on water usage and water rights, since there are no households and agricultural lands downstream of the existing dam.

On the other hand, there are famers scattered around and upstream of the proposed dam site. The creation of a new reservoir may affect the local water usage because the dam may cause the changes in the downstream water flows. Occurrence/nonoccurrence of such impacts and its degree are unclear at present since it relies on the detailed location of the new dam, its specifications and the operational plan. It is therefore necessary to conduct a detailed survey on the situations of water usage and water rights around the site at the F/S phase, and to confirm the degree and extent of the impacts.

7) Sanitation and Infectious Diseases such as HIV/ AIDS

Risks of HIV/ AIDS could temporarily increase as a result of inflow of construction workers into the project site. HIV-infection rate in Central Province is estimated 17.5 %[14], which is higher than the national average, and further spread of HIV infection is a matter of concern.

8) Cultural Heritage

No cultural heritages are identified around the site for the existing Lusiwasi Power Station and the proposed dam site through interviews with the District Commissioner, District Coordination Committee and local residents.

9) Topography and Geological Features

No valuable topographic and geological features are identified around the existing Lusiwasi Power Station and the proposed dam site.

10) Soil Erosion

Limited scale of soil erosion may occur due to construction works for the expansion of the Lusiwasi Power Station. In addition, the creation of a new reservoir upstream of the Lusiwasi River will cause soil erosion at the reservoir bank.

11) Local Hydrology and Groundwater

Water flow patterns will be changed due to the creation of a new reservoir. However, the water discharge pattern of the existing Lake Lusiwasi will significantly affect the water discharge patterns of the new reservoir, since the existing one is located upstream of the new one.

12) Flora and Fauna, and Biodiversity

Certain impacts on ecosystem in the decreased water area between the existing dam and the power station, since water decrease in the area will become larger after the expansion of the power station. Although the Lusiwasi Power Station is located upstream of South Luangwa National Park, water flow in the downstream of the power station will remain the same after the expansion of the power station. Thus the project the expansion of the existing power station will not adversely affect the national park.

Areas around the proposed dam site will be submerged due to the creation of a new reservoir. Tentative estimate based on map information revealed that backflow of a new dam may reach 9.5 km and 8.2 km upstream for the Luangala and the Lusiwasi River respectively. In this case, the reservoir may be 1 km wide in the Luangala River, and 1.2 km wide in the Lusiwasi River. This indicates significant impacts on vegetation along the rivers.

[14] Based on the website of the Central Statistics Office (http://www.zamstats.gov.zm/)

In terms of fauna, occasional sighting of large mammals including impalas or cane rats are reported by local residents. Some of the species are listed in the IUCN Red List, and thus they should be given due considerations (Table D.26).

Trees and other vegetation between the nearest trunk road and the proposed dam site will be removed when constructing a new road to the site.

13) Landscape

The existing Lusiwasi Power Station will not affect local landscape. On the other hand, local landscape around the proposed dam site will be changed due to the creation of a new reservoir.

14) Global Warming

The project aims to construct a new hydropower station, and thus will not contribute to global warming. The amount of greenhouse gases emitted by construction works is negligible.

15) Air Pollution

The project aims to construct a new hydropower station, and thus will not cause air pollution. There is no concern about accumulated air pollution since no air pollution sources such as industrial activities are found in Serenje District, and the traffic volume is very limited in the district. Emission of air pollutants due to construction works is negligible.

16) Water Pollution

Construction works for the expansion of the existing power station and the creation of a new dam may cause water pollution due to the inflow of muddy water into Lusiwasi River and other nearby rivers and streams. In particular, construction works for the creation of a new dam will be implemented in the Lusiwasi and Luangala River, and thus certain impacts are deemed to be inevitable.

17) Soil Contamination

There is no possibility of soil contamination.

18) Waste

Construction works will generate waste soils and other construction wastes.

19) Noise and Vibration

Construction works may cause limited noise and vibration, but they are negligible around the existing power station, since there are few households around the existing power station. With respect to the proposed dam site, certain noise and vibration may disturb local residents since settlements are dotted in the vicinity of the site. It is therefore necessary to conduct a field survey, when the detailed plan is determined, to identify villages to be affected and the extent of the impact.

20) Ground Subsidence

Ground subsidence may occur depending on the ground stability of the proposed dam site. With respect to the other components, there is no possibility of ground subsidence. It is necessary to conduct a geologic survey, when the detailed plan is determined, to identify possibility of ground subsidence and the degree.

21) Offensive Odor

There is no possibility of offensive odor.

22) Bottom Sediment

Bottom sediment is anticipated at a reservoir to be created.

23) Accident and Safety

Accidents during construction works may take place. Vehicles for construction works may cause traffic accidents.

(4) Necessary Mitigation Measures

Mitigation measures necessary for the potential environmental and social impacts described in (3) are presented below.

1) Involuntary Resettlement

It is necessary to conduct a field survey around the proposed dam site to identify settlement distribution of the site and whether involuntary resettlement is necessary. When determining the route of an access road to the site, it is necessary to select the route to avoid involuntary resettlement. If involuntary resettlement is unavoidable, it is essential to hold sufficient consultations with affected people, chiefs and local representatives, and to obtain their agreement. A project-specific resettlement plan shall be formulated, and the contents of the plan, including necessary compensation, shall be implemented. The plan shall include the contents described in 11.3.4 (2) 1).

2) Impacts on Local Economy (employment and livelihood) and Land Use

It is necessary to conduct a field survey on land use situation around the proposed dam site, and identify how the project affects local economic bases including agricultural lands and forests. When determining the route of an access road to the site, it is essential to select the route to avoid the acquisition of agricultural lands and others. If impacts on local economy and land use are anticipated, it is necessary to hold sufficient consultations with affected people, chiefs and local representatives, and to obtain their agreement. A project-specific plan for land acquisition, including necessary compensations, shall be formulated and implemented.

3) Water Usage and Water Rights

It is necessary to identify whether the project will affect the local water usage and water rights through the survey on local water usage in the vicinity of the proposed dam site. It is essential to have sufficient consultations with Chiefs, local representatives and local government, and to obtain their agreements on the construction of a new dam and the operation rules.

4) Sanitation and Infectious Diseases such as HIV/ AIDS

Educational and promotion activities to prevent infectious diseases should be implemented for construction workers and local residents. In particular, educational activities for construction workers, including the distribution of condoms, are essential. In addition, it is effective to employ as many local workers as possible.

5) Soil Erosion

Measures against soil erosion should be taken during construction works. In particular, for a slope area where penstocks will be installed, it is necessary to take measures to stabilize soils such as re-vegetation over the slope. Tree-planting and re-vegetation on a reservoir bank will be effective for a new reservoir to be created.

6) Local Hydrology and Groundwater

Monitoring activities on local hydrology shall be implemented. Items to be monitored include the transition of water flows in the areas between the existing Lake Lusiwasi and a new reservoir to be created, and between the new reservoir and the existing power station. Monitoring is also necessary on the transition of water flows in neighboring wetlands and changes in the water levels of adjacent wells. If any impacts are detected, adjustment of water discharge patterns shall be taken into considerations.

7) Flora and Fauna, and Biodiversity

Tree cutting and vegetation removal associated with construction works shall be minimized. The velocity limit of construction vehicles should be determined to prevent traffic accidents with wildlife animals around the project sites.

It is necessary to conduct a survey on flora and fauna around the proposed dam site, and to identify whether endangered, indigenous or other valuable species exists, and the possibility of submersion of their inhabitants. Based on the survey results, it is necessary to seek how to avoid the alternation of the valuable species' inhabitants. If some impacts are unavoidable, it is necessary to minimize the impacts by adjusting construction schedule and method such as the suspension of civil works during breeding period. If significant impacts on valuable species are anticipated, mitigation measures shall be undertaken according to the characteristics of anticipated impacts and species to be affected. Such mitigation measures may include the creation of alternative habitats for wildlife by reforestation in adjacent areas.

It is necessary to elaborate effective mitigation measures for wildlife protection, referring to the precedents of infrastructure development projects.

8) Landscape

It is necessary to have sufficient consultations with chiefs, local residents and local government, and to obtain their agreement on project implementation and mitigation measures. Mitigation measures such as re-vegetation around the proposed dam site should be undertaken.

9) Water Pollution

Necessary measures should be undertaken to prevent muddy water from nearby rivers such as the construction of small-scale temporary dams. Civil works in the Lusiwasi and Luangala River should be implemented in the dry season when river flows are small.

10) Waste

Education and instruction to properly dispose of construction wastes such as waste soil shall be provided to construction workers.

11) Noise and Vibration

Civil works shall be prohibited in the early morning and nighttime to minimize the disturbance of local residents' livelihoods. It is also necessary to inform local residents of the schedule of civil works in advance.

12) Ground Subsidence

Prior to the civil works, geological survey around the proposed dam site should be undertaken to ensure the safety of a new dam. Monitoring on the ground subsidence of the new dam is also necessary.

13) Bottom Sediment

Measures to prevent sedimentation in a new reservoir should be undertaken, including regular dredging activities and the construction of sediment pool dam.

14) Accident and Safety

Safety education and instruction shall be provided to construction workers to prevent accidents during construction works. Traffic safety education for construction workers and road traffic safety campaign should be implemented to ensure traffic safety.

(5) Stakeholder Consultations

Stakeholder consultation meetings are held in the vicinity of the sites of Lusiwasi Expansion Project. The overview of the stakeholder meetings and points to consider for the future hydropower development projects are presented in Chapter 11.

(6) Environmental Management Plan and Monitoring

A project-specific environmental management plan needs to be properly formulated, and the effective implementation should be ensured. The framework of the plan is described in Chapter 11, thus this section presents items to be monitored for Lusiwasi Expansion Project in particular (Table D.30).

Table D.30 Major Monitoring Items for Lusiwasi Expansion Project

Item	Description
Involuntary Resettlement and Land Acquisition	- Occurrence/ nonoccurrence of involuntary resettlement and land acquisition - For the proposed dam reservoir in the upstream, in particular, the status of the formulation and implementation of a land acquisition plan - Other monitoring items listed in Table 11.9, including process to reach agreements with people affected, resettlement process, and progress of support for the rebuilding of livelihood of relocated people
Water Usage and Water Rights	- Occurrence/ nonoccurrence of any impacts on local water usage and water rights after the creation of a new dam reservoir and the operation of the expanded power station
Sanitation and Infectious Diseases such as HIV/ AIDS	- Understandings of construction workers about infectious diseases - Progress of the proposed mitigation measures such as the distribution of condoms
Soil Erosion	- Situation of soil erosion around the proposed dam site and site for the expansion of generation facilities - Implementation status of soil stabilization measures such as re-vegetation of reservoir banks
Local Hydrology and Groundwater	- Monitoring on local hydrology including the transition of water flows of the Lusiwasi River, water flows in neighboring wetlands and water levels of adjacent wells
Flora and fauna, and biodiversity	- Changes in flora and fauna in the vicinity of the proposed dam site, such as the number of indicator species - Implementation status of a re-vegetation program after the completion of civil works - Progress of the other proposed mitigation measures and their effectiveness
Local landscape	- Existence/nonexistence of impacts of the creation of a new reservoir on local landscapes - Sufficiency and effectiveness of proposed mitigation measures
Water Pollution	- Implementation status of water pollution measures and their effectiveness
Waste	- Appropriateness of the disposal of construction wastes
Noise and vibration	- Implementation status of mitigation measures such as the notification of civil work schedules
Ground Subsidence	- Status of ground subsidence of a proposed new dam
Bottom Sediment	- Status of sediment in a new reservoir
Safety measures	- Implementation of safety measures during construction works - Maintenance and inspection of facilities, and prevention of fire breaking
Mitigation Measures	- Implementation status of proposed mitigation measures and their effectiveness
Complaints	- Establishment of system for accepting complaints and records of complaints - Appropriateness of processing complaints

(Source) JICA Study Team

(7) Conclusions

The component of a new dam reservoir construction may cause significant environmental and social impacts. On the other hand, the expansion of the existing Lusiwasi Power Station may not cause significant impacts.

A new reservoir to be created, though its submerged area is not so large, involuntary resettlement and land acquisition, impacts on ecosystem due to the submersion, and impacts on local hydrology are anticipated. The on-site investigation conducted during the case study identified no settlement within the proposed dam site, but there were communities in the vicinity of the site. In addition, cultivated lands and grazing lands were identified. It is necessary for project developers to conduct surveys on the distribution of settlements at the F/S phase. Consultations with project-affected-persons and chiefs are also critical. In terms of impacts on ecosystem, it is necessary to conduct a survey on flora and fauna including endangered and/or indigenous species around the area to be submerged. Based on the survey result, necessary measures to avoid, minimize or mitigate the impacts should be elaborated.

Certain impacts are also anticipated with respect to infectious diseases, soil erosion, landscape, water pollution, waste, noise and vibration, ground subsidence, bottom sediment, and accident and safety. A comprehensive environmental management plan that includes mitigation measures against the above impacts shall be formulated, and monitoring activities on these impacts shall be implemented.

Details of Lusiwasi Expansion Project have not yet been materialized, and thus the details will be determined by the subsequent F/S. Prior to the determination of the details of a project plan, it is important for project developers to hold sufficient consultations with project-affected-persons, chiefs, local governments and other stakeholders, and to obtain their agreements on the project plan and mitigation measures.

Appendix E Power development analysis using WASP

In preparation of the power source development plan mentioned above, the Study Team adopted the approach of using the simulation tool WASP to assist the planning.

WASP[15] is a simulation tool for preparation of optimal power source development plans. It is used for development management by the International Atomic Energy Agency (IAEA) and is distributed on a non-profit basis to countries around the world. It is in widespread use by research, financial, governmental, and other institutions and public works developers across the globe.

This section presents the confirmation of conformance between the estimated demand and the aforementioned source development (power supply) using WASP for hydropower station development, which has a high probability, and the power source development scenarios.

(1) Setting of conditions for WASP input

As noted above, two scenarios were applied in the study of power source plans using WASP: the 1-1 scenario “Primary enrgy basis self-supply scenario” and the 1-2 scenario “Electricity basis self-supply scenario”.

The candidate sources (power stations) applied in each scenario are the existing and planned hydropower stations in Zambia shown in Table 6.30, the coal-fired power station (100 MW x 2) at Maamba, and the coal-fired power stations using imported coal as generation fuel. The conditions postulated for each power station are as follows.

[15] WASP was used in the 1997 "Zambia: Long-Term Generation Expansion Study" sponsored by the World Bank. At the time, ZESCO personnel were furnished with the WASP software and instructed in its use by the Argonne National Laboratory, which distributes it.

Table E. 1 Data sets about hydro power stations

Plant Name	Hydro Condition－Normal [GWh]				Hydro Condition－Wet [GWh]				Hydro Condition－Dry [GWh]			
	1Q.	2Q.	3Q.	4Q.	1Q.	2Q.	3Q.	4Q.	1Q.	2Q.	3Q.	4Q.
Existing hydros	2352.4	2548.4	2450.4	2450.4	2728.8	2956.2	2842.5	2842.5	1976.0	2140.7	2058.4	2058.4
Kariba North Expansion	91.2	98.8	95.0	95.0	105.8	114.6	110.2	110.2	76.6	83.0	79.8	79.8
Itezhi Tezhi	189.4	134.4	134.4	152.8	219.7	155.9	155.9	177.2	159.1	112.9	112.9	128.3
Kafue Gorge Lower	576.0	624.0	600.0	600.0	668.2	723.8	696.0	696.0	483.8	524.2	504.0	504.0
Lusiwasi Expansion	58.1	58.1	38.1	46.1	67.4	67.4	44.2	53.5	48.8	48.8	32.0	38.7
Batoka Gorge	1049.4	1136.8	1093.1	1093.1	1217.3	1318.7	1268.0	1268.0	881.5	954.9	918.2	918.2
Devil's Gorge	672.5	728.5	700.5	700.5	780.1	845.1	812.6	812.6	564.9	612.0	588.4	588.4
Mpata Gorge	908.4	984.1	946.3	946.3	1053.7	1141.6	1097.7	1097.7	763.1	826.6	794.9	794.9
Mumbotua Fall, CiteCX	420.2	420.2	275.3	333.3	487.4	487.4	319.4	386.6	353.0	353.0	231.3	279.9
Mambilia Fall site2	290.9	290.9	190.6	230.7	337.4	337.4	221.1	267.6	244.3	244.3	160.1	193.8
Mambilia Fall site1	176.6	176.6	115.7	140.1	204.9	204.9	134.2	162.5	148.4	148.4	97.2	117.7
Kabompo Gorge	42.2	45.8	44.0	44.0	49.0	53.1	51.0	51.0	35.5	38.4	37.0	37.0
Kalungwishi Kabwleume Falls	94.0	94.0	61.6	74.5	109.0	109.0	71.4	86.4	78.9	78.9	51.7	62.6
Kalungwishi Kundabwika Falls	154.6	154.6	101.3	122.6	179.3	179.3	117.5	142.2	129.8	129.8	85.1	103.0
Mutinondo	54.5	54.5	35.7	43.2	63.2	63.2	41.4	50.2	45.8	45.8	30.0	36.3
Luchenene	40.3	40.3	26.4	32.0	46.8	46.8	30.6	37.1	33.9	33.9	22.2	26.9
Lunsemfwa	124.7	115.5	106.3	115.5	144.7	134.0	123.3	134.0	104.8	97.0	89.3	97.0
Mkshi	60.2	55.8	51.3	55.8	69.8	64.7	59.5	64.7	50.6	46.8	43.1	46.8

Note：Q. stands for quarter(s) in FY and represents 1Q.:Apr.-Jun., 2Q.:Jly.-Sep., 3Q.:Oct.-Dec., 4Q:Jan.-Mar. respectively.

Table E. 2 Data sets about coal fired thermal power stations

Coal fired thermal power plant	Fuel Type	Installed Capacity [MW]	Unit size [MW]	Fuel cost [UScent/10^6kcal]	Overnight cost [USD/kW]
Maamba Coal fired	Domestic coal (Maamba)	200	100	250	2222
Generic coal fired	Import coal	300	150	1130	2222

The following are the grounds of the calculation of the data noted for the specifications.

A. Selection of new candidate sources

We can think the new types of candidate source are coal- and gas-fired ones. Both types entail a relatively low capital cost and short construction term. They could very possibly be adopted in Zambia, too, depending on the prospects for fuel procurement.

Generally speaking, gas-fired power generation (with gas turbines; GT) offers a high environmental benefit, particularly if stations are installed with the latest combined-cycle gas turbines (CCGT). The fuel consumption per unit of generated output is 27 percent lower. In addition, the stations emit 58 percent less carbon dioxide (CO_2) and about 80 percent less nitrogen oxide. These features are behind the participation in the power sector by new enterprises equipped with CCGT in parts of the United Kingdom (England and Wales) following the privatization of power utilities. There have unfortunately been no reports of natural gas deposits in Zambia. Such deposits reportedly exist in the neighboring countries of Tanzania and Angola, but the prospects for import are totally unclear. As a land-locked country, Zambia would have to import gas resources by means of a gas pipeline, and this infrastructure inclusive of the storage facilities would have to be newly constructed. As such, the feasibility is very low. For this reason, the Study Team decided to exclude gas-fired power stations from the list of candidates for new types of power source.

There is an idea for colliery thermal power generation fueled with domestic coal (mined at Maamba), and it may easily be imagined that the development and operation of such stations would deepen knowledge about coal-fired power generation in Zambia. As for the sources of imported coal, the Study Team confirmed the existence of extensive activity related to development of coal mining in neighboring countries and interest in exporting to Zambia at several sites[16]. Therefore, it decided to treat power stations fired with imported coal as new source candidates.

B. Setting of the single-unit capacity in coal-fired power generation

The largest single-unit generation capacity in Zambia at present is that of 180 MW at the

[16] As far as the Study Team was able to determine, Riversdale Mining in Benga Concession, which acquired mining rights in Mozambique and Morupule Colliery (Pry) Ltd. of Botswana, are providing information about coal export.

Kariba North Bank station. Among those in planning, there is one of 200 MW in the cluster of dam-type stations along the Zambezi at locations such as Batoka Gorge. Ordinarily, determination of the single-unit capacity requires consideration of the system capacity. Input of a generator with a capacity that is too large for the system capacity may possibly cause system oscillation in forms such as frequency fluctuation if the unit is taken off the grid due to breakdown, for example. Generally speaking, a capacity in the range of 3 - 5 percent relative to the peak demand is considered suitable. In fiscal 2008-2009, the maximum single-unit capacity was 180 MW as compared to the peak demand of 1,600 MW. At 11 percent, the corresponding rate is somewhat high. Considering the future demand increase, however, this figure may be regarded as within an acceptable scope, and it would be advisable to adopt these figures for the single-unit capacity of coal-fired power stations.

As a result, the Study Team set the capacity of the coal-fired power station to be built at Maamba at 100 MW x 2, in light of the aforementioned coal development capability. It put the capacity of a power station fired with imported coal at 150 MW, or about 90 percent[17] of the single-unit capacity at the Kariba North Bank station.

C. Generation reserve margin

Power stations must have a reserve margin, i.e., a supply capability that is larger than the anticipated demand, so that they can supply power steadily even in the event of unforeseen situations, such as unplanned outages, droughts, and fluctuation of demand beyond the expected levels. The Grid Code in Zambia states that the definition of this long-term reserve margin is to be based on the SAPP Operation Guideline, which does not contain any specific numerical stipulation for it. A survey of SAPP reports and documentation thus far, however, found a shift from stipulation of a reserve margin of 8 percent to one of a 10-percent target[18].

As used here, the reserve margin is ordinarily obtained by the following equation.

$$\text{Reserve Margin} = \frac{\text{Total Generation Capacity} - \text{(Expected)Peak Demand}}{\text{(Expected)Peak Demand}} \times 100 \quad [\%]$$

In this equation, the total generation capacity (the aforementioned system supply capability) does not explicitly exclude items not actually contributing to supply capacity, such as planned repairs.

If the total generation capacity figure includes items not making an actual contribution to supply capacity, it would be an extremely risky target.

The total generation capacity envisioned by the Study Team is based on the following addition.

* Generation capacity in hydropower stations

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[17] At present, operation of the Kariba North Bank power station is, in effect, governor-free, and an output change in the range of 5 - 10 percent can be tolerated in the event of failure. Therefore, the figure was put at minus 10 percent to be on the safe side.

[18] Strictly speaking, this figure, too, cannot be equated with the long-term reserve margin; it is instead closer to the short-term operating reserve for routine compensation.

The definition of generation capacity in hydropower stations differs somewhat, depending on the type of generation.

(1) Run-of-river power stations

At stations that generate power without regulating the river flow, the generated output gradually fluctuates and is not constant even during a single day. For this reason, capacity is assessed[19] on the basis of the daily average flow and the daily average output on at least five days per month over a fixed period (at least ten years, if possible).

(2) Regulating-reservoir type power stations

Power stations of this type are operated while regulating the flow in correspondence with the demand on a daily or weekly basis.

For this reason, the subject is the peak output upon regulation, and the assessment is therefore based on the average annual output over the same period as for the run-of-river type (preferably at least ten years), calculated using the average peak output over at least five days per month.

(3) Reservoir type power stations

Power stations of this type are operated with regulation on a daily basis in addition to a yearly basis for seasons of high and low water levels.

Therefore, the subject is naturally the peak output, and the assessment is based on the same item as for regulating-reservoir power stations.

The hydropower generation capacity was sought by subtracting an amount corresponding with the estimated failure rate (0.5 - 2.5 percent)[20] from the figure for assessment noted in sections (1) - (3) above, as shown in the following equation.

* Generation capacity in thermal power generation

The calculation of generation capacity in thermal power plants is simpler than that for hydropower plants. The capacity is obtained by subtracting an amount corresponding with the estimated failure rate (2 - 10 percent) from the remainder after subtraction of the output corresponding with planned outages from the average available facility capacity.

* Generation capacity in international power pooling

In Zambia's case, it would be possible to add the increase in generation capacity from power import through international interconnections. However, the Study Team decided not to figure this into the calculation this time, because of the uncertainty surrounding future

[19] In this case, the average daily output on at least five days in each month is termed the "L5" (least five days) output.

[20] The estimated failure rate ought to be derived from past actual data. If such data are not available, it should be arrived at through analogy from information in neighboring countries or other organizations performing the same level of facility maintenance and management. For this study, the estimated failure rate in Japan was taken as the floor figure, and a five-fold rate was adopted for tolerance.

transactions. In other words, it was assumed that first priority would be placed on satisfaction of demand with supply from domestic power stations.

Cf : Supply reserve margin associated with the SAPP system

In studies of reserve margin, calculations ordinarily assume supply of power to meet the domestic demand by domestic power stations. On the Zambian side, however, some experts may view the entire SAPP system as a single grid and see no problem provided that the overall reserve margin is sufficient. It is true that the basic SAPP vision advocates the maintenance of supply capability and promotion of more efficient capital investment through an overall pool system. A check of current SAPP reports, nevertheless, revealed that the input of new power sources is not keeping abreast with the sharp increase in demand in the overall pool system, and is not enough to assure an adequate reserve margin. Even assuming that the reserve margin were assured in the pool system, the system itself is still in the stage of development and has not reached a level permitting Zambia to count on it for domestic reserve margin. This outlook would merit consideration once the pool system has reached maturity, and therefore was not applied for this study.

The requisite reserve margin derived from the judgments described above was basically in the range of 20 - 40 percent.

D. Operating reserve

In contrast to the aforementioned reserve margin, which is the generation margin to be maintained in long-term system operation, operating reserve is the reserve supply capability to be held in routine system operation, in preparation for daily demand fluctuation and system failures such as power source unavailability.

The SAPP Operating Guideline contains the following definition.

Every Operating Member in SAPP shall be obliged to maintain their calculated portion of Operating Reserve sufficient to cover 150% of the loss of the sent out capacity of the largest generating unit in service in the Interconnection at that time. Furthermore, this operating reserve shall be sufficient to reduce the Area Control Error (ACE) to zero within ten (10) minutes after a loss of generation.

The Operating Reserve shall be made up of Spinning Reserve and Quick Reserve. At least 50% of the Operating Reserve shall be Spinning Reserve which will automatically respond to frequency deviations. Interruptible load may be included in the Quick Reserve provided that it can be interrupted remotely in less than ten (10) minutes from the Control Centre.

$$\mathbf{SORR = PORR \times \frac{(2Ds/Dt + Us/Ut)}{3}}$$

where:

SORR = Minimum System Operating Reserve Requirement

PORR = Total Pool Operating Reserve Requirement

Ds = Individual System's Annual Peak Demand

Dt = Total Sum of Individual System's Annual Peak Demand

Us = Individual System's Largest Unit

Ut = Total Sum of Individual System's Largest Unit(sum of Us)

An example where the sharing of Spinning Reserve between Operating Members has been calculated can be found on the following Table:

	Largest Generator	Maximum Demand	Operating Reserve	Spinning Reserve	Quick Reserve
ESKOM	920	27972	1091,6	545,8	545,8
ZESA	220	1767	119,0	59,8	59,5
ZESCO	150	1030	76,1	38,0	38,0
BPC	33	215	16,4	8,2	8,2
EdM	24	169	12,3	6,1	6,1
NAMPOWER	80	321	34,0	17,0	17,0
SNEL	62	400	30,7	15,3	15,3
LEC		0			
SEB		0			
TANESCO		0			
ENE		0			
TOTAL	1489	31874	1380	690	690

The definition is accompanied by the note that this equation is for the minimum operating reserve that ought to be available.

The thinking here is that the other SAPP member countries will share and assure the reserve margin of South Africa, which has by far the highest single-unit capacities and peak demand in the pool. The idea of possession of reserve margin viewing SAPP as a single grid is part of the SAPP vision and correct in that context, but it poses some difficulties when considering Zambia's own reserve margin. In the case noted above (?), if what is currently the largest single-unit capacity in Zambia (180 MW) suddenly became unavailable (was taken off the grid), Zambia would not be able to meet the shortage solely with its own reserve power and would have to be immediately supplied with power from other countries. Properly speaking, it is necessary to have a spinning margin amounting to 3 - 5 percent of the system capacity for instantaneous activation in response to failures and an operating reserve on the order of the largest single-unit capacity for supply of power within ten minutes. As such, it was decided to target a spinning margin of at least 100 MW at present and at least 250 MW as of fiscal 2030-31, and an operating reserve of 200 MW.

E. Available energy

The available energy (generated output capable of supply) of the existing and candidate power stations was estimated as follows.

First, for the existing hydropower stations, the Study Team calculated the available energy each fiscal year over the period 1977-78 to 2004-05 (before implementation of the rehabilitation project), for which actual data on the same have been compiled.

Next, the Study Team set the available energy of the candidate power stations, as follows.

For the Itezhi Tezhi project, it used the estimate of monthly generated output in the existing feasibility study.

For the Lunsemfa and Mkushi projects, which are near the existing Mulungushi power station, it made a calculation with reference to the actual data for generated output at Mulungushi.

As for other new projects, the Study Team calculated the available energy of run-of-river power stations, for which it is difficult to estimate this item, based on the actual figures at the Victoria Falls station and mini-hydropower stations of this type. It also used actual figures at existing stations to calculate the available energy at new projects of the reservoir type.

F. High- and low-water probability and rates of change in available energy

The available energy is not considered uniform into the future; it is higher at higher river water levels and lower at lower ones. For the purpose of simulation using WASP, the Study Team set probability rates for high and low water, and corresponding rates of change in the available energy.

The probability rates for incidence of high and low water levels were calculated on the basis of actual figures for yearly generated output at existing power stations. More specifically, the Study Team used actual data for generated output from fiscal 1977-78 to 2004-05 (before implementation of the rehabilitation project). It set the top 20 percent (of years in terms of yearly generated output) as high-water years, the lower 20 percent as low-water years, and the remaining 60 percent as average-water years. In addition, as compared to the (average?) generated output, the high-water output was put 16 percent higher, and the low-water output, 16 percent lower.

Table E. 3 Hydrological data using WASP

Hydrological Condition	Probability[%]	Inc./Dec. rate against Normal[%]
Dry	20	+16
Normal	60	—
Wet	20	-16

G. Utilization rate

It was assumed that run-of-river power stations would operate 24 hours a day, 365 days a year, and dam-type power stations, 24 hours a day, 80 days per quarter. This is because of the assumption that, in the case of the dam type, generators would be stopped for periodic inspections for no more than about two weeks a year, and that outages due to failure or preventive maintenance would have a combined duration of no more than about one week per quarter. In contrast, run-of-river power stations have a lower capacity than dam types and a negligible influence on simulations. For this reason, it was decided not to make a more in-depth utilization rate setting for them.

* Operating hours per day

It was assumed that the Kariba North Bank Extension and Kafue Gorge Lower power stations would operate for five and 12 hours a day, respectively, because they are operated to meet peak demand.

Other power stations were basically assumed to operate continuously, 24 hours a day.

H. Coal-fired thermal power generation specifications

The Study Team estimated the capital cost of coal-fired thermal power generation units envisioned in Scenario 1-2 at power stations such as the one at Maamba.

The aforementioned World Bank report (i.e., the interim draft final report of the SAPP Regional Generation and Transmission Plan Study, 2008) contains the figure USD2,222 per kW (obtained from the report of a feasibility study) as the overnight capital cost for an ESKOM coal-fired power plant. This is thought to be a fairly high-specification facility. For the purpose of reference, a figure is also provided for the capital cost of an analogous power station in North America (from a document entitled "Coal-fired Power Plant Planning Assumptions", prepared by the Northwest Power & Conservation Council in 2006). This figure reflects the standard price worldwide.

Table E. 4 Sample figures for capital cost of coal-fired power stations

Type	Direct-fired Subcritical-1	Direct-fired Subcritical-2	IGCC(w/o CO2 Partitioning)-1	IGCC(w/o CO2 Partitioning)-2
	400MW subcritical pulverized cola-fired, evaporative cooling. Low-NOx bureners, flue gas desulfurization, fabric filter w/ activated charcoal ingjection	400MW subcritical pulverized cola-fired, evaporative cooling. Low-NOx bureners, flue as desulfurization, fabric filter w/ activated charcoal ingjection	425MW integrated gasification combined-cycle; sulfur stripping unit, activated carbon Hg removal, H-class gas turbine generator	425MW integrated gasification combined-cycle; sulfur stripping unit, activated carbon Hg removal, shift reactor &CO2 stripping unit, F-class gas turbine generator
Net Output	400MW	400MW	425MW	401
Availability (%)	84	84	83	83
Heat rate (Btu/kWh)	9426	9070	7813	9170
Capital Cost (USD/kW)	1435	1457	1617	2079

(Source) Coal-fired Power Plant Planning Assumptions, Northwest Power & Conservation Counsil, 2006

Nevertheless, because the detailed specifications have not yet been determined for coal-fired power plants at Maamba or other locations, the Study Team adopted this figure of USD2,222 per kW.

(2) Result

As shown in Table , the target functional values (aimed at cost minimization) in WASP are virtually same in scenarios 1-1 and 1-2.

Table E. 5 Determination on power source development scenarios

FY-year	Senario-1-1	Senario-1-2
2010		
2011		
2012		
2013	Kariba North Ext., Itezhi Tezhi	
2014	Lusiwasi Ext., Maamba coal	
2015	Mutinondo, Luchenene	
2016	Kabweluma Falls Kumdabwika Falls Lunsemfwa Mkushi	Kabweluma Falls Kumdabwika Falls Generic Coal 1
2017	Kafue Gorge Lower	Kafue Gorge Lower
2018	Kapombo Gorge	Lunsemfwa Generic Coal 2
2019	Devil’s Gorge	
2020		Mkushi Kapombo Gorge
2021	Mumbotuta Falls	Generic Coal 3
2022		
2023	Mpata Gorge	
2024		Devil’s Gorge
2025	Mambilima Falls site2	
2026		Mumbotuta Falls
2027	Batoka Gorge	
2028		
2029	Mambilima Falls site1	Mpata Gorge
2030		
Total Objective function	397047	395472

In other words, in either scenario, the investment cost would be about the same up to 2030, and either scenario could be chosen.

Appendix F Procedure for estimating demand at individual substations

The figures in this study for estimated demand at individual substations were based on the values for peak load in the Zambia power system obtained from Chapter 4. However, there are districts (such as Copperbelt) in which the demand trend differs from that in the country as a whole. In light of this characteristic, the Study Team did not make a mere proportionate distribution of the total peak load; instead, it estimated the demand at each substation by the following procedure.

(a) Load in regions other than Copperbelt

The Study Team calculated the future peak load X at each substation using the following equation.

$$X = L_1 (LF_{total} / L_{total})$$

Here:

- Current peak load at each substation = L_1
- Future peak load at each substation = X
- Current total peak load in the Zambian system = L_{total}
- Future total peak load in the Zambian system = LF_{total}

(b) Load in the Copperbelt region

For this region, the Study Team made estimates of the trend in demand associated with mining over the next ten years at each point, as shown in Table 5.3 and Table 5.4. The sum of these mining demand trends and the non-mining demand was taken as the demand estimate for substations in this region.

More specifically, the Study Team calculated the future peak load X at each substation using the following equation.

$$L_3 = L_{total} - L_4 - \Sigma L_2 , \quad LF_3 = LF_{total} - L_4F - \Sigma LF_2$$
$$X = L_1 (LF_3/L_3) + LF_2$$

Here:

- Current peak load at each substation = L_1
- Future peak load at each substation = X
- Current total peak load in the Zambian system = L_{total}
- Future total peak load in the Zambian system = LF_{total}
- Current mining load at each substation = L_2
- Future mining load at each substation = LF_2
- Current total non-mining peak load in the Copperbelt region = L_3
- Future total non-mining peak load in the Copperbelt region = LF_3
- Current total peak load outside the Copperbelt region = L_4
- Future total peak load in the Copperbelt region = LF_4

Appendix G　　Simulation result regarding dynamic stability

The Zambian power system consists mainly of hydropower sources whose siting is concentrated in the southern part of the country, in the Zambezi and Kafue river basins. It therefore is not very susceptible to stability problems. As a result, properly speaking, there should be little need for anaylsis of dynamic stability; it should be sufficient to watch the interconnection with SAPP. Furthermore, because the stability at the time of interconnection with the SAPP system depends largely on the status of power development in South Africa, it was viewed as a matter to be considered in the context of the overall SAPP plans as opposed to this study.

However, the future power development plans require development of hydropower stations on the Luapula river and coal-fired stations around Kitwe, and there is a risk of a worsening of the dynamic stability in the Zambian system as well. The stability situation is thought to become most critical in 2030. The Study Team therefore made an analysis of the dynamic stability in this year and confirmed the propriety of the formulated power development plan.

Table G - 1 shows the conditions applied in the analysis of dynamic stability.

Table G. 1　Conditions applied in analysis of dynamic stability

Time of Clear fault	120ms
Fault mode	3-phase fault (0 ohm)
Auto Re-closing	Not used
System Sepataration	240ms after the fault of 330kV Transmision Line from Kalungwishi

The Kalungwishi power station is connected with the main system by a single 330-kV transmission line, but the other connections are by 66-kV transmission lines. The 66-kV system, however, is marked by very long transmission distances, and the connection between the Kalungwishi power station and the main system cannot be maintained with the 66-kV system when there is a trip on the 330-kV transmission line between Kalungwishi and Kasama. For this reason, the analysis applied the additional condition of separation of this district from the main system when this transmission line is tripped.

Table G - 2 shows the results of analysis under these conditions, and Figure G - 1 and Figure G - 2, representative wave forms.

Table G. 2 Results of analysis of dynamic stability

Analyzed Case	Results	
	Scenario 1-1	Scenario 1-2
1LF of Kndabwika-Mporokoso 330kV Line	Stabilized with System Separation	Stabilized with System Separation
1LF of Mambilima-Mansa 330kV Line	Stabilized	-
1LF of Mambilima-Mumbotuta 330kV Line	Stabilized	-
1LF of Mumbotuta-Pensulo 330kV Line	Stabilized	Stabilized
1LF of Kafue Gorge-Leopards Hill 330kV Line	Stabilized	Stabilized
1LF of Kariba North- Leopards Hill 330kV Line	Stabilized	Stabilized
1LF of Kafue Gorge Lower-Lusaka South 330kV Line	Stabilized	Stabilized
1LF of Maamba-Kafue West 330kV Line	Stabilized	Stabilized
1LF of Batoka Gorge-Devil Gorge 330kV Line	Stabilized	Stabilized
Fault of Kndabwika 330/132kV Tr	Stabilized	Stabilized
1LF of Kitwe-Kitwe Coal P/S 330kV Line	-	Stabilized

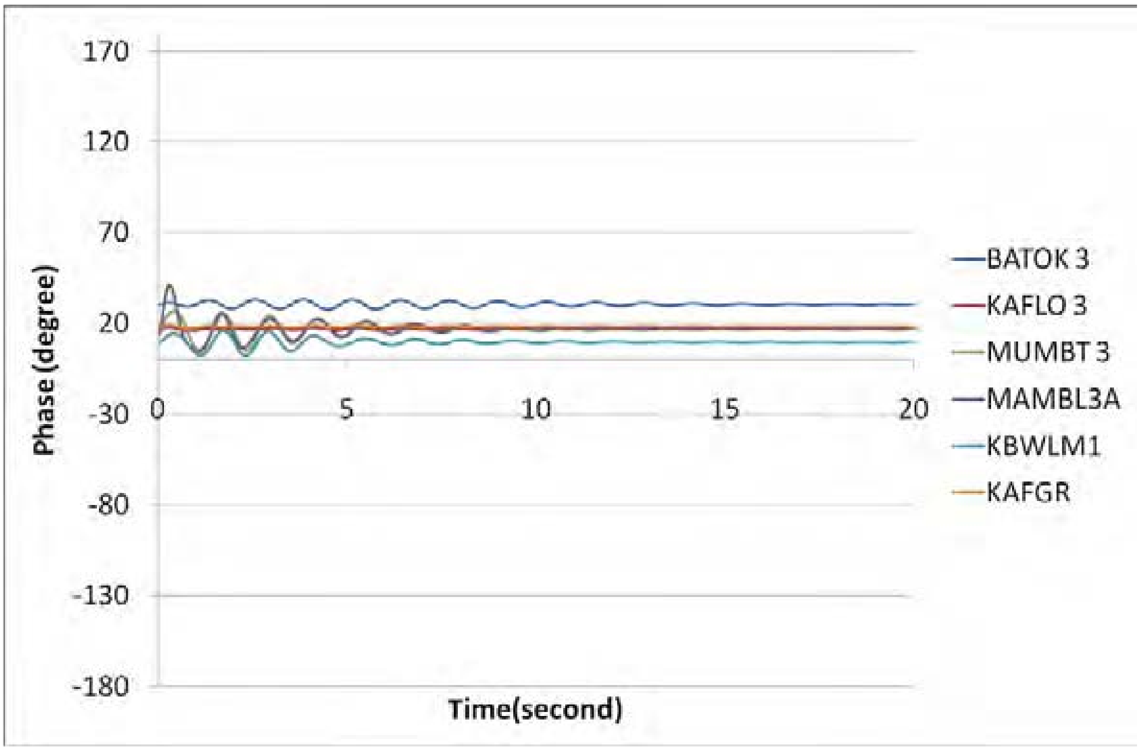


Figure G. 1 Dy namic stability in the event of failure on the Mambilima-Mumbotuta line (Scenario 1-1)

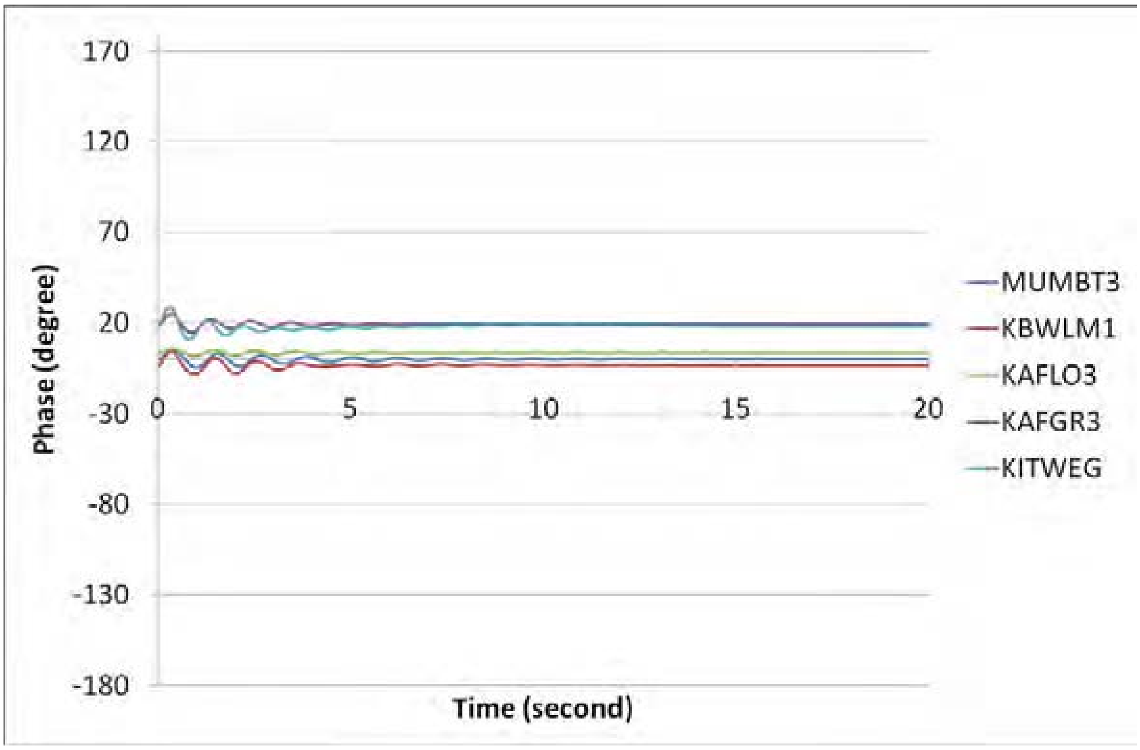


Figure G. 2 Dynamic stability in the event of failure on the Kitwe-Kitwe coal P/S line (Scenario 1-2)

Appendix H GIS Manual

This section comments on the framework and specific procedure for construction of a geographic information system (GIS) data base able to make a positive contribution to power system development in Zambia.

GIS express and combine various data on maps. They are effective tools for holistic, visual confirmation of information. However, the information in question is high in quantity and requires specialized knowledge in each field in order to set items. For this reason, it is necessary to have the information responsibly managed separately in each field (e.g., power sector, mining sector, and environmental sector). Therefore, this manual makes suggestions for procedures to be applied in management of information and construction of a GIS data base in the power sector. It was prepared with the hope that the information would be properly updated into the future and that the GIS data base in the power sector would assist the preparation of those in other sectors.

(1) Guidelines in conditioning of the GIS environment

Efforts were made to prepare the survey results into a GIS database that would match the needs of the C/P and concerned institutions.

More specifically, the prerequisites included avoidance of a situation in which the database could not be easily updated and go out of use if the product exceeded the skills of users, and the need for sure database management (swift data revision, smooth data provision, and management of amplified versions) into the future.

The Study Team ascertained the needs among the C/P and other concerned institutions, and made judgments on the types of role that could be played by each.

In consideration of the above, the following is a proposal of the type of involvement with the GIS database on the part of the concerned institutions.

* DOE:

The DOE is the central organization charged with directing the master plan, and in a position to exercise leadership for the power system development in this study. It must interlink the GIS databases that are at the concerned institutions and specialized for their work, and direct the power system development in multiple aspects, including environmental considerations, locations of mineral resources, and city planning. Because the collection of information related to power systems spans a wide range, it would be unreasonable to expect the DOE to perform all the collection and database construction itself. Therefore, the DOE should seek provision of information from the concerned institutions, check the content, and perform the conversion processing for input into the GIS database (the specific procedure for this processing is contained in the related manual).

* REA:

As the administrative institution promoting rural electrification, the REA desires to be constantly supplied with the latest information on the progress and orientation of power system development. It is presumably most interested in the location and demand situation at bulk supply points involved in the extension of medium-voltage distribution lines, and supply points, whose installation expands from bulk supply points. A check with the REA revealed that, at present, it does not make proposals on matters such as the establishment of supply points and is engaged solely in design for extension from the existing points. However, the projection of a change of demand in the retail division as suggested by plans for development of provincial cities indicates a need for coordination of views with the Ministry of Local Government and Housing, ZESCO, and other concerned entities. Knowledge of micro-grid system demand represented by solar home systems (SHS), micro hydropower, and other such sources constituting potential demand as viewed from the perspective of the on-grid system would also be important for dealing with future demand increase and system planning. The REA would be suitable for leading collection of information on such items.

* ZESCO:

ZESCO is on the front lines of power system development and management, and the primary principal for technical promotion of the master plan. It has the most information on plans and actual data regarding the power system. As such, ZESCO would, properly speaking, be best qualified to act as administrator in connection with this environment. Nevertheless, this would pose the risk of detraction from information accuracy, as ZESCO also performs the development design and management itself. For this reason, it would be advisable for ZESCO to perform design and production of related GIS databases on its own initiative, and to construct an operational routine for periodic inspection by the DOE as the administrative body. (As used here, the term "production" does not refer to the production of run-format files for GIS software; details of such production are contained in the related manual.)

* CEC

The CEC ranks alongside ZESCO as an enterprise supporting the power system in Zambia. It possesses information on the mining sector, which largely determines the trend of power demand. In addition, in formation of its own system facilities, it must pay attention to changes in the demand of the distribution system of ZESCO, which supplies power through its own facilities. As a result, like ZESCO, it must be a GIS database builder. GIS database design (framework design), however, should be unified, and ought to be led by ZESCO. In other words, the CEC would be a database builder and party that refers to data. Other private enterprises (Lunsemfwa etc.) may be treated in the same way as the CEC.

Augmentation of GIS databases by the approach outlined above would enable more in-depth and progressive power development. As a secondary benefit, it would also refine the GIS databases of other concerned governmental institutions and thereby contribute to Zambia's advancement.

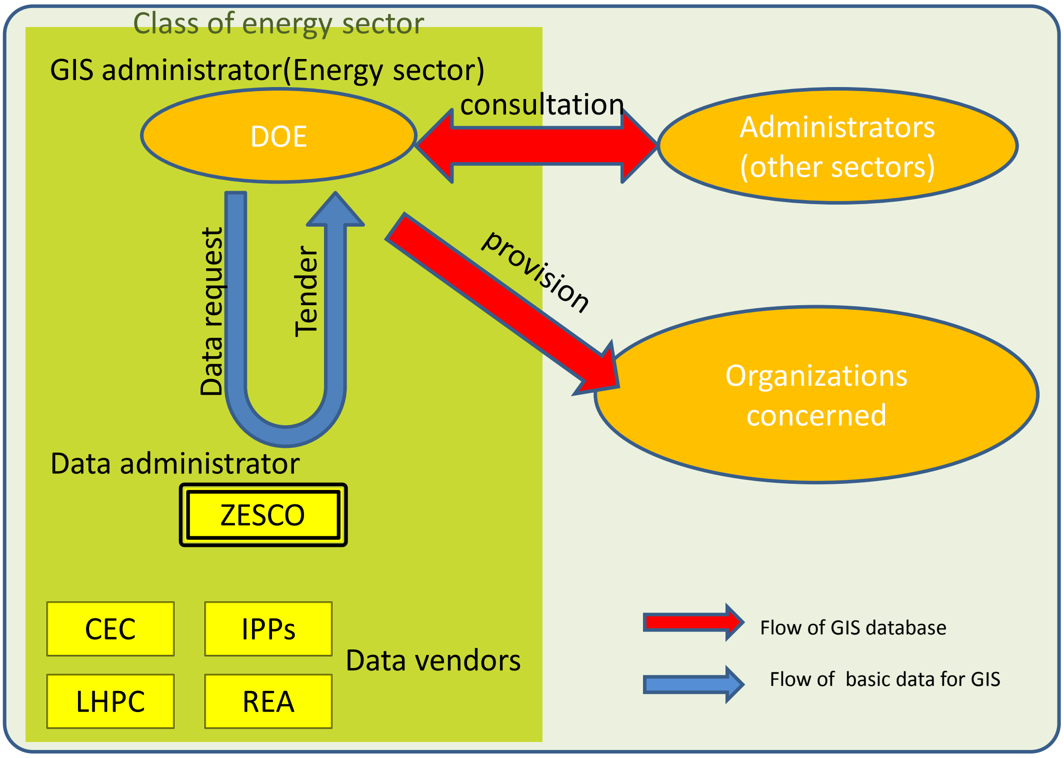


Figure H. 1 Procedure for preparation of data bases surrounding the GIS data base

(2) Procedures of the GIS database

The following are the minimum requisite items of natural feature information required for preparation of basic data.

* Natural feature name
* Latitude (WGS84 or latitude)
* Longitude (WGS84 or longitude)
* UTM35 x coordinate
* UTM35 y coordinate

Maps of Zambia are managed by UTM 35 as the coordinate system. As a result, all natural feature information must be in line with UTM 35. Tools for conversion to UTM coordinates are available on the Internet, and it would be efficient to make use of them.

http://home.hiwaay.net/~taylorc/toolbox/geography/geoutm.html

http://www.uwgb.edu/dutchs/usefuldata/UTMFormulas.HTM

This information will provide the basis for preparation of one class as one file. For example, in the case of information on the location of transmission line towers, it is necessary to enter information as follows.

* Class: 330-kV tower location
* Entity and attributes: tower name, latitude, longitude, x coordinate, y coordinate

The following is a list of information subjects (including existing ones) expected to be prepared in the power sector.

* Map showing the locations of transmission towers in each voltage class
* Map showing transmission line routes in each voltage class
* Map showing the locations of high-voltage distribution line towers
* Map showing the routes of high-voltage distribution lines
* Map showing the locations of medium-voltage distribution line towers
* Map showing the routes of medium-voltage distribution lines
* Map showing the locations of power stations in each category of type
* Map showing the locations of substations
* Map showing the locations of potential power source sites

These basic data should be prepared in the form of a spread sheet[21].

(3) Procedure for data conversion

The explanation of the data conversion procedure is preceded by an outline of the GIS data base to be provided at this time.

* Outline of the GIS data base provided this time

The GIS data base constructed in this master plan study is layered and preserved as shown below, with definitions of the "feature class" in each class.

[21] Microsoft Excel files are the most popular. Arc GIS does not handle the latest Excel format (.xlsx), and it would therefore be advisable to provide data in the (.xls) format or to prepare (.csv) files.

Super Class	Sub Class	GIS data	Attribute
Root	0_World landscape	Operational Navigation tool	Layer
		World Shade relief	Map Document
	1_Zambia landscape	Zambia map UTM35	Shape file
		Zambia photo map UTM35	Raster data set
	2_Recent data	330kV transmission	Shape file
		220kV transmission	Shape file
		132kV transmission	Shape file
		88kV transmission	Shape file
		66kV transmission	Shape file
		Hydro power stations	Shape file
		Substations	Shape file
		Diesel stations	Shape file
		Proposed hydro power stations	Shape file
		Proposed thermal power station	Shape file
		Network facilities	Map Document
		Point facilities	Map Document
	3_Recommendation	Plan in 2015	Map Document
	for Scenario 1-1	Plan in 2020	Map Document
		Plan in 2025	Map Document
		Plan in 2030	Map Document
		Related data	Shape file
	4_Rcommendation	Plan in 2015	Map document
	For Scenario 1-2	Plan in 2020	Map document
		Plan in 2025	Map document
		Plan in 2030	Map document
		Rlated data	Shape file
	5_Reference 1	Misc. in PMP	
	6_Reference 2	About REMP data	

The definitions of the subclasses are as follows.

0. World landscape

The information in this folder is a world map. The folder contains a map document file and a layer file. This information was added to the composition for management of information in SADC.

For example, it can be used to manage the transportation routes for the coal used to fuel power stations (through information on railways and key roads). It should be noted, however, that there is a lack of agreement with the coordinate system (UTM 35) in Zambia. As a result, when extracting information for Zambia only from the information added to this map, it is necessary to adjust the coordinates before use.

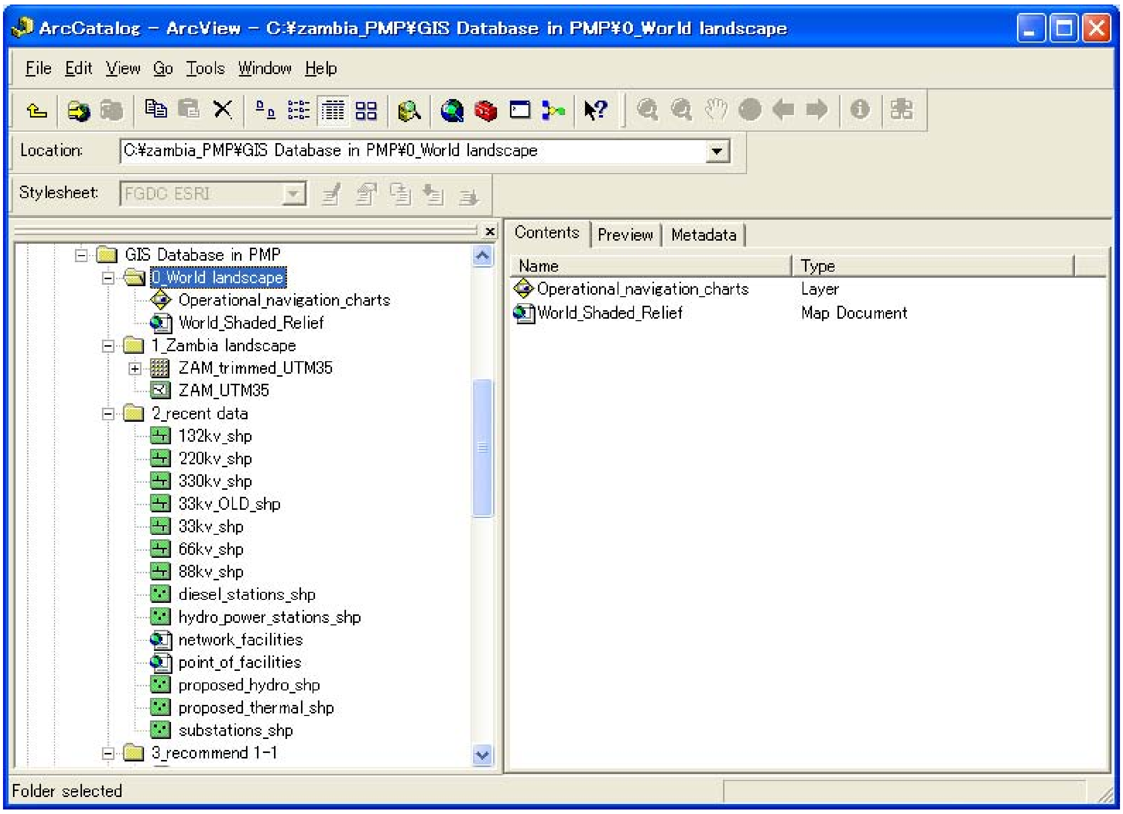


Figure H. 2 Information viewed with Arc Catalog (0. World landscape)

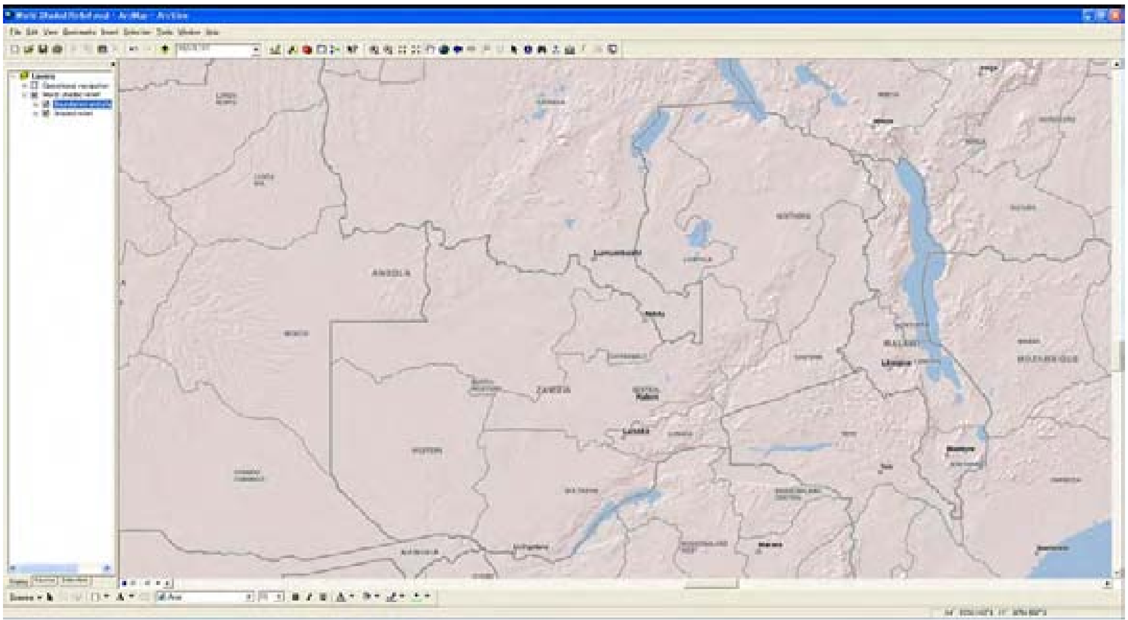


Figure H. 3 GIS data base (0. World landscape)

1. Zambia landscape

The information contained in the folder is plane maps of Zambia and raster data obtained by processing LANDSAT images. The locational relations between the two types of information are basically adjusted. This information can be used as a basic map of Zambia.

The raster data projections can be visualized by changing the transmissivity of the plane maps of Zambia.

This can be done by selecting View - Toolbar - Effects, displaying the Effects accelerator, and changing the transmissivity rate with the button for such change.

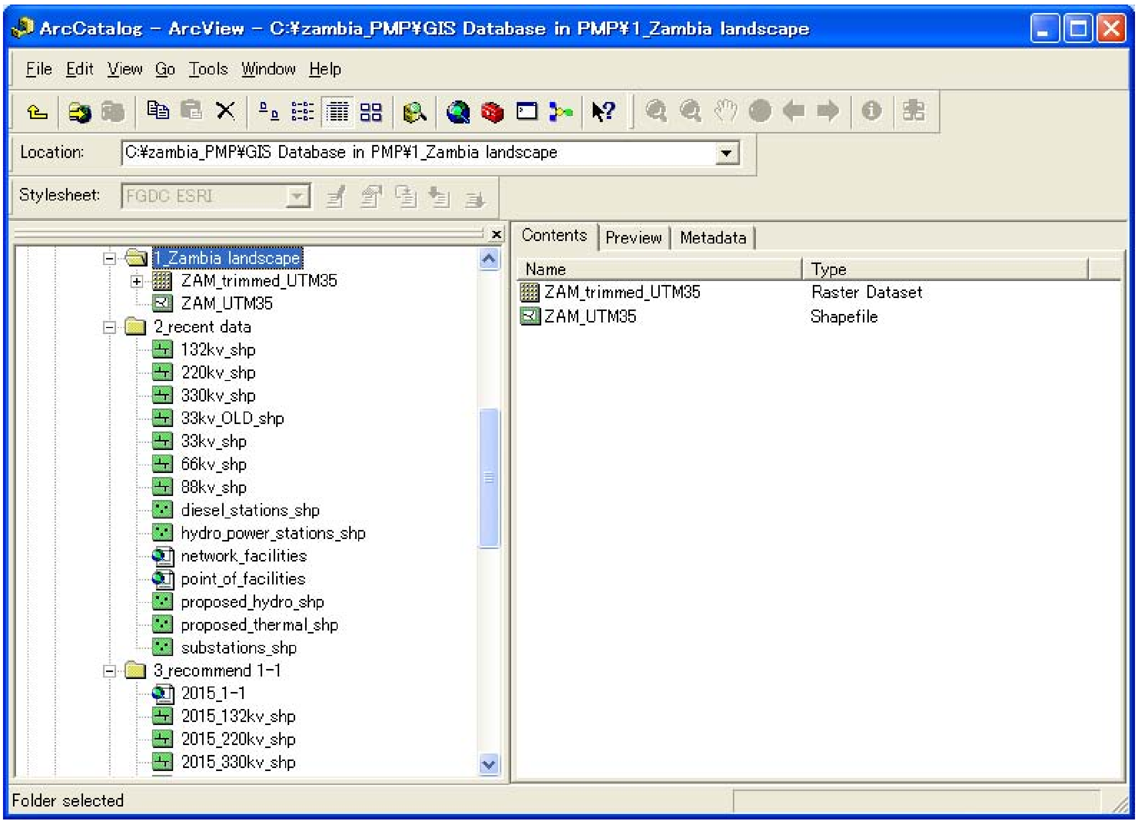


Figure H. 4 Information viewed with Arc Catalog (1. Zambia landscape)

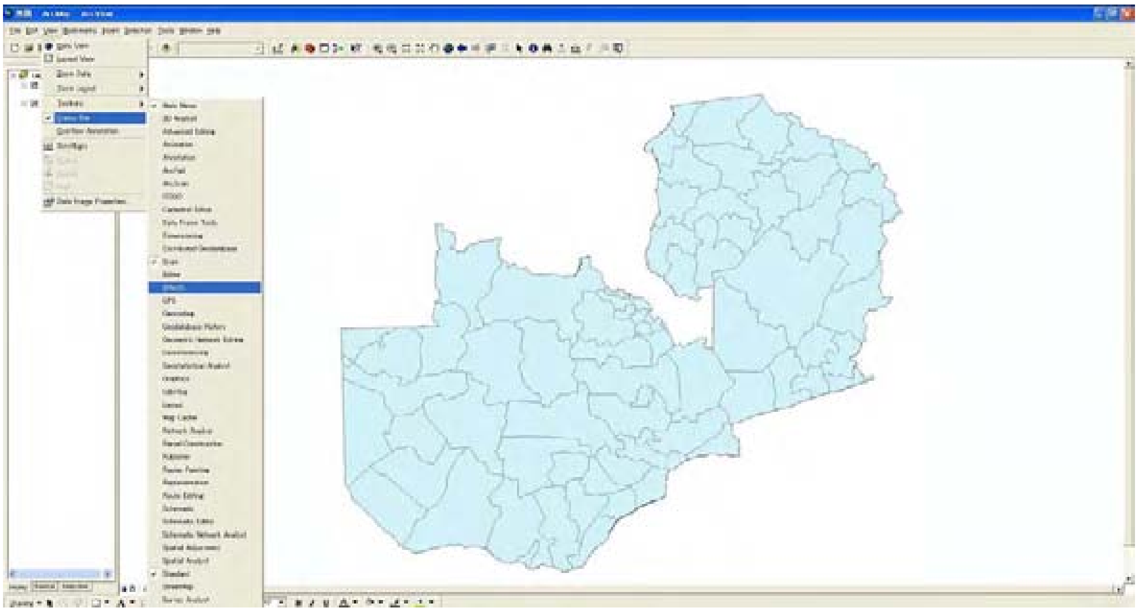


Figure H. 5 Procedure for display of the Effect accelerator

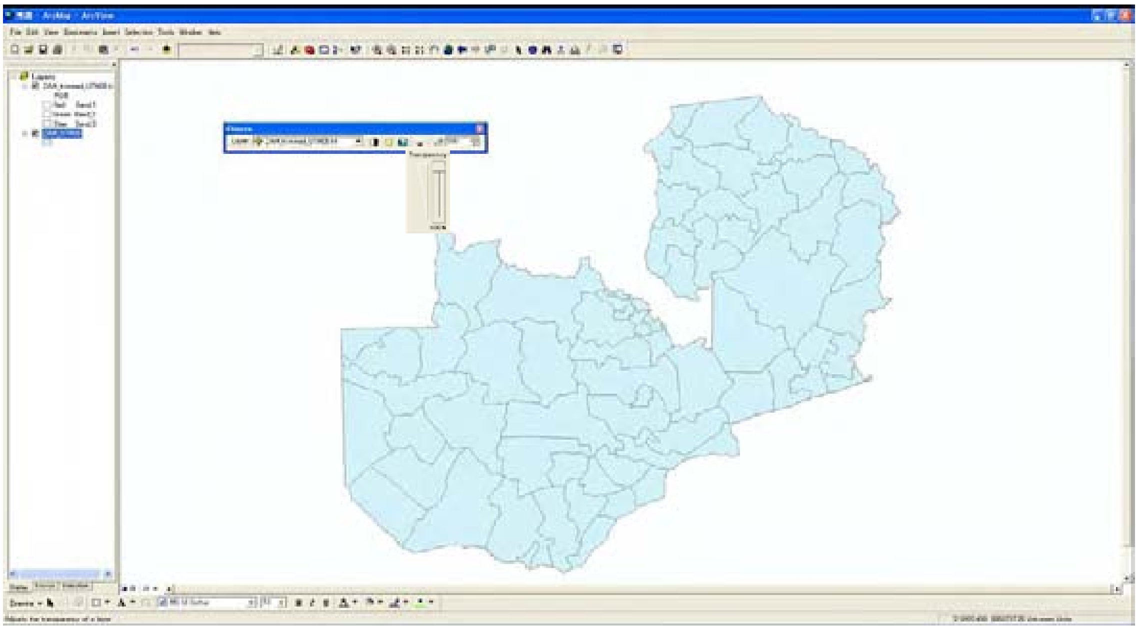


Figure H. 6 Procedure for change of transmissivity

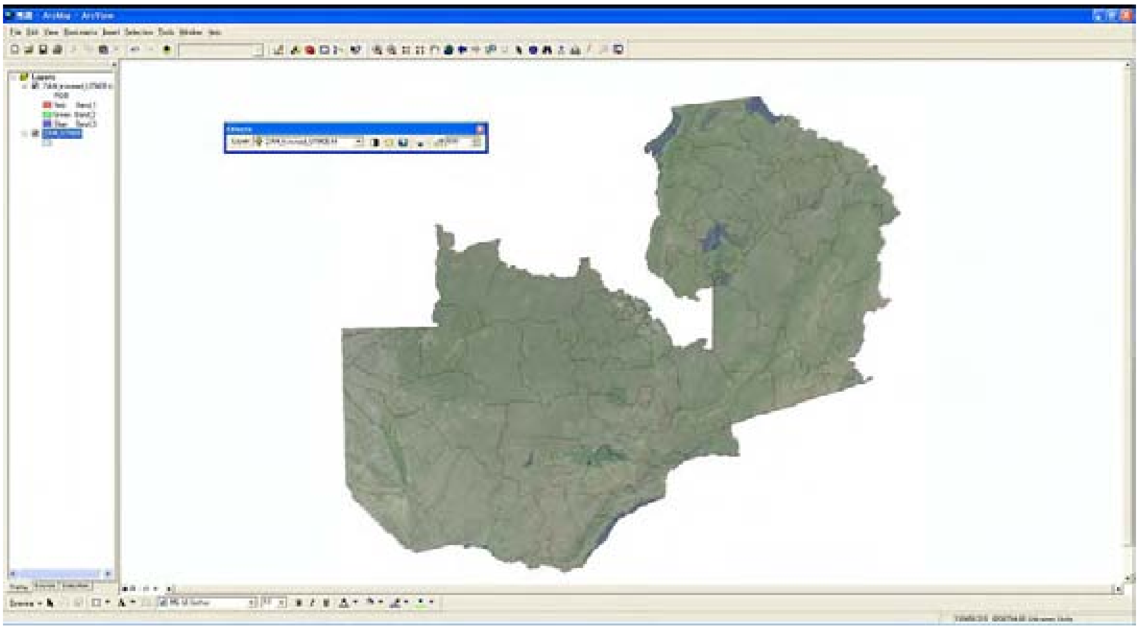


Figure H. 7 GIS data base (1. Zambia landscape)

2. Recent data

The information contained in the folder concerns the current facilities, hydropower potential, and thermal power potential. The map document file contains locational information (for substations, hydropower stations, and other facilities) and route information (for transmission lines). The superposition of each feature class (shape file) enables viewing of the needed information. The Zambia landscape folder is used for fixed information, and the subclass folders, for variable information.

The information in each feature class was prepared to preserve a compatibility with the shape file furnished by the REA. It is therefore thought to be in conformance with the other feature classes in the possession of the REA.

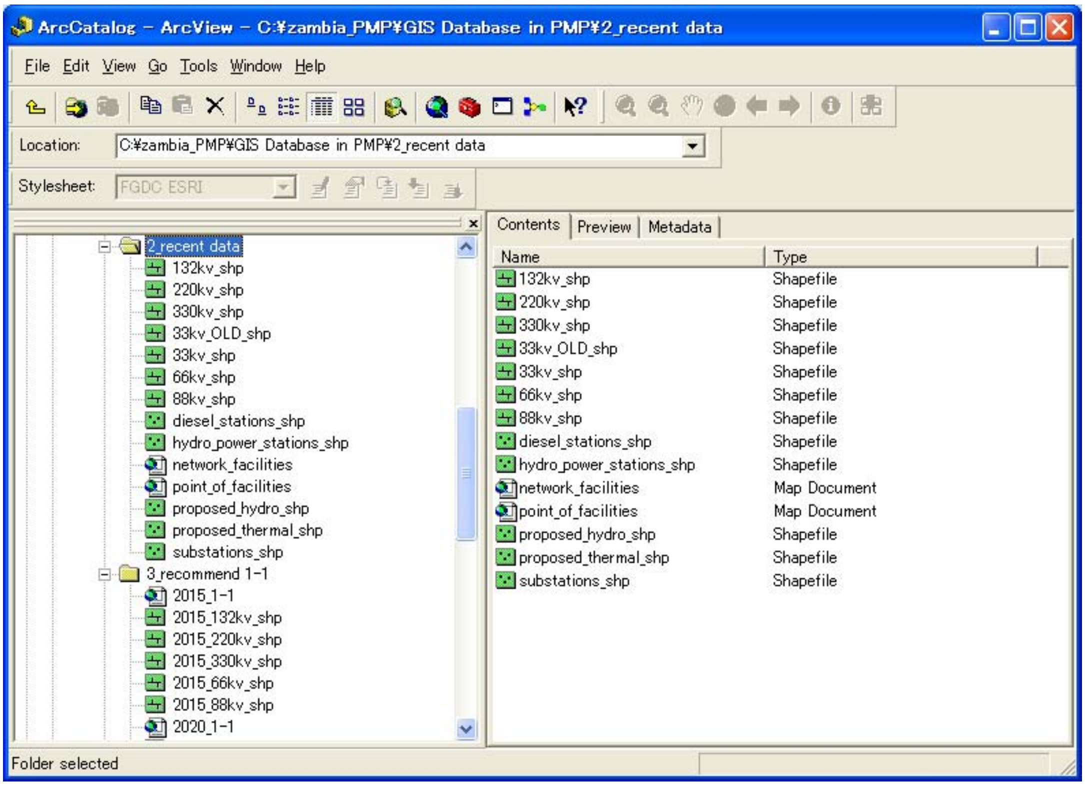
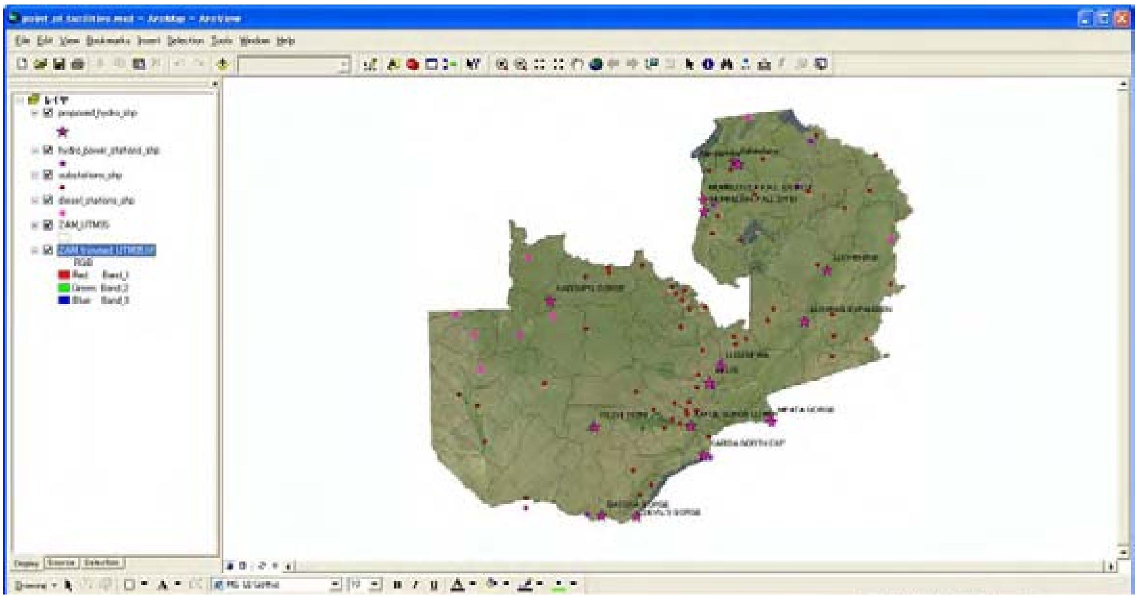


Figure H. 8 Information viewed with Arc Catalog (2. Recent data)



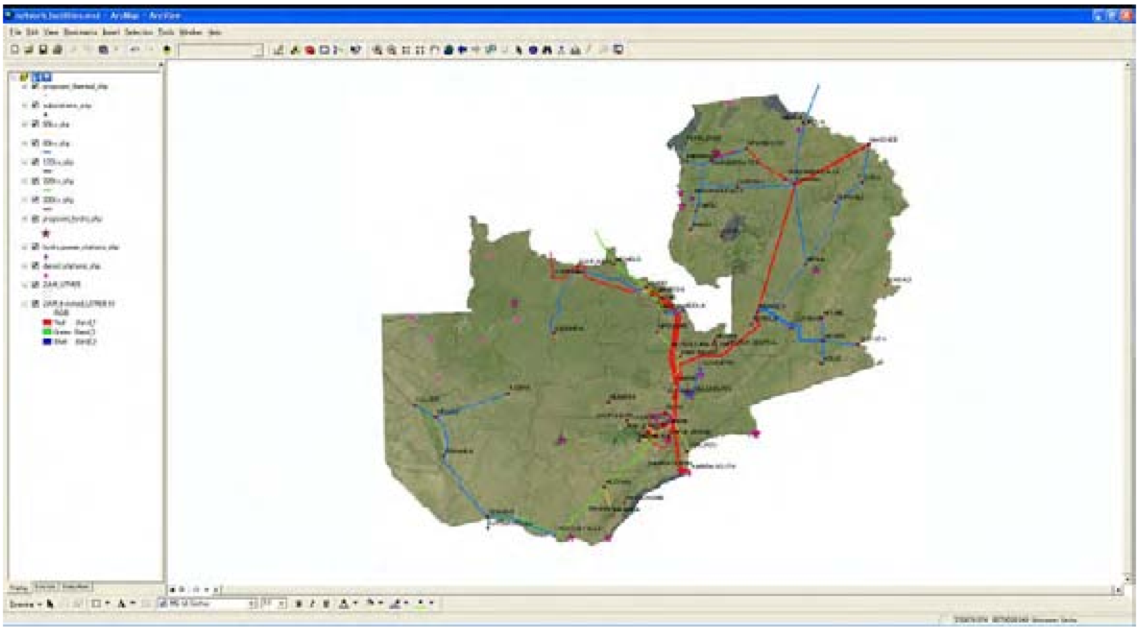


Figure H. 9　GIS data base (2. Recent data)

3. Recommendation for Scenario 1-1

This folder is for management of information for the primary-energy-basis self-supply scenario (Scenario 1-1 in the power source development plan).　It contains comprehensive information for the years 2015, 2020, 2025, and 2030.

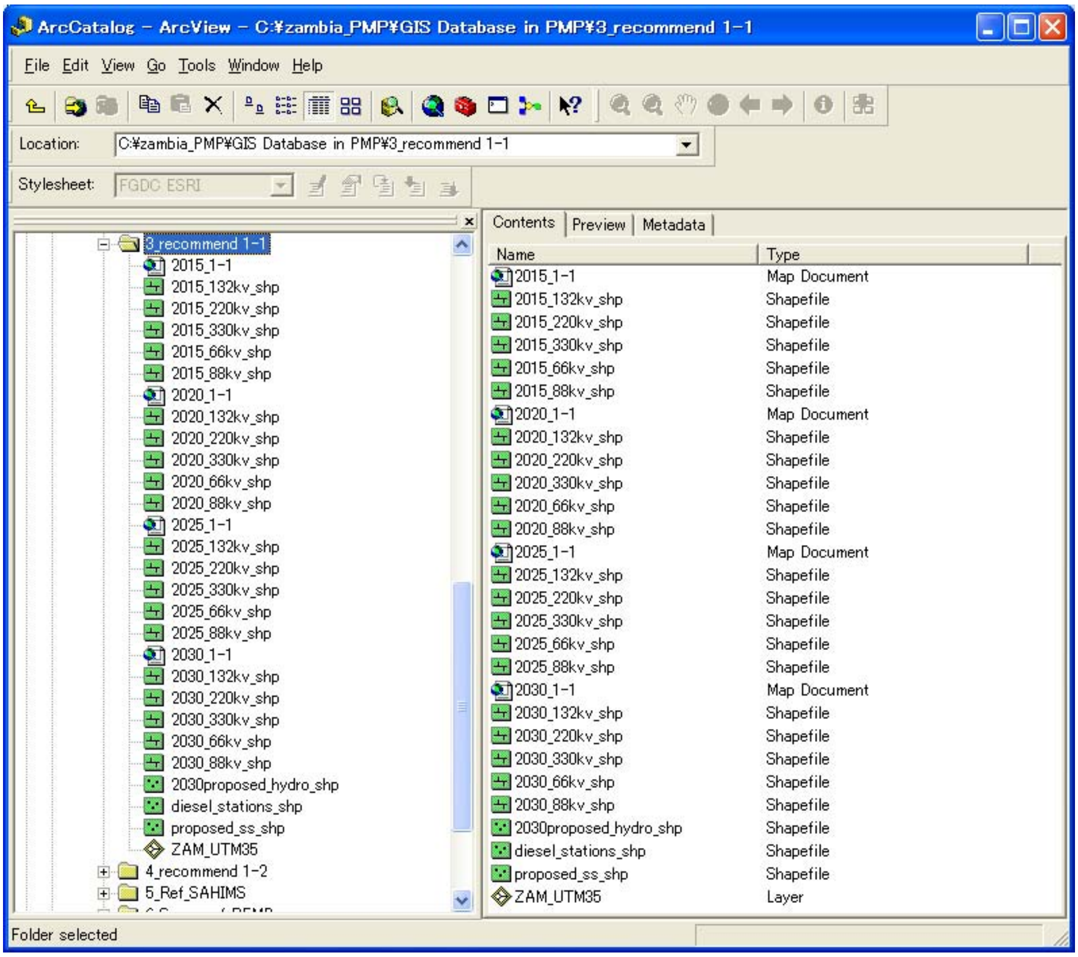


Figure H.10 Information viewed with Arc Catalog (3. Recommend 1-1)

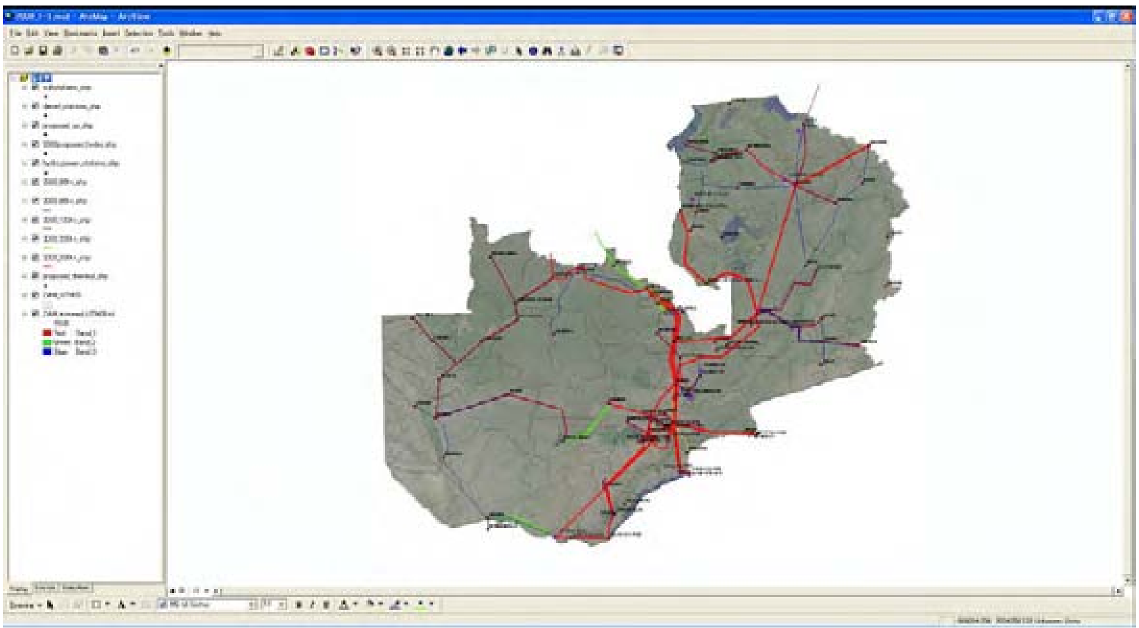


Figure H.11 GIS data base (3. Recommendation 1-1 2030 system diagram)

4. Recommendation for Scenario 1-2

This folder is for management of information for the electricity-basis self-supply scenario (Scenario 1-2 in the power source development plan). It contains comprehensive information for the years 2015, 2020, 2025, and 2030.

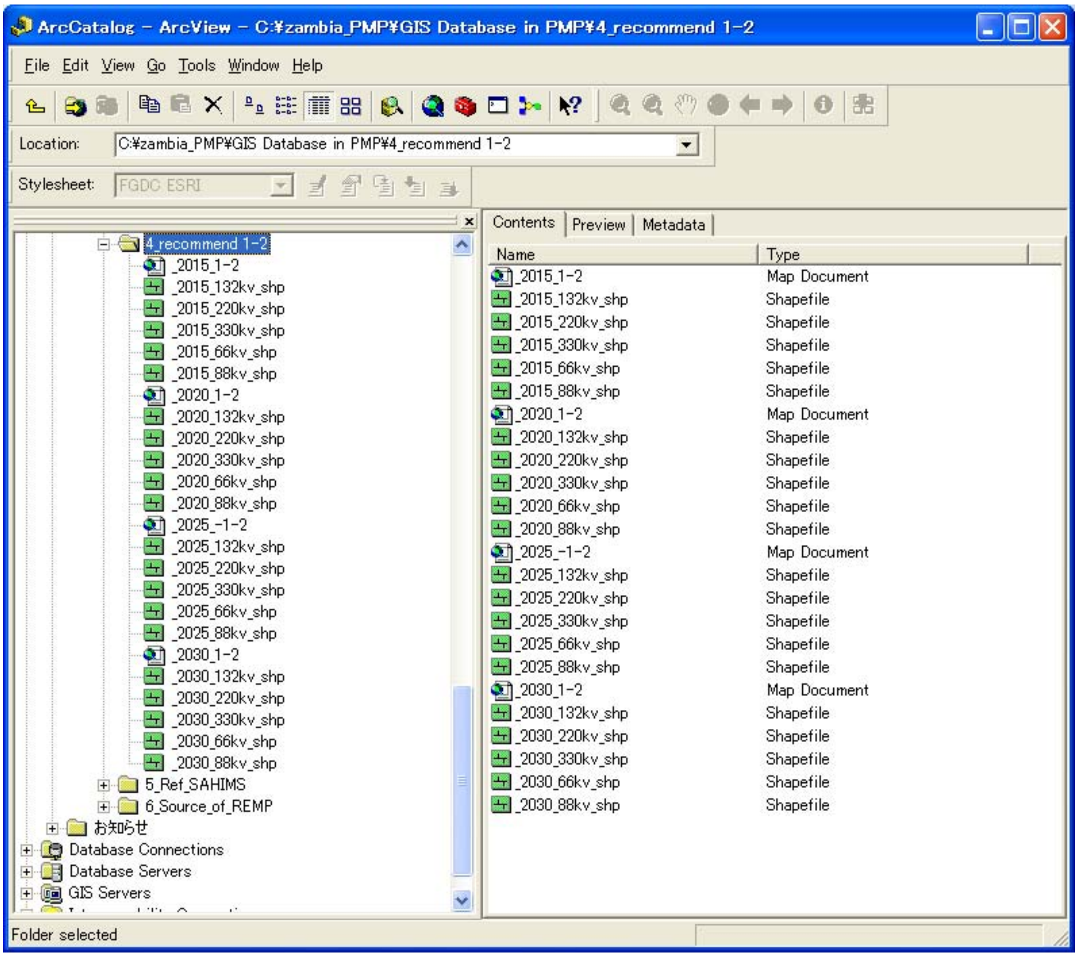


Figure H.12 Information viewed with Arc Catalog (4. Recommend 1-2)

5. Reference (miscellaneous of PMP)

This folder is used for management of information outside the aforementioned classes collected in the course of this study. It contains mainly information from the Southern Africa Humanitarian Information Management Network (SAHIMS).

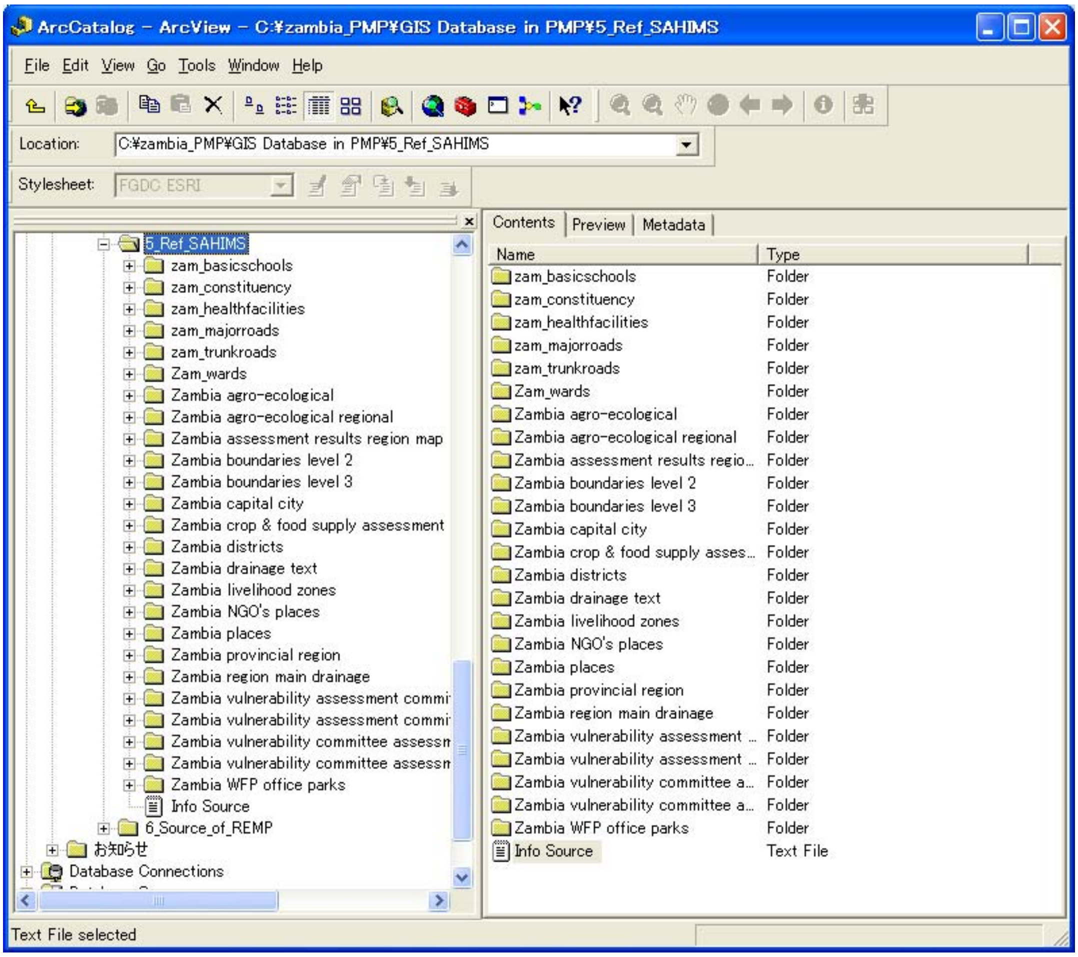


Figure H.13 Information viewed with Arc Catalog (5. Ref. SAHIMS)

6. Reference (information about REMP)

   This folder consolidates information collected at the REMP.

These components are a compilation of baseline information on the power sector. For an even fuller supply of this information, the following procedure can be applied for conversion of this basic information to the GIS data base by the GIS administrator.

Select [Tool] – [Add XY data…] on the Arc map for display of "XY data addition dialogue" as shown in the figure below. Next, input the file for the basic data[22] in question in the highest dialogue input box. Upon input of the basic data file, selectable data will be reflected in each column of the basic data file in the designated box of the X and Y coordinates in the middle of the dialogue.

[22] If the basic data files are prepared in the form of Microsoft Excel (.xls file), it should be noted that there are several worksheets in the Excel folder, each marked with a dollar sign. The operator therefore can select the requisite worksheet.

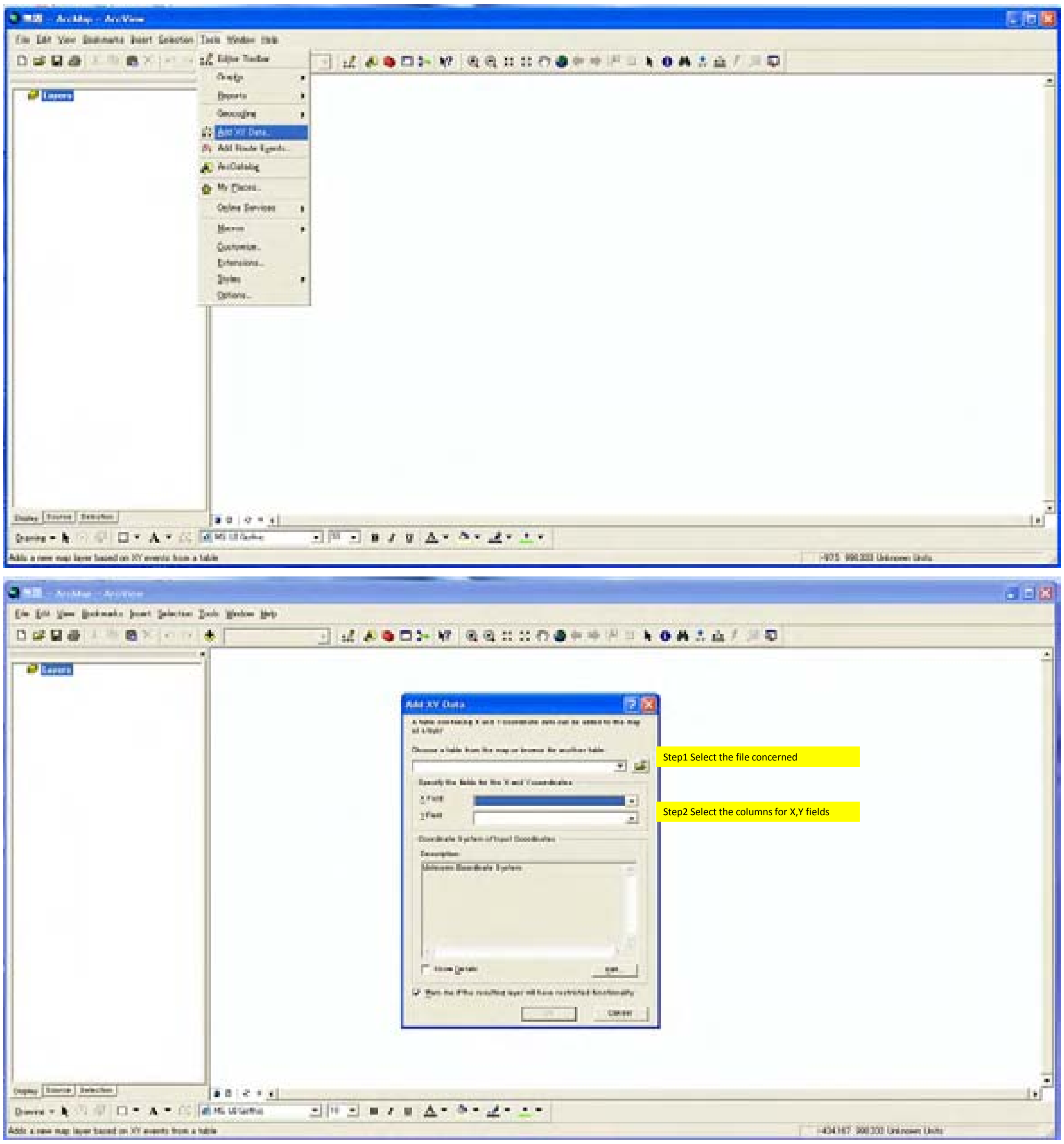


Figure H.14　XY data addition dialogue

Next, make the setting for the "input coordinate spatial reference" on the dialogue bottom row.

When "edit" is clicked, the dialogue is displayed as shown in the figure below. When "edit" is selected, "property related to spatial reference" is displayed. Select the proper coordinate system (WGS 84 or UTM 35)[23]. When addition is selected, the designated coordinate system is reflected in the property related to spatial reference. Furthermore, when OK is selected in the dialogue, this information is also reflected in the XY addition dialogue.

Finally, when OK is selected in the XY addition dialogue after performance of these

[23] If the needed coordinate system is not available, confirm the existing feature class, select the input button on "property related to spatial reference", and input the coordinate system.

operations, the basic data file is reflected in the GIS.

The GIS data obtained from these operations can be put to more effective utilization through combination with the GIS data for other sectors. The following are prospective combinations.

- Combination of the distribution of mineral resources and transmission line route charts
- Combination of urban development plans and transmission line route charts
- Combination of hydropower development potential and national park maps

GIS data from sectors other than the power sector should be compiled in the same way in the concerned national agencies and provided for use as necessary. By management of the GIS data for the sectors over which they have jurisdiction, the competent agencies could make exacting use of all such information.

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