No. 5

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

MINISTRY OF MINES AND ENERGY
REPUBLIC OF NAMIBIA

STUDY FOR THE ELECTRICITY MASTER PLAN IN THE REPUBLIC OF NAMIBIA

REPORT

SUMMARY

SEPTEMBER 1998

EPDC INTERNATIONAL LTD.

YACHIYO ENGINEERING CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

MINISTRY OF MINES AND ENERGY
REPUBLIC OF NAMIBIA

STUDY
FOR
THE ELECTRICITY MASTER PLAN
IN
THE REPUBLIC OF NAMIBIA

REPORT

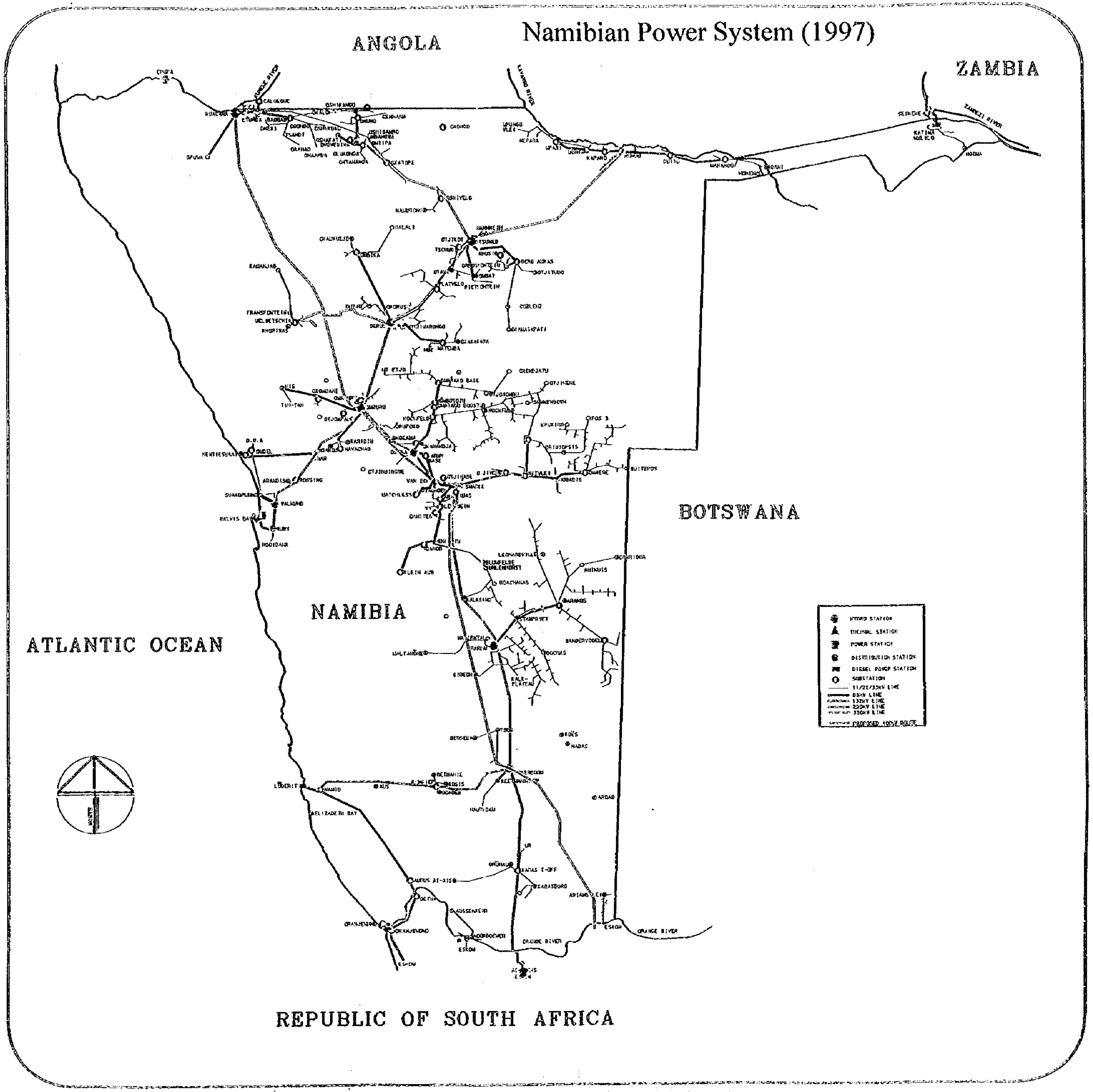
SUMMARY

SEPTEMBER 1998

EPDC INTERNATIONAL LTD.

YACHIYO ENGINEERING CO., LTD.

Namibian Power System (1997)

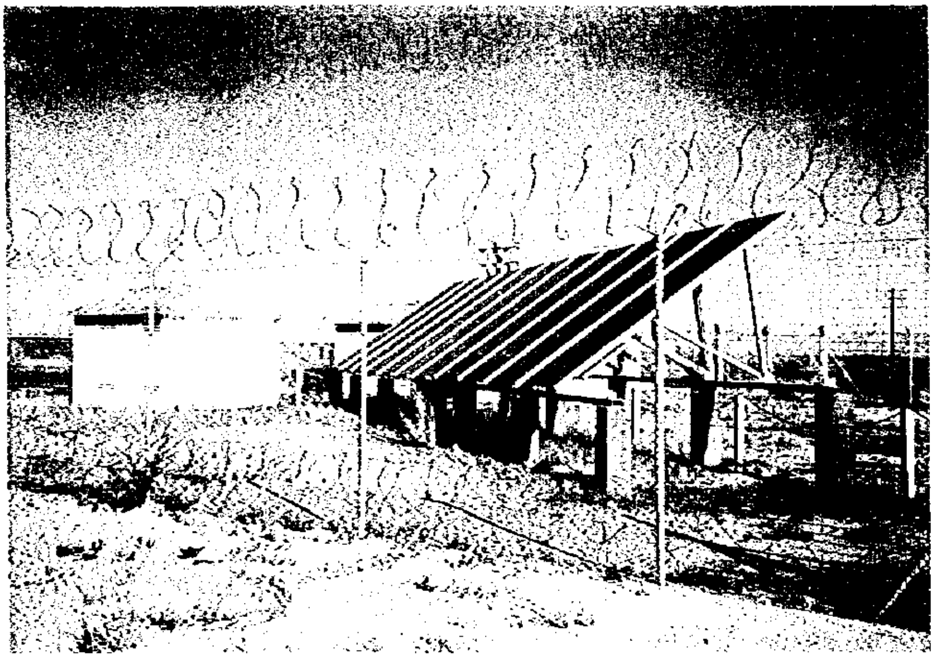


Windhoek(Capital)
Right: City office

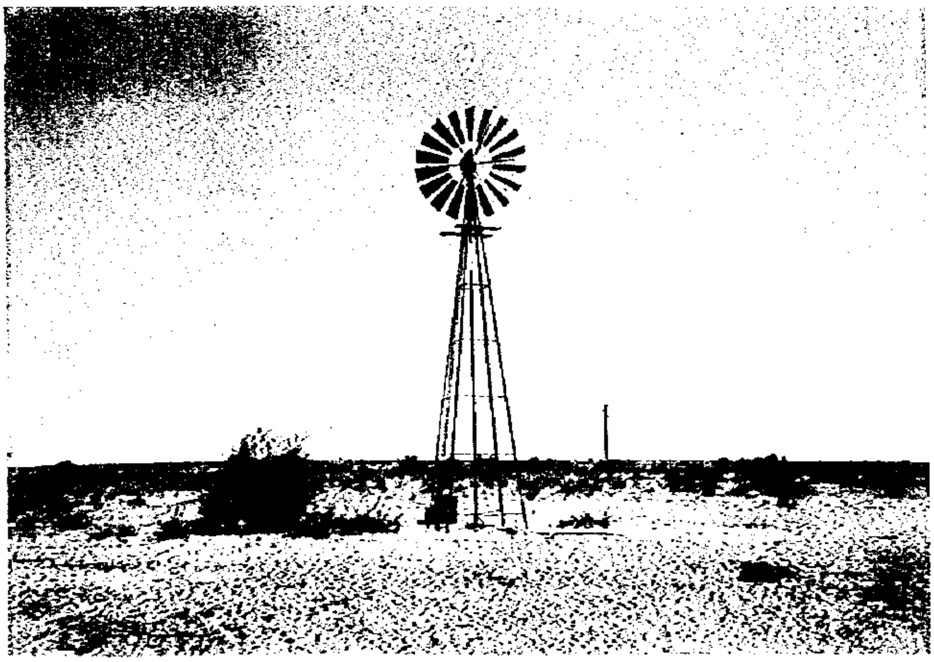
Non-Electricity Village
(Oshakati)
- Conventional Residents -

Non-Electricity Village
(Oshakati)
- Tranditional dwellings –

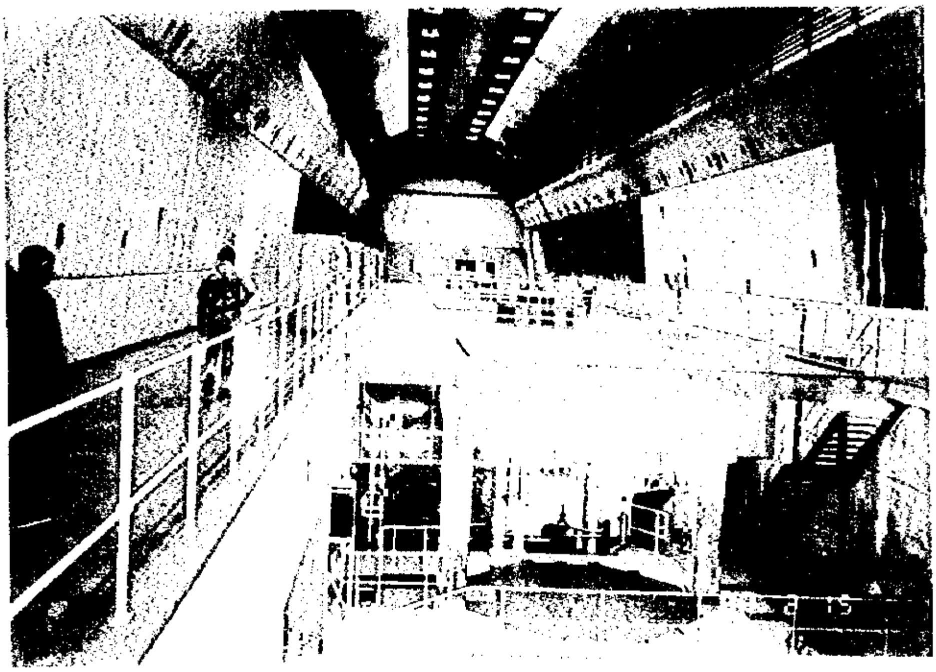
11kV Line
(Ondangwa)



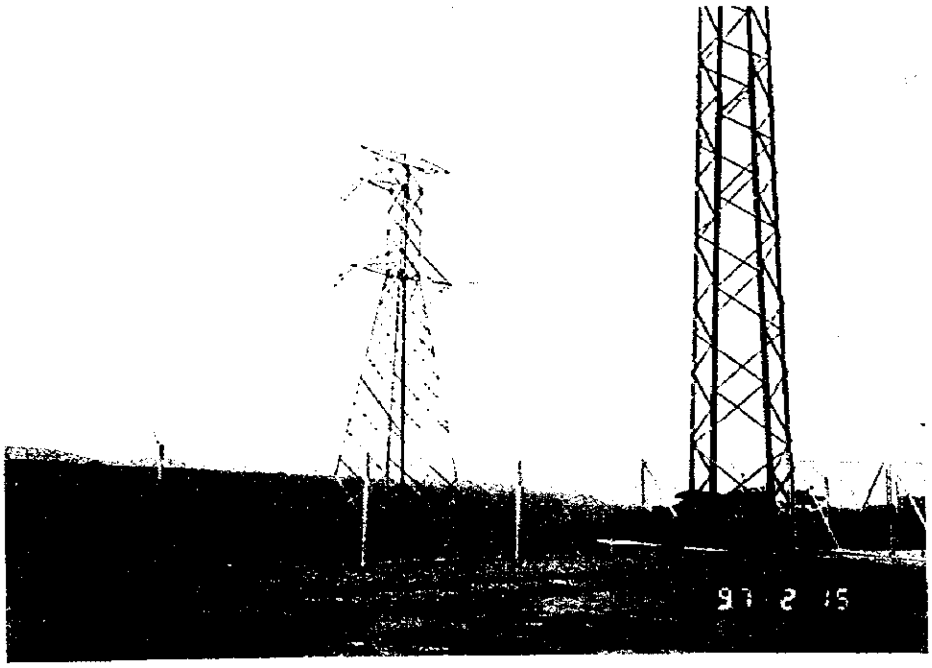
P.V System for Communications
(Mariental)



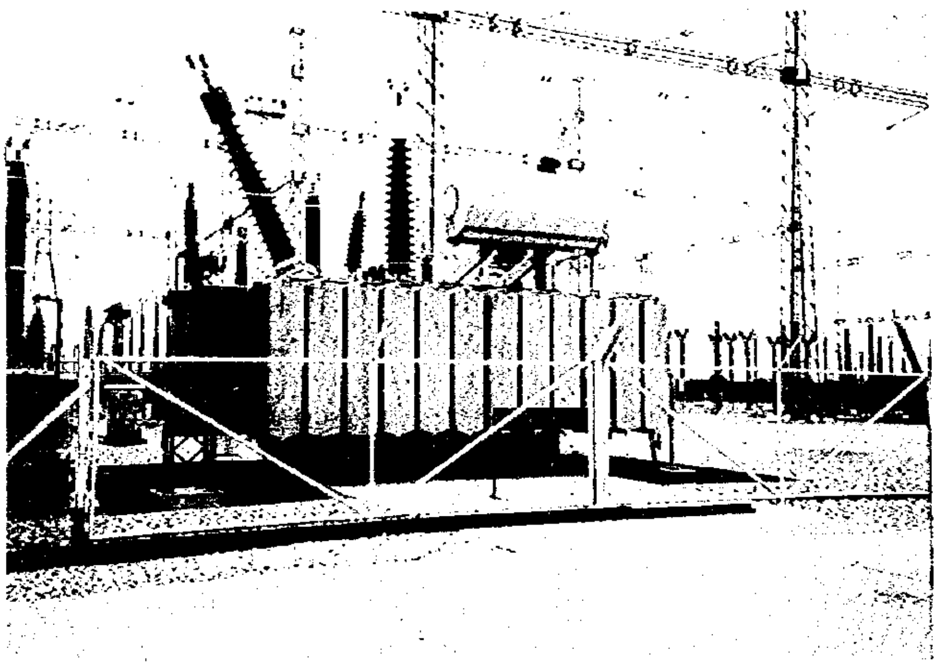
Water Pump with Wind Power
(Tses)



Ruacana Hydro Power Plant
Output: 240MW (3×80MW)



330kV Line (Ruacan – Omburu)



Omburu 330/220kV Substation
Trans. 2×315MVA

Summary

Background of Study

The Republic of Namibia has a average of annual rainfall of 500mm in the northern regions. Rain usually falls in the summer, from November to the end of March and the dry season is long and severe. Ruacana Power station is only one hydroelectric plant in Namibia. Gova regulation dam for the Ruacana has been destroyed in the Angola civil war and regulation of the river is impossible. For this reason, Ruacana's duration of full power generation is actually around 2,000 hours in a year and Ruacana is not operating at all during a certain time.

In spite of a high probability of energy resources such as natural gas, the exploitation has not been developed yet. Namibia is now importing coal and fuel for power generation from South Africa. Its costs are very high including the cost of transportation. The operation of thermal power plants is suppressed as much as possible.

Under the circumstances, imported power from South Africa has been steadily increasing and reached over 50% of the national electricity consumption. The Government of Namibia is planning to meet the growing demand by means of increased power import from South Africa in the short term and to build a structure for power supply self sufficiency in the long term.

In the background, The Government of Namibia formally requested to conduct the electricity master plan in February 1995.

JICA sent a preliminary survey mission complying with the request in October 1996 and decided to dispatch a study team after consultation with the Namibian side.

Implementation of Study

The study was started in January 1997, carried out over for three consecutive fiscal years and completed in September 1998. During this period, field surveys, procurement of data and documents, explanation and discussion about progress and outcomes and technical transfer seminars were implemented in field works in Namibia.

General Description of Namibia

On 21 March 1990 the Republic of Namibia finally got its independence after 106 years of

German, British and South African rule.

Namibia is a democratic republic and has an area of 824,295 square kilometers. The country has a semi -arid climate with irregular rainfall.

The population of the country is currently about 1.7 million people and increses at a rate of 3.1% per annum. The rate of urbanisation had increased over the last few years and most of the urban areas has a population growth of between 5% to 6% per annum.

Namibia has a very open economy i.e. it is highly dependant on exports and imports. Its economy also depends very heavily on the South African economy. About 85% of its imports come from South Africa. GDP per capita was about N$8,500 per annum in 1996 (current price), which approximately US$1,800 per annum. Welfare is very unequally distributed. About half of the population are poor with an income of less than N$500 per month. They are predominantly rural and principally in the north.

Modest annual growth in real GDP had been recorded since the recession namely 4.3% in 1986, 3.2% in 1987, 0.2% in 1988 and 1.9% in 1989. Namibia's GDP expanded by an average of 4.2% per year between 1990 and 1996. Growth in 1993 was adversely affected by the 1992/3 drought as well as the drop in uranium and diamond prices.

Social Analysis

Namibia faces the same legacy as South Africa with the following economy of extreme contrast:

- A dualistic economy with a sophisticated modern sector that employs only a minority of the population
- The economy is depending on a few natural resource based sectors, to a large extent, capital intensive with little contribution toward increasing employment and reducing income inequality.
- Regarding the distribution of resources, there are vast disparities between a small wealthy minority and a big majority of which may live below the poverty line.

A striking feature of the structure of Namibia's economy is that the total expenditure by government amount to almost 40% of the GDP. Among the reasons behind the relatively high percentage of government is the need to establish and organise government in accordance with the new and democratic contribution.

An attempt to illustrate the skewed distribution of economic resources among the population in Namibia was conducted b a UN mission in 1989. In this study the population was divided into three groups: "Whites", "Non-whites supported by modern economy" and "Non-whites supported by traditional economy".

Table 3.1 Population and GDP disaggregated by three population groups

	Whites	Non-whites supported by modern economy	Non-whites supported by traditional economy	All groups
Percentage of population, %	5.1	40.0	54.9	100
Distribution of GDP, %	71.2	25.4	3.4	100
Per capita GDP, N$	32,919	1,500	145	2,360

The overall per capita GDP in Namibia is greatly affected by the dualistic nature of the economy. In Namibia, two separate economies exist. On one hand, there is a modern sector which employs highly advanced technologies, techniques and method in the production process and ways of life. On the other hand, there is a traditional sector which depends on subsistence production and has not reached a level of sophistication and development. Therefore, the overall per capita GDP combining the economies of these two sectors is misleading and conceals great differences in the income.

5.3% of the population who have the highest per capita income have more than 50% of the total income of the private households. The other 94.7% of the population have only about 48% of the total income of the private households. The average per capita income is about N$29,500 in the better off group while it is about N$1,500 in the rest of the population.

There is a big difference in the per capita income between urbane households and rural households. The Khomas region has the highest level of private income in Namibia. A average annual per capita income in Khomas region is about N$10,000 and N$9,000~2,000 in the northern regions. Rural areas and the northern regions are worse off concerning economic standards.

Problems relating to the supply of household energies include:

- Family members', especially women's and children's overwork required for gathering firewood
- Social development being impeded for lack of living necessaries

- Natural environment being deteriorated due to the increasing consumption of wood
- Accessibility to alternative energies being impeded due to poverty and insufficient governmental supports

Priority targets of the on going rural electrification programme are socio-economic centres in comparatively large locality centers. The rural electrification so far might be called a town development. It is now moving to the second round of rural electrification including rural household, gradually ones in dispersed areas, namely covering poor households.

Effective assistance such as electricity supply free of charge or at a lower rate should be considered for the low income population who cannot afford access to electricity, furthermore for eliminating the economic disparity and suppressing the destruction of natural environment.

Existing Power System

The parastatal electrical utility, NamPower is responsible for electricity generation, transmission and a portion of distribution. The distribution system is complex. In the urban areas and a part of town and villages, local authorities distribute electricity. In the rural areas, MRLGH distributes. In seven regions in northern Namibia, Northern Electricity, a private distributor is responsible for electricity supply. NamPower operates as a bulk supplier to municipalities, mining, MRLGH, Northern Electricity and government facilities out of local authorities in the rural areas.

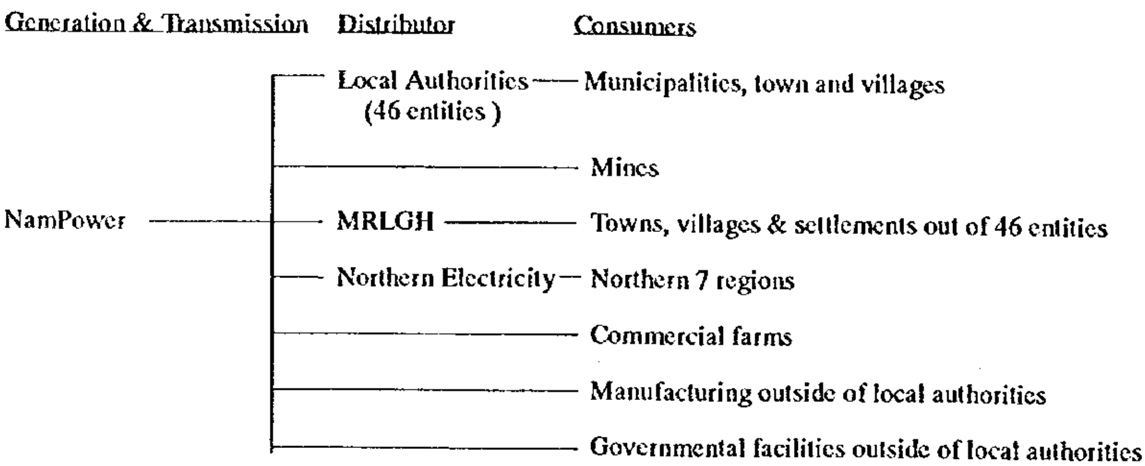


Figure 4.1 Electricity Supply

The total power supply capacity of NamPower grid at present is 584MW including South Africa interconnector.

Ruacana hydro electric power plant	240MW
Van Eck thermal power plant	120MW
Paratus diesel power plant	24MW
South Africa interconnector	200MW

In an isolated system Katima Mulilo diesel power plant (3MW)

The system peak load on the grid was 326.6MW for July 1997, when peak load from Eskom was 259.6MW (79% of the system peak load).

To meet a rapid growing demand in the country NamPower is constructing a new 400kV interconnector for strengthening the trunk line to import power from RSA. The first stage of construction, incorporating construction of the line from Aries to Kokerboom and the extension of Kokerboom substation, should be completed by May 1999. The second stage , comprising the construction of Auas substation and the line from Kokerboom to Auas, is expected to be completed by May 2000. (Refer to Figure 4.10)

The power purchase agreement between Eskom and NamPower is a ten year contract based on South African Power Pool principle and has started 11 September 1995. The tariff includes the following three component:

Firm Power	7.56 Rand/kW/week
System Energy	4.2 cent/kWh
Firm Energy	4.02 cent /kWh

Firm Power $=P_{peak} - P_{hydro} - P_{therm}$

The prices of imported power varies between 4.98 Nc/kWh and 8.28 Nc/kWh depending on the amount of power import and availability of surplus energy in the Eskom system.

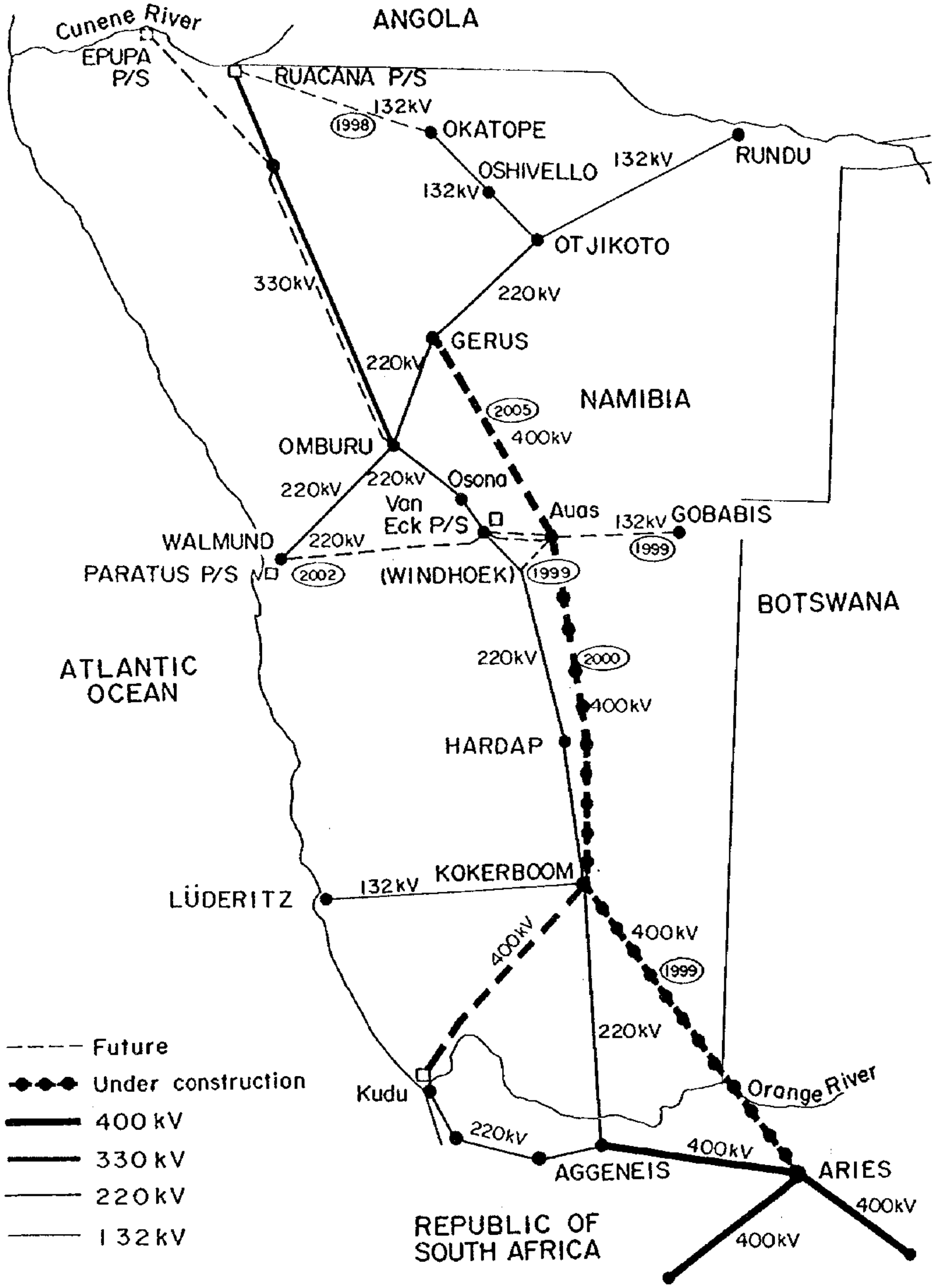


Figure 4.10 TRANSMISSION EXPANSION PLAN (1996-2010)

System and Organization

The government of Namibia consists of 20 ministries and two offices under the President, and the Ministries directly involved in power supply are MME and MRLGH.

MME is in charge of natural resources and energy and is responsible for advancing formulation of the power development master plan which covers power self-sufficiency and rural electrification, proclaimed in the First National Development Plan (NDP-1).

MRLGH is responsible for carrying out coordination with, and controlling and supervising local administrative organizations, and deeply involved in the rural electrification. It is responsible for maintenance and collection of electricity charges following completion of electrification works by MME.

NamPower is a 100% government-owned electricity utility and acts as the sole power operator responsible for all work concerned with generation and transmission. It operates under a self-supporting accounting system, and its operation is financially sound and technically capable. Its employees are 817 as of October 1997.

Northern Electricity is a private company which was established in December 1996 and is responsible for power distribution in seven regions in the north. It has taken distribution facilities owned by the government on lease and commenced fully independent operation in March 1997. The company has 56 employees (as of January 1998) and five service centers for customer service. In addition, Northern Electricity has established, under the permission of the government, a 1 N¢/kWh Electrification Surcharge for promotion of electrification in their regions, and a 1.1 N¢/kWh Community Development Fund for contributing to local infrastructure development.

MME is currently in a final process of establishing a New Electricity Act. The main objective of this Act is establishment of the Electricity Control Board to supervise and coordinate the power supply operations and secure the efficient power supply condition. This Act also includes a provision for establishing a Rural Electrification Fund for promoting rural electrification.

Electricity Demand Forecast

The forecast covers the period 1997 to 2020. It basically consists of the large power user (LPU) electrical energy forecast and the small power user (SPU) electrical energy forecast. The maximum demand forecast was finally done based on the sum of the LPU and SPU forecasts.

It is estimated that electricity comprised 14% of the total final energy consumed in Namibia in 1996. The figure for liquid fuels was 62%, while coal comprised 4% and traditional fuels (eg. biomass) 20% of final energy.

Local Authorities is the largest sector or category, and consumed about 56% of the electricity in Namibia in 1996. Their consumption increased at a rate of 7% over the past sixteen years.

Cognisance was also taken of the history, and the economic structure and performance of Namibia in the forecast.

(Large Power User Energy Forecast)
The large power users category includes proclaimed municipalities, mining, industry, government and parastatals and bulk water pumping.

Historical time series data from 1980 to 1996 was used. A Sectoral Model was used which disaggregates the electricity market into different homogenous end-use sectors, sub-sectors or even individual major customers, as they all have different characteristics.

As much information as possible on these categories was collected. The information was obtained through site visits, meetings and interviews with people of these and other organisations. Information from questionnaires which were completed by major customers were also used, as well as information from various reports, publications, magazines and news papers.

The forecast basically centres around knowledge of and understanding the behaviour of each one of the different sectors, sub-sectors and individual customers. An analysis was done for each one of them in terms of past growth patterns and trends, and correlation with exogenous variables. Possible future new expansions, developments or trends were also considered. Various possible new projects in Namibia have been, and are currently being investigated by investors. Most of these projects require a substantial amount of electricity. Opinions of existing individual major consumers electricity and their future production plans, as well as information from some institutions, were also taken into account.

As a result of uncertainties in the environment three forecasts were developed namely a high-, middle- and low forecast. The high forecast is based on economic growth of about 5% per annum on average over the period 1997 to 2020, and includes some probable new projects which are currently being planned. The middle forecast is based on moderate economic growth of about 3.5% per annum and includes almost all approved known projects. Economic growth in Namibia averaged 3.6% per annum over the past seven years. The low growth forecast sees average economic growth of 2% per annum up to 2020.

(Small Power User Energy Forecast)
The small power user (rural) forecast includes all small customers outside proclaimed municipalities and towns. These consist of rural households, rural social services and businesses, and commercial farms. The forecast was done on a regional basis, as per request by MME, and for each of three economic growth forecasts.

The methodology used included the following steps:

(1) Customer Classification. All rural customers were grouped together in classes that have similar demand and consumption characteristics. The classification was based on the 1991 Population Census, the 1994 NHIES Survey, and consumption figures from NamPower and Northern Electricity. The classes identified were Village Households, Dispersed Households, Clinics & Health Care, Schools (with and without hostels), Government Facilities, Shops (businesses), and Farming (Commercial and Irrigation).

(2) Class Population Forecast. The expected total numbers of each customer class for each year are then forecast, to provide the total numbers of potential rural customers. This was derived from the 1991 Population Census and the 1994 Provisional Population Projections and other related documentation. The 1997 UNDP Human Development Report provided additional data on the possible impact of AIDS on population growth.

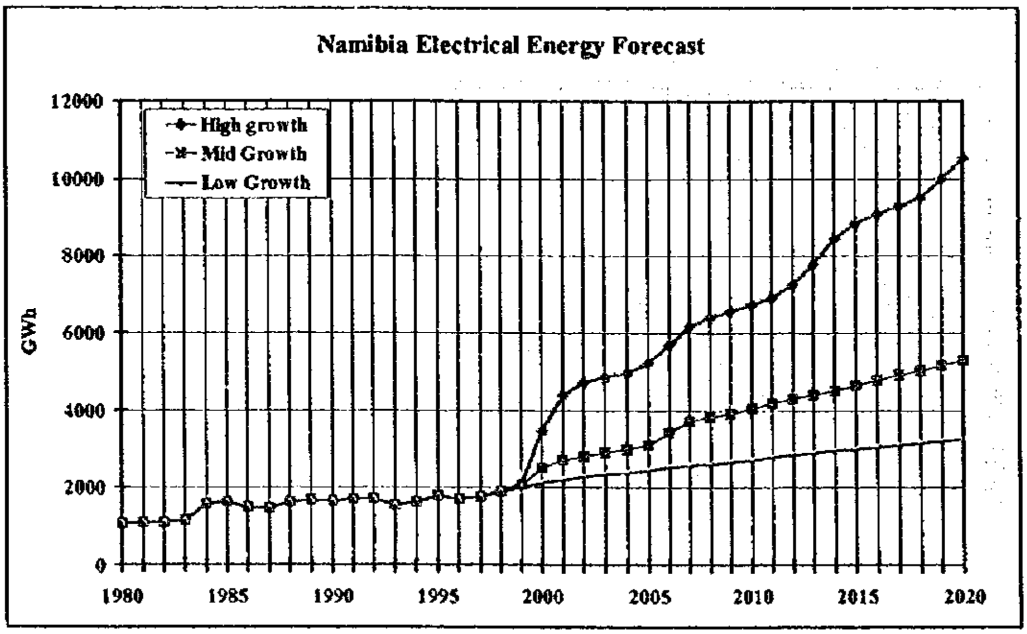
(3) Electrification Rate Forecast. This is based on a hypothetical electrification plan, based on assumptions about electrification priorities and available funding. The total electrification rate was based on a constant GDP contribution of 0.2% per annum. The priorities, both in terms of customer classes and regions, were established from discussions with MME.

(4) Class Consumption Forecast. The expected consumption for each type of customer is based on existing historical data from NamPower and Northern Electricity, as well as related experience from rural electrification programs in other developing countries. This was useful as historical data for rural customers in Namibia is limited.

Finally, the results of the forecasts were combined to provide a total electrical energy consumption forecast for rural customers. The data sets and forecasting model were implemented as an Excel spreadsheet workbook, which is easy to update and maintain.

(Total Electrical Energy Forecast)
The results of the LPU and SPU energy forecasts were combined and the figure below shows the final results.

Figure 6.19 - Namibia Electrical Energy Forecast



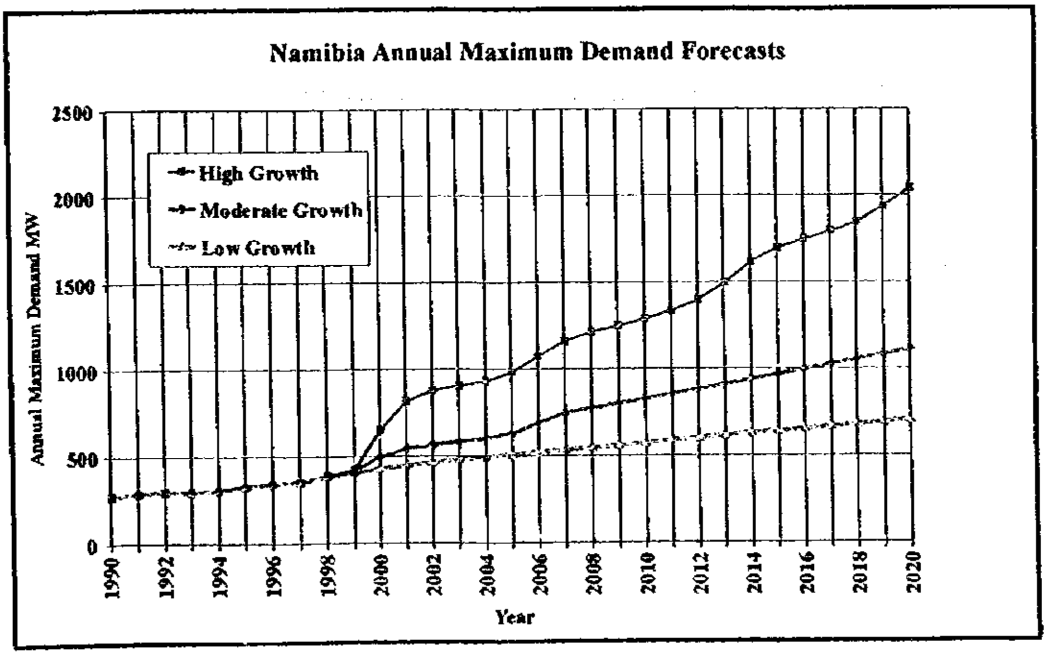
(Maximum Demand Forecast)

The MD forecasting technique used in this forecast is the Contribution to Load Factor (CLF) method. This method was first reported by the CEGB in the UK in 1969, and was recently 'rediscovered' in a paper presented at the AEIC Load Research Workshop in 1990. It has been used by small to medium sized utilities that require an improvement over simple extrapolation or the Assumed Load Factor (ALF) method, but lack the resources to implement complex end-use or aggregation models.

The CLF method is more accurate than the traditional ALF or trend extrapolation methods, particularly where the customer mix is expected to change. This is the case in Namibia, where the proportion of peaky residential and small commercial load is increasing as a result of a decline in the relative importance of mining in the economy and the impact of the high urbanisation rate on the residential and commercial demand in the larger municipalities. This, together with the additional demand created by the rural electrification program, has a negative impact on the long term evolution of the annual system load factor. This is countered to some extent by the additional mining load in the High Growth forecast.

The final forecast results are displayed in the figure below.

Figure 6.26 Forecast Annual Maximum Demands



Rural Electrification

About 30% of Namibia's households has access to electricity by mid-1997 and it is estimated that more than 75% of the urban population use electricity, compared to only 8-9% of the population in the rural areas. It is government's intention that at least 25% of rural households shall be connected to the national grid by the year 2010.

The rural electrification programme started by MME in the former Ovambo in 1991, financed by a NORAD grant, extended to Okavango in 1992, financed by the Namibian government and followed by the eastern part of the country and then to the southern rural areas, being financed jointly by the Namibian government and Norway. Some villages in the west are also being electrified.

In construction of rural electrification facilities, it is routine that NamPower constructs 33kV class high tension feeder from a secondary substation to bulk supply points, while further low tension distribution lines and reticulations are constructed by MME. The construction and maintenance costs of the high tension feeders are added to NamPower's tariff and be substantially borne by rural consumers.

The rural electrification programme up to the year 2000 by MME and the plan by NamPower are well coordinated between them and there is no discrepancy between the programme and the plan. NamPower's plan on the commercial farming scheme is being executed from 1996, spending more than 30 years. MME will be able to save the cost of rural electrification from 2000, if turning any part of these projects to account.

The Namibian government has provided revolving fund for population in off-grid areas to purchase Solar Home System (SHS). The government has a plan to increase kinds and number of SHS. Now applications exceed a programme. The revolving fund is being put to actual use and is judged to be a worthwhile concern.

In rural electrification for dispersed communities, photovoltaic power generation system (PV system) with 100 Wp capacity as minimum requirements on non-thermal basis could on average be advantageous in a northern community (the average household number of 29) more than 10.5 km far from an existing distribution line and in other regional community (the average household number of 4) more than 0.9 km over the extension of the distribution line. However, it is advisable that individual estimation be made every case.

A rough estimate indicates that the generation costs from wind power are 9.6USc/kWh at Walvis Bay and 6.6 USc/kWh at Lüderitz and these are severally three times the delivering costs from Kudu gas generation. This three times difference would be too big to be covered with a cost reduction by expected advances and more accurate estimation. Wind power introduction in Namibia could not be economically justfiable at present.

Power Development

There remains only three alternatives, which realistically may be considered in the time horizon.

- New 400kV interconnection with Eskom
- Kudu gas fired power generation
- Lower Cunene hydropower generation

The five scenarios have been defined for economic/technical evaluation. Each of them constitutes the least cost option.

- Scenario A Self sufficiency - CCGT
- Scenario B Self sufficiency - Hydropower
- Scenario C Business as usual - Extended import
- Scenario D Business as usual - CCGT
- Scenario E business as usual - Hydropower

The self sufficiency scenarios will aim at realization of the energy policy that 100% of the peak demand and at least 75% of the electricity demand will be supplied from internal sources by 2010. The business as usual scenarios will pursue the most economic measures, being free from the 100% peak target.

Table 9.26 Summary of Additions of Supply Facilities

Scenario / Year	Self Sufficiency		Business As Usual		
	A - CCGT	B - Hydro	C - Import	D - CCGT	E - Hydro
1999	400kV line-1 Aries-Koker.	400kV line-1 Aries-Koker.	400kV line-1 Aries-Koker.	400kV line-1 Aries-Koker.	400kV line-1 Aries-Koker.
2000	400kV line-1 Koker.-Auas	400kV line-1 Koker.-Auas	400kV line-1 Koker.-Auas	400kV line-1 Koker.-Auas	400kV line-1 Koker.-Auas
2002	CCGT-1	CCGT-1	CCGT-1	CCGT-1	CCGT-1
2008		Epupa Hydro			
2010	CCGT-2	(2xGT)			
2013				CCGT-2	Epupa Hydro
2014	CCGT-3	Configurate to CCGT-2	400kV line-2		
2017					(2xGT)
2018		(2xGT)			

Notes: The additions are to be completed by May of the year.

The 400kV Interconnection Project involves the construction of approximately 900km of a single circuit line from Aries substation to Auas substation and the construction of a new substation and upgrading of an existing one.

Lead time	30 months
Investment cost	209.2 MUS$ including substations and IDC

The most advanced type 1300℃ class combined cycle gas turbine(CCGT) offers maximum reliability, efficiency and economy. It is also highly flexible on cycle configuration, fuel selection and site adaptation.

Lead time	28 months
Total investment	406 MUS$ including a related line and IDC

Epupa is one of two hydro schemes on the lower Cunene river. The output is 360MW and annual average generation is 1730GWh. The economic comparison was made about the Epupa scheme which is more viable.

Lead time	9 ~ 10 years
Total investment	695 MUS$ including a related line and IDC

As short term expansion options, NamPower has started the construction of a new 400kV interconnector with Eskom. A generation addition is urgently required in the year 2002 in order to meet a sharply growing demand. CCGT would be only one option left, common to all scenarios.

As medium and long term options, a self sufficiency scenarios A or B costs additional US$406 million compared with a corresponding business as usual scenario D or E in the time horizon.

Economic Analysis

Economic benefit for the high growth was calculated as the base case and one for the medium growth case as a reference. The results are shown in Table 9.27.

In the high growth case, the economic internal rate of return (EIRR) which is usually used as a major economic indicator for a project is more than 10% for all scenarios, and they are all considered to be economically viable. Opportunity cost for capital for a power project is generally regarded as more than 10% in Namibia.

In the moderate growth case with smaller demand, EIRRs for four scenarios except for scenario D are less than 10% and the four scenarios are not economically viable any more. An economic indicator of scenario D in the low growth case is shown for reference. It can be seen that the lower demand has the bigger falling in the economic indicators.

Scenarios C and D have very close economic indicators and show a high level of economic viability. However, scenario D has the comparative advantage over scenario C in terms of foreign exchange savings and effective utilization of indigenous natural resources. Scenario D in the high growth case will remarkably yield foreign exchange savings of US$26.6 million per annum and bring the government in national revenues of US$5.8 million per annum as a royalty by development of Kudu gas field and power plant.

Table 9.27 Economic Analysis Results for Defined Scenarios

Indicators \ Scenarios		Self Sufficiency		Business As Usual		
		A - CCGT	B - Hydro	C - Import	D - CCGT	E - Hydro
NPV [MUS$]	High	282.1	168.7	305.6	301.4	266.7
	Moderate	-35.3	-141.8	-11.3	3.4	-40.6
	Low	-	-	-	-89.0	-
B/C	High	1.22	1.12	1.26	1.26	1.22
	Moderate	0.97	0.88	0.99	1.00	0.95
	Low	-	-	-	0.89	-
EIRR [%]	High	18.7	14.0	20.3	19.9	18.3
	Moderate	8.9	6.7	9.6	10.1	8.7
	Low	-	-	-	6.5	-

Investment Plan

Investment plan and financial analysis have been prepared for Scenario D for high growth cases which has been selected from the technical/economic analysis.

Table 9.22 Investment Plan

(N$ million)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1)Transmission Line		221.2	442.2	221.2	160.6	160.6						
2) CCGT					738.6	738.6						
Total	0.0	221.2	442.2	221.2	899.2	899.2	0.0	0.0	0.0	0.0	0.0	0.0

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1)Transmission Line				160.6	160.6							
2) CCGT				738.6	738.6							
Total	0.0	0.0	0.0	899.2	899.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Financial Analysis

The Financial Internal Rate of Return (FIRR) shows 18.2%. In this financial planning, 85% of all capital cost required for 1998~2002 is to be long term borrowing and 15% is self-financed. 20% of total capital costs will be borrowed for 2012~2013 because the internal cash reserve will increase.

The debt service coverage shows more than 1.5 until 2020 and the return on investment (ROI) will also be roughly between 20~30%. This indicates financial soundness is verified for the project implementation.

Evaluation of Scenarios

ScenrioD; Business as usual-CCGT with Scenario C; Extended import is found to be the least cost option for electricity supply compared to hydropower generation.

In the high growth case, the five scenarios are all technically and economically viable and close competitors. However, Scenario B; Self sufficiency-Hydropower is less superior. In the moderate growth case, economic indicators generally fall to an unacceptable level. Exceptionally, Scenario B; Self sufficiency-Hydropower is the worst and is even inferior to low growth case of Scenario D

The viability of the hydropower schemes to be shared on a 50-50 basis with Angolan side is to be studied. This is the biggest uncertainties at the moment for technical and economical evaluations of the hydropower schemes.

The degree of self sufficiency of Scenario D; Business as usual-CCGT would increase from 0 in 2001 to 73% in 2020 in high growth case and in terms of capacity balance. On the other hand that of Scenario C; Extended import would be only 37% in 2020. That of Scenario D in terms of energy balance would be 87% in 2020 and that of Scenario C 59% in 2020 (Refer to Table 9.28).

The two self sufficiency scenarios A for CCGT and B for hydropower could meet the national targets of 100% of peak load and 75% of energy demand. However, Scenario D could cope with one of the targets with much cost savings compared to Scenario A and B. It is deemed that Scenario D could satisfy the economic efficiency and alleviate a growing concern about security of supply to an acceptable level.

Table 9.28 Degree of Self Sufficiency (High Growth)

[%]

Scenarios	Self Sufficiency		Business As Usual		
	A - CCGT	B - Hydro	C - Import	D - CCGT	E - Hydro
Capacity Balance					
Year 2001	0	0	0	0	0
2005	78	78	78	78	78
2010	100	100	59	59	59
2015	100	100	45	89	63
2020	100	100	37	73	76
Energy Balance					
Year 2001	22	22	22	22	22
2005	89	89	89	89	89
2010	100	100	79	79	80
2015	100	100	71	95	82
2020	100	100	59	87	88

Short, Middle and Long Term System Expansion Plan

In order to meet the increasing electricity demand in Namibia, short, middle and long term system expansion plan has been set up consisting of Scenario D business as usual - CCGT as a core which JICA Study Team recommends, and transmission lines under construction and transmission expansion plan and rural electrification plan in its electricity master plan by NamPower. A capacity has been increased at some substations by the Study Team based on its demand forecast (Refer to Table 9.29).

Existing, short-, middle- and long-term expansion steps of the plan are shown in sequence with regard to generation and transmission in Figures 9.9 to 9.12.

Table 9.29 Expansion Programs in Primary Network

Terms/Year	Power stations	Transmission lines	Substations	Remarks
Short term (1997~2001) 1997		132 kV, 1cct Ruakana		Refer to Figure 9.10
1998		~ Okatope 235 km 220 kV, 2 cct Harib ~ Haib mine, 66 km	Ruacana 330/132 kV,1x80 MVA Harib 220 kV Bus Section Bay Haib mine 220/11, 3 x 90 MVA	
1999		400 kV, 1cct RSA border~Koker-Boom 270 km 220 kV, (1+2) cct Auas~Van Eck 31 km	Kokerboom 400/220kV,2x315 MVA 400 kV Reactors 5 x 100 Mvar	
2000		400 kV, 1cct Koker boom~Auas 455 km 132 kV, 1cct Auas~Gobabis 170km	Auas 400/220kV, 2x315 MVA 220/132 kV, 2x40 MVA 220/66 kV, 2x 40 MVA 400 kV Reactors 2 x 100 Mvar Gobabis 132/66kV, 1x20 MVA	
Middle term (2002~2006) 2002	Kudu CCGT Block 1 750 MW	400 kV, 1 cct Kudu PS~Kokerboom, 350 km		Refer to Figure 9.11
2005		400 kV, 1 cct Auas~Gerus, 240 km 220 kV, 1 cct Van Eck~Dune~Walmund, 272 km	Gerus 400/220 kV, 1x315 MVA Walmund 220/66 kV, 1 x 90 MVA	Walmund Substation is proposed by JICA.
Long term (2007~2020)	2013 Kudu CCGT Block 2 750 MW	400 kV, 1 cct Kudu PS~Kokerboom 350 km	Kokerboom 400/220 kV, 1x315 MVA Gerus 400/220 kV, 1x315 MVA Walmund 220/66 kV, 4 x 90 MVA	Refer to Figure 9.12 3 substations on the left column are proposed by JICA.

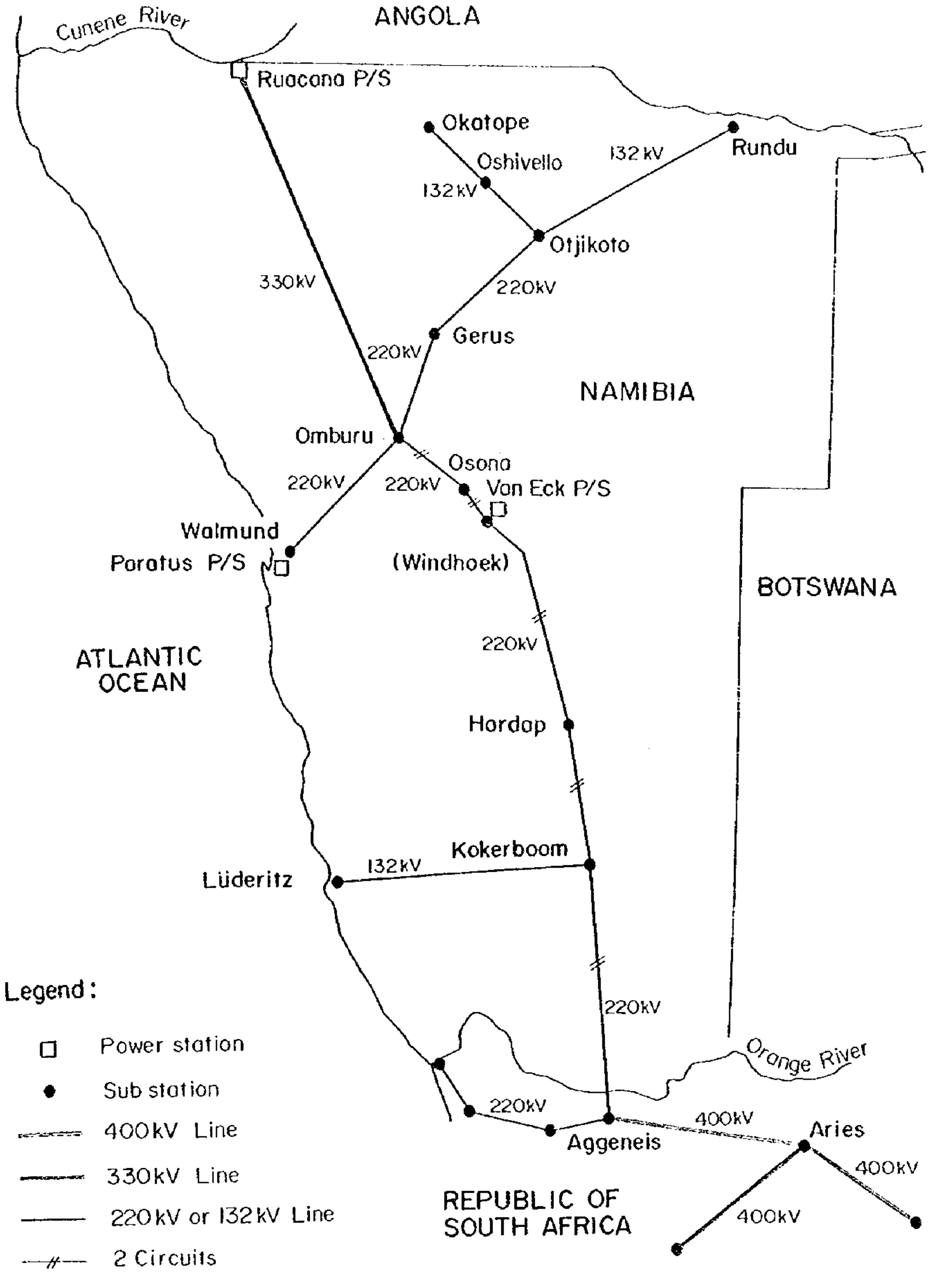


Figure 9.9 EXISTING POWER SYSTEM (As of 1997)

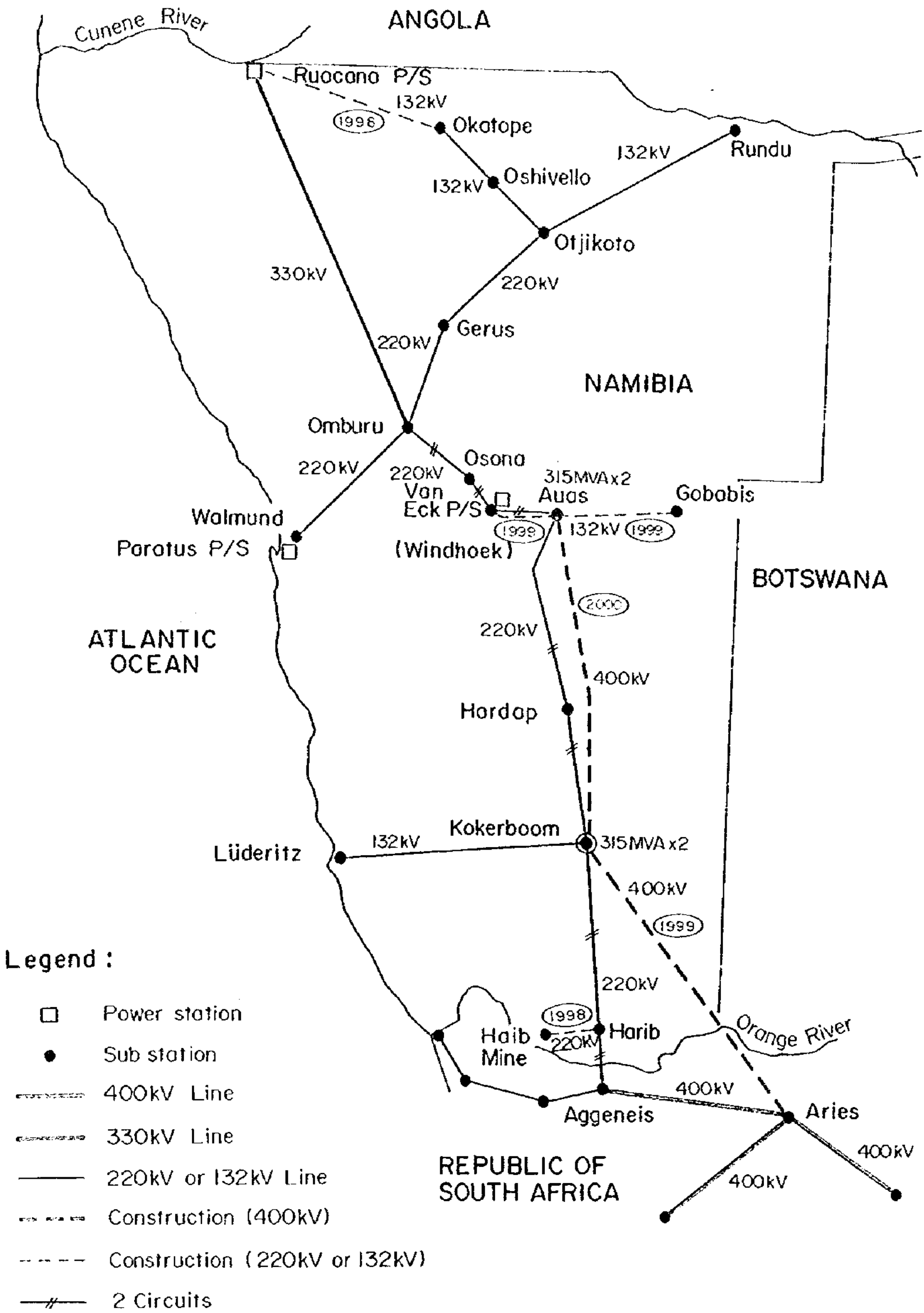


Figure 9.10 POWER SYSTEM EXPANSION PLAN (1997-2001)

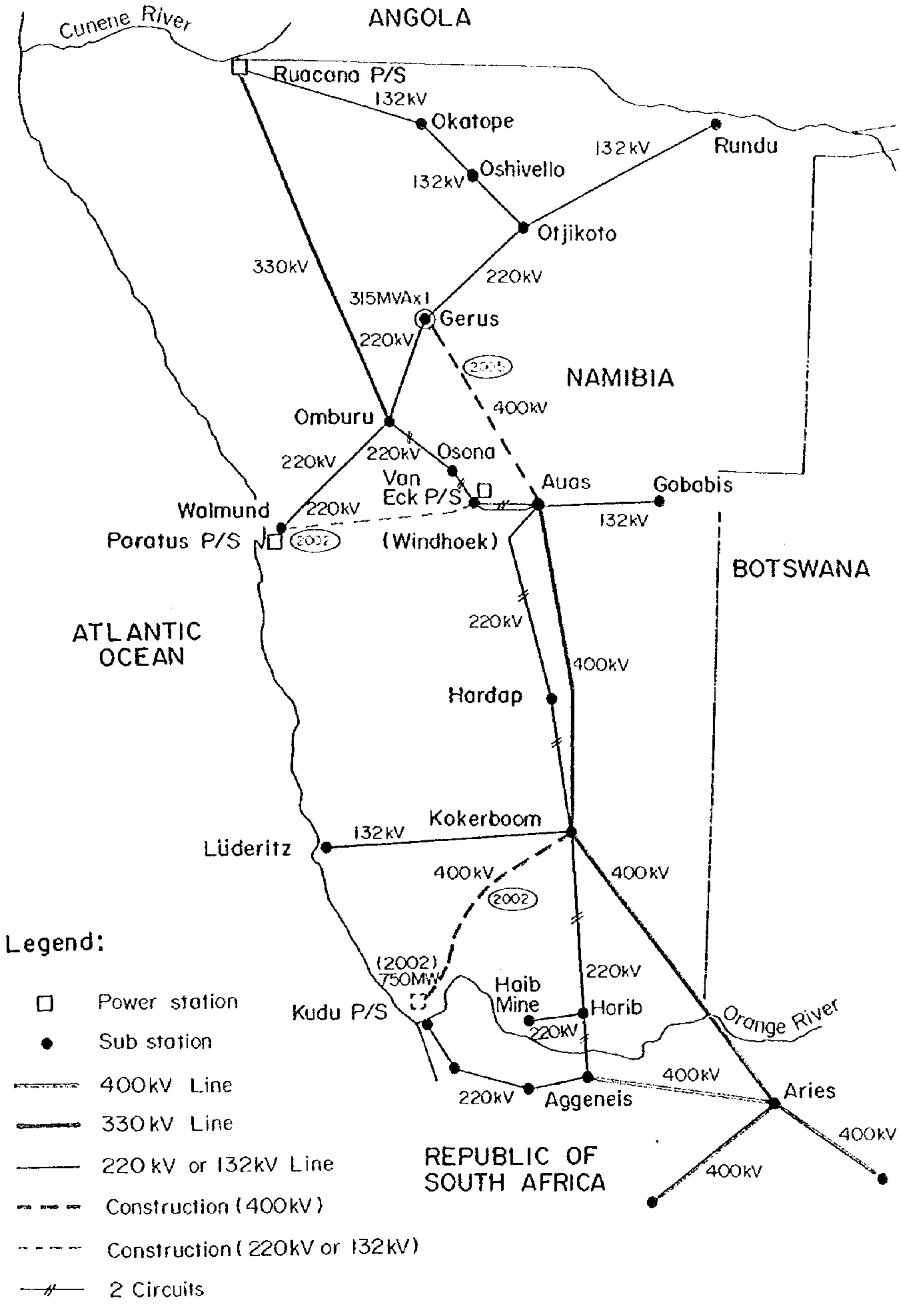


Figure 9.11 POWER SYSTEM EXPANSION PLAN (2002-2006)

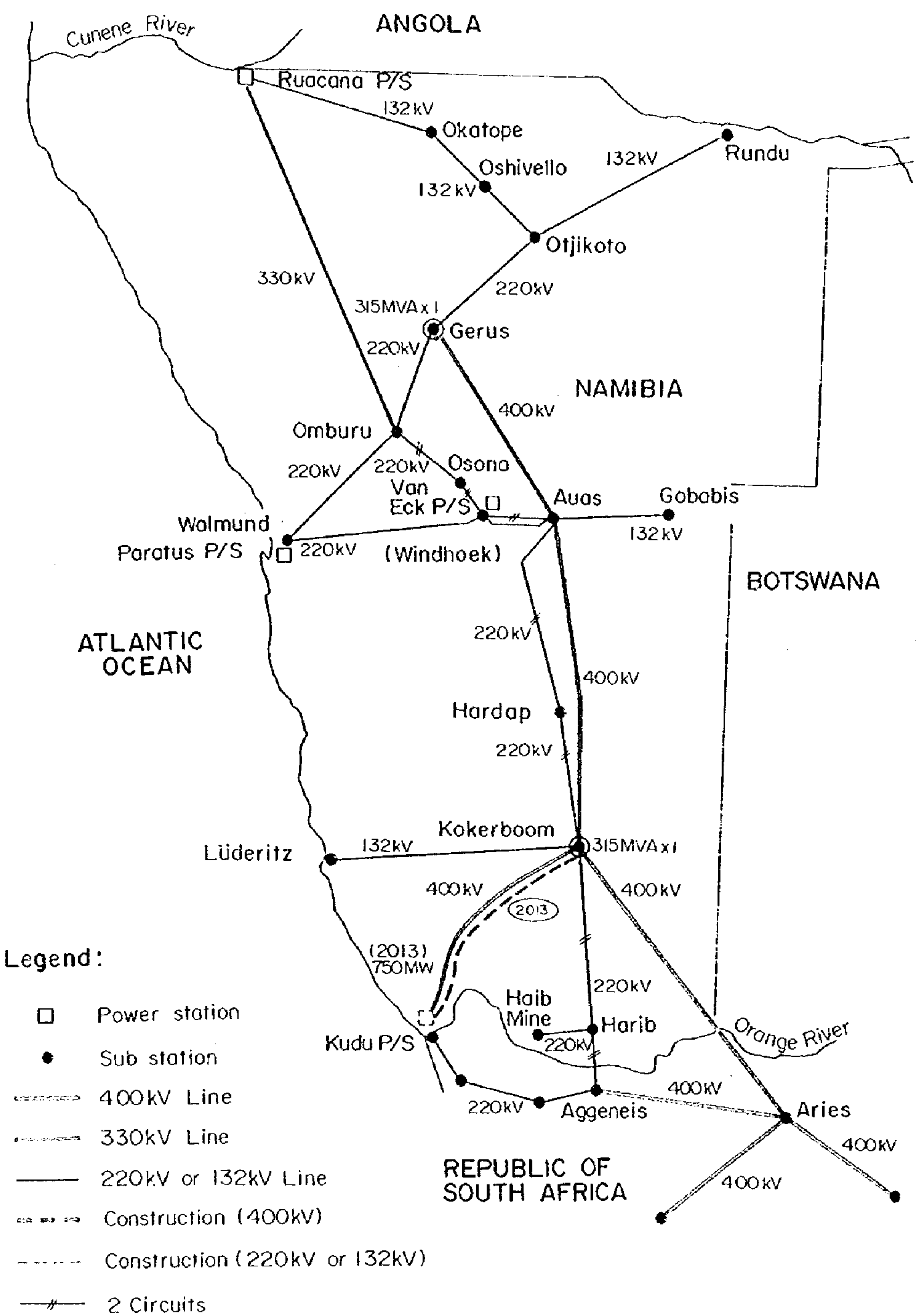


Figure 9.12 POWER SYSTEM EXPANSION PLAN (2007-2020)

Environmental Consideration and Energy Conservation

The Article 95(1) of the Constitution of the Republic of Namibia states that "The State shall actively promote and maintain the welfare of the people by adopting policies aimed at ..., the maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future ....". This statement reflects the environmental basic policy of the nation.

In May 1995, the Ministry of Environment and Tourism published the Namibia's Environment Assessment (EA) Policy. The policy requires that EAs must be carried out for all future development projects and programs that are specified by the EA Policy. However, Namibia does not as yet have a coherent and comprehensive environmental law framework, as indicated by the document "Namibia Environment, Volume 1, 1996". There are many regulations and statutes which are outdated and of South Africa origin. These regulations and statutes are still being utilized after the nation's independence. On the other hand, environmental legislation is fragmented and the administrative framework of the central government to supervise, monitor and enforce legislative measures is still inadequate. For example, legislation on pollution control is contained in five different statutes, and administrated by different ministries with no uniform standards or coordinated system. Making improvement is desired.

Namibia is not a highly industrialized country, and therefore environmental pollution has not yet become its social and natural problems. Air and water qualities are still in good condition. Therefore, the issue will be how to maintain the clean environment, including conservation of the beautiful nature.

[Recommendations]

Recommended Optimum Scenario

Business as usual scenario D (CCGT) is recommendable as the least cost option for the short, medium and long term supply of power. It is also technically feasible and environmentally friendly. The environmental issues are not considered to create unacceptable risks. It could not fully meet the target of the national energy policy, but it is deemed to satisfy the economic efficiency and to alleviate a growing concern to an acceptable level.

The two self sufficiency scenario A and B is not recommendable because of their inferior economic efficiency although they could meet the target of the national energy policy. They would require US$406 million investment for an additional CCGT block compared to corresponding business as usual scenarios D and E in the time horizon.

The extended import scenario C is not recommendable, because with further interconnection with Eskom, Namibia would become still more dependent on one outside supplier to a substantial extent, although it is at the same level as the CCGT scenario D in terms of economy. This should be avoided.

It is recommended to investigate the power system stability thoroughly. A preliminary system study indicates the northern power system would become unstable as the load increases. This suggests that the northern power system might require to be strengthened.

Hydropower business as usual scenario E is ranked the third in economic terms. The annual possible generation would fluctuate with a wide range of ten to one. A long lead time might result in a big disparity between a forecast at the construction decision and the actual demand when completed. These are very risky to operation and finances for NamPower. And there are a lot of environmental issues to be solved. Thus the hydropower scenario is not recommendable in the time horizon. A strong hydropower plant, however, would be required in the northern power system for the system stability in 2020s. And energy saving for prolonged life of Kudu gas field might as well be considered after its kickoff.

Policy, System and Organisation

(1) Electricity Pricing Reform

Concerning the current system of electricity tariff rates described in Chapter 5, the following proposals are to be put forward for immediate discussion.

a) Pricing Method

Pricing method should be set up so that the low income people could pay their charges less expense. The step system according to size of contract (including subdivision of less than 10A) should be considered.

b) Appropriate Tariff

In almost municipalities and local authorities it appears that the electricity tariff is determined after adding on a charge to cover part of the cost of other infrastructure development. Electricity tariff should be made more appropriate by reducing the said additional charge and clarifying the elements that make up the tariff.

(2) Electricity Sector Governance

Study of the following subjects is recommended.

a) Co-ordination of generation and transmission, and distribution operations
b) Beef up staffing of ministries (MME and MRLGH)
c) Long term plan for self-sufficiency in electric power

(3) Human Resource Development

In order to implement the Power Development Master Plan efficiently, development of human resource is indispensable.

a) Short-term measures

- Promotion of overseas training (1-2 years) for young staffs
- Staff exchange between the MME and NamPower
- Invitation of long-term stationed technical instructors from abroad

b) Long-term measures

- Review the school system and raise the rate of receiving education and education level of citizens.
- Select the most capable students and establish scholarship schemes to enable them to receive university education (at home and abroad).

(4) Recommendation for Realization and Implementation of the Master Plan

a) Effective use of Electric Control Board

In order to promote co-operated and balanced development between the power generation and transformation operation and distribution operation, it is essential to make effective use of the Electricity Control Board proposed under the New Electricity Act.

b) Establishment Rural Distribution Board

It is recommended that Regional Distribution Boards be established to carry out promotion and co-ordination work in the development and improvement of electric power distribution in the whole region.

c) Establish special low rate charges.

- Taking the overall regional viewpoint described in b) above, adopt a pricing system whereby low income users pay a cheap rate and high income users (large domestic consumers in the municipalities, etc.) pay a higher rate, in order to achieve greater balance over whole regions.
- Study a special low rate charges or a government subsidy system to low income people.
- Exemption of electricity charge for extremely low income house hold (a certain level of income or less)

Environmental consideration and energy conservation

For hydro-electric power development, attentions must be paid to the nature and social environments. For fossil fuel electric power development projects, selection of the combined cycle gas-fired power plant with high thermal efficiency will be a promising option due to its low air pollution. Therefore, the development of Kudu gas field and its use for gas-fired power plants are very desirable from point of view of environmental consideration.

For remote rural areas, some kind of scattered small scale power generation system may become meaningful. Wind power for water pumping and solar cell power are now being actually utilized by some livestock breeding farmers located at remote areas. A study on the use of wind power in combination with gas-fired thermal power for Walvis Bay area has been carried out currently, and concluded that such use of wind power will be feasible. Therefore, further research and development on effective use of renewable energy is recommended.

JICA