## 9.7 Economic Analysis

An economic analysis for the 5 Scenarios stated in Section 9.3 has been prepared to show the their economic viability. As economic indicators to show the economic merit of the project, the Economic Internal Rate of Return (EIRR), the Net Present Value (NPV) and the Benefit / Cost (B/C) Ratio have been prepared (refer to "Notes").

### 9.7.1 Preconditions for Economic Analysis

The economic indicators mentioned above are calculated under the following conditions.

(1) Scope of Analysis

The analysis covers the comparison of newly incremental economic benefits and newly incremental economic costs which will be derived by the implementation of the proposed projects. In other words the analysis does not include the benefits and costs from the existing power supply system. This means that the electricity supply from Ruacana Hydropower Station is not considered and the existing transmission and distribution lines are regarded as sunk cost.

The scope of economic evaluation is illustrated in Figure 9.1.

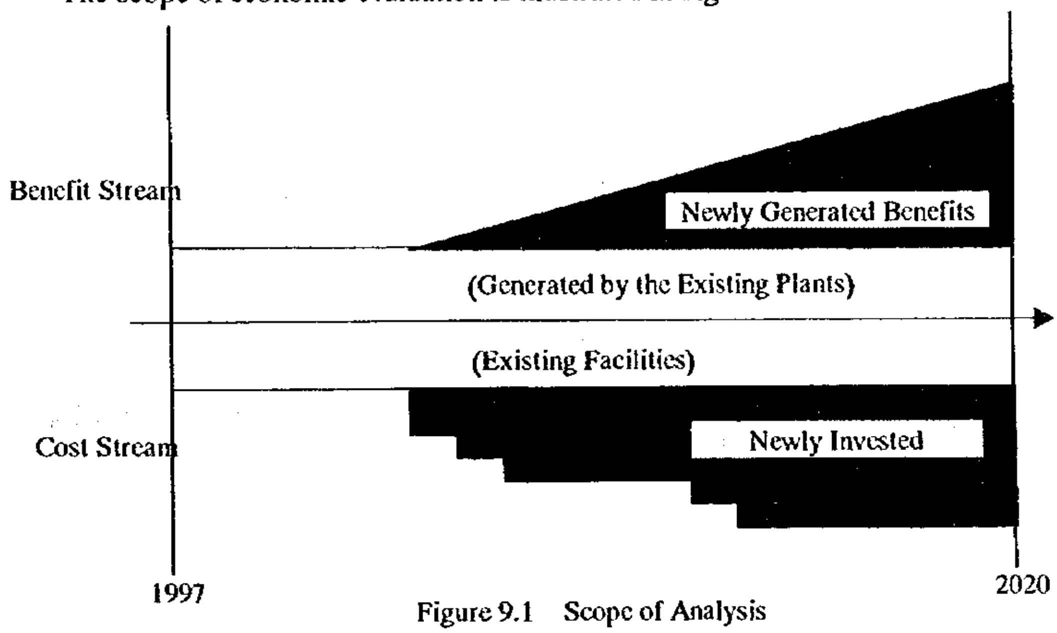



Figure 9.1 Scope of Analysis

Notes

1. The Economic Internal Rate of Return (EIRR): The internal rate of return of a project is defined as that discount rate which equates the present values of the project's benefits and costs, so that the net present value is zero. The decision rule for the IRR criterion is: accept the project if IRR is greater than or equal to relevant discount rate; reject if otherwise. In the case of competing projects, select the project with the highest IRR.
2. Net Present Value (NPV): Net present value is defined as the difference between the present values of project benefits and project costs. The decision rule for the NPV criterion is: accept projects with greater than or equal to 0, and reject if otherwise. In the case of competing projects, select the project with the highest NPV.
3. Benefit-Cost Ratio (B/C): The benefit-cost ratio is the ratio of the present value of gross benefits to the present value of gross costs. The decision rule is: accept projects with B/C greater or equal to 1; reject it otherwise. In the case of competing projects, select the project with the highest B/C.

The economic evaluation will be made for the following 5 Scenarios

- 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

(2) Economic Benefit

The benefit stream will be based upon the electricity consumption during the planned period which will derive from the economic unit price of the electricity.

a) Electricity consumption

The electricity consumption in Chapter 6 is predicted by way of 3 cases such as the "High Growth" Case, the "Moderate Growth" Case and the "Low Growth" Case .

| Case | Electricity Consumption Prediction(GWh) | |
|---|---|---|
| | year 2010 | year 2020 |
| High growth | 6,739 | 10,647 |
| Moderate growth | 4,034 | 5,283 |
| Low growth | 2,724 | 3,255 |

b) Economic unit price

The economic unit price of the electricity is normally assumed by "Users' Willingness to Pay" for the electricity supply service. In a market oriented economy, scale of "Users' Willingness to Pay'' is determined by the quantity and the quality of the service to be provided. In case of electricity price fixed by the tariff policy, "Users' Willingness to Pay" for the electricity service is rather difficult to assume at the market price.

In Namibia, NamPower classifies power into two wholesale electricity prices, one for the large users and the other for the small users. Each municipality and MRLGH also set up their electricity sales price subject to approval of the Ministry of Finance via the MME. The electricity sales price is varies between 28.0~37.0 Nc/kWh depending upon the Municipality. The electricity sales price at Windhoek is 29.0 Nc/kWh. MRLGH sets the rate at 34.0 Nc/kWh for the Pre-payment system and 27.0~29.0 Nc/kWh for other users.

The electricity demand forecast is made for the "High Growth", "Moderate Growth" and "Low Growth" cases divided into categories such as Local Authorities, Mining, Industry, Water, Government & Parastatals, etc.

Since the electricity wholesale price of NamPower is very different for the large users and small users, the economic unit price (calculated price) of the electricity is calculated from the weighted average value of the electricity tariff based upon users' categories until the year 2020.

The economic unit price will be calculated from the following two categories.

Category "A": The users of this category are the large users such as municipalities, local authorities, mines, industry, water, the government & parastatals and foreign consumers. The average wholesale rate of 18.0 Nc/kWh is applied to this category in terms of demand charge of 41.44 N$/month/kVA, energy price of 8 Nc/kWh and load factor of 60%.

Category "B": The users of this category are the small users exclusively. The electricity sales price of 29.0 Nc/kWh is applied to this category.

**Table 9.12 Economic Unit Price (Calculating Price) of Electricity**

| | Estimated Use in 1997 (GWh/yr) | Estimated Use in 2020 (GWh/yr) | Annual Average Use | | Average Price | Weighted Average Value |
|---|---|---|---|---|---|---|
| | | | (GWh/yr) | Proportion of Use | (Nc/kWh) | (Nc/kWh) |
| Moderate Growth | | | | | | |
| Users' Category "A" | 1643 | 4176 | 3180 | 90% | 18 | 16.20 |
| Users' Category "B" | 113 | 567 | 340 | 10% | 29 | 2.90 |
| Total | 1756 | 5283 | 3520 | 100% | | 19.10 |
| High Growth | | | | | | |
| Users' Category "A" | 1644 | 9846 | 5745 | 93% | 18 | 16.74 |
| Users' Category "B" | 113 | 801 | 457 | 7% | 29 | 2.03 |
| Total | 1757 | 10,647 | 6202 | 100% | | 18.77 |
| Low Growth | | | | | | |
| Users' Category "A" | 1639 | 2855 | 2247 | 90% | 18 | 16.20 |
| Users' Category "B" | 113 | 400 | 257 | 10% | 29 | 2.90 |
| Total | 1752 | 3255 | 2504 | 100% | | 19.10 |

As a result of the above, the economic unit price (weighted average value) is set at 4.08USc/kWh (18.77Nc/kWh) in the "High Growth" case and 4.15USc/kWh (19.1Nc/kWh) in the "Moderate Growth" and "Low Growth" cases, at the exchange rate of US$1=N$4.6

c) Export unit price

In this study, several Scenarios are expected to have the capacity to export the electricity. The export unit price of electricity is assumed at 2.5USc/kWh equivalent to the average import price which is calculated from a generating cost of 2.05USc/kWh and the transmission cost.

d) Electricity loss

The electricity transmission loss is assumed as 12% of total energy sales at the terminal point of user because the transmission loss fluctuates between 8~12% at the terminal point of the electricity supply, based on the data provided by NamPower

(3) Economic Cost

The cost stream is derived from the capital costs, the operation and maintenance costs and others related to the proposed projects during the planned period.

a) Capital cost

The economic capital costs of the proposed projects are shown in Table 9.13. IDC is excluded from the project costs estimated at the 1997 international price in Section 9.1.

**Table 9.13 Economic Capital Cost by Project**

(MUS$)

| Project | Power Station | Transmission Line | Total Cost |
|---|---|---|---|
| 400KV Line | | 183.6 | 183.6 |
| CCGT | 308 | 67.0 | 375.0 |
| Epupa | 440 | 98.8 | 539.4 |
| 2×GT | 154 | 67.0 | 221.0 |

b) Project life

The project life is different depending upon the type of project. In this study, the expected life for the proposed projects is assumed as follows.

| | | |
|---|---|---|
| Transmission line | : | 25 years |
| CCGT, 2xGT | : | 20 years |
| Epupa Hydropower station | : | 50 years |

The salvage value of the capital cost of the project shall be calculated after the year 2020.

c) Operation and maintenance cost

The operation and maintenance (O&M) cost is also different according to the type of the project. In this study, O&M cost per annum is applied in the following ratio to the capital cost, based on the value obtained from similar projects.

| | | |
|---|---|---|
| Transmission line | : | 1.8% |
| CCGT, 2xGT | : | 5.5% |
| Epupa Hydropower station | : | 0.5% |

The transmission line project consists of new 400 KV interconnection line with Eskom and new lines between the substations and the power plants to be proposed. O&M cost mainly consists of the salaries of employees and operation and maintenance costs for the transmission lines and substations. In case of the CCGT and GT, O&M cost ratio to the capital cost is relatively high because maintenance cost of the generating plant is higher even if the fuel cost is excluded.

Some 50% of the net construction cost of Epupa hydropower station is accounted for by the civil works for dam. The O&M cost for the civil works is negligible. The O&M cost ratio to the capital cost of the power station should be mainly considered. Therefore the O&M cost ratio to the total capital cost would be rather small.

d) Capacity utilization ratio and fuel cost

The annual electricity generation of CCGT is assumed as 70% of the capacity utilization ratio. The gas price of 1.6 US$/MBtu is assumed from various data. The heat rate of 50.7% is assumed from the average level of a similar plant. Under these conditions, the fuel cost is assumed at 1.08 USc/kWh.

e) Import unit price

The average import price of electricity from Eskom is 2.2USc/kWh. The following economic unit price of the imported electricity is assumed for the case of firm power of 1,740GWh per annum (dry season : 220MW x 3,000h = 660GWh, wet season : 360MW x 3,000h = 1,080GWh)

| | | |
|---|---|---|
| 1997~2005 | : | 1.16USc/kWh (up to 1,740GWh),<br>2.88USc/kWh (over 1,740GWh) |
| 2006~2015 | : | 2.50USc/kWh |
| 2016 onward | : | 3.0USc/kWh |

f) Other economic costs

In the case of Epupa Hydropower station, the land lost due to inundation by the reservoir and the loss of tourism opportunities shall be considered as an economic cost.

In the feasibility study for Epupa Hydropower Station (September 1997),the economic costs assumed are as follows.

a. The value of land inundated is US$2.66 million, to be added to the investment cost and
b. Loss of tourism opportunities is US$0.3 million to be added to O&M cost

(4) Discount Rate

The opportunity cost of capital is basically different according to the type of projects and the countries. The discount rate is very difficult to assume because

information on the opportunity cost of capital for the energy power project is limited in Namibia.
From the viewpoint of the bank interest rate, real rate ranges between 8~11% in current years. The opportunity cost of capital for electric power projects in African countries is regarded as more than 10% by the World Bank and others in general. Therefore a discount rate of 10% is adopted for this study.

### 9.7.2 Economic Analysis for Proposed Scenarios

The economic analysis is made for the "Moderate Growth" and the "High Growth" cases and for a total 10 cases. As the result of analysis, the EIRR of the "High Growth" cases except for Scenario "B", shows more than 18%. The EIRR of all the "High Growth" cases is higher than all the "Moderate Growth" cases. This implies that the investment planning is in accordance with the "High Growth" case and the impact on the export of electricity is a relatively small factor affecting the economic viability.

The economic viability of all Scenarios is almost of the same level except for Scenario "B". Both Scenarios "C" and "D" are very close and show an high level of economic viability. However, there are large discrepancies between Scenario "C" and "D" in terms of a) foreign exchange savings and b) effective utilization of natural resources.
The viability of Scenario "C" mostly depends on electricity import. Therefore Scenario "C" is less advantageous than Scenario "D" in terms of foreign exchange savings.

In the "High Growth" Case, Scenario "D" yields foreign exchange savings of US$26.6 million (N$125million) per annum (different international outpayment amont (US$584million=US$1232-US$648million)/22years) more than Scenario "C" upto the year 2020. This has the effect of changing the deficit in the balance of merchandise trade from N$(-)107 million in the year 1996 to a surplus.

Scenario "D" has the comparative advantage over the Scenario "C" in terms of effective utilization of natural resources as Scenario "D" plans to use Kudu gas for the operation of CCGT. By development of the Kudu gas fields, the Government will be able to secure new financial resources of US$5.8million per annum (gas fuel cost for CCGT: US$46million x 12.5%) as a royalty and a corporate tax from the Kudu IPP Consortium.

Regarding selection of Scenario, it should be noted that not only economic indicators are important but also the lead time of the project, i.e. 9~10 years for Epupa Hydropower station and 2~2.5 years for CCGT. CCGT has the possibility to implement phased development according to the electricity demand.

In the case of Scenario "D", the economic analysis is made for the "Low Growth" case as a reference. The economic indicators show there is not much difference in the gap between the "Moderate Growth" and the "Low Growth" case when compared to the gap between the "Moderate Growth" and the "High Growth" cases

**Table 9.14 Economic Analysis Results for Proposed Scenarios**

| Indicators | Scenarios | Self Sufficiency | | Business As Usual | | |
|---|---|---|---|---|---|---|
| | | A-CCGT | B-Hydro | C-Import | D-CCGT | E-Hydro |
| NPV (MUS$) | High | 282.1 | 168.6 | 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 | - |

The work sheets for the "High Growth" case by Scenario are shown in Tables 9.16~9.20.

### 9.7.3 Sensitivity Analysis

Based upon the results of the economic analysis, sensitivity analysis is made for the "High Growth" case which shows relatively high economic viability. The sensitivity factors and magnitude which affect the project are assumed for the following conditions.

(1) Decreasing Electricity Demand

The electricity demand would be decreased by 10% of expected level or the level in the "Moderate Growth" case.

(2) Increased Capital Cost

The capital cost for the proposed projects would be increased by 10% and 20% each of the expected cost.

(3) Increasing O&M Cost and Fuel Cost of CCGT

The O&M cost and the fuel cost of CCGT would be increased by 10% and 20% of the expected costs. In the case of these costs they would be increased by 10% and 20% in addition to the increase in capital cost

The results of the sensitivity analysis based on the various preconditions are shown in Table 9.15.

## Table 9.15 Sensitivity Analysis for "High Growth" Case

(EIRR: %)

| | CC (+10%) | CC (+20%) | O & M, FC (+10%) | O & M, FC (+20%) | CC, O & M, FC (+10%) | CC, O & M, FC (+20%) |
|---|---|---|---|---|---|---|
| Scenario " A " | 17.2 | 15.8 | 17.7 | 16.6 | 16.2 | 13.8 |
| Demand (-10%) | 11.9 | 10.8 | 12.1 | 10.9 | 10.8 | 8.7 |
| Demand ( "Moderate" ) | 7.3 | * | * | * | * | * |
| Scenario " B " | 13.1 | 12.3 | 13.3 | 12.5 | 12.3 | 10.8 |
| Demand (-10%) | 9.1 | 8.4 | 9.0 | 8.2 | 8.3 | 6.9 |
| Demand ( "Moderate" ) | 5.8 | * | * | * | * | * |
| Scenario " C " | 18.8 | 17.7 | 19.3 | 18.4 | 18.1 | 16.1 |
| Demand (-10%) | 13.4 | 12.5 | 13.5 | 12.6 | 12.5 | 10.8 |
| Demand ( "Moderate" ) | 7.3 | * | * | * | * | * |
| Scenario " D " | 18.8 | 17.5 | 19.3 | 18.4 | 17.9 | 15.9 |
| Demand (-10%) | 13.2 | 12.2 | 13.4 | 12.4 | 12.3 | 10.3 |
| Demand ( "Moderate" ) | 8.9 | * | * | * | * | * |
| Scenario " E " | 18.0 | 16.1 | 17.5 | 17.5 | 16.3 | 14.5 |
| Demand (-10%) | 11.8 | 11.0 | 11.8 | 11.0 | 11.0 | 9.5 |
| Demand ( "Moderate" ) | 7.6 | * | * | * | * | * |

Note: 1. CC: Capital Cost, O&M: Operation & Maintenance cost, FC: Fuel Cost

2. * means "needless to calculate rates because the figures are lower than the figures displayed in the first column."

As a result, decreasing the electricity demand is the most serious factor in the reduction of the EIRR. In case, electricity demand is not changed and the capital cost is increased by 20%, the EIRR will still be more than 10% except for Scenario "B". In other cases, when the electricity demand is not changed, and both the capital cost and the O&M cost including fuel cost, are increased by 10%, the EIRR still shows viability for all Scenarios except Scenario "B".

Consequently, a decrease in electricity demand is the most serious factor to change the economic viability of the project. The EIRR of Scenario "C" and "D" still shows economic viability of the project when the capital cost, O&M and fuel costs are all increased by 20%.

Table 9.16 Economic Analysis Worksheet --- Alternative A: Self Sufficiency-CCGT (High)

| No | Year | Energy Forecast (GWh) | Energy Source and Supply(GWh) Kudu | Ruacana | Hydro | Import | Export | Total | A: Benefit Stream (US$ Million) Dometic Selling | Export | Total | Cost Stream(US$ Million) B: Capital Cost Trans. Line | Power Station | Total | C: Operation Cost Fuel Cost | O & M Cost | Payment for Imort | Total Cost | Balance (A-B-C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1997 | 1757.7 | | | | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1998 | 1920.4 | | | | | | 0 | 0 | 0 | 0 | 45.9 | | 45.9 | 0 | 0 | 0 | 0 | -45.9 |
| 3 | 1999 | 2099.3 | 0 | 1055 | | 1184 | | 2239 | 46.2 | 0 | 46.2 | 91.8 | | 91.8 | 0 | 0.8 | 13.7 | 14.6 | -60.2 |
| 4 | 2000 | 3469.3 | 0 | 1055 | | 2718 | | 3773 | 100.8 | 0 | 100.8 | 45.9 | | 45.9 | 0 | 2.5 | 59.7 | 62.2 | -7.2 |
| 5 | 2001 | 4407.2 | 0 | 1055 | | 3769 | | 4824 | 138.3 | 0 | 138.3 | 33.5 | 154.0 | 187.5 | 0 | 3.3 | 102.2 | 105.5 | -154.7 |
| 6 | 2002 | 4733.4 | 2291 | 1055 | | 1843 | | 5189 | 151.3 | 0 | 151.3 | 33.5 | 154.0 | 187.5 | 24.7 | 12.4 | 24.3 | 61.5 | -97.7 |
| 7 | 2003 | 4850.7 | 3866 | 1055 | | 400 | | 5321 | 156.0 | 0 | 156.0 | | | 0 | 41.8 | 21.5 | 4.6 | 67.8 | 88.1 |
| 8 | 2004 | 4973.4 | 3923 | 1055 | | 480 | | 5458 | 160.9 | 0 | 160.9 | | | 0 | 42.4 | 21.5 | 5.6 | 69.4 | 91.5 |
| 9 | 2005 | 5227.0 | 4047 | 1055 | | 640 | | 5742 | 171.0 | 0 | 171.0 | | | 0 | 43.7 | 21.5 | 7.4 | 72.6 | 98.4 |
| 10 | 2006 | 5697.0 | 4304 | 1055 | | 910 | | 6269 | 189.7 | 0 | 189.7 | | | 0 | 46.5 | 21.5 | 22.8 | 90.7 | 99.0 |
| 11 | 2007 | 6154.8 | 4556 | 1055 | | 1170 | | 6781 | 208.0 | 0 | 208.0 | | | 0 | 49.2 | 21.5 | 29.3 | 99.9 | 108.1 |
| 12 | 2008 | 6413.4 | 4686 | 1055 | | 1330 | | 7071 | 218.3 | 0 | 218.3 | | | 0 | 50.6 | 21.5 | 33.3 | 105.3 | 113.0 |
| 13 | 2009 | 6568.7 | 4760 | 1055 | | 1430 | | 7245 | 224.5 | 0 | 224.5 | 33.5 | 154.0 | 187.5 | 51.4 | 21.5 | 35.8 | 108.6 | -71.6 |
| 14 | 2010 | 6739.0 | 6381 | 1055 | | 0 | 1429 | 8865 | 231.3 | 35.7 | 267.0 | 33.5 | 154.0 | 187.5 | 84.3 | 30.5 | 0 | 114.9 | -35.3 |
| 15 | 2011 | 6936.5 | 6602 | 1055 | | 0 | 1153 | 8810 | 239.2 | 28.8 | 268.0 | | | 0 | 83.8 | 39.6 | 0 | 123.4 | 144.7 |
| 16 | 2012 | 7254.1 | 6957 | 1055 | | 0 | 767 | 8779 | 251.9 | 19.2 | 271.0 | | | 0 | 83.4 | 39.6 | 0 | 123.0 | 148.0 |
| 17 | 2013 | 7790.2 | 7558 | 1055 | | 0 | 159 | 8772 | 273.2 | 4.0 | 277.2 | | | 0 | 83.3 | 39.6 | 0 | 122.9 | 154.3 |
| 18 | 2014 | 8431.3 | 8276 | 1055 | | 0 | 4041 | 13372 | 298.8 | 101.0 | 399.8 | 33.5 | 154.0 | 187.5 | 133.0 | 48.7 | 0 | 181.7 | 30.7 |
| 19 | 2015 | 8871.2 | 8769 | 1055 | | 0 | 3514 | 13338 | 316.4 | 87.9 | 404.2 | 33.5 | 154.0 | 187.5 | 132.7 | 57.7 | 0 | 190.4 | 26.3 |
| 20 | 2016 | 9118.8 | 9040 | 1055 | | 0 | 3169 | 13264 | 326.3 | 79.2 | 405.5 | | | 0 | 131.9 | 57.7 | 0 | 189.6 | 215.9 |
| 21 | 2017 | 9351.9 | 9307 | 1055 | | 0 | 2844 | 13206 | 335.6 | 71.1 | 406.7 | | | 0 | 131.2 | 57.7 | 0 | 189.0 | 217.7 |
| 22 | 2018 | 9592.9 | 9577 | 1055 | | 0 | 2507 | 13139 | 345.2 | 62.7 | 407.8 | | | 0 | 130.5 | 57.7 | 0 | 188.3 | 219.6 |
| 23 | 2019 | 10091.2 | 10135 | 1055 | | 0 | 1919 | 13109 | 365.1 | 48.0 | 413.0 | | | 0 | 130.2 | 57.7 | 0 | 187.9 | 225.1 |
| 24 | 2020 | 10647.4 | 10758 | 1055 | | 0 | 1275 | 13088 | 387.2 | 31.9 | 419.1 | | | -392.0 | 130.0 | 57.7 | 0 | 187.7 | 623.5 |
| Total | | | | | | | | | 5134.9 | 569.4 | 5704.4 | 384.6 | 924.0 | 916.6 | 1604.6 | 713.6 | 338.6 | 2656.7 | 2131.1 |
| | | | | | | | | | | | | | | | | | | NPV | 282.1 |
| | | | | | | | | | | | | | | | | | | B/C | 1.22 |
| | | | | | | | | | | | | | | | | | | EIRR | 18.7% |

Table 9.17 Economic Analysis Worksheet --- AlternativeB: Self Sufficiency-Hydropower (High)

| No | Year | Energy Forecast (GWh) | Energy Source and Supply(GWh) | | | | | | A: Benefit Stream (US$ Million) | | | Cost Stream(US$ Million) | | | | | | | Balance (A-B-C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | B: Capital Cost | | | C: Operation Cost | | | | |
| | | | Kudu | Ruacana | Hydro | Import | Export | Total | Dometic Selling | Export | Total | Trans. Line | Power Station | Total | Fuel Cost | O & M Cost | Payment for Imort | Total Cost | |
| 1 | 1997 | 1757.7 | | | | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1998 | 1920.4 | | | | | | 0 | 0 | 0 | 0 | 45.9 | | 45.9 | 0 | 0 | 0 | 0 | -45.9 |
| 3 | 1999 | 2099.3 | 0 | 1055 | | 1184 | | 2239 | 46.2 | 0 | 46.2 | 91.8 | | 91.8 | 0 | 0.8 | 13.7 | 14.6 | -60.2 |
| 4 | 2000 | 3469.3 | 0 | 1055 | | 2718 | | 3773 | 100.8 | 0 | 100.8 | 45.9 | | 45.9 | 0 | 2.5 | 59.7 | 62.2 | -7.2 |
| 5 | 2001 | 4407.2 | 0 | 1055 | | 3769 | | 4824 | 138.3 | 0 | 138.3 | 33.5 | 154.0 | 187.5 | 0 | 3.3 | 102.2 | 105.5 | -154.7 |
| 6 | 2002 | 4733.4 | 2291 | 1055 | | 1843 | | 5189 | 151.3 | 0 | 151.3 | 33.5 | 156.2 | 189.7 | 24.7 | 12.4 | 24.3 | 61.5 | -99.9 |
| 7 | 2003 | 4850.7 | 3866 | 1055 | | 400 | | 5321 | 156.0 | 0 | 156.0 | | 37.7 | 37.7 | 41.8 | 21.5 | 4.6 | 67.8 | 50.4 |
| 8 | 2004 | 4973.4 | 3923 | 1055 | | 480 | | 5458 | 160.9 | 0 | 160.9 | | 75.4 | 75.4 | 42.4 | 21.5 | 5.6 | 69.4 | 16.1 |
| 9 | 2005 | 5227.0 | 4047 | 1055 | | 640 | | 5742 | 171.0 | 0 | 171.0 | | 88.1 | 88.1 | 43.7 | 21.5 | 7.4 | 72.6 | 10.3 |
| 10 | 2006 | 5697.0 | 4304 | 1055 | | 910 | | 6269 | 189.7 | 0 | 189.7 | | 145.0 | 145.0 | 46.5 | 21.5 | 22.8 | 90.7 | -46.0 |
| 11 | 2007 | 6154.8 | 4556 | 1055 | | 1170 | | 6781 | 208.0 | 0 | 208.0 | 49.4 | 80.2 | 129.6 | 49.2 | 21.5 | 29.3 | 99.9 | -21.5 |
| 12 | 2008 | 6413.4 | 3860 | 1055 | 1730 | 426 | | 7071 | 218.3 | 0 | 218.3 | 49.4 | 11.8 | 61.2 | 41.7 | 23.1 | 10.7 | 75.4 | 81.7 |
| 13 | 2009 | 6568.7 | 3926 | 1055 | 1730 | 534 | | 7245 | 224.5 | 0 | 224.5 | 16.8 | 77.0 | 93.8 | 42.4 | 24.4 | 13.4 | 80.2 | 50.6 |
| 14 | 2010 | 6739.0 | 4651 | 1055 | 1730 | 0 | 1735 | 9171 | 231.3 | 43.4 | 274.7 | 16.8 | 77.0 | 93.8 | 78.1 | 29.0 | 0 | 107.1 | 73.8 |
| 15 | 2011 | 6936.5 | 4872 | 1055 | 1730 | 0 | 1459 | 9116 | 239.2 | 36.5 | 275.7 | | | 0 | 77.2 | 33.5 | 0 | 110.8 | 164.9 |
| 16 | 2012 | 7254.1 | 5227 | 1055 | 1730 | 0 | 1073 | 9085 | 251.9 | 26.8 | 278.7 | | | 0 | 76.7 | 33.5 | 0 | 110.3 | 168.4 |
| 17 | 2013 | 7790.2 | 5827 | 1055 | 1730 | 0 | 466 | 9078 | 273.2 | 11.7 | 284.9 | 16.8 | 77.0 | 93.8 | 76.6 | 33.5 | 0 | 110.1 | 81.0 |
| 18 | 2014 | 8431.3 | 6546 | 1055 | 1730 | 0 | 1281 | 10612 | 298.8 | 32.0 | 330.8 | 16.8 | 77.0 | 93.8 | 101.3 | 38.1 | 0 | 139.4 | 97.7 |
| 19 | 2015 | 8871.2 | 7039 | 1055 | 1730 | 0 | 754 | 10578 | 316.4 | 18.9 | 335.2 | | | 0 | 100.8 | 42.6 | 0 | 143.4 | 191.9 |
| 20 | 2016 | 9118.8 | 7310 | 1055 | 1730 | 0 | 411 | 10506 | 326.3 | 10.3 | 336.5 | | | 0 | 99.6 | 42.6 | 0 | 142.2 | 194.3 |
| 21 | 2017 | 9351.9 | 7577 | 1055 | 1730 | 0 | 86 | 10448 | 335.6 | 2.2 | 337.7 | 16.8 | 77.0 | 93.8 | 98.7 | 42.6 | 0 | 141.3 | 102.7 |
| 22 | 2018 | 9592.9 | 7847 | 1055 | 1730 | 0 | 2815 | 13447 | 345.2 | 70.4 | 415.5 | 16.8 | 77.0 | 93.8 | 122.3 | 47.1 | 0 | 169.4 | 152.4 |
| 23 | 2019 | 10091.2 | 8405 | 1055 | 1730 | 0 | 2226 | 13416 | 365.1 | 55.7 | 420.7 | | | 0 | 121.8 | 51.7 | 0 | 173.4 | 247.3 |
| 24 | 2020 | 10647.4 | 9028 | 1055 | 1730 | 0 | 1582 | 13395 | 387.2 | 39.6 | 426.8 | | | -644.0 | 121.4 | 51.7 | 0 | 173.1 | 897.7 |
| Total | | | | | | | | | 5134.9 | 347.2 | 5482.1 | 450.2 | 1210.4 | 1016.3 | 1406.9 | 619.6 | 293.6 | 2320.1 | 2145.7 |
| | | | | | | | | | | | | | | | | | | NPV | 168.7 |
| | | | | | | | | | | | | | | | | | | B/C | 1.12 |
| | | | | | | | | | | | | | | | | | | EIRR | 14.0% |

Table 9.18 Economic Analysis Worksheet --- Alternative C: Business As Usual Scenario-Extended Import (High)

| No | Year | Energy Forecast (GWh) | Energy Source and Supply(GWh) | | | | | | A: Benefit Stream (US$ Million) | | | Cost Stream(US$ Million) | | | | | | | Balance (A-B-C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | B: Capital Cost | | | C: Operation Cost | | | | |
| | | | Kudu | Ruacana | Hydro | Import | Export | Total | Dometic Selling | Export | Total | Trans. Line | Power Station | Total | Fuel Cost | O & M Cost | Payment for Imort | Total Cost | |
| 1 | 1997 | 1757.7 | | | | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1998 | 1920.4 | | | | | | 0 | 0 | 0 | 0 | 45.9 | | 45.9 | 0 | 0 | 0 | 0 | -45.9 |
| 3 | 1999 | 2099.3 | 0 | 1055 | | 1184 | | 2239 | 46.2 | 0 | 46.2 | 91.8 | | 91.8 | 0 | 0.8 | 13.7 | 14.6 | -60.2 |
| 4 | 2000 | 3469.3 | 0 | 1055 | | 2718 | | 3773 | 100.8 | 0 | 100.8 | 45.9 | | 45.9 | 0 | 2.5 | 59.7 | 62.2 | -7.2 |
| 5 | 2001 | 4407.2 | 0 | 1055 | | 3769 | | 4824 | 138.3 | 0 | 138.3 | 33.5 | 154.0 | 187.5 | 0 | 3.3 | 102.2 | 105.5 | -154.7 |
| 6 | 2002 | 4733.4 | 2291 | 1055 | | 1843 | | 5189 | 151.3 | 0 | 151.3 | 33.5 | 154.0 | 187.5 | 24.7 | 12.4 | 24.3 | 61.5 | -97.7 |
| 7 | 2003 | 4850.7 | 3866 | 1055 | | 400 | | 5321 | 156.0 | 0 | 156.0 | | | 0 | 41.8 | 21.5 | 4.6 | 67.8 | 88.1 |
| 8 | 2004 | 4973.4 | 3923 | 1055 | | 480 | | 5458 | 160.9 | 0 | 160.9 | | | 0 | 42.4 | 21.5 | 5.6 | 69.4 | 91.5 |
| 9 | 2005 | 5227.0 | 4047 | 1055 | | 640 | | 5742 | 171.0 | 0 | 171.0 | | | 0 | 43.7 | 21.5 | 7.4 | 72.6 | 98.4 |
| 10 | 2006 | 5697.0 | 4304 | 1055 | | 910 | | 6269 | 189.7 | 0 | 189.7 | | | 0 | 46.5 | 21.5 | 22.8 | 90.7 | 99.0 |
| 11 | 2007 | 6154.8 | 4556 | 1055 | | 1170 | | 6781 | 208.0 | 0 | 208.0 | | | 0 | 49.2 | 21.5 | 29.3 | 99.9 | 108.1 |
| 12 | 2008 | 6413.4 | 4686 | 1055 | | 1330 | | 7071 | 218.3 | 0 | 218.3 | | | 0 | 50.6 | 21.5 | 33.3 | 105.3 | 113.0 |
| 13 | 2009 | 6568.7 | 4760 | 1055 | | 1430 | | 7245 | 224.5 | 0 | 224.5 | | | 0 | 51.4 | 21.5 | 35.8 | 108.6 | 115.9 |
| 14 | 2010 | 6739.0 | 4831 | 1055 | | 1550 | | 7436 | 231.3 | 0 | 231.3 | | | 0 | 52.2 | 21.5 | 38.8 | 112.4 | 118.9 |
| 15 | 2011 | 6936.5 | 4912 | 1055 | | 1690 | | 7657 | 239.2 | 0 | 239.2 | | | 0 | 53.0 | 21.5 | 42.3 | 116.8 | 122.4 |
| 16 | 2012 | 7254.1 | 5082 | 1055 | | 1875 | | 8012 | 251.9 | 0 | 251.9 | | | 0 | 54.9 | 21.5 | 46.9 | 123.2 | 128.6 |
| 17 | 2013 | 7790.2 | 5388 | 1055 | | 2170 | | 8613 | 273.2 | 0 | 273.2 | 91.8 | | 91.8 | 58.2 | 21.5 | 54.3 | 133.9 | 47.6 |
| 18 | 2014 | 8431.3 | 5756 | 1055 | | 2520 | | 9331 | 298.8 | 0 | 298.8 | 91.8 | | 91.8 | 62.2 | 23.1 | 63.0 | 148.3 | 58.8 |
| 19 | 2015 | 8871.2 | 5913 | 1055 | | 2825 | | 9793 | 316.4 | 0 | 316.4 | | | 0 | 63.9 | 24.8 | 70.6 | 159.2 | 157.1 |
| 20 | 2016 | 9118.8 | 5913 | 1055 | | 3133 | | 10101 | 326.3 | 0 | 326.3 | | | 0 | 63.9 | 24.8 | 94.0 | 182.6 | 143.6 |
| 21 | 2017 | 9351.9 | 5913 | 1055 | | 3394 | | 10362 | 335.6 | 0 | 335.6 | | | 0 | 63.9 | 24.8 | 101.8 | 190.4 | 145.1 |
| 22 | 2018 | 9592.9 | 5913 | 1055 | | 3664 | | 10632 | 345.2 | 0 | 345.2 | | | 0 | 63.9 | 24.8 | 109.9 | 198.5 | 146.6 |
| 23 | 2019 | 10091.2 | 5913 | 1055 | | 4222 | | 11190 | 365.1 | 0 | 365.1 | | | 0 | 63.9 | 24.8 | 126.7 | 215.3 | 149.8 |
| 24 | 2020 | 10647.4 | 5913 | 1055 | | 4845 | | 11813 | 387.2 | 0 | 387.2 | | | -160.6 | 63.9 | 24.8 | 145.4 | 234.0 | 313.9 |
| Total | | | | | | | | | 5134.9 | 0 | 5134.9 | 434.2 | 308.0 | 581.6 | 1013.9 | 426.6 | 1232.1 | 2672.5 | 1880.8 |
| | | | | | | | | | | | | | | | | | | NPV | 305.6 |
| | | | | | | | | | | | | | | | | | | B/C | 1.26 |
| | | | | | | | | | | | | | | | | | | EIRR | 20.3% |

Table 9.19 Economic Analysis Worksheet --- Alternative D: Business As Usual Scenario-CCGT (High)

| No | Year | Energy Forecast (GWh) | Energy Source and Supply(GWh) | | | | | | A: Benefit Stream (US$ Million) | | | Cost Stream(US$ Million) | | | | | | | | Balance (A-B-C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | B: Capital Cost | | | C: Operation Cost | | | | | |
| | | | Kudu | Ruacana | Hydro | Import | Export | Total | Dometic Selling | Export | Total | Trans. Line | Power Station | Total | Fuel Cost | O & M Cost | Payment for Imort | Total Cost | |
| 1 | 1997 | 1757.7 | | | | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1998 | 1920.4 | | | | | | 0 | 0 | 0 | 0 | 45.9 | | 45.9 | 0 | 0 | 0 | 0 | -45.9 |
| 3 | 1999 | 2099.3 | 0 | 1055 | | 1184 | | 2239 | 46.2 | 0 | 46.2 | 91.8 | | 91.8 | 0 | 0.8 | 13.7 | 14.6 | -60.2 |
| 4 | 2000 | 3469.3 | 0 | 1055 | | 2718 | | 3773 | 100.8 | 0 | 100.8 | 45.9 | | 45.9 | 0 | 2.5 | 59.7 | 62.2 | -7.2 |
| 5 | 2001 | 4407.2 | 0 | 1055 | | 3769 | | 4824 | 138.3 | 0 | 138.3 | 33.5 | 154.0 | 187.5 | 0 | 3.3 | 102.2 | 105.5 | -154.7 |
| 6 | 2002 | 4733.4 | 2291 | 1055 | | 1843 | | 5189 | 151.3 | 0 | 151.3 | 33.5 | 154.0 | 187.5 | 24.7 | 12.4 | 24.3 | 61.5 | -97.7 |
| 7 | 2003 | 4850.7 | 3866 | 1055 | | 400 | | 5321 | 156.0 | 0 | 156.0 | | | 0 | 41.8 | 21.5 | 4.6 | 67.8 | 88.1 |
| 8 | 2004 | 4973.4 | 3923 | 1055 | | 480 | | 5458 | 160.9 | 0 | 160.9 | | | 0 | 42.4 | 21.5 | 5.6 | 69.4 | 91.5 |
| 9 | 2005 | 5227.0 | 4047 | 1055 | | 640 | | 5742 | 171.0 | 0 | 171.0 | | | 0 | 43.7 | 21.5 | 7.4 | 72.6 | 98.4 |
| 10 | 2006 | 5697.0 | 4304 | 1055 | | 910 | | 6269 | 189.7 | 0 | 189.7 | | | 0 | 46.5 | 21.5 | 22.8 | 90.7 | 99.0 |
| 11 | 2007 | 6154.8 | 4556 | 1055 | | 1170 | | 6781 | 208.0 | 0 | 208.0 | | | 0 | 49.2 | 21.5 | 29.3 | 99.9 | 108.1 |
| 12 | 2008 | 6413.4 | 4686 | 1055 | | 1330 | | 7071 | 218.3 | 0 | 218.3 | | | 0 | 50.6 | 21.5 | 33.3 | 105.3 | 113.0 |
| 13 | 2009 | 6568.7 | 4760 | 1055 | | 1430 | | 7245 | 224.5 | 0 | 224.5 | | | 0 | 51.4 | 21.5 | 35.8 | 108.6 | 115.9 |
| 14 | 2010 | 6739.0 | 4831 | 1055 | | 1550 | | 7436 | 231.3 | 0 | 231.3 | | | 0 | 52.2 | 21.5 | 38.8 | 112.4 | 118.9 |
| 15 | 2011 | 6936.5 | 4912 | 1055 | | 1690 | | 7657 | 239.2 | 0 | 239.2 | | | 0 | 53.0 | 21.5 | 42.3 | 116.8 | 122.4 |
| 16 | 2012 | 7254.1 | 5082 | 1055 | | 1875 | | 8012 | 251.9 | 0 | 251.9 | 33.5 | 154.0 | 187.5 | 54.9 | 21.5 | 46.9 | 123.2 | -58.9 |
| 17 | 2013 | 7790.2 | 7399 | 1055 | | 159 | | 8613 | 273.2 | 0 | 273.2 | 33.5 | 154.0 | 187.5 | 79.9 | 30.5 | 4.0 | 114.4 | -28.7 |
| 18 | 2014 | 8431.3 | 8003 | 1055 | | 273 | | 9331 | 298.8 | 0 | 298.8 | | | 0 | 86.4 | 39.6 | 6.8 | 132.9 | 166.0 |
| 19 | 2015 | 8871.2 | 8253 | 1055 | | 516 | | 9824 | 316.4 | 0 | 316.4 | | | 0 | 89.1 | 39.6 | 12.9 | 141.6 | 174.7 |
| 20 | 2016 | 9118.8 | 8374 | 1055 | | 672 | | 10101 | 326.3 | 0 | 326.3 | | | 0 | 90.4 | 39.6 | 20.2 | 150.2 | 176.1 |
| 21 | 2017 | 9351.9 | 8491 | 1055 | | 816 | | 10362 | 335.6 | 0 | 335.6 | | | 0 | 91.7 | 39.6 | 24.5 | 155.8 | 179.8 |
| 22 | 2018 | 9592.9 | 8611 | 1055 | | 966 | | 10632 | 345.2 | 0 | 345.2 | | | 0 | 93.0 | 39.6 | 29.0 | 161.6 | 183.6 |
| 23 | 2019 | 10091.2 | 8893 | 1055 | | 1242 | | 11190 | 365.1 | 0 | 365.1 | | | 0 | 96.0 | 39.6 | 37.3 | 172.9 | 192.2 |
| 24 | 2020 | 10647.4 | 9201 | 1055 | | 1557 | | 11813 | 387.2 | 0 | 387.2 | | | -221.6 | 99.4 | 39.6 | 46.7 | 185.7 | 423.2 |
| Total | | | | | | | | | 5134.9 | 0 | 5134.9 | 317.6 | 616.0 | 712.0 | 1236.4 | 541.2 | 647.7 | 2425.3 | 1997.6 |
| | | | | | | | | | | | | | | | | | | NPV | 301.4 |
| | | | | | | | | | | | | | | | | | | B/C | 1.26 |
| | | | | | | | | | | | | | | | | | | EIRR | 19.9% |

## Table 9.20 Economic Analysis Worksheet --- Alternative E: Business As Usual Scenario-Hydropower (High)

| No | Year | Energy Forecast (GWh) | Energy Source and Supply(GWh) | | | | | | A: Benefit Stream (US$ Million) | | | Cost Stream(US$ Million) | | | | | | | Balance (A-B-C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | B: Capital Cost | | | C: Operation Cost | | | | |
| | | | Kudu | Ruacana | Hydro | Import | Export | Total | Dometic Selling | Export | Total | Trans. Line | Power Station | Total | Fuel Cost | O & M Cost | Payment for Imort | Total Cost | |
| 1 | 1997 | 1757.7 | | | | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1998 | 1920.4 | | | | | | 0 | 0 | 0 | 0 | 45.9 | | 45.9 | 0 | 0 | 0 | 0 | -45.9 |
| 3 | 1999 | 2099.3 | 0 | 1055 | | 1184 | | 2239 | 46.2 | 0 | 46.2 | 91.8 | | 91.8 | 0 | 0.8 | 13.7 | 14.6 | -60.2 |
| 4 | 2000 | 3469.3 | 0 | 1055 | | 2718 | | 3773 | 100.8 | 0 | 100.8 | 45.9 | | 45.9 | 0 | 2.5 | 59.7 | 62.2 | -7.2 |
| 5 | 2001 | 4407.2 | 0 | 1055 | | 3769 | | 4824 | 138.3 | 0 | 138.3 | 33.5 | 154.0 | 187.5 | 0 | 3.3 | 102.2 | 105.5 | -154.7 |
| 6 | 2002 | 4733.4 | 2291 | 1055 | | 1843 | | 5189 | 151.3 | 0 | 151.3 | 33.5 | 154.0 | 187.5 | 24.7 | 12.4 | 24.3 | 61.5 | -97.7 |
| 7 | 2003 | 4850.7 | 3866 | 1055 | | 400 | | 5321 | 156.0 | 0 | 156.0 | | | 0 | 41.8 | 21.5 | 4.6 | 67.8 | 88.1 |
| 8 | 2004 | 4973.4 | 3923 | 1055 | | 480 | | 5458 | 160.9 | 0 | 160.9 | | | 0 | 42.4 | 21.5 | 5.6 | 69.4 | 91.5 |
| 9 | 2005 | 5227.0 | 4047 | 1055 | | 640 | | 5742 | 171.0 | 0 | 171.0 | | | 0 | 43.7 | 21.5 | 7.4 | 72.6 | 98.4 |
| 10 | 2006 | 5697.0 | 4304 | 1055 | | 910 | | 6269 | 189.7 | 0 | 189.7 | | | 0 | 46.5 | 21.5 | 22.8 | 90.7 | 99.0 |
| 11 | 2007 | 6154.8 | 4556 | 1055 | | 1170 | | 6781 | 208.0 | 0 | 208.0 | | 2.2 | 2.2 | 49.2 | 21.5 | 29.3 | 99.9 | 105.9 |
| 12 | 2008 | 6413.4 | 4686 | 1055 | | 1330 | | 7071 | 218.3 | 0 | 218.3 | | 37.7 | 37.7 | 50.6 | 21.5 | 33.3 | 105.3 | 75.3 |
| 13 | 2009 | 6568.7 | 4760 | 1055 | | 1430 | | 7245 | 224.5 | 0 | 224.5 | | 75.4 | 75.4 | 51.4 | 21.5 | 35.8 | 108.6 | 40.5 |
| 14 | 2010 | 6739.0 | 4831 | 1055 | | 1550 | | 7436 | 231.3 | 0 | 231.3 | | 88.1 | 88.1 | 52.2 | 21.5 | 38.8 | 112.4 | 30.8 |
| 15 | 2011 | 6936.5 | 4912 | 1055 | | 1690 | | 7657 | 239.2 | 0 | 239.2 | | 145.0 | 145.0 | 53.0 | 21.5 | 42.3 | 116.8 | -22.6 |
| 16 | 2012 | 7254.1 | 5082 | 1055 | | 1875 | | 8012 | 251.9 | 0 | 251.9 | 49.4 | 80.2 | 129.6 | 54.9 | 21.5 | 46.9 | 123.2 | -1.0 |
| 17 | 2013 | 7790.2 | 4826 | 1055 | 1730 | 1272 | | 8883 | 273.2 | 0 | 273.2 | 49.4 | 11.8 | 61.2 | 52.1 | 23.1 | 31.8 | 107.0 | 105.0 |
| 18 | 2014 | 8431.3 | 4923 | 1055 | 1730 | 1623 | | 9331 | 298.8 | 0 | 298.8 | | | 0 | 53.2 | 24.4 | 40.6 | 118.2 | 180.6 |
| 19 | 2015 | 8871.2 | 5173 | 1055 | 1730 | 1811 | | 9769 | 316.4 | 0 | 316.4 | | | 0 | 55.9 | 24.4 | 45.3 | 125.6 | 190.8 |
| 20 | 2016 | 9118.8 | 5094 | 1055 | 1730 | 2049 | 0 | 9928 | 326.3 | 0 | 326.3 | 16.8 | 77.0 | 93.8 | 55.0 | 24.4 | 61.5 | 140.9 | 91.6 |
| 21 | 2017 | 9351.9 | 6911 | 1055 | 1730 | 708 | 0 | 10404 | 335.6 | 0 | 335.6 | 16.8 | 77.0 | 93.8 | 86.6 | 29.0 | 21.2 | 136.8 | 105.0 |
| 22 | 2018 | 9592.9 | 7031 | 1055 | 1730 | 873 | 0 | 10689 | 345.2 | 0 | 345.2 | | | 0 | 88.5 | 33.5 | 26.2 | 148.2 | 197.0 |
| 23 | 2019 | 10091.2 | 7313 | 1055 | 1730 | 1161 | 0 | 11259 | 365.1 | 0 | 365.1 | | | 0 | 93.0 | 33.5 | 34.8 | 161.4 | 203.7 |
| 24 | 2020 | 10647.4 | 7621 | 1055 | 1730 | 1476 | 0 | 11882 | 387.2 | 0 | 387.2 | | | -565.2 | 98.0 | 33.5 | 44.3 | 175.8 | 776.6 |
| Total | | | | | | | | | 5134.9 | 0 | 5134.9 | 382.9 | 902.4 | 720.1 | 1092.7 | 459.5 | 772.1 | 2324.3 | 2090.5 |
| | | | | | | | | | | | | | | | | | | NPV | 266.1 |
| | | | | | | | | | | | | | | | | | | B/C | 1.22 |
| | | | | | | | | | | | | | | | | | | EIRR | 18.3% |

## 9.8 Investment Planning and Financial Analysis

### 9.8.1 Investment Planning

According to the results of the economic analysis, the investment cost for the "High Growth" case of Scenario "D" is calculated and its investment plan is prepared.

(1) Project Cost

The project cost (fixed capital cost) of Scenario "D" consists of the costs of the 400kV transmission line and CCGT. The domestic market price (N$) is calculated a both for the machinery and equipment portion which is deemed as the foreign portion. To this added 5% of customs duty to the international market price (US$) which was computed from the economic price mentioned earlier and a local portion (N$) for installation works.

**Table 9.21 Capital Cost of Scenario "D"**

| | 400KV Transmission Line | | CCGT | |
|---|---|---|---|---|
| | Foreign Portion (MUS$) | Local Portion (MN$) | Foreign Portion (MUS$) | Local Portion (MN$) |
| a)Plant Equipment Cost | 174.42 | 40.1 | 318.75 | 73.3 |
| b)Installation Cost | - | 42.2 | - | 258.8 |
| Subtotal (a+b) | 174.42 | 82.3 | 318.75 | 332.1 |
| Total (MN$) | 884.6 | | 1,798.4 | |

Note: 1. Prices: Prices are estimated at constant 1997 prices.

2. Exchange Rates: Namibian dollar (N$) 4.6 equivalent to US$ 1.

(2) Project implementation:

The projects will be implemented in accordance with the demand forecast, i.e. 400kV transmission line from Kokerboom to Auas is expected to be completed by May 2000 and CCGT with transmission line is expected to be completed in two phases by the end of 2002 and 2013 respectively.

**Table 9.22 Investment Plan**

(MN$)

| | 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 |

### 9.8.2 Preconditions for Financial Analysis

The following preconditions for financial analysis are assumed through discussion with the Namibian side.

(1) Financial Revenues

a) Electricity sales:

Electricity sales are the same as in the economic analysis.

b) Electricity tariff:

The electricity tariff of NamPower for large users is assumed at 17.93 Nc/kWh (3.89USc/kWh).

(2) Expenditures

a) Fuel cost

Fuel gas cost is assumed at 7.0Nc/kWh at the 1977 market price.

b) O&M cost

For calculation of O&M cost (fixed and variable cost), the following annual ratios are applied to the capital cost.

Transmission line : 1.8%

CCGT, 2xGT : 5.5%

Epupa Hydropower station : 0.5%

c) Import prices:*

The import prices of electricity from Eskom are assumed as follows.

| | | |
|---|---|---|
| 1997~2005 | : | 5.5Nc/kWh (up to 1,740GWh), 13.5Nc/kWh (over 1,740GWh) |
| 2006~2015 | : | 11.8Nc/kWh |
| 2016 onward | : | 14.1Nc/kWh |

d) Depreciation

Depreciation is calculated by the straight line method as per NamPower accounting system and the durable life of the capital investments are as follows.

| | | |
|---|---|---|
| Transmission line | : | 25 years |
| Power plant | : | 20 years |
| Civil and building works | : | 50 years |

e) Borrowing of capital

Long term borrowing of capital may be required when shortage of capital occurs during implementation of the proposed projects. The borrowing conditions of the capital are fixed as follows.

| | | |
|---|---|---|
| Repayment | : | 20 years (including 5 years grace period) |
| Interest | : | 6% per annum at US$ rates |

f) Tax

Tax is assumed at 35% of net income (operating revenue-operating expense and interest) according to the past records of NamPower's financial reports.

g) Working capital

The working capital is allocated for 2 months of expenditures

h) Discount rate

Discount rate is applied with 10% from the viewpoint of current bank's lending rate (20%) and inflation rate (8~9% per annum).

* Recent development in South Africa was taken into consideration. Preparations for the restructuring of Eskom has been begun. It is seen as a first step towards eventual privatization. Parliament has begun a series of public hearings on the Eskom amendment bill to define ownership of the company and transform it into a tax and dividend-paying corporate entity. Eskom currently does not pay tax and dividend, but this situation is to be reversed, eventually pushing up the electricity tariff. And there might be increasing environmental restrictions against Eskom's coal-fired power plants without de-SOx and de-NOx facilities. These situations could eventually push up the tariff for imported electricity. And it is unknown how much Kudu output is considered in firm power calculation in the power purchase agreement on completion of Kudu power station. This also affects the electricity price.

### 9.8.3 Financial Cash Flow

The financial analysis for the project (Case "High Growth" of Scenario "D") is made under the assumptions stated above (refer to Table 9.23). The Financial Internal Rate of Return (FIRR) shows 16.5%.

The projected revenue and expenditure statement and the projected fund flow statement are also prepared respectively in terms of NamPower as the project executor (refer to Table 9.24and Table 9.25).

In this financial planning, long term borrowing for the years 1998~2002 will be required for 85% of all capital costs from foreign loans and the remaining 15% will be self-financed. Long term borrowing for the years 2012~2013 will be required for 20% of the total capital cost because the internal cash reserve is to be increased.

As a result, the debt service coverage shows more than 1.5 until the year 2020. The return on investment (ROI) also is roughly between 20~30%. Therefore financial soundness is verified for the project implementation.

The financial indicators such as return on investment(ROI), debt service coverage are calculated by the following formulas.

| | |
|---|---|
| Return on Investment (%) = | Net Profit/(Long Term Borrowing + Equity Capital) |
| Debt Service Coverage (times) = | Internal Cash Generation/Debt Service (Repayment + Interest ) |

### 9.8.4 Sources of Finance

Kudu CCGT project will be the largest project in Namibia with the total investment of 400 MUS$ and its financing is very important. The draft energy white papers mentions the following and promote a dialog with private investors and financiers: "The electricity sector faces considerable financing needs related to necessary system expansion, development of new Namibian generating sources, and continuation of the rural electrification programme. It is unlikely that the required financial resources can be mobilised from public sectors. Private sector involvement may therefore be required in the form, for instance of Independent Power Producers (IPPs)."

There has been a basic agreement on set up of IPPs regarding Kudu project between NamPower, Eskom, Shell Power and National power UK and equity share, power distribution and IPP operation are under discussion. However the contents are closed.

Procurement of information and study were done under the restriction that NamPower's generation mix, its costing and finance was confidential to the Study team. Accordingly a discussion about the financing and operation with the Namibian side was impossible. The description of NamPower as the project prosecutor in section 9.8.2 is a provisional measure. And it is not deemed that there is a large disparity in the financial analysis between NamPower and IPP as the project executor.

Table9.23 Financial Analysis Worksheet --- Alternative D: Business As Usual Scenario-CCGT (High)

| No | Year | Energy Forecast (GWh) | Energy Source and Supply(GWh) | | | | | | A: Benefit Stream (N$ Million) | | | Cost Stream(N$ Million) | | | | | | | Balance (A-B-C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | B: Capital Cost | | | C: Operation Cost | | | | |
| | | | Kudu | Ruacana | Hydro | Import | Export | Total | Dometic Selling | Export | Total | Trans. Line | Power Station | Total | Fuel Cost | O & M Cost | Payment for Imort | Total Cost | |
| 1 | 1997 | 1757.7 | | | | | | 0.0 | 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 | 1998 | 1920.4 | | | | | | 0.0 | 0.0 | 0.0 | 0.0 | 221.2 | | 221.2 | 0.0 | 0.0 | 0.0 | 0.0 | -221.2 |
| 3 | 1999 | 2099.3 | 0 | 1055 | | 1184 | | 2239.0 | 217.2 | 0.0 | 217.2 | 442.2 | | 442.2 | 0.0 | 4.4 | 65.1 | 69.5 | -294.5 |
| 4 | 2000 | 3469.3 | 0 | 1055 | | 2718 | | 3773.0 | 474.4 | 0.0 | 474.4 | 221.2 | | 221.2 | 0.0 | 13.3 | 281.5 | 294.8 | -41.6 |
| 5 | 2001 | 4407.2 | 0 | 1055 | | 3769 | | 4824.0 | 650.4 | 0.0 | 650.4 | 160.6 | 738.6 | 899.2 | 0.0 | 17.7 | 481.2 | 498.9 | -747.7 |
| 6 | 2002 | 4733.4 | 2291 | 1055 | | 1843 | | 5189.0 | 711.7 | 0.0 | 711.7 | 160.6 | 738.6 | 899.2 | 116.3 | 73.2 | 115.3 | 304.8 | -492.3 |
| 7 | 2003 | 4850.7 | 3866 | 1055 | | 400 | | 5321.0 | 733.7 | 0.0 | 733.7 | | | 0.0 | 196.2 | 128.7 | 22.0 | 347.0 | 386.7 |
| 8 | 2004 | 4973.4 | 3923 | 1055 | | 480 | | 5458.0 | 756.7 | 0.0 | 756.7 | | | 0.0 | 199.1 | 128.7 | 26.4 | 354.3 | 402.4 |
| 9 | 2005 | 5227 | 4047 | 1055 | | 640 | | 5742.0 | 804.3 | 0.0 | 804.3 | | | 0.0 | 205.4 | 128.7 | 35.2 | 369.4 | 434.9 |
| 10 | 2006 | 5697 | 4304 | 1055 | | 910 | | 6269.0 | 892.5 | 0.0 | 892.5 | | | 0.0 | 218.5 | 128.7 | 107.4 | 454.6 | 437.9 |
| 11 | 2007 | 6154.8 | 4556 | 1055 | | 1170 | | 6781.0 | 978.4 | 0.0 | 978.4 | | | 0.0 | 231.3 | 128.7 | 138.1 | 498.1 | 480.4 |
| 12 | 2008 | 6413.4 | 4686 | 1055 | | 1330 | | 7071.0 | 1027.0 | 0.0 | 1027.0 | | | 0.0 | 237.9 | 128.7 | 156.9 | 523.5 | 503.4 |
| 13 | 2009 | 6568.7 | 4760 | 1055 | | 1430 | | 7245.0 | 1056.1 | 0.0 | 1056.1 | | | 0.0 | 241.6 | 128.7 | 168.7 | 539.1 | 517.0 |
| 14 | 2010 | 6739 | 4831 | 1055 | | 1550 | | 7436.0 | 1088.1 | 0.0 | 1088.1 | | | 0.0 | 245.2 | 128.7 | 182.9 | 556.9 | 531.2 |
| 15 | 2011 | 6936.5 | 4912 | 1055 | | 1690 | | 7657.0 | 1125.2 | 0.0 | 1125.2 | | | 0.0 | 249.3 | 128.7 | 199.4 | 577.5 | 547.7 |
| 16 | 2012 | 7254.1 | 5082 | 1055 | | 1875 | | 8012.0 | 1184.8 | 0.0 | 1184.8 | 160.6 | 738.6 | 899.2 | 258.0 | 128.7 | 221.3 | 608.0 | -322.4 |
| 17 | 2013 | 7790.2 | 7399 | 1055 | | 159 | | 8613.0 | 1285.4 | 0.0 | 1285.4 | 160.6 | 738.6 | 899.2 | 375.6 | 184.3 | 18.8 | 578.6 | -192.4 |
| 18 | 2014 | 8431.3 | 8003 | 1055 | | 273 | | 9331.0 | 1405.7 | 0.0 | 1405.7 | | | 0.0 | 406.2 | 239.8 | 32.2 | 678.2 | 727.5 |
| 19 | 2015 | 8871.2 | 8253 | 1055 | | 516 | | 9824.0 | 1488.3 | 0.0 | 1488.3 | | | 0.0 | 418.9 | 239.8 | 60.9 | 719.6 | 768.7 |
| 20 | 2016 | 9118.8 | 8374 | 1055 | | 672 | | 10101.0 | 1534.8 | 0.0 | 1534.8 | | | 0.0 | 425.1 | 239.8 | 94.8 | 759.6 | 775.2 |
| 21 | 2017 | 9351.9 | 8491 | 1055 | | 816 | | 10362.0 | 1578.5 | 0.0 | 1578.5 | | | 0.0 | 431.0 | 239.8 | 115.1 | 785.8 | 792.7 |
| 22 | 2018 | 9592.9 | 8611 | 1055 | | 966 | | 10632.0 | 1623.8 | 0.0 | 1623.8 | | | 0.0 | 437.1 | 239.8 | 136.2 | 813.1 | 810.7 |
| 23 | 2019 | 10091.2 | 8893 | 1055 | | 1242 | | 11190.0 | 1717.3 | 0.0 | 1717.3 | | | 0.0 | 451.4 | 239.8 | 175.1 | 866.3 | 851.0 |
| 24 | 2020 | 10647.4 | 9201 | 1055 | | 1557 | | 11813.0 | 1821.7 | 0.0 | 1821.7 | | | -1127.6 | 467.0 | 239.8 | 219.5 | 926.4 | 2022.9 |
| Total | | | | | | | | | 24156.1 | 0.0 | 24156.1 | 1527.0 | 2954.4 | 3353.8 | 5811.2 | 3258.8 | 3053.9 | 12123.9 | 8678.4 |
| | | | | | | | | | | | | | | | | | | NPV | 1193.5 |
| | | | | | | | | | | | | | | | | | | B/C | 1.21 |
| | | | | | | | | | | | | | | | | | | FIRR | 18.2% |

Table 9.24 Projected Revenue and Expenditure Statements (Scenario "D"--High Growth)

N$ million

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Operating Revenue** | **0** | **0** | **207.5** | **453.2** | **621.3** | **679.8** | **700.8** | **722.8** | **768.3** | **852.6** | **934.7** | **981.0** | **1008.9** | **1039.4** |
| 1) Domestic Selling | 0 | 0 | 207.5 | 453.2 | 621.3 | 679.8 | 700.8 | 722.8 | 768.3 | 852.6 | 934.7 | 981.0 | 1008.9 | 1039.4 |
| 2) Export | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **B. Operating Expenses** | **0** | **0** | **69.5** | **316.9** | **543.1** | **349.0** | **481.1** | **488.4** | **503.5** | **531.4** | **558.5** | **573.9** | **583.2** | **593.4** |
| 1) Fuel Cost | 0 | 0 | 0 | 0 | 0 | 116.3 | 196.2 | 199.1 | 205.4 | 218.5 | 231.3 | 237.9 | 241.6 | 245.2 |
| 2) O & M Cost | 0 | 0 | 4.4 | 13.3 | 17.7 | 73.2 | 128.7 | 128.7 | 128.7 | 128.7 | 128.7 | 128.7 | 128.7 | 128.7 |
| 3) International Outpayment (Import) | 0 | 0 | 65.1 | 281.5 | 481.2 | 115.3 | 22.0 | 26.4 | 35.2 | 50.1 | 64.4 | 73.2 | 78.7 | 85.3 |
| 4) Depreciation | 0 | 0 | 0 | 22.1 | 44.2 | 44.2 | 134.2 | 134.2 | 134.2 | 134.2 | 134.2 | 134.2 | 134.2 | 134.2 |
| **C. Operating Income (A-B)** | **0** | **0** | **138.0** | **136.2** | **78.2** | **330.8** | **219.7** | **234.4** | **264.8** | **321.2** | **376.2** | **407.1** | **425.7** | **446.0** |
| Less : Interest | 0 | 0 | 11.3 | 33.8 | 45.1 | 91.0 | 136.8 | 107.3 | 136.1 | 133.9 | 131.1 | 125.4 | 117.0 | 109.2 |
| **D. Net Income Befor Tax** | **0** | **0** | **126.7** | **102.4** | **33.1** | **239.8** | **82.9** | **127.1** | **128.7** | **187.3** | **245.1** | **281.7** | **308.7** | **336.8** |
| Tax (35%) | 0 | 0 | 44.3 | 35.8 | 11.6 | 83.9 | 29.0 | 44.5 | 45.0 | 65.6 | 85.8 | 98.6 | 108.0 | 84.2 |
| **E. Net Income Before Interest** | **0** | **0** | **93.6** | **100.4** | **66.6** | **246.9** | **190.7** | **189.9** | **219.7** | **255.6** | **290.4** | **308.5** | **317.7** | **361.8** |

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Operating Revenue** | **1074.8** | **1132** | **1228** | **1343** | **1422** | **1466** | **1508** | **1551** | **1640** | **1740.2** | | | | |
| 1) Domestic Selling | 1074.8 | 1131.8 | 1227.9 | 1342.8 | 1421.7 | 1466.1 | 1507.9 | 1551.1 | 1640.5 | 1740.2 | | | | |
| 2) Export | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| **B. Operating Expenses** | **711.6** | **742.1** | **712.7** | **902.3** | **943.7** | **983.7** | **1010** | **1037** | **1090** | **1128** | | | | |
| 1) Fuel Cost | 249.3 | 258.0 | 375.6 | 406.2 | 418.9 | 425.1 | 431.0 | 437.1 | 451.4 | 467.0 | | | | |
| 2) O & M Cost | 128.7 | 128.7 | 184.3 | 239.8 | 239.8 | 239.8 | 239.8 | 239.8 | 239.8 | 239.8 | | | | |
| 3) International Outpayment (Import) | 199.4 | 221.3 | 18.8 | 32.2 | 60.9 | 94.8 | 115.1 | 136.2 | 175.1 | 219.5 | | | | |
| 4) Depreciation | 134.2 | 134.2 | 134.2 | 224.1 | 224.1 | 224.1 | 224.1 | 224.1 | 224.1 | 202 | | | | |
| **C. Operating Income (A-B)** | **363.2** | **389.7** | **515.1** | **440.5** | **478** | **482.4** | **498** | **514** | **550.1** | **611.9** | | | | |
| Less : Interest | 101.9 | 95.8 | 90.1 | 84.7 | 79.6 | 74.8 | 70.3 | 66.1 | 62.1 | 58.4 | | | | |
| **D. Net Income Befor Tax** | **261.2** | **293.8** | **425.1** | **355.9** | **398.5** | **407.6** | **427.7** | **447.9** | **487.9** | **553.5** | | | | |
| Tax (35%) | 91.4 | 102.8 | 148.8 | 124.6 | 139.5 | 142.7 | 149.7 | 156.7 | 170.8 | 193.7 | | | | |
| **E. Net Income Before Interest** | **271.7** | **286.8** | **366.4** | **316.0** | **338.6** | **339.8** | **348.3** | **357.2** | **379.3** | **418.2** | | | | |

Table 9.25 Projected Funds Flow Statements (Scenario "D"--High Growth)

N$ million

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Sources** | **0** | **221.2** | **535.8** | **414.5** | **1120.3** | **1283.2** | **567.0** | **696.4** | **871.5** | **1026.8** | **1204.4** | **1350.6** | **1464.5** | **1638.6** |
| 1) Net Income before Interest | 0 | 0 | 93.6 | 100.4 | 66.6 | 246.9 | 190.7 | 189.9 | 219.7 | 255.6 | 290.4 | 308.5 | 317.7 | 361.8 |
| 2) Depreciation | | | | 22.1 | 44.2 | 44.2 | 134.2 | 134.2 | 134.2 | 134.2 | 134.2 | 134.2 | 134.2 | 134.2 |
| 3) Balanece Brought Forward | 0 | 33.2 | 66.3 | 103.9 | 245.2 | 227.8 | 242.2 | 372.4 | 517.6 | 637.1 | 779.9 | 908.0 | 1012.7 | 1142.6 |
| 4) Long Term Borrowing | 0 | 188.0 | 375.9 | 188.0 | 764.3 | 764.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **B. Application** | **0** | **221.2** | **465.1** | **304.2** | **1027.5** | **1041.0** | **194.7** | **178.9** | **234.4** | **246.9** | **296.5** | **338.0** | **321.9** | **307.1** |
| 1) Construction Progress | 0 | 221.2 | 442.2 | 221.2 | 899.2 | 899.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2) Debt Services | 0 | 0 | 11.3 | 33.8 | 45.1 | 91.0 | 136.8 | 119.8 | 172.8 | 180.7 | 225.7 | 264.7 | 247.1 | 230.6 |
| Interest | | | 11.3 | 33.8 | 45.1 | 91.0 | 136.8 | 107.3 | 136.1 | 133.9 | 131.1 | 125.4 | 117.0 | 109.2 |
| Principal | | | | | | | | 12.5 | 36.8 | 46.8 | 94.7 | 139.3 | 130.0 | 121.4 |
| 3) Working Capital | 0 | 0 | 11.6 | 49.1 | 83.2 | 50.8 | 57.8 | 59.0 | 61.6 | 66.2 | 70.7 | 73.3 | 74.8 | 76.5 |
| **C. Balance(A-B)** | **0** | **0** | **70.8** | **110.3** | **92.9** | **242.2** | **372.4** | **517.6** | **637.1** | **779.9** | **908.0** | **1012.7** | **1142.6** | **1331.5** |
| Return on Investment (%) | | 0 | 21% | 0% | 7% | 25% | 79% | 51% | 42% | 40% | 37% | 34% | 31% | 32% |
| Debt Service Coverage (time) | | | 8.3 | 3.6 | 2.5 | 3.2 | 2.4 | 2.7 | 2.0 | 2.2 | 1.9 | 1.7 | 1.8 | 2.2 |

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| **A. Sources** | **1737.4** | **2296.5** | **2044.5** | **1400.2** | **1673.0** | **1951.4** | **2242.1** | **2547.3** | **2879.1** | **3227.5** |
| 1) Net Income before Interest | 271.7 | 286.8 | 366.4 | 316.0 | 338.6 | 339.8 | 348.3 | 357.2 | 379.3 | 418.2 |
| 2) Depreciation | 134.2 | 134.2 | 134.2 | 224.1 | 224.1 | 224.1 | 224.1 | 224.1 | 224.1 | 202.0 |
| 3) Balanece Brought Forward | 1331.5 | 1425.9 | 1094.4 | 860.1 | 1110.4 | 1387.6 | 1669.8 | 1966.0 | 2275.8 | 2607.4 |
| 4) Long Term Borrowing | 0 | 449.6 | 449.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **B. Application** | **311.5** | **1202.1** | **1184.4** | **289.8** | **285.5** | **281.6** | **276.2** | **271.5** | **271.8** | **273.7** |
| 1) Construction Progress | 0 | 899.2 | 899.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2) Debt Services | 215.2 | 201.5 | 188.7 | 176.8 | 165.5 | 155.0 | 145.2 | 136.0 | 127.4 | 119.3 |
| Interest | 101.9 | 95.8 | 90.1 | 84.7 | 79.6 | 74.8 | 70.3 | 66.1 | 62.1 | 58.4 |
| Principal | 113.3 | 105.7 | 98.7 | 92.1 | 86.0 | 80.2 | 74.9 | 69.9 | 65.2 | 60.9 |
| 3) Working Capital | 96.2 | 101.3 | 96.4 | 113.0 | 119.9 | 126.6 | 131.0 | 135.5 | 144.4 | 154.4 |
| **C. Balance(A-B)** | **1425.9** | **1094.4** | **860.1** | **1110.4** | **1387.6** | **1669.8** | **1966.0** | **2275.8** | **2607.4** | **2953.8** |
| Return on Investment(%) | 20% | 15% | 24% | 37% | 30% | 24% | 21% | 18% | 17% | 16% |
| Debt Service Coverage (time) | 1.9 | 2.1 | 2.7 | 3.1 | 3.4 | 3.6 | 3.9 | 4.3 | 4.7 | 5.2 |

## 9.9 Primary Network Plans

### 9.9.1 Expansion of Related Transmission Lines

The Namibian primary network consists of 220kV and 330kV transmission lines depending on the locations and scale of power sources, demand distribution, interconnections with neighboring countries, and geographic conditions. 400kV lines are planned to be added in response to the expected increase in power demand. The following expansion projects should have been implemented by around 2020.

(1) Transmission lines for power stations

A planned major power station "Kudu" will bring the improvement of power demand and supply balance of the NamPower system. The approximate output and installed capacity of the Kudu station and its related transmission lines are summarized below.

| Output (MW) | Kudu - Kokerboom lines |
|---|---|
| 750 | 400kV x 1 circuit |
| 1250 | 400kV x 2 circuits |
| 1500 | 400kV x 2 circuit |
| 2250 | 400kV x 3 circuits |

(2) Interconnection with ESKOM

The interconnection lines between NamPower and ESKOM are significantly affecting the stability of NamPower's systems. Because many of the major power stations of ESKOM are located at the eastern side of RSA, the distance between the NamPower's generators and ESKOM's ones is long enough to make it difficult to maintain synchronizing both generators.

An interconnection between Kokerboom (NamPower) and Aries (ESKOM) will be completed in 1999. However, depending on the output amount of the Kudu station and/or the amount of export/import to ESKOM, one additional circuit may be necessary to maintain power system stability.

(3) The Middle and Northern systems

According to forecast for around the year 2020, the demand distribution - share by region - will have been allocating to 13% at the Northern part, 55% at the Middle part, and 32% at the Southern part. The increasing share in the Middle and Northern parts (about 70% in total) cannot be covered without enhancing the existing transmission capacity. Practical ways for satisfying this increase in demand include expansion of both 220kV and 400kV lines. 400kV lines will serve as main supply, while 220kV lines will serve as supply lines for secondary substations.

Currently planned 400kV transmission lines include:

| | | |
|---|---|---|
| Kokerboom - Auas | : | 1 circuit |
| Auas - Gerus | : | 1 circuit |

### 9.9.2 Distribution Substations

Increasing peak in power flow as indicated in forecasting studies for around 2020 may require the 400/220kV substations to have the following transformer capacities.

| Substation | 400/220 substation peak load (MW) | Transformer capacity (MVA) |
|---|---|---|
| Kokerboom | 945 | 315 x 3 |
| Auas | 430 | 315 x 2 |
| Gerus | 430 | 315 x 2 |

Since the power flow at the 400/220kV substations depends on the system configuration (e.g. loop or radial operation with 220kV and 400kV lines), the expansion plans should detail the configuration of 400kV and 220kV lines.

### 9.9.3 Power System Calculation

For each of the development scenarios (4) proposed by the power development plan, approximate system calculations have been done: power flow calculations for all the scenarios; stability calculations only for "D" scenario.

(1) Conditions for calculations

a) Target year and demand scale

The target year of the calculations is 2020 that is the last year of the master plan. The reason for this year selection is that such larger demand as expected in 2020 may expose more problems of power systems, and consequently, maintaining stability requires more challenges to be addressed. In 2020, it is expected that the maximum demand will have increased to 2,062MW. These calculations assumed that a small portion of this demand, about 20MW for the areas along the Namibia-South Africa border will be supplied from Eskom systems; and consequently, NamPower systems will bear 2,042MW. These calculations are to obtain the balance between the above mentioned demand forecast and NamPower's supply capabilities while absorbing the excess or deficiency by exporting to or importing it from Eskom.

Regional demands were estimated from Table 6.28 Namibia Regional Electrical Energy Forecast (High Forecast). These demands were allocated to relevant 220 kV substations.

b) System configurations

Inputs for calculations such as system configurations, line constants and equipment constants were estimated by referring to Power System Data-Base (Nov. 1996) and Swawek-System Expansion for 1996-2006, both of which were given by NamPower. These data cover up to 2005. Though it is arguable whether obtaining data for 2020 by extrapolation from the data up to 2005 is valid, we believe that calculations of power flow and stability values for 400 kV systems based on such data may give approximate but meaningful results.

c) Control functions

Stability calculations assumed that control systems (i.e. automatic voltage regulators, governors and power system stabilizers) for generators do not work. Instead, these controls either of which is helpful for enhancing stability were considered a component of the stability-related safety factor. This assumption is indispensable, because these calculations aim to demonstrate whether the systems are capable of self-supporting in maintaining stability.

(2) Calculation results

Figures 9.2 through 9.6 show the power flow for each scenario. Figures 9.7 and 9.8 show the generator swing curves to represent the stability of the scenario "D". The stability calculations were done for the following two failure modes.

Mode (assumption) 1:

A 3-phase-ground-fault (3 Φ G) occurs at Kokerboom on the 400kV Aries-Kokerboom line, and 3-phase-reclosure (3ΦG-R.C) is performed 0.7 second after its fault clearing in 0.1 second.

Mode (assumption) 2:

A 3-phase-ground-fault occurs at the middle of the 400kV Kudu-Kokerboom line, and 3-phase-reclosure is performed 0.7 second after its fault clearing in 0.1 second.

Figures 9.6 shows the generator swing curve for Mode 1. In this case with the Kudu generator output of 1,500MW, the phase difference between the Kudu generator and the generators of the Eskom systems (represented by a simplified one machine system) will settle into an acceptable range between Lag 47.11 degrees and Lead 31.48 degrees. This means that stability can be kept.

Figures 9.8 shows the generator swing curve for Mode 2. This shows the case with the Kudu generator output of 1,260MW. The generator will step-out if the output is 1,500MW. Stability power limit at a 3ΦG disturbance was calculated 1,260MW. Note that it may vary with the disturbance level. Since the ratio of 3 ΦG to 1ΦG may normally fall between 1:1.3 and 1:1.4, the stability power limit at a 1ΦG disturbance may be 1,600 to 1,700MW. This means that the Kudu-Kokerboom 400kV line with 2-circuits can be kept stable when it is operating at 1,500MW output.

We recommend that detailed stability studies be done in line with the NamPower's design criteria. These studies should include investigations on the possibilities of enhancing 220kV systems, control functions and S.V.C capacities according to the actual demand profiles.

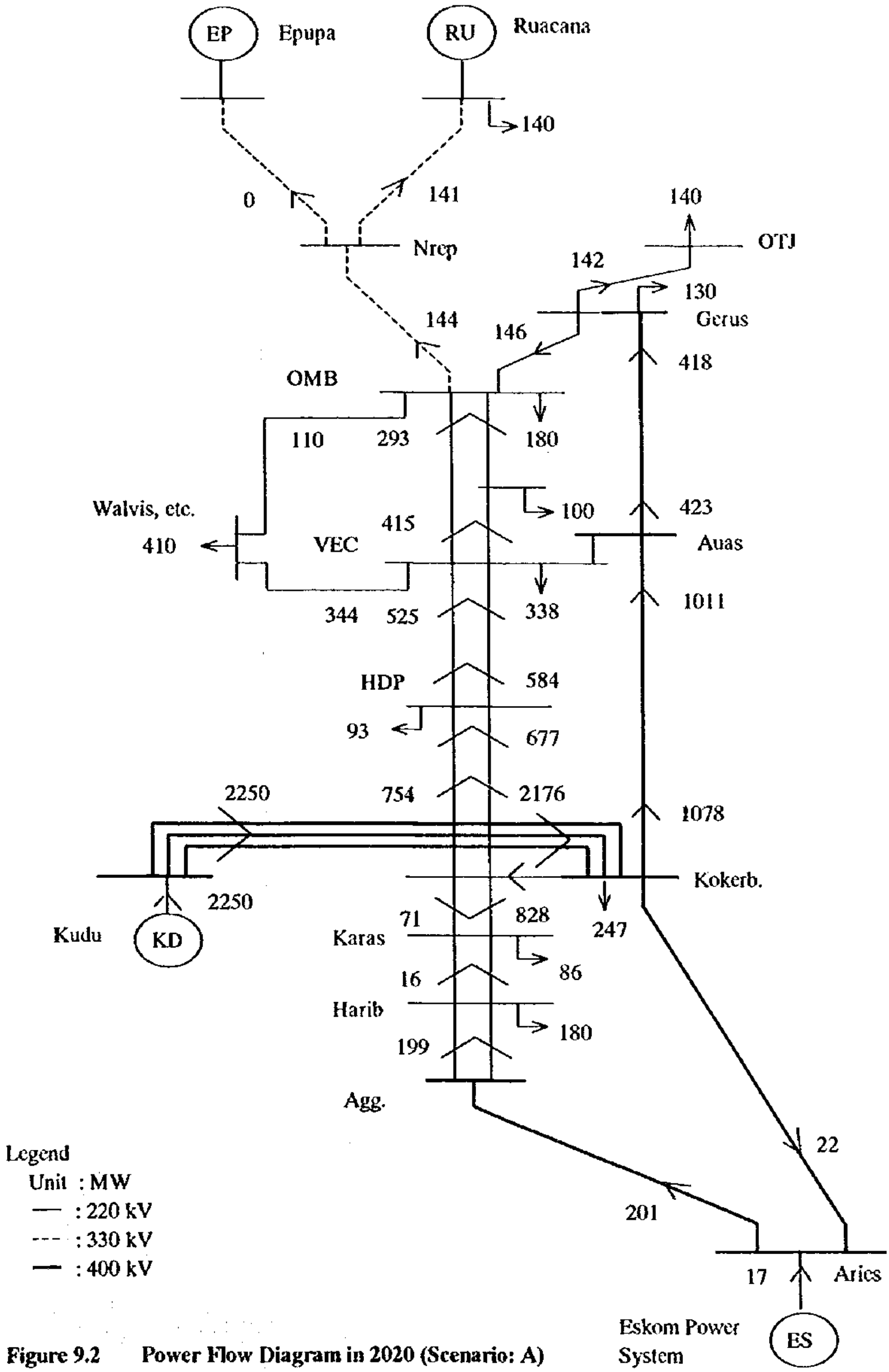



**Figure 9.2 Power Flow Diagram in 2020 (Scenario: A)**

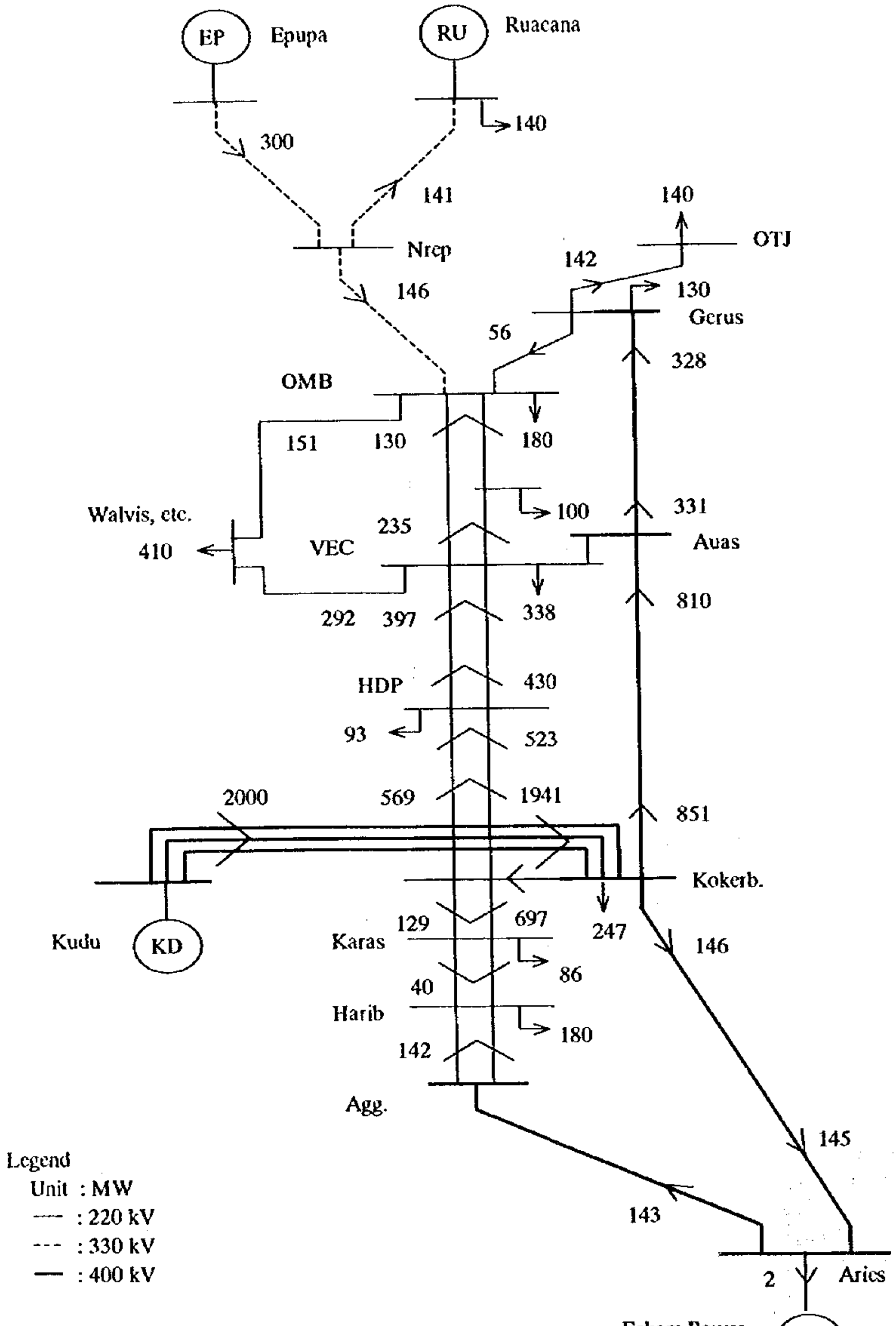



**Figure 9.3 Power Flow Diagram in 2020 (Scenario: B)**

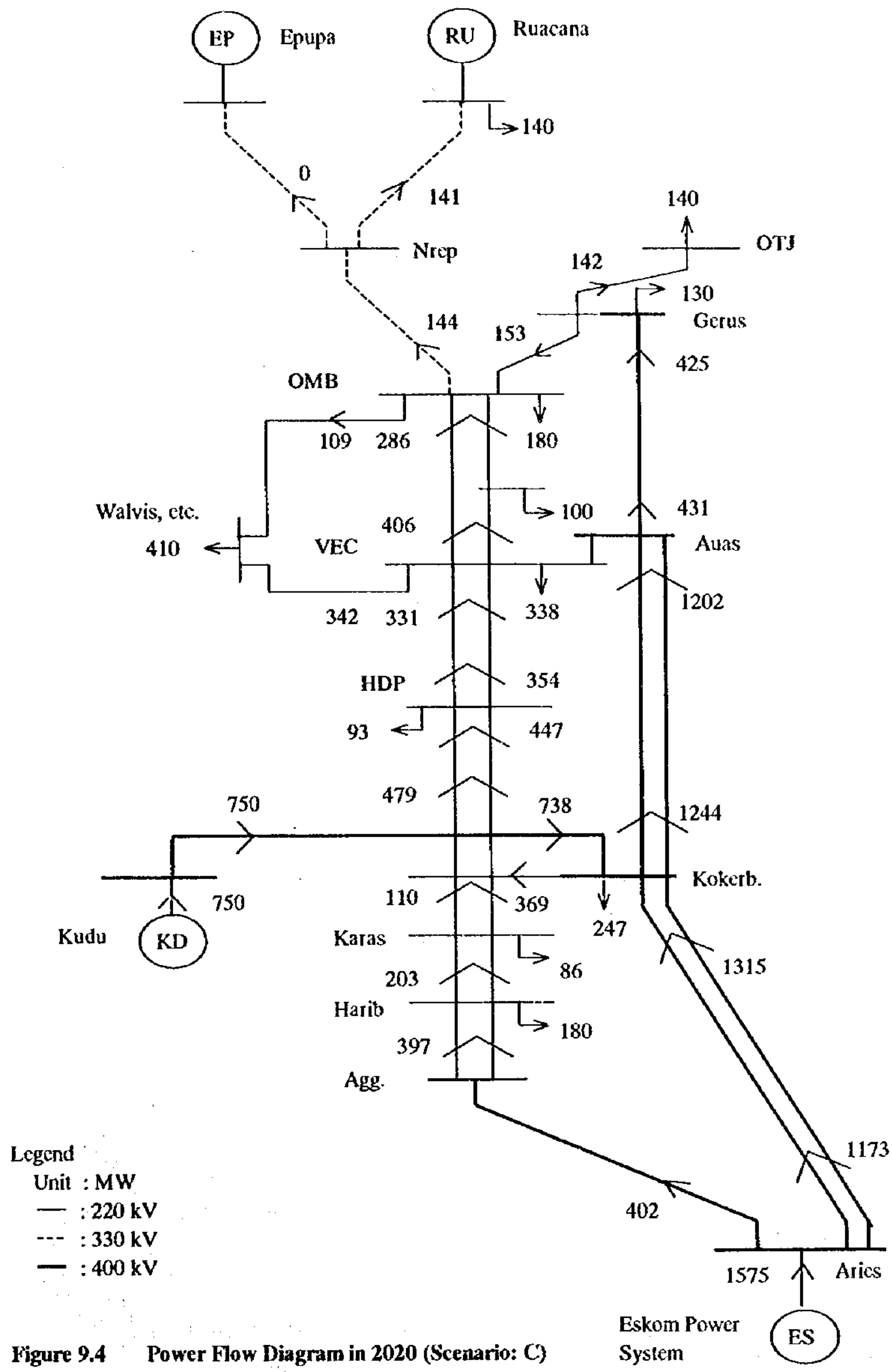



**Figure 9.4 Power Flow Diagram in 2020 (Scenario: C)**

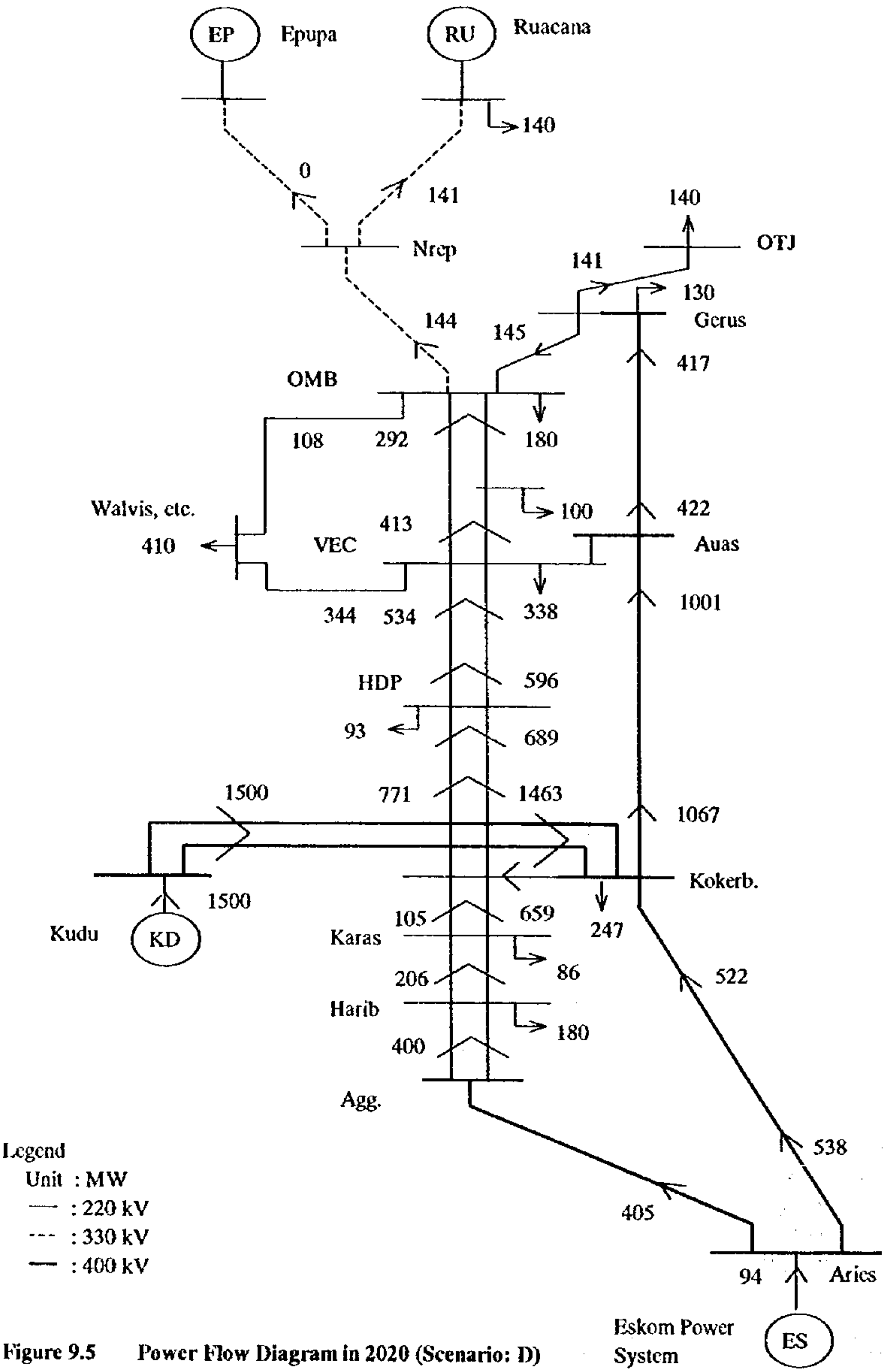
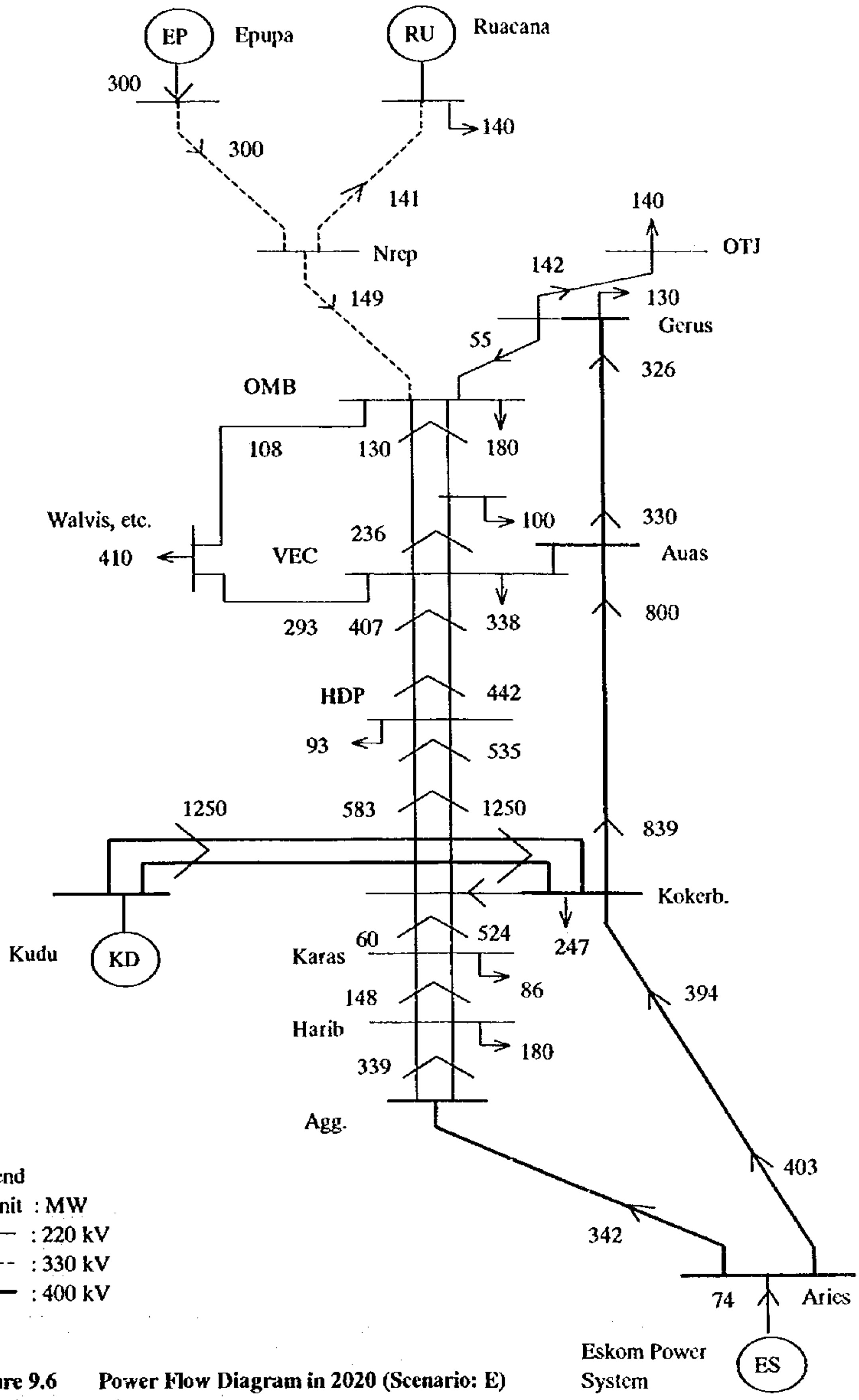



**Figure 9.5 Power Flow Diagram in 2020 (Scenario: D)**




Legend
Unit : MW
— : 220 kV
--- : 330 kV
**—** : 400 kV

**Figure 9.6 Power Flow Diagram in 2020 (Scenario: E)**

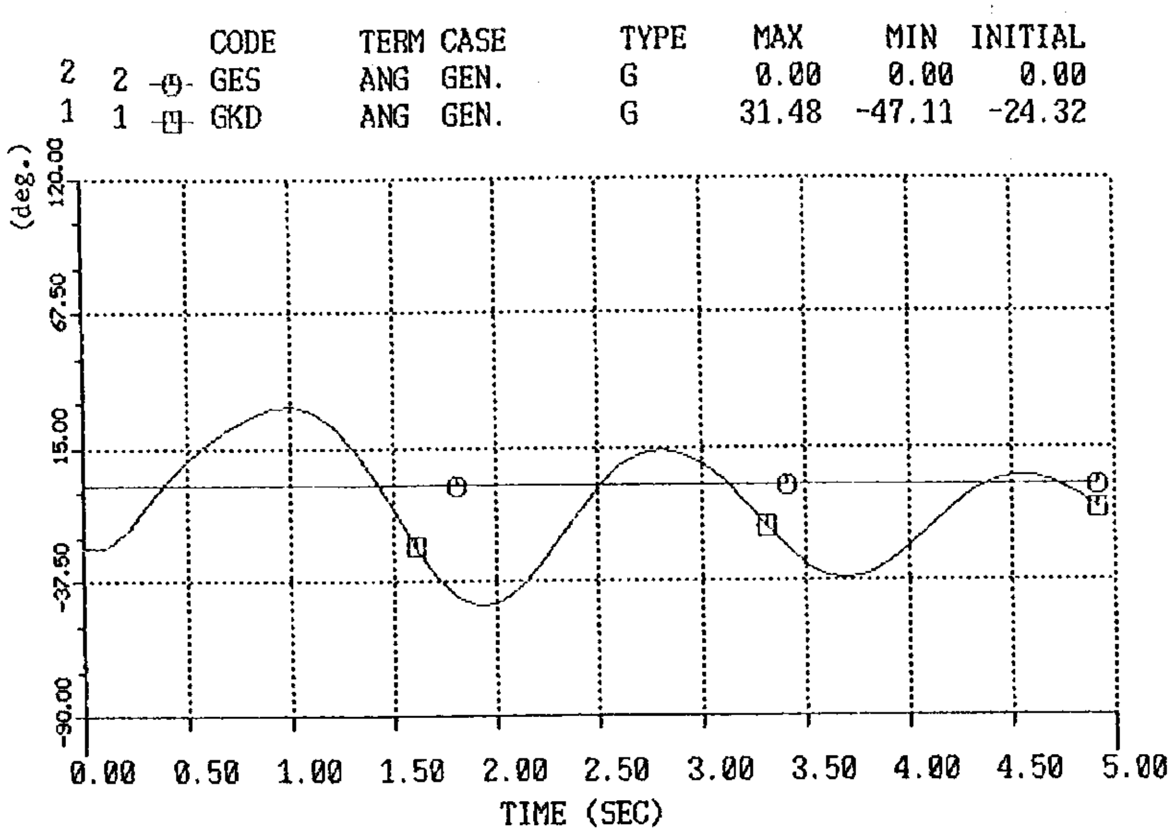



Figure 9.7 Generator Swing Curves (Kokerb.-Aries fault)

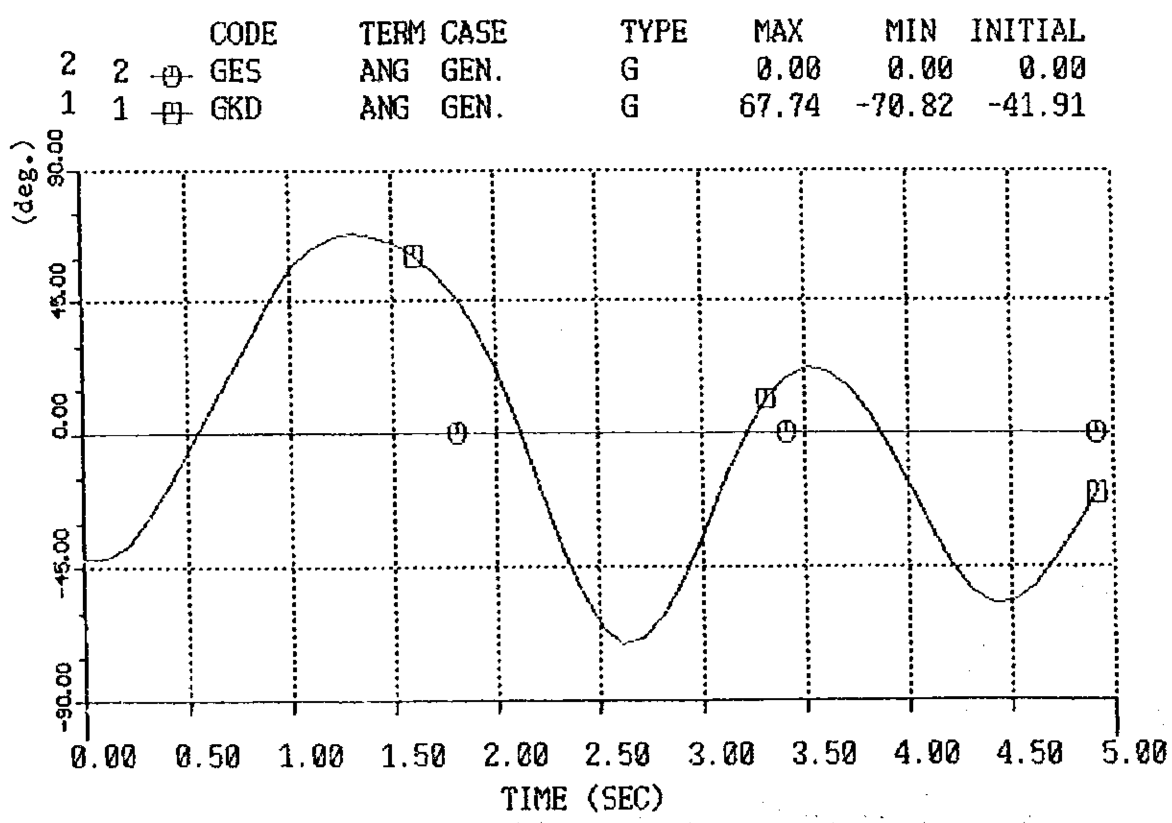



Figure 9.8 Generator Swing Curves (Kudu - Kokerb. fault)

## 9.10 Evaluation

### 9.10.1 Summary

Alternatives

There remains only the following three alternatives, which realistically may be considered for power supply in the NamPower grid in the time horizon until 2020:

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

Scenarios

The following five scenarios have been defined for studies. They constitute the least cost solution in the best mix under the respective theme.

- 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 realisation of the energy policy (draft) 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.

Addition of supply facilities

An addition of power supply facilities has been designed to meet the maximum demand in the high growth case forecast by the Study Team (Chapter 6). It is considered as power utilities' responsibility to provide a supply capability against the probable highest peak demand, that is, high growth demand. This is also NamPower's resolution. The measure for energy policy's 100% of the peak demand would be provision against the probable highest peak load. The addition was planned for in-country use only till the year 2008. Summary of additions in each scenario is shown in Table 9.26.

In terms of security of supply, diversification of source of supply is apparently not required in the country in an enhanced degree of self sufficiency, for complications between regions are unlikely to occur in Namibia.

**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) | | | |

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

400kV line

400kV line involves the construction of approximately 900km single circuit transmission line from Aries substation in RSA to Auas substation near Windhoek. The construction is divided into two phases. The first stage is the construction of the line from Aries substation up to Kokerboom substation near Keetmanshoop (about 450km), the second phase being from Kokerboom substation to Auas substation (about 450km).

| | |
|---|---|
| Lead time | 30 months |
| Total investment cost | 209.2 MUS$ including substations and IDC |

CCGT

CCGT is the most advanced type (1300°C class) 750MW combined cycle gas turbine with high efficiency, remarkable economy and flexibility on cycle configuration. Two gas turbine generator machines (2xGT) and one steam turbine generator configurate one CCGT generation block.

| | |
|---|---|
| Lead time | 28 months |
| Total investment cost | 406 MUS$ with transmission and IDC |

Epupa

Epupa is one of two lower Cunene hydropower schemes. Its installed capacity is 360MW and the annual possible generation is 1730GWh. The economic comparison was made about Epupa scheme which shows better viability.

| | |
|---|---|
| Lead time | 9~10 years |
| Total investment cost | 695 MUS$ with transmission and IDC |

Short term expansion options

The decision was made by NamPower to construct a new 400kV interconnector with Eskom and the construction has started. A generation addition will be urgently required in the year 2002 in order to meet a sharply growing demand. Construction of the second 400kV interconnector should be avoided to get nearer to the energy self sufficiency. A hydropower plant requires a long lead time. Thus CCGT would be only one option left, common to all scenarios, and is deemed to be technically reasonable, too.

Medium and long term expansion options

The year 2008 would be the earliest possible time for completion of a hydro plant in Scenario B, self sufficiency-hydro, and the year 2013 be its required time by the system demand in Scenario E, business as usual-hydro. It is too heavy and risky for the national economy to build two large hydropower plants. A self sufficiency scenario costs additional US$406 million compared with a corresponding business as usual scenario in the time horizon.

Economic evaluation

An economic analysis to the five scenario has been investigated for their economic viability. Economic indicators for that are Economic Internal Rate of Return (EIRR), Net Present Value(NPV) and Benefit/Cost Ratio(B/C). Economic benefit for high growth cases was calculated as the criteria, and one for medium growth cases as a reference. Economic indicators were also calculated to Scenario D, business as usual-CCGT for low growth case as a reference.

For **high growth cases**, results of the calculation shows that the EIRRs are more than 10% which is assumed as the opportunity cost of capital in Namibia and all five scenarios for high growth cases are considered to be economically viable (See Table 9.27). Such a small difference between Business As Usual Scenarios C for extended import and D for CCGT are deemed to be the same level in economic superiority in an economic evaluation. Synthetically Scenario D is superior to Scenario C. Scenario B, Self Sufficiency-Hydro, is inferior in economy.

For **moderate growth cases**, on the other hand the EIRR is all less than 10% except for Scenario D, business As Usual-CCGT. Due to designing of generation addition for the high growth this is inevitable to a certain extent. And it is so designed that electricity exporting to Eskom could not be expected until 2008. This might be one of the causes for the lower economic indicators. For moderate growth case, Scenario D for CCGT is fairly superior to Scenario C for increased in economy.

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 | - |

### 9.10.2 Evaluation of Scenarios

Scenario D, Business as usual-CCGT, with Scenario C, Extended import, is found to be the least cost option for electricity supply in Namibia compared to hydropower electricity 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. 3.7USc/kWh of willingness to pay used in the economic evaluation is in the world's cheapest level. It should be noted that they are economically viable at this cheapest level.

In the moderate growth case, however, economic indicators generally fall to an unacceptable level. Exceptionally, Scenario D, Business as usual-CCGT, is economically viable. Scenario B, Self sufficiency-Hydropower, is the worst and is even inferior to low growth case of Scenario D.

Although this is a matter of course, the minus impact on NamPower's finances could be remarkable. A big disparity between a forecast and an actual demand should cautiously be avoided. The timing of the investment for the supply facilities must be more flexible and timed in consideration of the development of the power demand. In this regard a hydropower project with a long lead time could be very risky in Namibian context.

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 high growth case in terms of capacity balance would increase from 0% in 2001 to some 70% in 2020 in the business as usual scenarios. Of them, Scenario C, Extended import, is 37% in 2020 (See Table 9.28). That of energy balance would reach from 22% in 2001 to some 80% in 2020 in the business as usual scenarios D and E, and about 60% in 2020 in Scenario C, Extended import.

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

In terms of security of supply, diversification of source of supply is apparently not required in the country in an enhanced degree of self sufficiency, for complications between regions are unlikely to occur in Namibia.

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 |

## 9.11 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).

Total investment required for the system expansion up to the year 2020, from power generation to rural electrification, is roughly estimated 1,600 MUS$ (Refer to Table 9.30).

Degree of achievement of national energy policy targets by implementation of the system expansion plan is shown in Table 9.31. Capacity balance of power supply will not achieve its target up to the year 2020. On the other hand, however, the plan can save a lot of investment compared with the self sufficiency scenario. Nevertheless the draft White Paper mentions electricity supply shall be based on a balance of economically efficient and sustainable electricity sources. It is deemed this case could be allowable. Regarding rural electrification a base case using 3.5% GDP growth with a 0.2% contribution to rural electrification was selected for this plan. This plan will achieve the target of 25% of rural households connected by the year 2015, which is five years later than desired in the energy policy. The government therefore needs to investigate creation of a rural electrification fund.

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 Plans in Primary Network

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

## Table 9.30 Investment for Future System Expansion

(MUS$)

| Term/ Year | (1) Gener'n | (2) Trans.line | (3) Substat'n | (4) Distribution | | | (1)+(2)+(3)+(4) Total | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Nampower | MME | Sub-total | | |
| Short Term (1997-2001) | | | | | | | | |
| 1997 | | 7.28 | | 5.57 | 6.27 | 11.84 | 19.12 | |
| 1998 | | 52.84 | 13.49 | 6.11 | 6.53 | 12.64 | 78.97 | |
| 1999 | | 109.87 | 14.96 | 6.64 | 6.78 | 13.42 | 138.25 | |
| 2000 | | 76.19 | 8.72 | 7.17 | 7.04 | 14.21 | 99.12 | |
| 2001 | 167.00 | 36.00 | | 7.70 | 7.30 | 15.00 | 218.00 | |
| Sub Total | 167.00 | 282.18 | 37.17 | 33.19 | 33.92 | 67.11 | 553.46 | ① |
| Middle Term (2002-2006) | | | | | | | | |
| 2002 | 167.00 | 36.00 | | 7.96 | 7.91 | 15.87 | 218.87 | |
| 2003 | | | | 8.63 | 8.28 | 16.91 | 16.91 | |
| 2004 | | 28.80 | 1.39 | 9.73 | 8.67 | 18.40 | 48.59 | |
| 2005 | | 47.84 | 2.55 | 9.73 | 9.08 | 18.81 | 69.20 | |
| 2006 | | | | 9.73 | 9.50 | 19.23 | 19.23 | |
| Sub Total | 167.00 | 112.64 | 3.94 | 45.78 | 43.44 | 89.22 | 372.80 | ② |
| Long Term (2007-2020) | | | | | | | | |
| 2012 | 167.00 | 36.00 | | | | | | |
| 2013 | 167.00 | 36.00 | | | | | | |
| Sub Total | 334.00 | 72.00 | 10.20 | 92.91 | 188.49 | 281.40 | 697.60 | ③ |
| Grand Total | 668.00 | 466.82 | 51.31 | 171.88 | 265.85 | 437.73 | 1,623.86 | ①+②+③ |

Note: 1 Estimate is based on 1996 price and an exchange rate of 4.52 N$/US$.

2. Cost of Kudu CCGT is estimated by JICA Team.

## Table 9.31 Degree of Achievement of Targets

| Item | Target | Achieved Percentage (%) | | | |
|---|---|---|---|---|---|
| | | 2001 | 2006 | 2010 | 2020 |
| Self Sufficiency of Supply | | | | | |
| Capacity Balance | 100 % by 2010 | 0 | 29 | 59 | 73 |
| Energy Balance | 75 % by 2010 | 22 | 85 | 79 | 87 |
| Rural Electrification | | | | | |
| Rural Households | 25 % by 2010 | 12 | 17 | 20 | 32 |

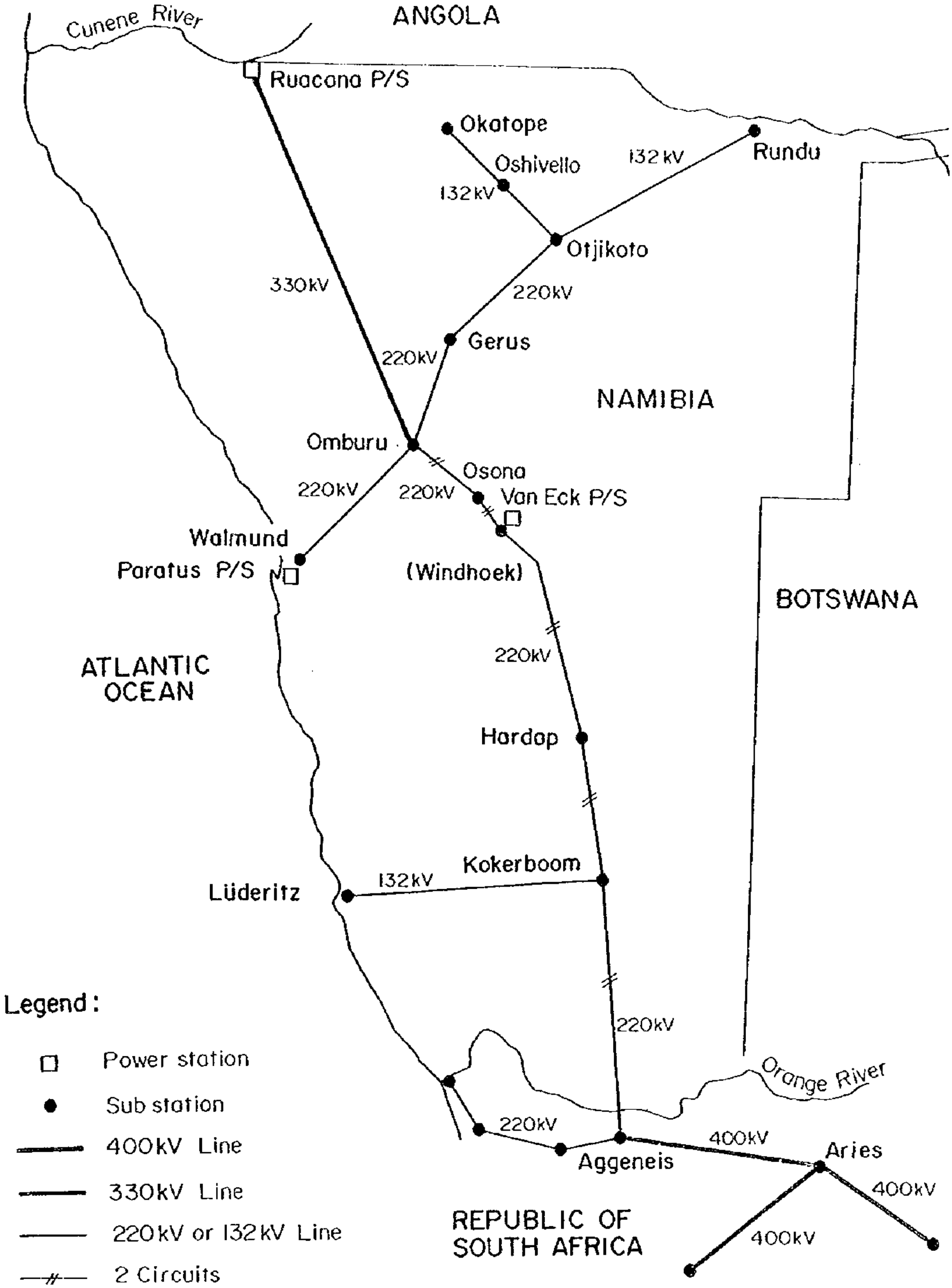



Figure 9.9 EXISTING POWER SYSTEM (As of 1997)

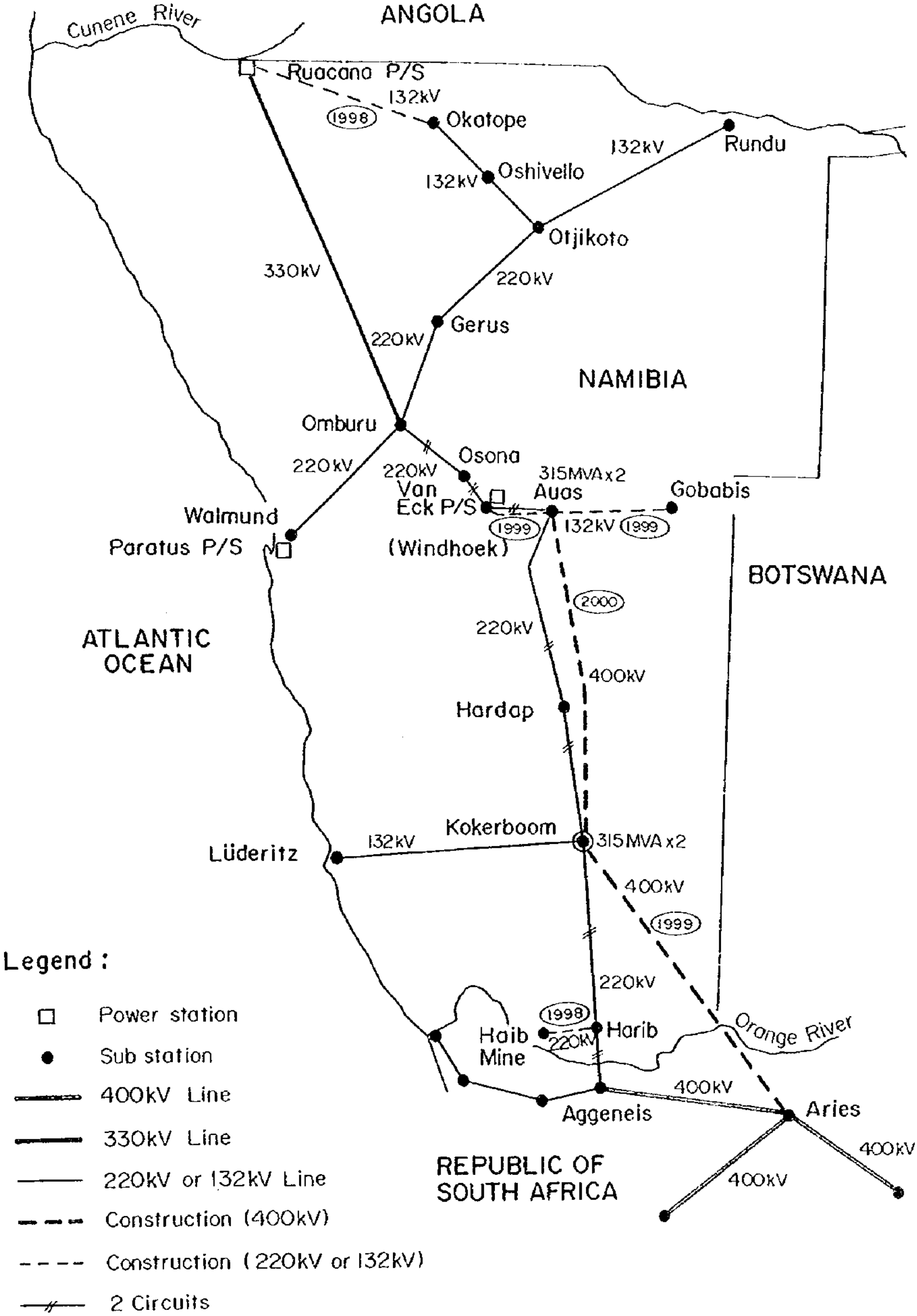



Figure 9.10 POWER SYSTEM EXPANSION PLAN (1997-2001)

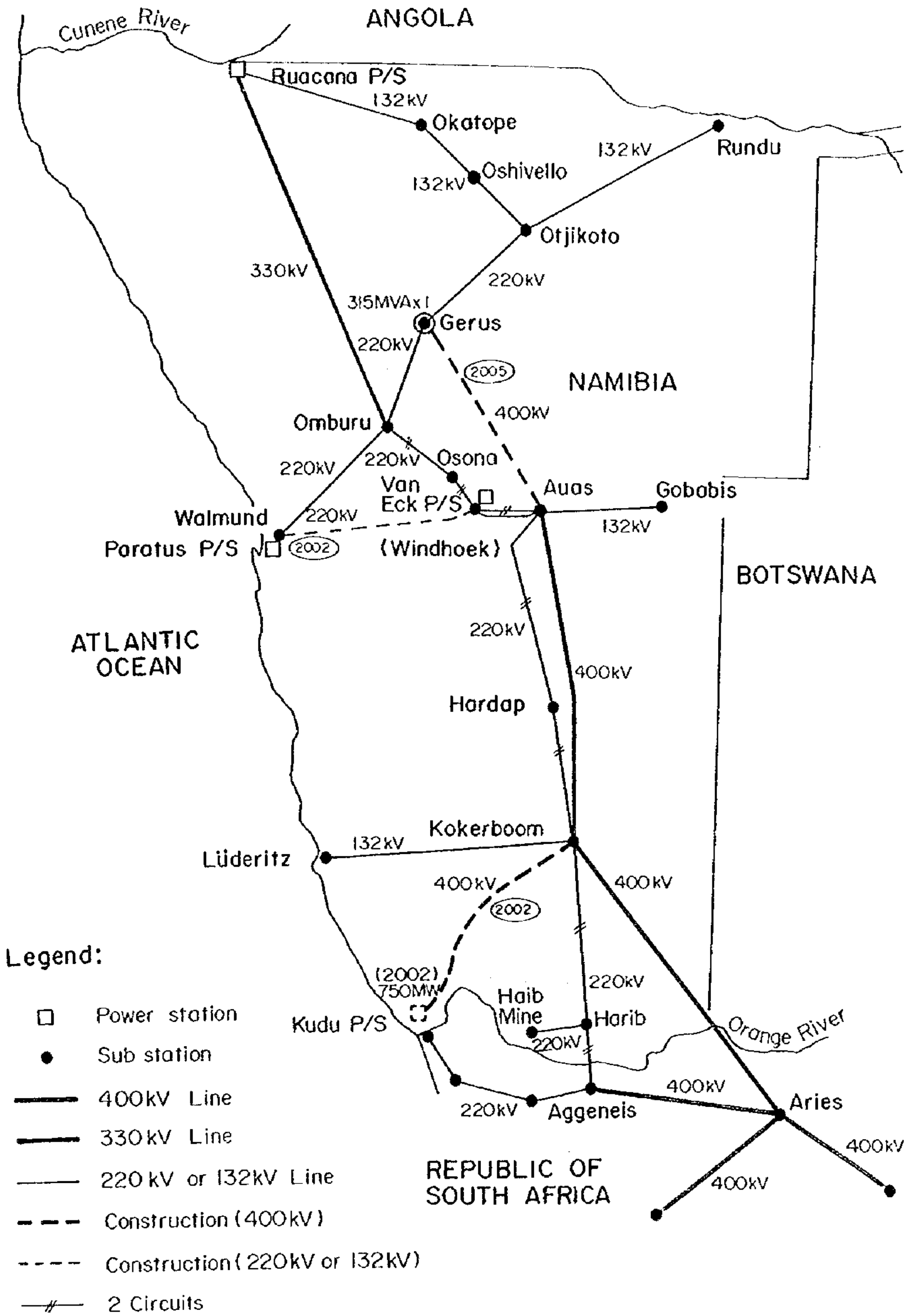



Figure 9.11 POWER SYSTEM EXPANSION PLAN (2002-2006)

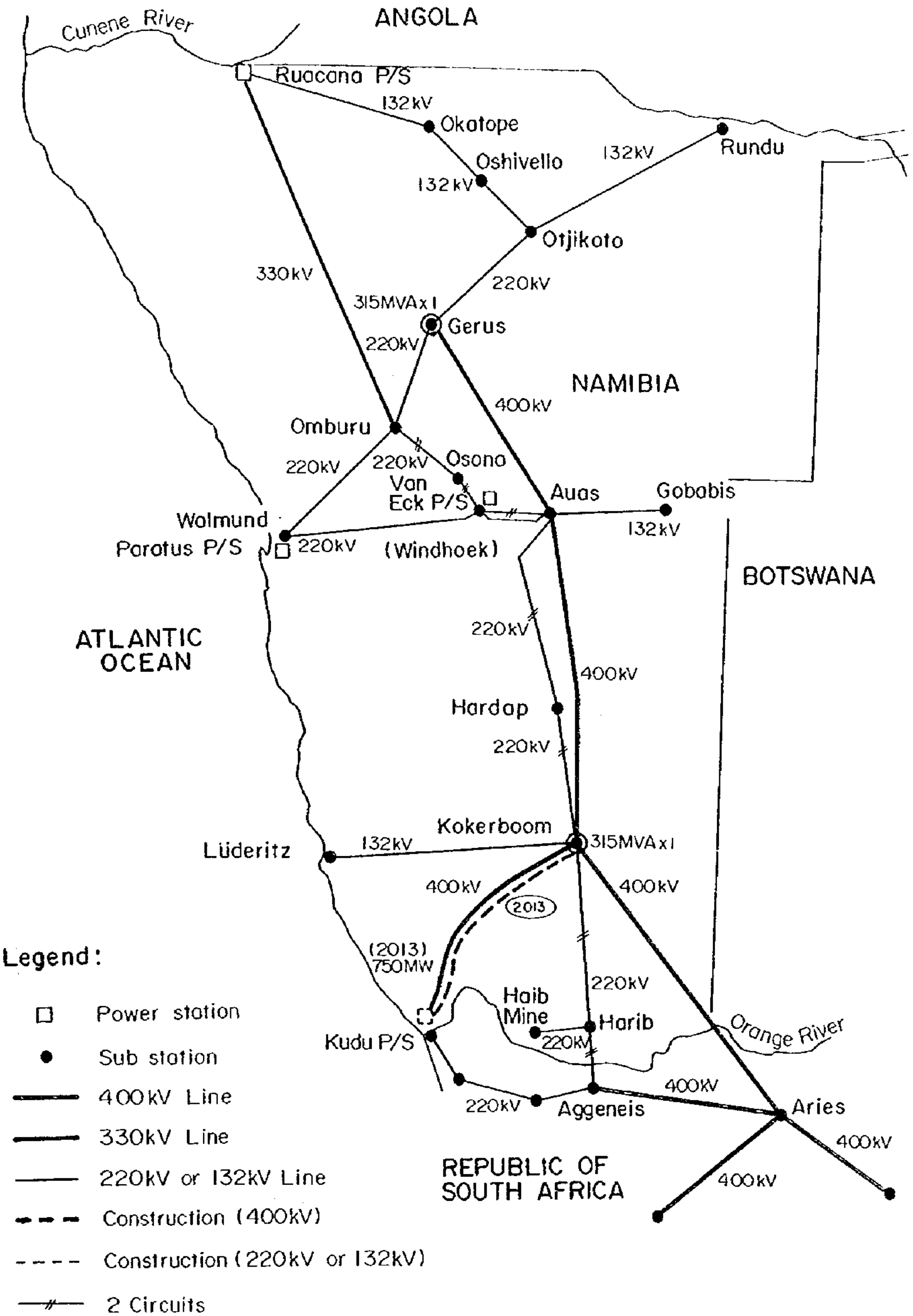



Figure 9.12 POWER SYSTEM EXPANSION PLAN (2007-2020)

# CHAPTER 10

# STUDY ON ENVIRONMENTAL CONSIDERATION AND ENERGY CONSERVATION

# CHAPTER 10 STUDY ON ENVIRONMENTAL CONSIDERATION AND ENERGY CONSERVATION

As an important part of the study for the electricity master plan in The Republic of Namibia, understanding the environmental policy, legislation and nature environment of the country is needed. Thereby, environmental consideration will be incorporated into development projects in future. In addition, study on possible energy conservation policy is also required to save renewable energy and preserve nature environment of the country.

From the points of view of the above, related information and reference documents were collected. Field surveys were also carried to understand actual situations and supplement necessary information. The following describes and reflects the results of the study.

## 10.1 Study on Environmental Consideration

### 10.1.1 Environmental Legislation and Environmental Assessment Policy

(1) Environmental legislation

In connection with basic policy of environmental consideration, the Article 95(1) of the Constitution of the Republic of Namibia provides the following statement:

"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 environmental basic policy of the country.

However, It is indicated by the document "Namibia Environment, Volume 1, 1996" that Namibia does not as yet have a coherent and comprehensive environmental law framework. There are many regulations and statutes which are outdated and of South African origin. After independence, there are several Acts have been established, such as Minerals (Prospecting and Mining) Act (1992), Petroleum (Exploration and Production) Act (1991) and Sea Fisheries Act (1992), all of them included environmental clauses to be complied. Table 10.1 shows a list of the key environmental legislation of Namibia.

In May 1995, the Ministry of Environment and Tourism issued " Namibia's Environmental Assessment Policy". The policy provides mandatory requirement to implement environmental assessment for up to 54 projects, programs and policies.

The following describe environmental requirements of most current Acts issued after 1990.

a) Environmental requirement of Petroleum Act of 1991

Article 71 of the Act sets force liability of holders of production licenses for pollution of environment or other damages or losses caused. Brief content of the liability is as below.

a. When, in course of production operations carried out under a production license, any petroleum or other substances are spilled in the sea or on land or in any water area, or such land or water is otherwise polluted or any plants or animal life is endangered or destroyed, or any damage or loss is caused to any person, including the State, by such spill or pollution, the holder of such production license shall forthwith:

 (i) report such spilling, pollution, loss or damage to the Minister of the Ministry of Mines and Energy (MME);
 (ii) take at its own costs all such steps as may be necessary in accordance with good oil field practices or otherwise as may be necessary to remedy such spilling, pollution, loss or damage.

b. If the holder referred to in subsection 1) of the above fails to comply with the provisions of paragraph (b) of that subsection within such period as the Minister may deem reasonable, the Minister may order the license holder to take steps to remedy the spilling, pollution or damage or loss within a specified period of time.

b) Environmental requirement of Minerals Act of 1992

Article 130 of the Act sets force liability of holders of production licenses for pollution of environment or other damages or losses caused. Brief content of the liability is as below.

a. When, in the course of any reconnaissance operations, prospecting operations or mining operations carried out under any related license, any mineral or group of minerals is spilled in the sea or on land or in any water area, or such land or water is otherwise polluted or any plants or animal life is endangered or destroyed, or any damage or loss is caused to any person, including the State, by such spill or pollution, the holder of such production license shall forthwith :

   (i) report such spilling, pollution, loss or damage to the Minister of the MME;
   (ii) take at its own costs all such steps as may be necessary in accordance with good reconnaissance practices, good prospecting practices or mining practices or otherwise as may be necessary to remedy such spilling, pollution, loss or damage.

b. If the holder referred to in subsection 1) of the above fails to comply with the provisions of paragraph (b) of that subsection within such period as the Minister may deem reasonable, the Minister may order the license holder to take steps to remedy the spilling, pollution or damage or loss within a specified period of time.

(2) Environmental assessment policy

The Namibia's Environmental Assessment(EA) Policy was developed and approved in August 1994 by Cabinet Resolution 16.8.94/002. As indicated by the Policy document, recent EAs have concentrated on individual projects. However, the EA policy also stresses the need for the assessment of programs and policies. The Policy aims to promote sustainable development and economic growth while protecting the environment in the long term. It is expressed by the Policy that Sector Ministries, the Private sector, NGOs, and prospective investors and donors are urged to comply with this policy for all future projects, programs and policies.

The following describes the EA procedure and provides the list of activities which will need implementation of EA.

a) Environmental assessment procedure

The Policy defined a clear procedure to be followed by an activity to implement an EA. The procedure includes such steps as from submission of project plan, development of project proposal, decision making on whether an EA would be needed or not, implementation of an EA when deemed required, review EA result, results, project approval, project implementation, monitoring and so forth. The whole procedure is shown by Figure 10.1 attached.

The EA procedure is intended to achieve the following objectives.

- To better inform decision makers and promote accountability for decisions taken.
- To consider a broad range of options and alternatives.
- To strive for a high degree of public participation and involvement by all sectors in the EA process.
- To take into account the environmental costs and benefits of proposed project, etc.
- To incorporate internationally accepted norms and standards where deemed appropriate to Namibia.
- To take into account the secondary and cumulative environmental impacts.
- To ensure that the EA procedure is paid for by the proponent.
- To promote sustainable development in Namibia and to ensure that a reasonable attempt is made to minimize anticipated negative impacts and maximize the benefits of all developments.
- To be flexible and dynamic, thereby adapting new issues, information and techniques as they become available.

b) The list of activities which will need implementation of EA.

Table 10.1 shows the list of activities which will need implementation of EA. It is said by the Policy that the list is provided as a guide for the Environmental Commissioner and Board. Where the scale of activities is not provided, it will be up to the Commissioner and/or Board to use their discretion.

**Table 10.1 Key Environmental Legislation of Namibia**

| |
|---|
| 1. Resource Conservation and Exploitation<br>• Water Act (No.54 of 1956)<br>• Artesian Water Control Ordinance (No.35 of 1955)<br>• Forest Act (No.72 of1968)<br>• Preservation of Forests and Trees Ordinance (No.37 of1952)<br>• Nature Conservation Ordinance (No.4 of 1975)<br>• Minerals (Prospecting and Mining) Act (No.33 of 1992)<br>• Petroleum (Exploration and Production) Act (No.3 of 1991)<br>• Sea Fisheries Act (No.29 of 1992)<br>• Foreign Investment Act (No.96 of 1990) |
| 2. Pollution Control and Waste Management<br>• Hazardous Substances Ordinance (No.14 of 1974)<br>• Atmospheric Pollution Prevention Ordinance (No.11 of 1976)<br>• Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (No.36 of 1947)<br>• Nuclear Installations (Licensing and Security) Act (No.43 of 1963)<br>• Atomic Energy Act (No.90 of 1967)<br>• Public Health Act (No. 36 of 1919)<br>• Agricultural Pests Act (No. 3 of 1973) |
| 3. Land and Marine Matters<br>• Territorial Sea and Exclusive Economic Zone of Namibia (No. 3 of 1990)<br>• Sea Shore Ordinance (No. 37 of 1958)<br>• Soil Conservation Act (No. 76 of 1969)<br>• Mountain Catchment Area Act (No. 6 of 1970)<br>• Agriculture (Commercial ) Land Reform Act (No. 6 of 1995)<br>• Township and Division of Land Ordinance No.11 of 1963 as amended by the Townships and Division of Land Amendment Act (No. 28 of 1992)<br>• Sub-division of Agricultural Land Act (No. 70 of 1970)<br>• Fencing Proclamation (No. 57 of 1921)<br>• National Monuments Council Act (No. 76 of 1969) |
| 4. Workplace<br>• Labor Act (No. 6 of 1992)<br>• Workmen's Compensation Act (No. 39 of 1941)<br>• Factories, Machinery and Building Work Ordinance (No. 34 of 1952)<br>• Mines, Works and Minerals Ordinance (No. 20 of 1968)<br>• Occupational Diseases in Mines and Works Act (No. 78 of 1973) |

Source: Namibia Environment, Volume 1, by the Ministry of Environment and Tourism, Namibia

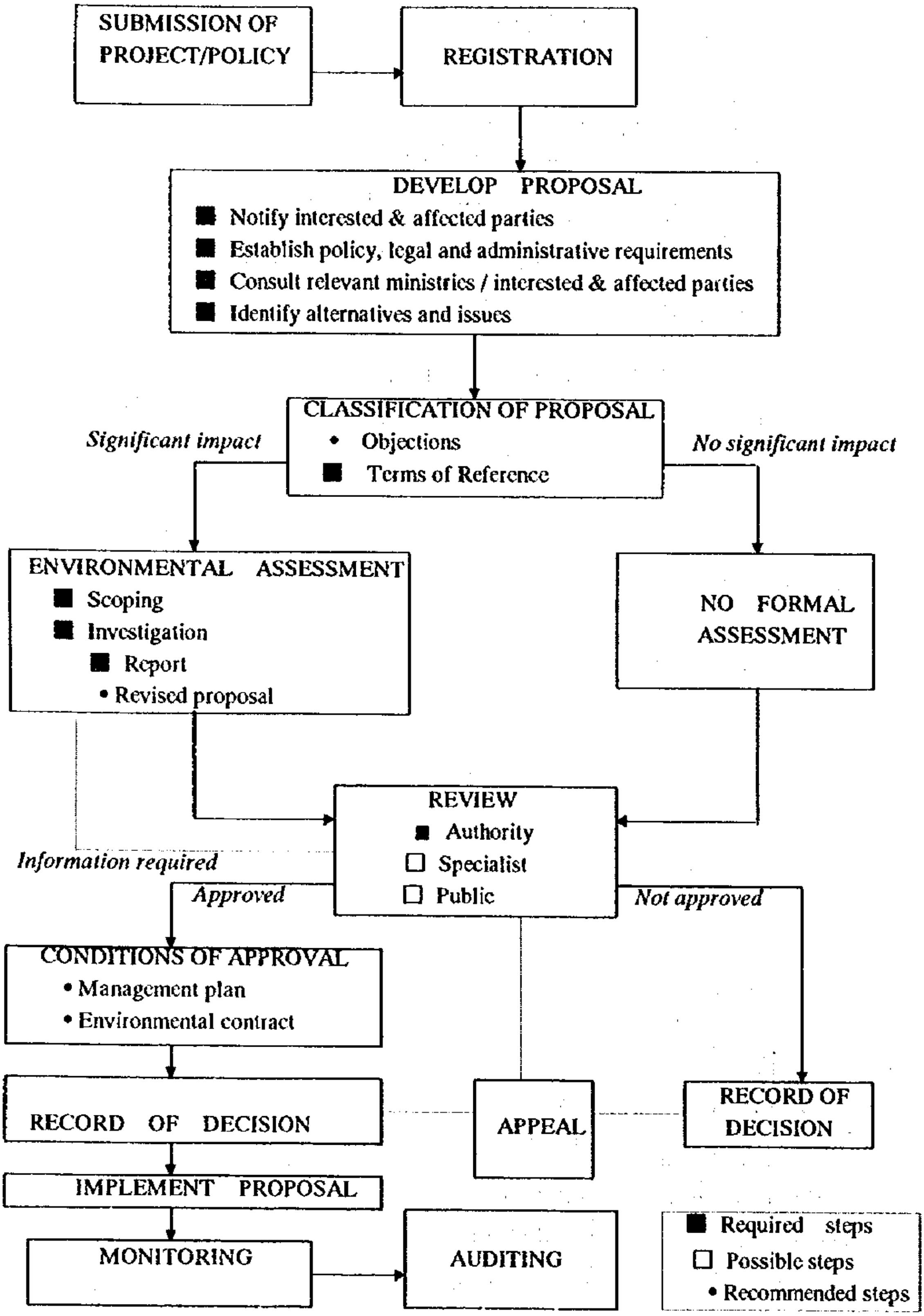



**Figure 10.1 Environmental Assessment Procedure**

Source: Namibia's Environmental Assessment Policy, January 1995

## Table 10.2 Projects, Programs and Policies Requiring an Environmental Assessment

| No. | Name of Projects, Programs and Policies | No. | Name of Projects, Programs and Policies |
|---|---|---|---|
| 1 | Structure Plans (eg. Land-use plans and policies) | 28 | Major canals, aqueducts, river diversions and water transfer |
| 2 | Rezoning applications | 29 | Permanent flood control schemes |
| 3 | Land acquisition for national parks, nature reserves, marine reserves, protected natural environments or wilderness areas | 30 | Major dams, reservoirs, levees and weirs |
| 4 | Establishment of settlements | 31 | Establishment of armament testing ares |
| 5 | Declaration of limited development areas | 32 | Reclamation of land from sea |
| 6 | Any government policy, program or project on the use of nature resources | 33 | Major agricultural activities (e.g. livestock & cultivation projects in undeveloped area) |
| 7 | Pest control programs | 34 | Small scale (formal) water supply scheme |
| 8 | Human population growth/management programs | 35 | Human resettlement |
| 9 | Nuclear installations | 36 | Water intensive industries |
| 10 | Transportation of hazardous substances and radioactive wastes | 37 | Deforestation projects |
| 11 | Mining, mineral extraction & mineral beneficiation | 38 | Desalination plants |
| 12 | Power generation facilities with an output of more than 1 MW | 39 | Effluent plants |
| 13 | Electrical substations and transmission lines having equipment with an operating voltage in excess of 30 KV rms phase-to-phase | 40 | Salt works |
| 14 | Storage facilities for chemical products | 41 | Marine petroleum exploration |
| 15 | Industrial installations for bulk storage of fuels | 42 | Major groundwater abstraction schemes |
| 16 | Bulk distribution facilities | 43 | Aquaculture and mariculture |
| 17 | Manufacture of explosives | 44 | Oil exploration |
| 18 | Introduction and/or propagation of invasive alien plant and animal species | 45 | Multinational projects |
| 19 | Afforestation projects | 46 | Chemical production industries |
| 20 | Genetic modification of organisms & release of such organisms | 47 | Veterinary fencing |
| 21 | Major roads | 48 | Tanneries |
| 22 | Railways | 49 | Military exercises in sensitive areas |
| 23 | Commercial airdromes | 50 | Waste disposal sites |
| 24 | Ports and harbors | 51 | Alternate energy programs |
| 25 | Major pipelines | 52 | Commercial tourism and recreation facilities |
| 26 | Cableways and related stations | 53 | Significant use of pesticides, herbicides and defoliants |
| 27 | TV and radio transmission masts | 54 | Drought relief schemes |

Sourc: Namibia's Environmental Assessment Policy, January 1995

### 10.1.2 Environmental Administration

(1) The Ministry of Environment and Tourism

The Ministry of Environment and Tourism has been established to be responsible for environmental management and tourism development/control. There are four Directorates(Tourism and Resorts, Resource Management, Forestry and Environmental Affairs) and two Services Divisions within the Ministry to carry out its duties. The mission of the Ministry is " To maintain and rehabilitate essential ecological processes and life support system, to conserve biological diversity and to ensure that the utilization of natural renewable resources is sustainable for the benefit of all Namibians, both present and future, as well as for the international community.". Figure 10.2 shows the structure of the Ministry.

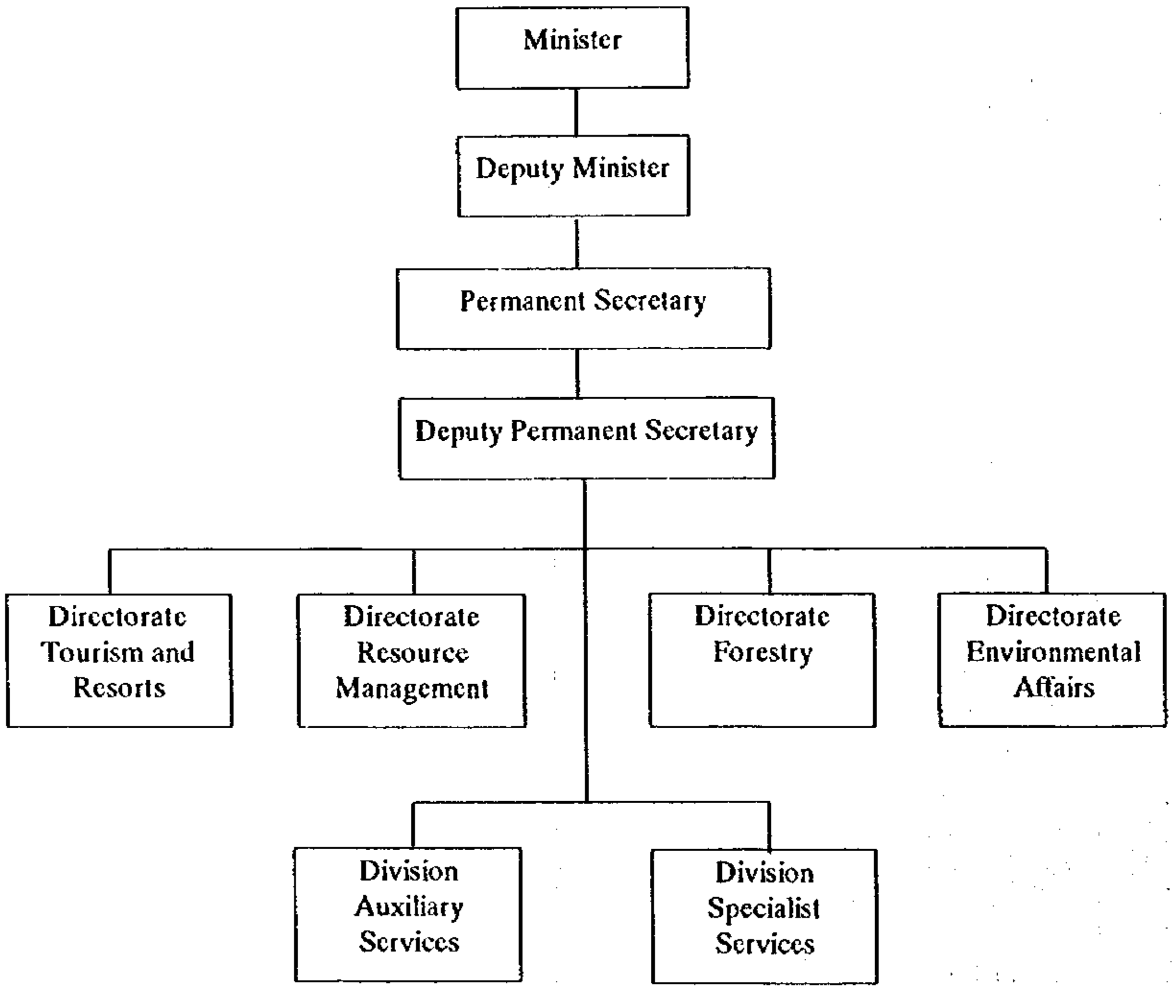



**Figure 10.2 Structure of The Ministry of Environment and Tourism**

(2) Environmental institutional framework

It can be said that environmental institutional framework has not yet been fully established. As indicated in the document "Namibia Environment, Volume 1, 1996", legislation is fragmented and the institutional framework to supervise, monitor and enforce legislative measures is inadequate. For example, legislation on pollution is contained in five different statutes, and administered by different ministries with no uniform standards or coordination among them.

The functional and enforcement duties of one ministry are sometimes carried out by the same ministry. The Ministry of Agriculture, Water and Rural Development promotes agriculture production but must also control the use of harmful pesticides. It is also that the Ministry of Environment and Tourism is responsible for both environmental management and tourism/resort development, which may make its function and enforcement activities difficult.

It is also said that the legal system in Namibia gives low priority to environmental protection, and the enforcement agencies, such as government inspectors, the police and the court, are inadequately equipped to enforce legislation.

From the above, it is clear that there are still many things to be done in the country in the area of environmental administration, such as to update the outdated laws and regulations, to restructure the institutional framework and so on.

### 10.1.3 Nature Environment

(1) Geography and hydrometeorology

a) Geography and geology

The territory of Namibia is located in the range about between the latitudes 17°N to 29°N and longitudes 12°E to 21°E, with a projection area named Caprivi East located at north eastern part. Total area is about 824.3 $km^2$, which is about 2.2 times of that of Japan. The Tropic of Capricorn is crossing the central part of the country.

West side of the country is the coastal plain facing Atlantic Ocean. The plain stretches about 80 to 150 km inland and rises to the elevation of approximately

800 m at the foot of the escarpment mountains in the east. There are three main types of landform, which are the coast (Namib Desert), the plateau area along the middle and gravel/sand terrace area in the east side. Southern part of the gravel/sand terrace area forms a part of Kalahari Desert. Figure 10.3 shows the relief structure of Namibia.

There are about five geological formations appear in Namibia. The following describes briefly the features of the formations.

a. Recent to Cretaceous (age: from 1 to 120 million years) :
   Eolian and alluvial sand, gravel, and calcrete (Kalahari and Namib Desert areas).
b. Karoo (age: from 120 to 180 million years) :
   Extrusive basaltic lava flows and tuffs overlying sandstone, mudstone, shale, coal, and tillite.
c. Cambrian Nama (age: from 470 to 570 million years) :
   Sandstone, shale, limestone.
d. Precambrian Damara (age: from 570 to 900 million years)
   Metamorphosed sediments, lavas, and granite.
e. Older Precambrian (age: from 900 to 2100 million years)
   Quartzites, schists, gneisses, metamorphosed lavas, and granitic intrusives.

Namibia's mineral wealth is mostly due to the fact that geologically very old rock formations appears here. Most of Namibia's base metal deposits are in the Damara formation. This formation appears all along the west coast of Africa, from Gabon to South Africa. One of the arms barnches off north-eastward into the interior of central Namibia. The most important deposits in Namibia are Rössing uranium deposit, the Matchless and Otjihase mines with silver, copper and pyrite, the Rosh Pinah with lead and zinc, and the klein-Aub with copper. All these deposits lie in the Damara formation.

The oldest Pre-Cambrian formation in Namibia is made upof metamorphosed rocks with granite. These very old rocks are found in the Kunene area and in the Orange River valley. Figure 10.4 shows the geological map of Namibia.

b) Hydrometeorology

Namibia is a very dry, or arid country. There is hardly any rainfall in the central

and southern region of Namibia. Only the northern regions get some rain within seasonal limits. Some regions, such as the desert areas, do not get any rainfall at all, or get little rainfall about once every twelve years.
There are two main types of climate in large regions of Namibia as below.

a. Savanna climates, where the rainfall is just enough to support spare trees, bush and grass vegetation. Average yearly rainfall is about 400 to 600 mm. In the Caprivi area, yearly rainfall may reach more than 600 mm, where is called wet savanna climate.

b. Desert climates, which can be categorized again into cool desert, and steppe and hot desert climates, where, because of the lack of rain, no plants can survive except in favorable local conditions. The area of Namib Desert belongs to cool desert climate.
Figure 10.5 shows the map of climatic regions and rainfall distribution of Namibia, and Figure 10.6 shows the climate diagrams of some Namibian waether stations and their locations.

The following shows some weather data of the capital Windhoek.

**Some weather data of the area of Windhoek** (average values)

| Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | 24 | 23 | 21 | 19 | 16 | 13 | 13 | 16 | 19 | 22 | 22 | 24 |
| Hours of sun daily | 9 | 9 | 8 | 9 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 10 |
| Rainfall (mm) | 78 | 77 | 79 | 38 | 7 | 1 | 1 | 1 | 3 | 11 | 27 | 42 |
| Days of rainfall | 11 | 11 | 11 | 5 | 2 | 1 | 1 | 0 | 1 | 3 | 5 | 7 |

Source: Geography of Namibia, 1990

There are five perennial rivers in Namibia, all of them bordering the country. There are no perennial rivers within the Namibia's boundary.

- Kunene River
- Okavango River
- Mashi-Linyanti-Chobe River
- Zambezi River
- Orange River

All these rivers have water throughout the year, but the amount of water varies according to the rainfall over their catchment areas. Okavango River flows into the territory of Botswana and forms a delta wet land. Figure 10.7 shows rivers and drainage regions in Namibia.

(2) National parks, nature reserves and game parks

There are 21 parks and recreation areas in Namibia. About 13.6% of Namibia's total land area has been proclaimed as conservation areas. Parks are categorized into national and nature parks. Wildlife in the parks are protected. There are two categories for game parks, one is the State operated game park and the other is private owned game park. Hunting is allowed in some game parks under licenses. Therefore, wildlife is well protected and controlled. The parks are open to be the recreation and resort areas, which forms an important income source as same with many other countries in Africa.

Table 10.3 shows the list of Namibia's state owned parks and recreation areas.

Etosha National Park

Etosha National Park is one of the most famous parks in Namibia. The park is located at northern part of the country, which covers now an area of 22,270 km$^2$. There are saline pans in the central part of the park.

Etosha has 114 mammal species, 340 bird species, 110 reptile species, 16 amphibian species and one fish species. Typical animals are giraffe, oryx, rhinoceros, lion, buffalo, zebra, springbok, flamingo and so on. The nature attracts thousands of tourists annually.

(3) Vegetation and forest

Namibia has three broad types of vegetation, those are deserts, savannas and woodlands (based on Giess, 1971). The deserts are the Namib Desert and the Etosha Pan. Woody vegetation occurs in Namib Desert only in the river beds, includes small trees and shrubs. The Etosha Pan is fairly barren, but some *Acacia nebroenii* are found. Savannas cover 64% of the territory of Namibia, which can be divided into several savannas, such as dwarf shrub savanna, mixed tree and shrub savanna, highland savanna, mopane savanna, etc. In the savannas, a certain vegetation type is wide spread in northwestern Namibia. The domonant tree species is *Colophospermum mopane*, a 7 to 10 m tall deciduous tree.

Woodlands cover one fifth of the territory of Namibia, and spread in the northeastern part of the country, including East Caprivi. Due to much rainfall in this area, semievergreen trees are domonant. One of the dominant species is *Baikiaea plurijuga* (Zambezi teak). Its hight is up to 8 to 18 m. Figure 10.8 shows natural vegetation map of the country.

Figure 10.9 shows the photographs of typical trees (mopane and marula) in Owambo area.

### 10.1.4 Environmental Issues

Namibia is not a highly industrialized country. About 70% of the population make a living from agriculture. Therefore, environmental pollution has not yet become its social and natural problems. Air quality is still in very good condition. Therefore, the issue will be how to maintain the clean environment, including conservation of the beautiful nature. Paying attentions to the following points of concern will be beneficial to the sustainable development of the country.

(1) Conservation of forest

Namibia is a dry or arid country. Forest area is only about 20% of the total territory. Most of the trees are sparsely distributed. Others are dwarf shrubs and grasses. During dry season, the vegetation is hardly surviving. Breeding vegetation is not easy. Therefore, the following attentions shall be paid to maintain the existing forest.

a. To avoid the use of trees as fuelwood.
b. To avoid the use of woods as the material of fence structures.
c. To avoid the use of wood material as the electric distribution poles.

(2) Avoiding soil and groundwater pollutions

Mining is a very active and important industry in this country. Uranium, copper, gold and diamond minings are typical and very active. It is impressive that some of the enterprises are now establishing their own environmental management programs based on ISO 14000s standards. To enhance such programs, it is recommended that the following issues will be well dealt with.

a. Facilities for treatment and disposal of mining tailings will be well established
b. Liquid wastes will be well treated before dumping to the environment
c. Facility and disposal sites for other solid wastes will be well designed and utilized.

The above measures shall be cost beneficial from point of view of sustainable development of the country.

## 10.2 Study on Energy Conservation

### 10.2.1 Power Generation Facilities and Rural Electrification

(1) Power generation facilities

Hydro-electric power generation facility is a promising option from point of view of energy conservation, if the following conditions will be satisfied.

- Environmental issues, such as those to be incurred from dam construction and formation of reservoirs, can be mitigated or avoided.
- Environmental cost and benefit can be balanced or even better than equal.

Therefore, solving environmental issues in connection with Epupa hydropower project is essential for achieving energy conservation policy of Namibia.

On the other hand, gas-fired combined cycle power generation is another promising option from points of view of both energy conservation and environmental protection. The reasons are listed below.

- Using combined cycle, higher thermal efficiency can be achieved than any other type of thermal power cycle, which in turn less fuel will be needed for generating same power.
- Sulfur content of natural gas is almost zero, and therefore SOx emission will be negligible. SOx treatment system will become unnecessary.

Therefore, it is recommended that Kudu gas combined cycle thermal power generation project will be pursued as an important alternative for Namibia.

(2) Rural electrification

Assuming the above power generation facilities with large capacity are feasible, to provide electricity to rural areas through power distribution network will be reliable and practical. On the other hand, it is also considered that some kind of back-up system may become necessary from the following points of view.

- Power output by hydropower plants will usually be decreased during dry season.
- Total power output may be decreased when a couple of power plants would be shut down at the same period for plant maintenance, and power shortage could be happened due to lack of excess power facilities.

For remote rural areas, some kind of scattered small scale power generation system may become meaningful. In such areas, effective use of renewable energy, such as wind power or solar energy system may become important. Therefore, research and development effort for such system shall be continued, because such power generating system are now playing an important role in industrialized countries, such as the United States and some European countries and also in Japan.

Through discussions with MME staff members, it is known that research and development work on potential use of renewable energy in Namibia has already been actively implemented, and results obtained to date show the use of such energy is promising.

### 10.2.2 Other Considerations for Energy Conservation

At present, population is still not very large and the amount of energy consumption is still not very big in Namibia. Therefore, the effectiveness of energy saving efforts would not be apparent. However, energy conservation is usually an important target to be pursued.

From the point of view of the above, attentions should also be paid to the following items.

- To promote using energy saving type of electrical equipment and tools.
- To promote using high heat value fuel for household affairs purpose.

Using oil or gas as heat source will also play an important role for forest protection, which is one of important environmental issues in Namibia.
The issue of energy conservation will become more critical, when population becomes larger. Therefore, any effort to achieve energy conservation will be meaningful at any moment.

## 10.3 Environmental Checklists of International and Foreign Financing Agencies

Based on the "Environmental Assessment Policy" of Namibia, it is clear that electric power plant owners/operators of the country have to comply with environmental requirements of its government. It a plant owner/operator of the country will need financial loan from an international or foreign financing agency for its new construction project, the plant owner/operator will also have to comply with the environmental requirements set force by such agency. The following introduces the environmental requirements and related environmental checklists of the agencies.

### 10.3.1 Environmental Requirements and Environmental Checklists of the World Bank

(1) Environmental consideration requirement

The World Bank issued on October 1991 a document titled "Operational Directive on Environmental Assessment, OD 4.01". Under the Directive, The World bank classified development projects into three categories for project appraisal by the Bank. The following shows the definition in brief of each of the categories.

a) Category A

The projects either have or are likely to have adverse impacts that may be sensitive, irreversible, and diverse. The adverse potential impacts may be significant. A full-scale environmental assessment (EA) is required for such a project. Examples of such projects are shown below.

- Dams and reservoirs
- Forestry and production projects
- Industrial plants (large scale)
- Irrigation, drainage, and flood control (large scale)
- Land clearance and leveling
- Mineral development (large scale)
- Port and harbor development

- Reclamation and new land development
- River basin development
- Thermal and hydropower development
- Manufacture, transportation, and use of pesticides and other hazardous and/or toxic materials

b) Category B

The projects may have environmental impacts for which more limited analysis is appropriate. The projects often differ from A type projects only in scale. Although a full-scale EA is not required, some environmental analysis is required. Examples of the projects are shown below.

- Agro-industries
- Electrical transmission
- Aquaculture and mariculture
- Irrigation and drainage (small scale)
- Renewable energy
- Rural electrification
- Tourism
- Rural water supply and sanitation
- Watershed projects (management and rehabilitation)
- Rehabilitation, maintenance, and upgrading projects (small scale)

c) Category C

These projects are likely to have negligible or minimal environmental impacts. No environmental assessment or analysis is required. Examples of such projects are shown below.

- Education
- Family planning
- Health
- Nutrition
- Institution development
- Technical assistance
- Most human resource projects

(2) Environmental checklist

Attached Table 10.4 and Table 10.5 show the environmental checklists for hydroelectric and thermal electric power projects, respectively. These checklists are given in a World Bank document titled "Environmental Assessment Sourcebook, Volume III, 1991". For details, refer to the Sourcebook.

### 10.3.2 Environmental Requirements and Environmental Checklists of the Asian Development Bank

(1) Environmental consideration requirements

The Asian Development Bank (ADB) requires various environmental studies throughout different stages of a project. A project is divided into the following three stages. The required environmental study for each stage is also explained below.

a) Preliminary Study stage

Under the stage, "Preliminary Environmental Survey" will have to be performed to understand and clarify the present conditions of nature and social environments of the project site area, and to identify the environmental factors and potential environmental impacts which have to be studied in more details under the next stage.

b) Feasibility Study stage

Under the stage, "Initial Environmental Examination, IEE" will have to be performed. If the result of the IEE shows that the project plan is not appropriate, the project plan will have to be changed to satisfy the environmental considerations. If the result show the project plan is appropriate, then "Environmental Impact Assessment " has to be implemented, and the necessary measures to protect or mitigate identified potential impacts have to be incorporated into the project plan..

c) Construction and Operation stage

Implement necessary measures to protect or mitigate potential environmental impacts and also the environmental monitoring required as a part of the EIA results.

(2) Environmental checklist

Attached Table 10.6 shows the environmental checklist for dams and reservoirs, and hydropower projects. The checklist provides also the potential environmental damages and recommended protection measures.

### 10.3.3 Environmental Requirements and Environmental Checklist of JICA

(1) Environmental consideration requirements

JICA ( Japan International Cooperation Agency ) requires environmental consideration by identifying potential environmental impacts of a development project through the following stages.

a) Initial Planning stage

Under the stage, it is required to carry out "Preliminary Survey". In the survey, "screening of environmental factors" has to be performed to determine if an "Environmental impact survey" (equivalent to EIA) will be needed. If it is judged that the impact survey will be needed, then "scoping" the necessary scope of work of the impact survey has to be carried out.

b) Master Plan Study and Feasibility Study stage

The two studies may be combined into a Feasibility Study. For master planning, "Initial environmental examination (IEE) has to be carried out. For feasibility study, detailed EIA has to be implemented.

c) Construction and Operation Stages

During construction stage, all measures to protect or mitigate potential environmental impacts have to be implemented. Also that various environmental monitoring has to be implemented to verify if the measures taken are effective.

During operation of a project facility, environmental monitoring has to be implemented periodically to verify if environmental pollution and other impacts are avoided or mitigated as intended.

(2) Environmental Checklist

Attached Table 10.7 shows the environmental checklist for dam construction project. The checklist will be used for making "screening and scoping" of the environmental factors concerned.

### 10.3.4 Environmental Requirements and Environmental Checklist of OECF, Japan

(1) Environmental consideration requirements

OECF ( The Overseas Economic Cooperation Fund, Japan ) classifies various development projects into three categories to differentiate the extent and depth of environmental impact assessment to be required. The Environmental Guidelines (second edition) was issued on August 1995. The following shows the definitions of the three categories.

a) Category A

Large scale development or rehabilitation projects, the projects that will be located at the areas where protected/preserved nature and social environments are concerned, the projects that may cause significant environmental pollution or irreversible environmental impacts, etc. are classified into this category.

Submission of environmental impact assessment (EIA) report to the OECF is required for such a project. The project will then be appraised by the OECF in light of the requirements of the OECF Guidelines.

b) Category B

The projects which are not belonging to Category A and will have less environmental impacts. Submission of an EIA report to the OECF will not be required. However, such a project will be subject to appraisal by the OECF in light of the Guidelines.

c) Category C

The projects that are not normally expected to have an environmental impact. Certain telecommunication, education, human resources development projects, etc. would fall within this category. Submission of an EIA report is not required, and appraisal in light of the OECF Guidelines may be omitted.

(2) Environmental checklist

Attached Table 10.8 and Table 10.9 show the environmental checklists for hydroelectric and thermal electric power projects, respectively.

**Table 10.3 Sizes and proclamation dates of Namibia's state owned Parks and Recreation Areas**

| Name of Parks | Area ( km$^2$) | Date Proclaimed |
|---|---|---|
| Etosha National Park | 22,270 | 1975 |
| Namib - Naukluft Park | 49,768 | 1990 |
| Gross Barmen Hot Springs | 0.1 | 1966 |
| Caprivi Game Park | 5,715 | 1968 |
| Hardap Recreation Resort | 251.8 | 1968 |
| Daan Viljoen Game Park | 39.5 | 1968 |
| Cape Cross Seal Reserve | 60 | 1968 |
| Hot Springs Ai - Ais | 461.2 | 1988 |
| The South West Nature Park | 0.04 | 1970 |
| Skeleton Coast Park | 16,390 | 1973 |
| Waterberg Plateau Park | 405.5 | 1990 |
| Von Bach Recreation Resort | 42.9 | 1972 |
| National West Coast Recreation Area | 7,800 | 1974 |
| National Diamond Coast Recreation Area | unknown | 1978 |
| Huns Mountains | 3,000 | 1988 |
| Naute Recreation Resort | 224.6 | 1988 |
| Popa Game Park | 0.25 | 1989 |
| Mahango Game Reserve | 244.6 | 1989 |
| Khaudum National Park | 3,841.6 | 1989 |
| Mudumu National Park | 1,009.6 | 1990 |
| Mamili National Park | 319.9 | 1990 |

( Total area = 111,844.6 km$^2$ or 13.6% of Namibia )

Source: Namibia Environment, Volume 1, January 1996

## Table 10.4 Environmental Checklist for Hydroelectric Projects ( World Bank )



| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Direct** | |
| 1. Negative environmental effects of construction<br>・Air and water pollution from construction and waste disposal<br>・Soil erosion<br>・Destruction of vegetation<br>・Sanitary and health problems from construction camps | 1. ・ Measures to minimize impacts:<br>・Air and water pollution control<br>・Careful location of camps, buildings, borrow pits, quarries, spoil and disposal sites<br>・Precautions to minimize erosion<br>・Land reclamation |
| 2. Dislocation of people living in inundation zone | 2. ・ Relocation of people to suitable area<br>・Provision of compensation in kind for resources lost<br>・Provision of adequate health services, infrastructure, and employment opportunities. |
| 3. Loss of land (agriculture, forest, range, wetlands) by inundation to form reservoir. | 3. ・ Siting of dam to decrease losses.<br>・Decrease of dam and reservoir size.<br>・Protection of equal areas in region to offset losses.<br>・Creation of useable land in previously unsuitable areas to offset losses. |
| 4. Loss of historic, cultural or aesthetic features by inundation. | 4. ・ Siting of dam or decrease of reservoir size to avoid loss.<br>・Salvage or protection of cultural properties. |
| 5. Loss of wildlands and wildlife habitat. | 5. ・ Siting of dam or decrease of reservoir size to avoid/minimize loss.<br>・Establishment of compensatory parks or reserved areas.<br>・Animal rescue and relocation. |

## Table 10.4 Environmental Checklist for Hydroelectric Projects ( World Bank ) (continued)



| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Direct (continued)** | |
| 6. Proliferation of aquatic weeds in reservoir and downstream impairing dam discharge, irrigation system, navigation and fisheries and increasing water loss through transpiration. | 6. · Clearance of woody vegetation from inundation zone prior to flooding (nutrient removal).<br>· Weed control measure.<br>· Harvest of weeds for compost, fodder or biogas.<br>· Regulation of water discharge and manipulation of water levels to discourage weed growth. |
| 7. Deterioration of water quality in reservoir. | 7. · Clearance of woody vegetation from inundation zone prior to flooding.<br>· Control of land uses, wastewater discharges, and agricultural chemical use in watershed.<br>· Limit retention time of water in reservoir.<br>· Provision for multi-level releases to avoid discharge of anoxic water. |
| 8. Sedimentation of reservoir and loss of storage capacity. | 8. · Control of land use in watershed (especially prevention of conversion of forest to agriculture).<br>· Reforestation and/or soil conservation activities in watersheds (limited affect).<br>· Hydraulic removal of sediments (flushing, sluicing, release of density currents).<br>· Operation of reservoir to minimize sedimentation (entails loss of power benefits). |

**Table 10.4 Environmental Checklist for Hydroelectric Projects ( World Bank )**
(continued)



| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Direct (continued)** | |
| 9. Formation of sediment deposits at reservoir entrance creating backwater effect and flooding and waterlogging upstream. | 9. Sediment flushing, sluicing. |
| 10. Scouring of riverbed below dam. | 10. Design of trap efficiency and sediment release (e.g., sediment flushing, sluicing) to increase salt content of released water. |
| 11. Decrease in floodplain (recession) agriculture. | 11. Regulation of dam release to partially replicate natural flooding regime. |
| 12. Salinization of floodplain lands. | 12. Regulation of flow to minimize effect. |
| 13. Salt water intrusion in estuary and upstream. | 13. Maintenance of at least minimum flow to prevent intrusion. |
| 14. Disruption of riverine fisheries due to changes in flow, blocking of fish migration, and changes in water quality and limnology. | 14. · Maintenance of at least minimum flow for fisheries.<br>· Provision of fish ladders and other means of passage.<br>· Protection of spawning grounds.<br>· Aquaculture and development of reservoir fisheries in compensation. |
| 15. Snagging of fishing nets in submerged vegetation in reservoir. | 15. Selective clearance of vegetation before flooding. |
| 16. Increase of water-related diseases. | 16. · Design and operation of dam to decrease habitat for vector.<br>· Vector control.<br>· Disease prophylaxis and treatment. |

### Table 10.4 Environmental Checklist for Hydroelectric Projects ( World Bank ) (continued)

4/5

| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Direct (continued)** | |
| 17. Conflicting demands for water use. | 17. · Planning and management of dam in context of regional development Plans.<br>· Equitable allocation of water between large and small holders and between geographic regions of valley. |
| 18. Social disruption and decrease in standard of living of resettled people. | 18. · Maintenance of standard of living by ensuring access to resources at least equaling those lost.<br>· Provision of health and social services. |
| 19. Environmental degradation from increased pressure on land. | 19. · Choice of resettlement site to avoid surpassing carrying capacity of the land.<br>· Increase of productivity or improve management of land (agriculture, range, forestry improvements) to accommodate higher population. |
| 20. Disruption/destruction of tribal/indigenous groups. | 20. Avoid dislocation of unacculturated people and where not possible, relocate in area allowing them to retain lifestyle and customs. |
| 21. Increase in humidity and fog locally, creating favorable habitat for insect disease vectors (mosquitos, tsetse). | 21. Vector control. |

**Table 10.4 Environmental Checklist for Hydroelectric Projects ( World Bank )**
(continued)



| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Indirect** | |
| 22. Uncontrolled migration of people into the area made possible by access roads and transmission lines. | 22 Limitation of access, provision of rural development, and health services to try to minimize impact. |
| 23. Environmental problems arising from development made possible by dam (irrigated agriculture, industries, municipal growth). | 23. Basin-wide integrated planning to avoid overuse, misuse, and conflicting uses of water and land resources. |
| **External** | |
| 24. Poor land use practices in catchment areas above reservoir resulting in increased siltation and changes in water quality. | 24. Land use planning efforts which include watershed areas above dam. |

## Table 10.5 Environmental Checklist for Thermoelectric Projects ( World Bank )

1/4

| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Direct** | |
| 1. Air emission effects to human health, agriculture, and native wildlife and vegetation. | 1. · Locate facility away from sensitive air quality receptors.<br>· Design higher stacks to reduce ground level concentrations.<br>· Use cleaner fuel (e.g., low sulfur coal).<br>· Install air pollution control equipment. |
| 2. Increased noise and vibration. | 2. · Use lower rated equipment.<br>· Control the timing of noise and vibration to least disruptive periods.<br>· Install noise barriers. |
| 3. Change in surface water and groundwater quality. | 3. · Treat discharges chemically or mechanically on-site.<br>· Prevent groundwater contamination through use of liners.<br>· Use deep well injection below potable zones.<br>· Construct liners for ponds and solid waste disposal areas.<br>· Dilute effluent at point of discharge. |
| 4. Toxic effects of chemical discharges and spills. | 4. · Develop spill prevention plans.<br>· Develop traps and containment systems and chemically treat discharges on-site. |
| 5. Thermal shock to aquatic organisms. | 5. · Use alternative heat dissipation design (e.g., closed cycle cooling).<br>· Dilute thermal condition by discharging water into larger receiving water body.<br>· Install mechanical diffusers. |

**Table 10.5 Environmental Checklist for Thermoelectric Projects ( World Bank )**
(continued)



| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Direct (continued)** | · Cool water on-site in holding pond prior to discharge.<br>· Explore opportunities to use waste heat. |
| 6. Entrainment and impingement of aquatic organisms. | 6. · Select water intake in area that avoids significant impact.<br>· Install screens to eliminate entrainment and impingement. |
| 7. Change in surface water and groundwater quality. | 7. · Develop water recycling plan. |
| 8. Change in surface water flow and discharge. | 8. · Construct drainage ways and holding ponds on-site. |
| 9. Vegetation removal and habitat loss. | 9. · Select alternative site or site layout to avoid loss of ecological resources.<br>· Restore or create similar vegetation or habitats. |
| 10. Dredging and filling of wetlands. | 10. · Select alternative site or site layout to avoid loss of wetlands.<br>· Restore or create similar wetlands. |
| 11. Avian hazards from stacks, towers, and transmission lines. | 11. · Site stacks and towers away from flyways.<br>· Install deflectors, lights, and other visible features. |
| 12. Human population displacement. | 12. · Select alternative site or site layout to avoid displacement.<br>· Involve affected parties in the resettlement planning and program.<br>· Construct socially and culturally acceptable settlements/infrastructure development. |

**Table 10.5 Environmental Checklist for Thermoelectric Projects ( World Bank )**
(continued)



| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Direct (continued)** | |
| 13. Disruption of traffic. | 13. · Develop traffic plan that includes phasing road use by workers.<br>· Upgrade roads and intersections. |
| 14. Modification of historically or archaeologically significant structures or lands (e.g., churches, temples, mosques, cemeteries). | 14. · Select alternative site or site layout.<br>· Develop and implement "chance find" procedures to recover, relocate or restore structures.<br>· Fence or construct other barriers to protect structures or lands. |
| 15. Visual impact on historical, archaeological, and cultural resources and on landscapes. | 15. · Select alternative site or site layout.<br>· Construct visual buffers (e.g., plant trees). |
| 16. Worker exposure to dust from ash and coal. | 16. · Provide dust collector equipment.<br>· Maintain dust levels $\leqq$ 10 mg/m$^3$.<br>· Monitor for free silica content.<br>· Provide dust masks when levels are exceeded. |
| 17. Worker exposure to toxic gases leaking from boilers. | 17. · Maintain boilers properly.<br>· Monitor concentrations with levels not to exceed:<br>$SO_2$ 5 ppm<br>CO 50 ppm<br>$NO_2$ 5 ppm |
| 18. Worker exposure to excessive noise. | 18. · Maintain noise levels below 90 dBA, or provide ear protection. |

**Table 10.5 Environmental Checklist for Thermoelectric Projects ( World Bank )**
(continued)

4/4

| Potential Negative Impacts | Mitigating Measures |
|---|---|
| **Indirect** | |
| 1. Induced secondary development including increased demands on infrastructure. | 1. · Provide infrastructure plan and financial support for increased demands.<br>· Construct facilities to reduce demands. |
| 2. Changes in demographic patterns and disruption of social and cultural values and patterns. | 2. · Develop plan to educate workers on sensitive values and patterns.<br>· Provide behavioral and/or psychological readjustment programs and services. |

## Table 10.6 Checklist of Environmental Parameters for Dams and Reservoirs/Hydropower Projects (ADB)



| Actions Affecting Environmental Resources and Values | Potential Damages to Environment | Recommended Feasible Protection Measures |
|---|---|---|
| A. Environmental Problems Due to Project Location | | |
| 1. Resettlement | 1. Serious social iniquities | 1. Carefully planned resettlement program including "hard" budget |
| 2. Encroachment into precious ecology | 2. Loss of ecological values | 2. Careful planning plus use of offsetting measures |
| 3. Encroachment on historical/ cultural values | 3. Loss of the values | 3. Careful planning plus mitigation measures |
| 4. Watershed erosion and silt runoff | 4. Shortened reservoir life | 4. Watershed management program |
| 5. Impairment of navigation | 5. Economic loss | 5. Careful planning plus mitigation measures |
| 6. Effects on groundwater hydrology | 6. Economic loss | 6. Careful planning plus mitigation measures |
| 7. Migrating valuable fish species | 7. Decrease in fish species catch | 7. Furnish fish traps |
| 8. Inundation of mineral resources | 8. Loss of these values | 8. Mines before inundation if feasible |
| 9. Other inundation losses or adverse effects | 9. Depends on type of effect | 9. Careful planning/design/O&M monitoring |
| B. Environmental Problems Related to Design | | |
| 1. Road erosion | 1. Impairment of water quality | 1. Careful planning/design/O&M monitoring |
| 2. Reservoir site preparation | 2. Affects reservoir water quality including nutrients for fishery | 2. Prepare site to suit optimal reservoir uses |
| 3. Water rights conflicts | 3. Serious social conflicts | 3. Careful management of water rights allocation |
| 4. Fish screens | 4. Loss of fish stock | 4. Proper screening |

Table 10.6 Checklist of Environmental Parameters for Dams and Reservoirs/Hydropower Projects (ADB) (Continued)



| Actions Affecting Environmental Resources and Values | Potential Damages to Environment | Recommended Feasible Protection Measures |
|---|---|---|
| C. Environmental Problems Associated with Construction Stage | | |
| 1. Soil erosion/silt runoff | 1. Impairment of water quality and land values | 1. Proper construction planning plus monitoring |
| 2. Other construction hazards | 2. Various hazards | 2. Proper construction planning plus monitoring |
| (a) Safety of workers | (a) Hazards to workers' health and safety | (a) Proper construction planning plus monitoring |
| (b) Sanitation at workers' camp | (b) Hazards to health of workers and nearby communities | (b) Same as above |
| (c) Water-oriented diseases | (c) Hazards to health of workers and nearby communities | (c) Same as above |
| (d) Dust/odors/fires/noise/ vibration | (d) Hazards to workers and neighbors | (d) Same as above |
| (e) Quarrying hazards (blasting) | (e) Hazards to workers and neighbors | (e) Same as above |
| (f) Environmental aesthetics | (f) Loss of scenic values | (f) Same as above |
| 3. Construction monitoring | 3. Without it, contractors not likely to observe constraints | 3. Appropriate construction audits |
| D. Environmental Problems Related to Project Operations | | |
| 1. Downstream flow variations | 1. Disturbances to downstream fisheries, navigation and other uses | 1. Minimize adverse effects |
| 2. Depreciation of downstream | 2. Loss of fisheries formerly growing in inundated fields | 2. Offset by promotion of aquaculture |
| 3. Downstream erosion | 3. Erosion of banks and river bottom damaging downstream riverside facilities | 3. Careful design to control problem plus monitoring |
| 4. Lack of reservoir management | 4. Social conflicts in reservoir community | 4. Appropriate reservoir management |

Table 10.6 Checklist of Environmental Parameters for Dams and Reservoirs/Hydropower Projects (ADB) (Continued)



| Actions Affecting Environmental Resources and Values | Potential Damages to Environment | Recommended Feasible Protection Measures |
|---|---|---|
| 5. Eutophication (aquatic weeds) | 5. Heavy evaporation plus impairment of fishing and power generation | 5. Phenomena may usually be temporary |
| 6. Downstream water quality | 6. Impairment of downstream water quality from flow restrictions | 6. Careful operations planning to minimize problem |
| 7. Insect vector disease hazards | 7. Community health hazards | 7. Careful monitoring plus use of appropriate control measures |
| 8. Estuary and marine fisheries impacts | 8. Loss of fisheries/aquatic ecology | 8. Careful operations to minimize/offset problem |
| 9. Reservoir bank stability | 9. Impairment of reservoir uses and water quality | 9. Careful planning/design |
| 10. Operation monitoring | 10. Without it, operators not likely to comply with requirements | 10. Appropriate monitoring |
| E. Potential Environmental | | |
| 1. Reservoir fishery enhancement | 1. Considerable extra reservoir fishery potential realized | 1. Appropriate reservoir fishery management |
| 2. Promotion of agriculture | 2. Considerable extra agricultural production realized | 2. Appropriate measures to promote agriculture |
| 3. Downstream community water supply | 3. Improvement in community living standards | 3. Planning for optimal use of stored water |
| 4. Downstream agriculture | 4. Improvement in community living standards | 4. Planning for optimal use of stored water |
| 5. Forests/wildlife reserves | 5. Conservation of forests and wildlife | 5. Establishment of reserved areas to offset losses |
| 6. Recreation | 6. Improvement of community quality of life including the poor | 6. Planning for optimal multipurpose reservoir use |

Table 10.6 Checklist of Environmental Parameters for Dams and Reservoirs/Hydropower Projects (ADB) (Continued)



| Actions Affecting Environmental Resources and Values | Potential Damages to Environment | Recommended Feasible Protection Measures |
|---|---|---|
| F. Additional Consideration for Hydropower Projects | | |
| 1. Multipurpose management need | 1. Opportunity to optimize overall project benefits | 1. Integrated multipurpose reservoir management |
| 2. Rural electrification | 2. Improving quality of life for rural poor | 2. Planning to accommodate this need |
| 3. Transmission lines | 3. Potential losses | 3. Protection measures |
| (a) Encroachment on precious ecology | (a) Loss of forest resources | (a) Careful planning/design/monitoring to minimize and offset problems |
| (b) Impairment of wildlife | (b) Impairment of wildlife values | (b) Same as above |
| (c) Impairment of environmental aesthetics | (c) Loss of scenic beauty | (c) Same as above |
| (d) Soil erosion from construction and areas left exposed | (d) Depreciation of water quality and land value | (d) Same as above |
| G. Critical Review Criteria | | |
| 1. Loss of irreplaceable natural resources | | 1. Planning should be consistent with national environmental protection policies |
| 2. Accelerated use of resources for short-term gains | | 2. Same as above |
| 3. Endangering of species | | 3. Same as above |
| 4. Undesirable rural-to-urban migration | | 4. Same as above |
| 5. Increase in affluent/poor people gap | | 5. Same as above |

## Table 10.7 Environmental Checklist for Dam Construction Project ( JICA) (for use in preliminary study stage)

1/2

| Environmental Factors | No. | Check Items | Evaluation | Reasons |
|---|---|---|---|---|
| **I. Social Environment** | | | | |
| **Population** | 1 | Change in the local population distribution (minority ethnic group problem included) | | |
| | 2 | Relocation (minority ethnic group problem included) | | |
| **Industry** | 3 | Agriculture and forestry | | |
| | 4 | Fishery | | |
| | 5 | Secondary industry (mining and mineral resources included) | | |
| | 6 | Tertiary industry (tourism and recreation included) | | |
| **Communication** | 7 | Local cut-off (minority ethnic group problem included) | | |
| **Transportation** | 8 | Influence on land transportation | | |
| | 9 | Influence on water transportation | | |
| **River basin and its utilization** | 10 | Influence on water rights and fishing rights, etc. | | |
| **Sanitation conditions** | 11 | Occurrence and transmission of river basin related diseases | | |
| | 12 | Deterioration of sanitary environment during construction | | |
| **Scenery** | 13 | Deterioration of landscape | | |
| **Cultural assets, etc.** | 14 | Influence on cultural assets | | |
| **II. Natural Environment** | | | | |
| **Toposphere** · Subject | 15 | Influence on inducible earthquakes | | |
| · Topography | 16 | Slope slide | | |
| | 17 | Sedimentation in back water area | | |
| | 18 | Influence on downstream channels | | |
| | 19 | Influence on beaches | | |
| · Geology | 20 | Soil erosion | | |
| | 21 | Soil contamination | | |

## Table 10.7 Environmental Checklist for Dam Construction Project ( JICA)
### (for use in preliminary study stage)

(continued) 2/2

| Environmental Factors | | No. | Check Items | Evaluation | Reasons |
|---|---|---|---|---|---|
| **II. Natural Environment** (continued) | | | | | |
| **Hydrosphere** | • Hydrologic phenomena | 22 | River basin change | | |
| | | 23 | Influence on groundwater | | |
| | | 24 | Flow condition change | | |
| | • Water quality | 25 | Water temperature change | | |
| | | 26 | Eutrophication | | |
| | | 27 | Turbid water | | |
| | • Sediment | 28 | Sediment component change | | |
| **Biosphere** | • Plants | 29 | Influence on plants | | |
| | • Animals | 30 | Influence on animals | | |
| | • Aquatic organisms | 31 | Influence on aquatic organisms | | |
| | • Ecological system | 32 | Destruction of ecological system | | |
| **Atmosphere** | • Air | 33 | Air pollution | | |
| | | 34 | Microclimate change | | |
| | • Odor | 35 | Generation odor substances | | |
| | • Noise/vibration | 36 | Occurrence of noise and vibration | | |

Note 1. Evaluation Classification

A: Serious impact

B: Medium level impact

C: Slight impact

D: Unknown (Study is necessary. It is also necessary to consider that the impact may be clarified as the study progresses.)

X: Environmental impact does not exist under the study.

Note 2. Regarding an inducible earthquake, its occurrence is considered extremely rare except an extremely large scale dam construction. This evaluation is conducted within a possible range since it is difficult to evaluate its impact in the Preliminary Study Stage.

**Table 10.8 Environmental Checklist for Hydropower Project ( OECF, Japan )**

| Environmental Factors | Check Items | Potential Impacts | | | | Problems | Action and Countermeasures Planned | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | Major | Small | None | Not Clear | | | |
| Pollution | 1. Deterioration of water quality (including detrimental changes in water temperature) in the dam reservoir and downstream | | | | | | | |
| Natural Environment | 1. Effect of construction of the facility on the ecology<br>2. Effect on landscape | | | | | | | |
| Human Environment | 1. Effect of construction of the facility on the historical and cultural heritage<br>2. Effect on existing infrastructure<br>3. Relocation of people<br>4. Effect on traffic<br>5. Effect on other downstream utilization<br>6. Occurrence of diseases, such as malaria, carried by insects or water | | | | | | | |
| Others | 1. Effect on the environment during construction period<br>2. Environmental monitoring | | | | | | | |

**Table 10.9 Environmental Checklist for Thermal Power Project ( OECF, Japan )**

1/2

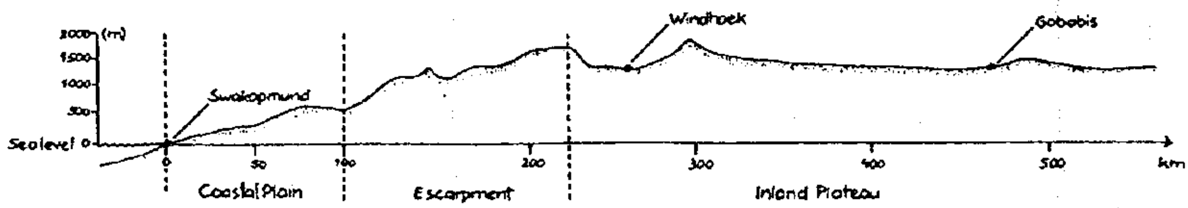
| Environmental Factors | Check Items | Potential Impacts | | | | Problems | Action and Countermeasures Planned | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | Major | Small | None | Not Clear | | | |
| Pollution | 1. Air pollution through the emission of soot and dust, sulfur oxides, and nitrogen oxides released in the combustion of fuel.<br>2. Offensive odors<br>3. Effect of thermal effluent and land reclamation on aquatic organisms, fisheries, and other water utilization.<br>4. Water pollution resulting from ordinary effluent.<br>5. Noise and vibration<br>6. Ground subsidence<br>7. Effect on the water level of a lake, marsh or river<br>8. Effect of industrial waste | | | | | | | |
| Natural Environment | 1. Effect of construction of the facility on the ecology<br>2. Effect on landscape | | | | | | | |

**Table 10.9 Environmental Checklist for Thermal Power Project ( OECF, Japan )**

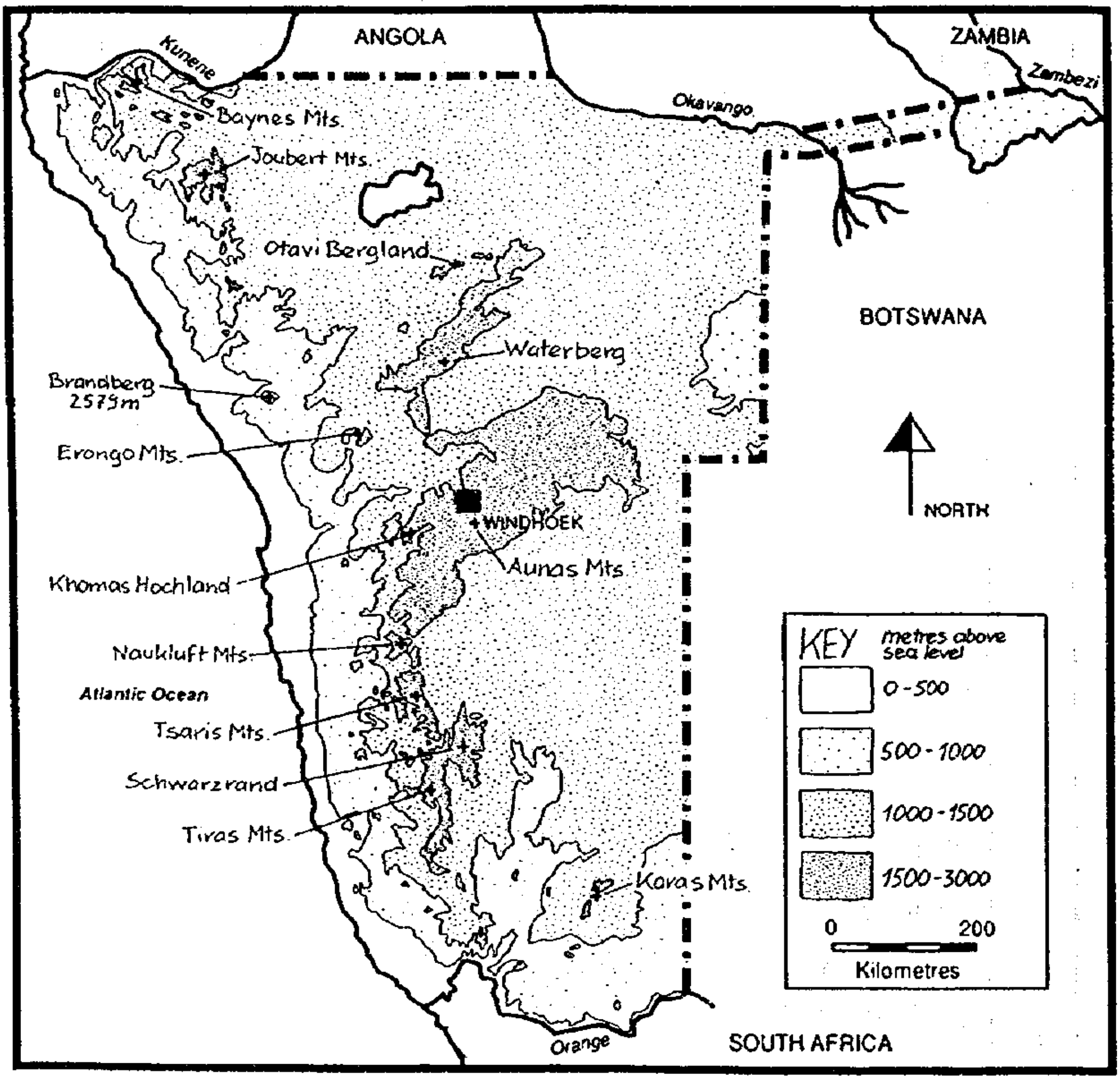
(continued)

2/2

| Environmental Factors | Check Items | Potential Impacts | | | | Problems | Action and Countermeasures Planned | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | Major | Small | None | Not Clear | | | |
| Human Environment | 1. Effect of construction of the facility on the historical and cultural heritage<br>2. Effect on existing infrastructure<br>3. Effect on land-use | | | | | | | |
| Others | 1. Effect on the environment during construction period<br>2. Environmental monitoring | | | | | | | |



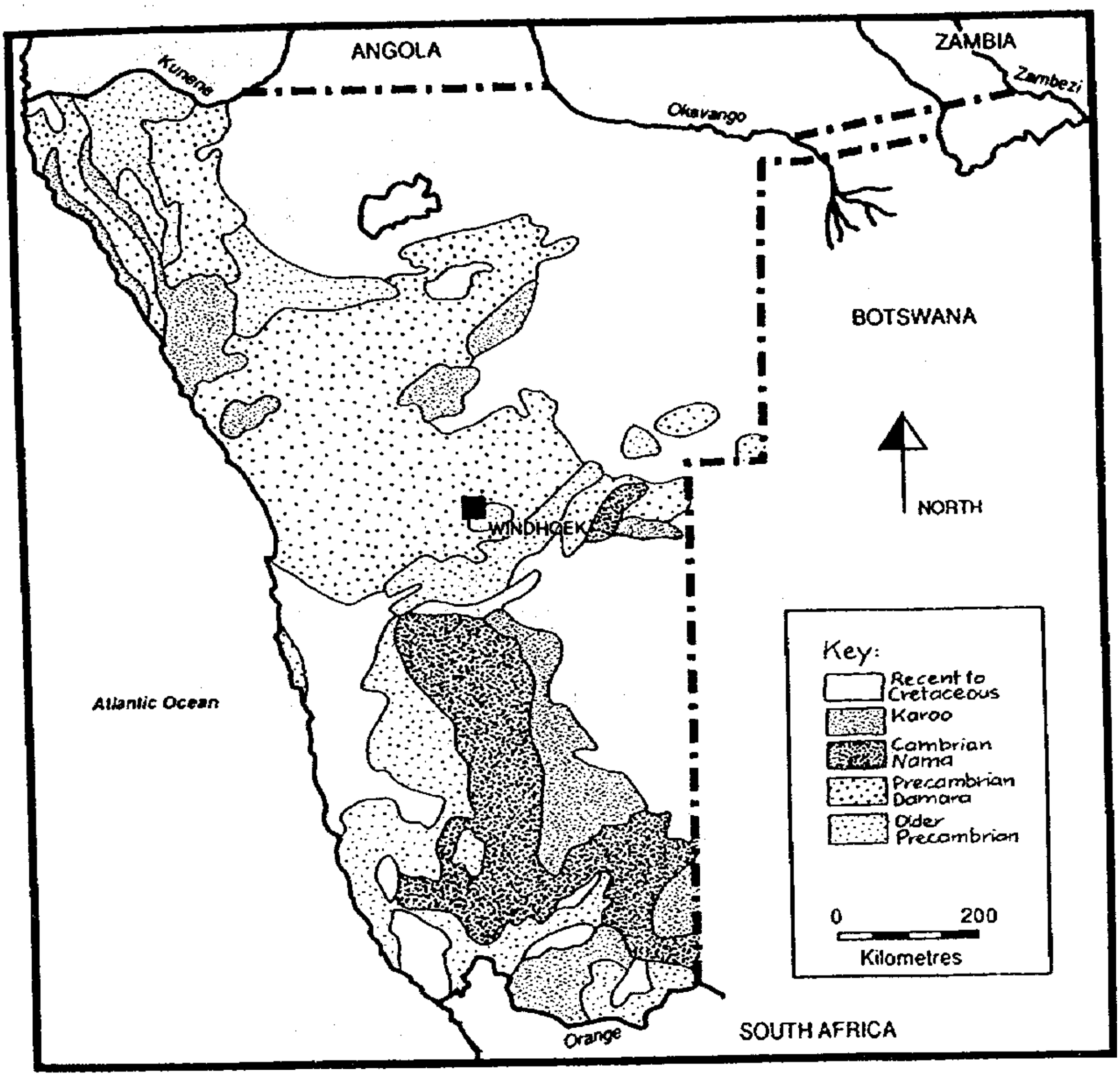

*Cross-section from the Namibian coast to the border of Botswana*




*Relief structure of Namibia*

**Figure 10.3 Geographical Relief Structure of Namibia**

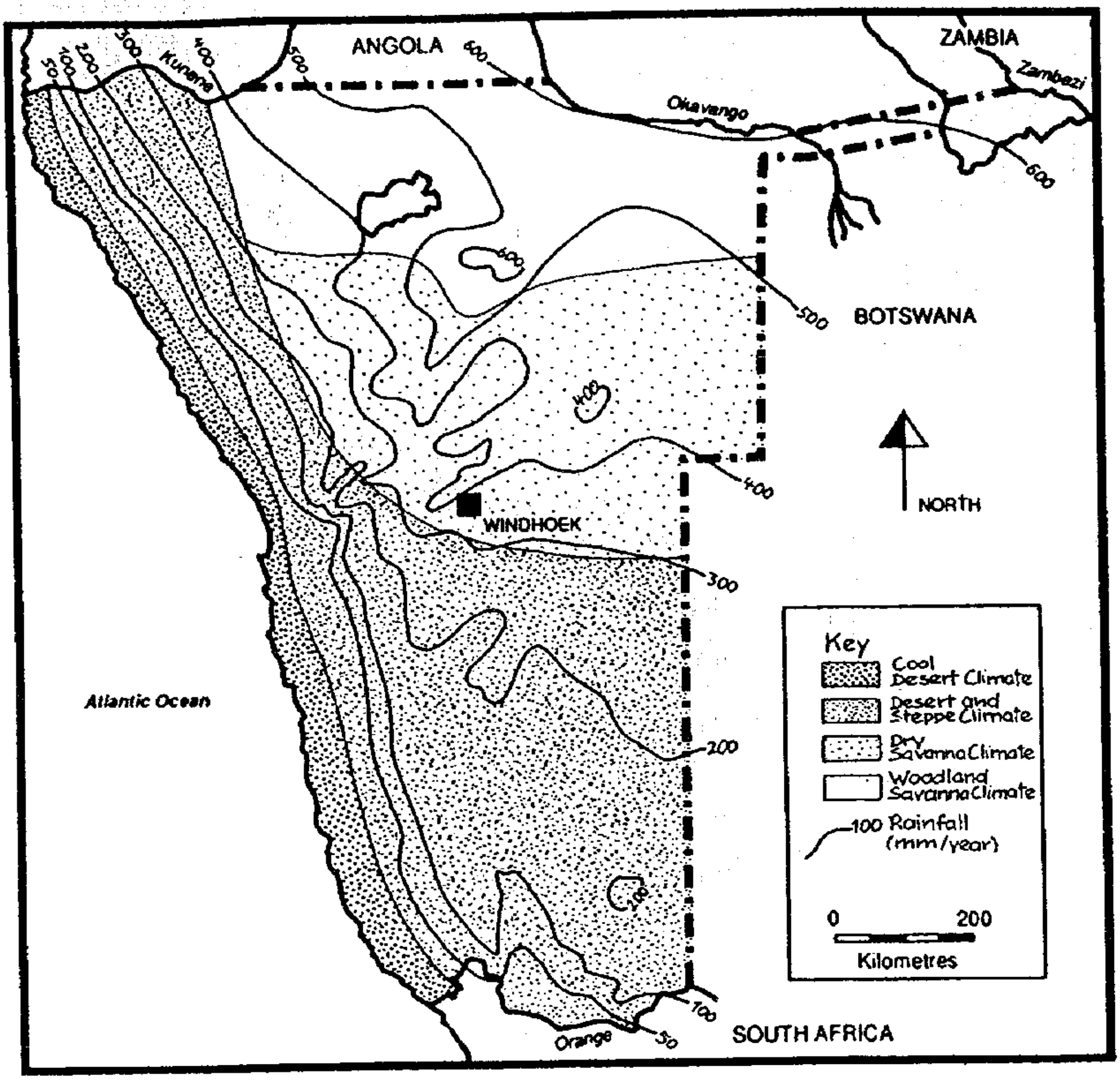
( Source: "Geography of Namibia", 1990 )




*Geological map of Namibia*

**Figure 10.4 Geological Map of Namibia**

( Source: "Geography of Namibia", 1990 )




*Climatic regions and rainfall*

**Figure 10.5 Climate Regions and Rainfall Distribution of Namibia**

( Source: " Geography of Namibia", 1990 )

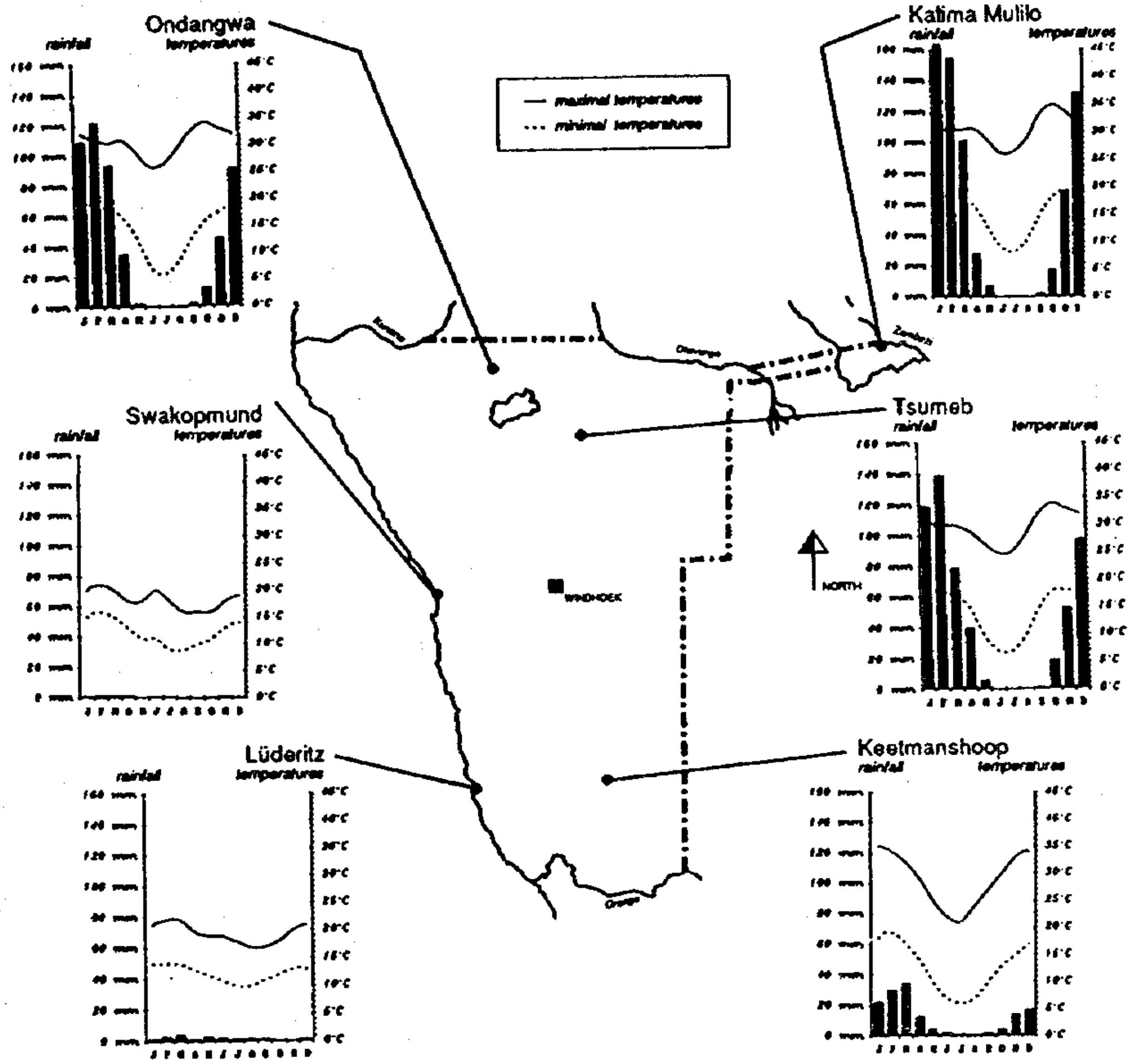
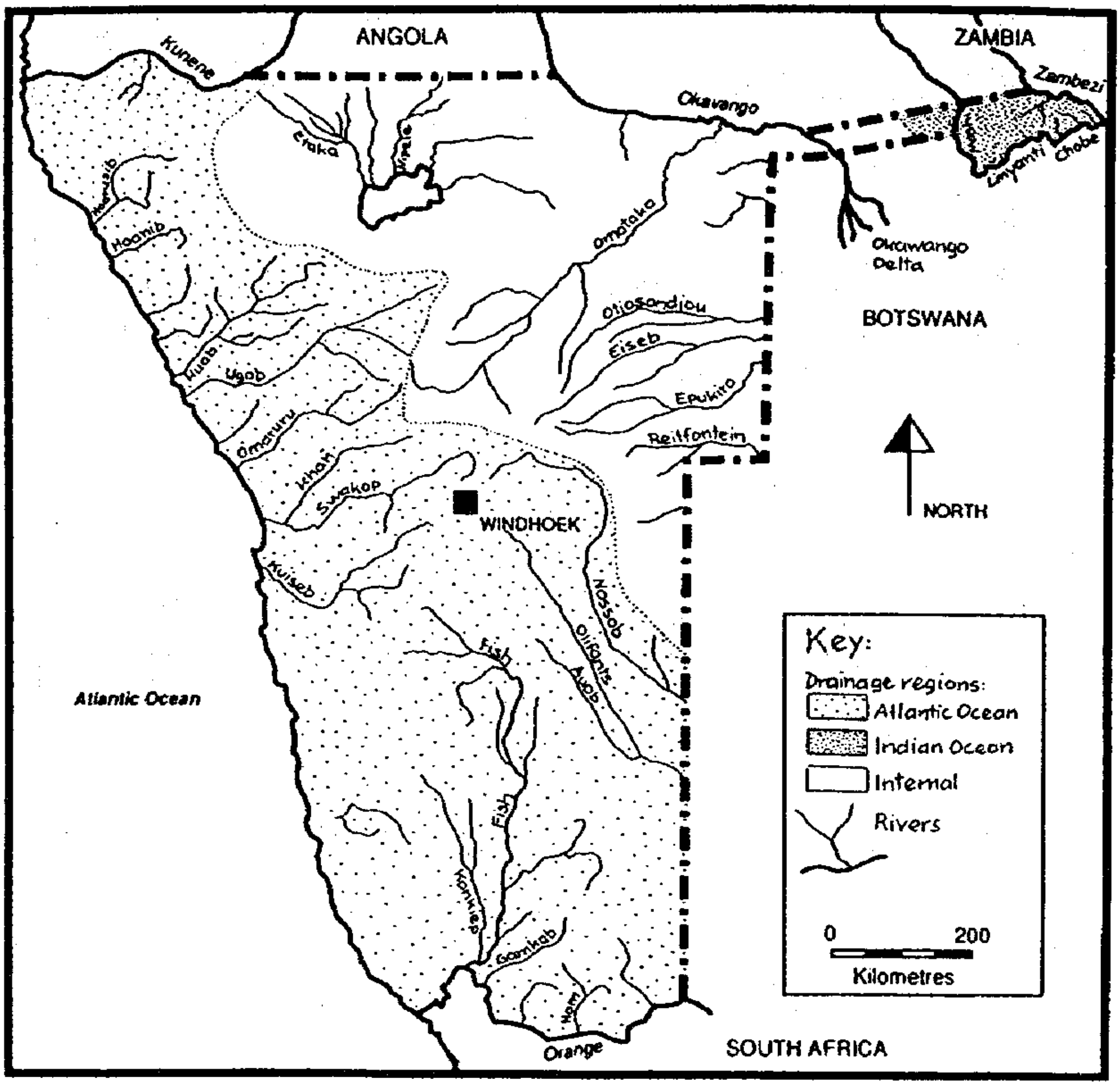



**Figure 10.6 Climate Diagrams of Some Weather Stations and Their Location**

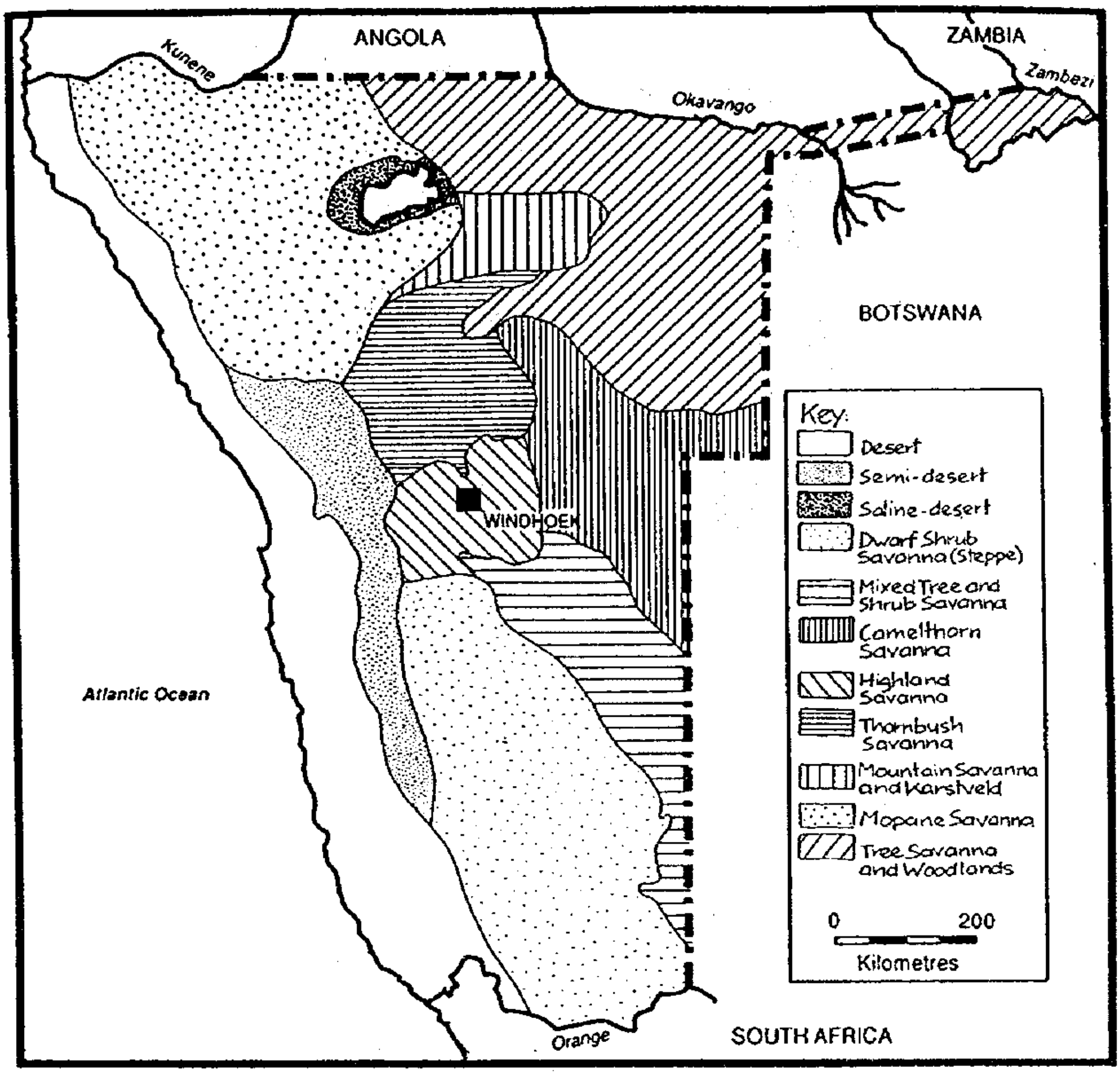
( Source: "Geography of Namibia", 1990 )




*Rivers and drainage regions*

**Figure 10.7 Rivers and Drainage Regions of Namibia**

(Source: "Geography of Namibia", 1990)




*Natural vegetation map*

**Figure 10.8 Natural Vegetation Map of Namibia**

(Source: "Geography of Namibia", 1990)

*Colophospermun mopane* (mopane) is the dominant tree species in western Owambo.


Owambo market under marula (*Sclerocarya birrea* subsp. *caffra*) tree.

**Figure 10.9 Photographs of Typical Trees in Owambo, Namibia**

( Source: "Forestry in Namibia 1850 - 1990", University of Joensuu, 1992 )