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EXAMENSARBETE

Namibia's Energy Support Problem
The Epupa Scheme

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ABSTRACT

The objective of this paper has been to analyse the effect on the Namibian power market when the Epupa power station comes on line. Three hypotheses are put forward. These are a) that the Epupa scheme will make Namibia independent from electricity imports, b) will reduce the electricity price and c) make Namibia able to meet future demand with domestically produced electricity. The analysis was conducted using traditional microeconomic theory. After giving a detailed description of the Namibian power market both in its present and its expected future state, a supply function and a demand function are derived. The supply function was derived using a stepwise procedure which ranks the individual electricity producer in Namibia according to there respective generation costs. The demand curve was derived from an econometric estimation of a basic demand function. After combining the earlier results from the demand and supply sides, an entire market situation was obtained and the hypotheses could be tested. The conclusions were that all three hypotheses could not be refuted, although the reductions in electricity prices were not very high.

SAMMANFATTNING

Syftet med denna uppsats har varit att studera den Namibiska elmarknaden, givet att Epupa kraftverket byggs. Tre hypoteser ställdes upp, nämligen att Epupa projektet kommer att ge Namibia en självförsörjande elmarknad, att den kommer att reducera elpriserna och att Namibia kommer att kunna möta framtida el-efterfrågan med inhemsk produktion. Analysen genomfördes med hjälp av traditionell mikroekonomiska teorier. Efter att jag presenterat den Namibiska elmarknaden både i sitt nuvarande tillstånd som dess förväntade framtida, kunde en utbudsfunktion samt en efterfrågefunktion härledas. Utbudsfunktionen härleddes genom en stegvis procedur som rangordnade de individuella elproducenterna efter deras respektive produktions kostnad. Efterfrågefunktionen härleddes genom ekonometriska tillvägagångssätt. Efter att ha sammanslagit de tidigare resultaten från både efterfrågesidan som utbudssidan kunde hela marknaden studeras och hypoteserna testas. Som slutsats menas att ingen av de tre hypoteserna kan förkastas. Men reduktionen på elektricitetspriset blev inte särskilt högt.

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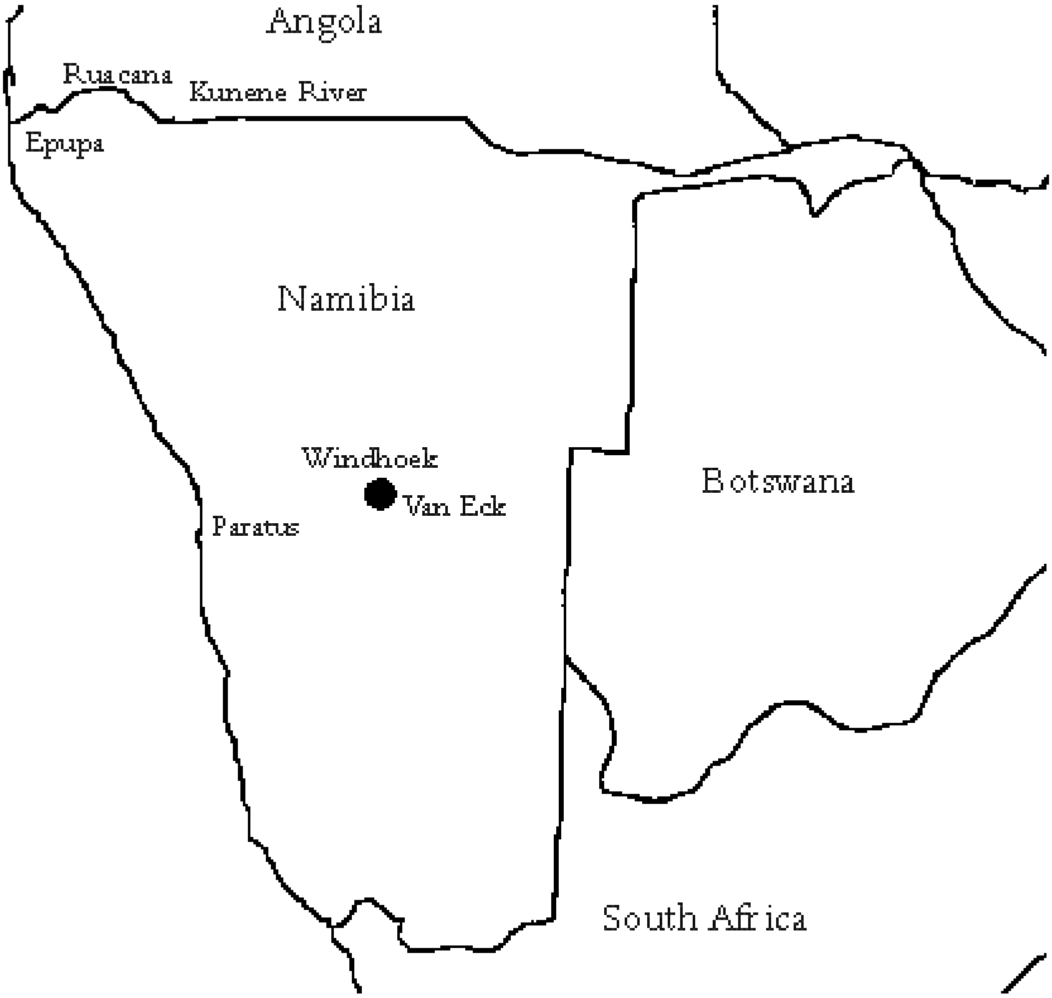
MAP OF NAMIBIA



The map shows Namibia and it’s neighbour. The Kunene River is a border river between Angola and Namibia. All major power stations are also marked on the map for easy reference.

Chapter 1
INTRODUCTION

Background

Namibia was the last colony in Africa, gaining her independence from South Africa in 1991. This vast and arid country has a size corresponding to the Scandinavian peninsula and a population of 1,5 million. Since her independence, Namibia has experienced positive economic development, mainly due to the existence of a new democratic constitution, enormous reserves of natural resources and an extended infrastructure (Nation Account, 1993).

Economic and population growth in Namibia have resulted in an increasing demand for electrical power. However, in the 1990s this demand already exceeded peak domestic supply during certain periods, depending on the availability of the main power station at Ruacana, and is therefore partially met by imports from South Africa. The gap between demand and supply is expected to widen even further as an expected urban and rural electrification program gets underway. Namibian independence has also brought about a great desire to be independent of imported South Africa power. It is common to think that it is in the interest of every sovereign state to have an independent power source of supply and not to rely so much on foreign production, as Namibia currently does.

Namibia's energy sector is generally characterized by a strong reliance on imports. All petroleum products, gas, coal and coke requirements are imported and in 1991-1992 about 47 per cent of Namibia's electricity needs had to be imported (van der Linden, 1993). Still, most households do not yet have access to commercial energy. It is only during the later part of the 1990s that the larger population centers in the north and northeast are beginning to be connected to the national electricity grid. It is from this household sector that the main increase in electricity demand is expected to come. To meet this expanding demand, two sources of great energy potential are currently under consideration, a hydroelectric power expansion along the Kunene River and a commercial development of the large Kudu gasfield off the Orange river mouth. A number of studies by the Swedish International Development Aid (SIDA) are currently in progress. Their purpose is to illustrate the technical, economic, environmental and social aspect of constructing a hydroelectric power station along the Kunene River in the vicinity of the Epupa falls.

Given Namibia's current domestic generating, that capacity and energy supply are fare from satisfying the Namibian powermarket, the Epupa scheme could solve the import reliance from South Africa, both at present and in the future. It is should therefore be in the interest for Namibia to know what the effects of the Epupa scheme will have on the Namibian powermarket.

Purpose

The purpose of this paper is to analyze what the effect will be on the Namibian power market when the Epupa power station is coming on line, with special focus on supply, prices and the ability to meet future demand. This will be done using price adjustment and price elasticity in a comparative static analysis. Three hypotheses are listed below, and have been formulated in order to fulfill this purpose.

1) The first hypothesis is that the Epupa scheme will give an independent Namibian power market by supplanting current imports completely with domestically produced electricity.

2) The second hypothesis is that the Epupa scheme will reduce the current electricity prices.

3) The third hypothesis is Namibia's desire to meet future demand with domestic produced electricity, will be met.

Scope

This paper will only take into consideration the Namibian power market, and disregard the possibility of sharing the production with Angola. It also assumes a competitive market were no single producer has the ability to affect prices, or alternatively regulated so as to act as a perfectly competitive market, meaning that the

Namibian government intervene on the electricity market to regulate the electricity price to a more desirable level. Furthermore, the data used consist of time series from 1980-1996. Additional assumptions are presented in later chapters.

Outline

Chapter 2 describes the Namibian power market as it is currently organized and gives an insight of the economic activity that takes place in Namibia. In chapter 3 the future supply decisions, in the case of Epupa hydroelectric power station becoming a reality, and expected demand of electricity in Namibia are presented. The models used in this paper are presented and tested in chapter 4 and 5. The theory of supply and demand in a competitive market will be used. Chapter 6 summarizes the results and draws some conclusions.

Chapter 2
THE NAMIBIAN POWER MARKET TODAY

This chapter provides a brief overview of the Namibian power market and explains how the Namibian power market operates and how it is organized. It gives a detailed geographical presentation and show how the different transmission lines have expanded.

General Economic Activity in Namibia

Given that Namibia has only been independent from South Africa since 1991, it is not surprising to note that it is still very dependent on its neighbor and former colonial masters, in an economic sense. In 1995 approximately 90 per cent of all the imports into Namibia came from South Africa and over 40 per cent of the capital assets in Namibia are still controlled by South African interests (National Accounts, 1993).

The Namibian economy can roughly be divided into three main sectors; Primary, secondary and tertiary. The primary sector consists of agriculture, fishing and mining. The secondary consists of manufacturing, electricity, water and construction, while the tertiary sector involves of wholesale, tourism, transport and communication, finance, real estate, general government and other services.

Figure 2.1 illustrates the contribution to GDP by these sectors during the period 1980 to 1995. There has been a decline in the relative contribution of the primary sector from about 2762 million N$ to 1561 million N$ during to period 1980-1984 affecting, in a negative way, the whole economy. In addition, the relative contribution of the primary sector decreased again from 1989 and only started to level out in 1995. One reason is the decline in the export dependent mining sector. However, the major reason for both declines in the primary sector is that Namibia suffered from severe droughts in both periods.

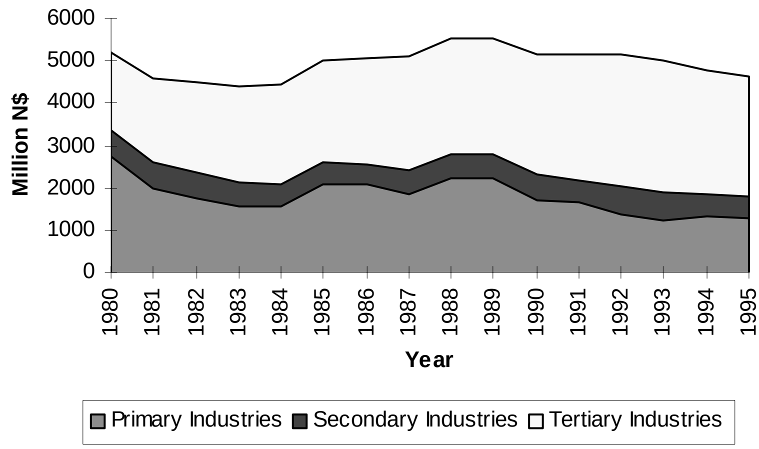


Figure 2.1: Development of real GDP in Namibia 1980-1995

Source: Central Statistics office, National Accounts (1993).

The Electricity Sector

The Namibian electricity authority was formed in December 1964 as the South West Africa Water and Electricity Corporation, SWAWEK. The primary aim was to develop a hydroelectric scheme utilizing the water of the Kuene River and to establish a network to distribute the power as far south as the capital of Windhoek, a distance of over 600 km. In 1996 SWAWEK was renamed NamPower. Today NamPower supplies power to all the major towns and mines in Namibia (Sundqvist, 1997).

NamPower falls under the Ministry of Mines and Energy but operates on a fully autonomous, commercial basis. NamPower supplies bulk electricity to public authorities that then deal with individual consumers. NamPower supplies a few large consumers directly, but the municipalities, the urban development boards and the Ministry of Local Government and Housing, supply most large consumers and households. No regulatory system is in place for the control of electricity tariffs. Each municipality is allowed to set its own tariffs (MME, 1996).

Electricity Supply

There are two major facilities in Namibia that are driven by conventional sources of energy. These are the 120 MW van Eck thermal power station in Windhoek, which operates on coal imported from South Africa, the Paratus 24 MW power station in Walvis Bay running on both diesel and gas. In addition, there are numerous small diesel generators operating throughout the country for small-scale electricity generation. However, the bulk of Namibian produced electricity is generated by a 240 MW hydroelectric power station situated below the Ruacana Falls on the Kuene River on the Angolan border.

The supply of electricity in Namibia has had an unstable past. The Van Eck power station supplied on average less than 5 per cent of total electricity generation in Namibia during the period 1989-1992, varying from 8.4 per cent in the financial year 1989-1990 to 0.52 per cent in 1991-1992. The Van Eck power station has for the past 6 to 7 years been operating at only 10 per cent of its total capacity. This is because of its high operational costs arising from the ever increasing cost of imported coal prices (van der Linden, 1993)[1]. In figure 2.2 the different power stations utilization level is shown. Due to missing data not all desired years are presented. However, the Ruacana power station together with the imports from South Africa (Eskom) is the main suppliers and consists almost of the entire market.

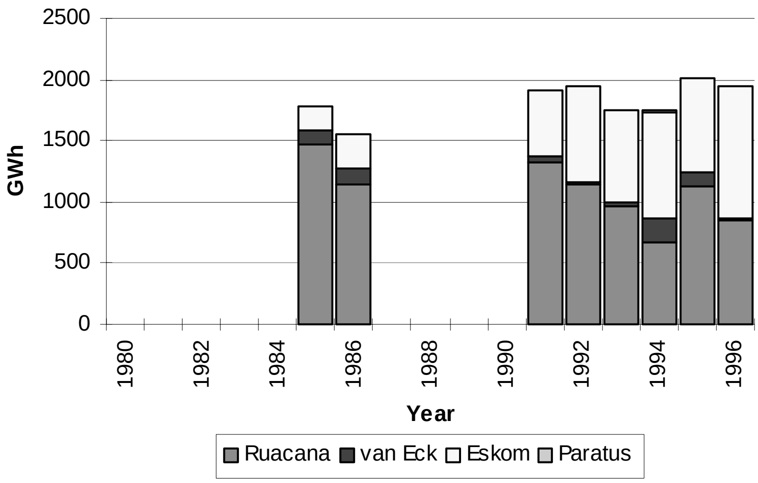


Figure 2.2: Electricity supplied by the major power stations
Source: NamPower Annual Reports.

The total domestic electricity generation capacity, from these 3 power stations, amounts to no more than 386 MW. The gap in supply is made up with imports from NamPower's counterpart in South Africa, Eskom. A 200 MW interconnecter has been

[1] The Van Eck power station consumes about 1000 tons of coal daily under normal use (Rivers, 1985).

built. Namibia is also linked into the Zambian grid providing Katima Mulilo in the Caprivi with a 2 MW import capacity. This leaves the Namibian power market with a total generation capacity of 588 MW[2] as shown in Table 2.1.

Table 2.1: Installed capacity available for Namibia

Power station	**Station type**	**Installed capacity**
Ruacana	Hydro	240 MW
Van Eck	Thermal	120 MW
Paratus	Thermal	24 MW
ESKOM	Import	200 MW
ZESCO	Import	2 MW
Total		**588 MW**

Source: NamPower Annual Reports and van der Linden (1993).

Ruacana Hydroelectric Power Station

The station was put into operation in 1981-1983. It is an underground power station with 3 units of 80 MW each (Burmeister, 1993). The station has, however, never operated according to the initial designs. The river flow at Ruacana is seasonal and largely fluctuating, varying from extensive spilling during the wet seasons and nearly nothing on certain occasions during periods of drought. Daily regulation is facilitated by a small reservoir adjacent to the plant. The seasonal nature of the water flow down the Kuene, severely regulates the output from the Ruacana power station. Fuel costs and other variable costs for the Ruacana power station has been assessed at 0,1 cents per kWh (Burmeister, 1993).

Van Eck Thermal Power Station

The van Eck coal fired steam power station is located in the Windhoek area. The plant consists of 4 steam turbine generator units of 30 MW each. Each unit is coupled to a boiler. The power station was brought into operation in the period 1970-1977.

[2] Generation and import capacity was compiled from van der Linden (1993) and NamPower Annual Reports.

Coal to van Eck is brought by rail and boat from South Africa. The 1996 coal price is N$ 214 per ton (NamPower, 1996) of which the major part refers to transport. With a specific fuel consumption of 0.55 kg per kWh this fuel costs results in a rather high energy price (Burmeister, 1993). Hence, the station is mostly used as a backup source. Fuel costs and variable costs for the van Eck power station has been assessed at 15.4 cents per kWh (Burmeister, 1993), substantially higher than the Ruacana power station.

Electricity Imports

Namibia has, since her independence, been dependent on electricity imported from South Africa. Depending on the magnitude of the river flow at Ruacana, Namibia has to import nearly 50 per cent of its total electricity needs. This puts Namibia in an unfavourable bargaining position leaving South Africa to dictate trade terms. However, a new electricity supply agreement between NamPower and Eskom in 1996 reduced the import price of electricity by 18.4 per cent to 7.07 cents compared to 8.66 cents in 1995. Resulting in a demand increase by NamPower for Eskom power, which proved cheaper than the electricity generated from the coal fired van Eck power station.

Electricity Consumption

The consumption of electricity is not documented in a detailed way. NamPower collects information about electricity consumption by sector but the data is not publicly available. In its annual reports only limited information is included on the consumption of electricity by sector. The Central Statistics Office receives all detailed information on electricity consumption by sector from NamPower but has agreed not to provide any such data to third parties.

The annual electricity consumption has been divided into four sectors in figure 2.3; rural areas, Eskom, Mines and Municipalities. The period between 1980 and 1986 lack the necessary information to be divided into selected categories and is therefore only presented as total consumption.

The average annual growth of total electricity consumption has been 3.85 per cent during the period 1980 to 1996. Between 1982 and 1984 Namibia saw a major increase in electricity consumption with a average growth rate on more then 22 per cent per annum. This increase was the result of a major mineral and ore export boom during the same period (National Accounts, 1993). The growth in electricity consumption started to decline in 1986 and the electricity consumption has thereafter only slowly increased till present date. The major fluctuations in electricity consumption arise mainly out of the variations in the Eskom consumption, i.e. export to South Africa[3]. Municipalities, Mines and Rural areas all had a steady growth in electricity consumption with a average growth rate of 7.01 per cent, 0.49 per cent and 11.04 per cent respectively.

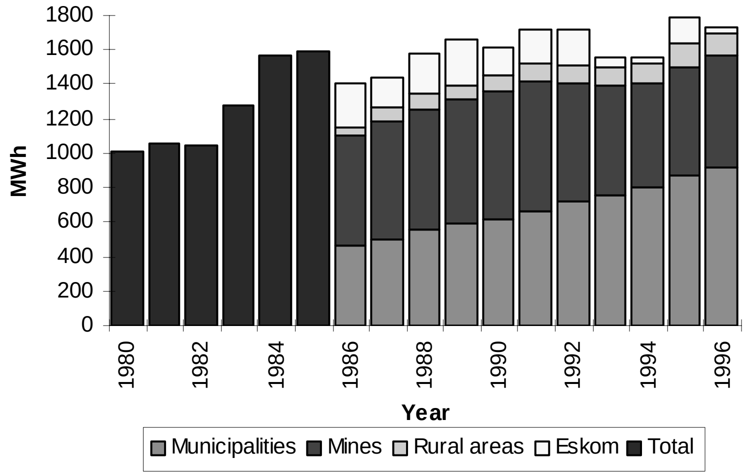


Figure 2.3: The total electricity consumption by sector during 1986-1996
Source: NamPower Annual Reports.

Transmission

An increasing number of households, organizations and corporations are constantly being connected to the Namibian national electricity grid. The low load transmission lines, of 66 kV and below, have been the subject of the bulk of the extension, shown in figure 2.4. The 66 kV transmission line has been extended from only 1736 km in 1980 to more than 10546 km in 1996. The 132 kV and 220 kV transmission lines have only been subject to a ”stepwise” expansion and not, as the 66 kV lines, an

[3] During high production periods at the Ruacana power station, i.e. very wet periods, Namibia export surplus electricity to South Africa. However, Namibia is still a net energy importer.

annual expansion. The high load transmission line of 330 kV has not been extended during the period between 1980 and 1996. This supports the earlier observation that the bulk of expansion will be among households.

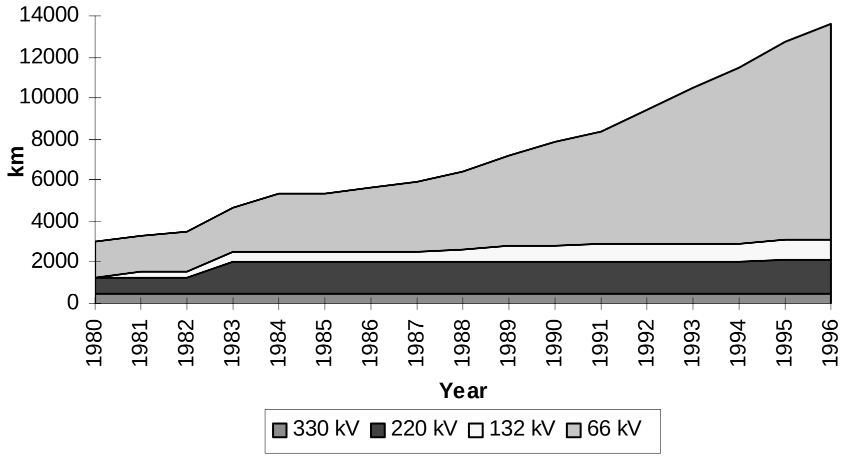


Figure 2.4: Expansions and lengths of the various transmission lines
Source: NamPower Annual Reports.

Electricity Prices

The electricity tariffs set by NamPower are divided into two different categories, one tariff for small customers consisting of large individual farms, and one tariff for large customer consisting of municipalities and mines. The prices presented in figure 2.5 are the prices that NamPower charged its customers on average and do not reflect the actual price level paid by the final consumer. Since there is no general pricing agreement with the final consumer, the prices may vary considerably depending on the respective municipality pricing policies. Figure 2.5 shows the real electricity price for the period 1980-1996 using the consumer price index as a deflator.

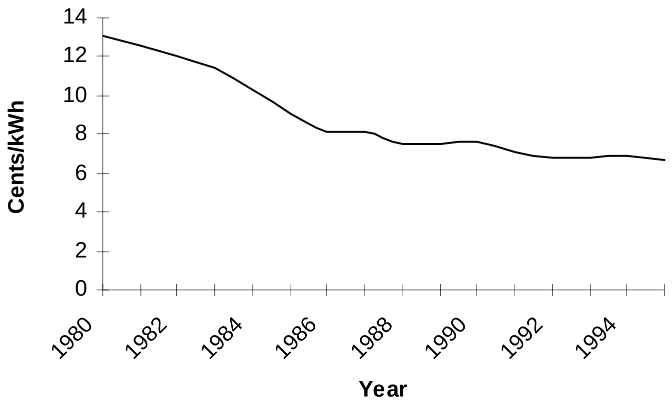


Figure 2.5: The electricity prices between 1980-1996 in 1990 price level
Source: NamPower Annual Reports.

Real electricity prices have dropped from 13.1 cents per kWh in 1980 to 6.7 cents per kWh in 1995, see figure 2.5. The main decrease occurred between 1980-1986 with an annual reduction of the electricity price with 8.8 per cent. These large reductions of electricity price were the effect of the Ruacana power station coming into operation. After 1986 the electricity price has been relatively stable.

Chapter 3
THE NAMIBIAN POWER MARKET IN THE FUTURE

This chapter describes how the Namibian power market is expected to develop in the future on both the demand and supply side. This is after taking into account the coming online of the Epupa scheme.

Future Production

The present power generation capacity will not be sufficient to meet future demands. To this end NamPower is investigating alternative options to increase Namibia's electricity generation and/or imports. A temporary solution would be to add capacity to the existing Ruacana power station, by installing a fourth 80 MW unit. This can be done at a relative low cost since the required infrastructure is already in place. This is, however, only a short-term solution and will not provide a long run answer.

Another option is the construction of a second hydroelectric power station some 60 km downstream of Ruacana. A pre-feasibility study for the construction of a hydroelectric power station along the Kunene River at Epupa Falls has been commissioned by NamPower and was carried out by NORPOWER and SWEPOWER. The economic pre-feasibility study shows that the Epupa scheme is economically viable[4] and will produce enough electricity to enable Namibia to become independent from South African imports.

Epupa Hydroelectric Power Station

The maximum potential of the Epupa site is substantial, and technically between 2000-2500 GWh per year could be generated depending on the chosen construction site.

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[4] Pre-feasibility study of Epupa scheme.

In the pre-feasibility study three different future load scenarios were tested. These scenarios range between load levels of 363 MW for the low load scenario and 500 MW for the high load scenario. The low load scenario has been selected to represent the earliest year when the Epupa hydroelectric power station can be commissioned. For the low load scenario the best economic results[5] would be a capacity of 200 MW with a total annual cost of 215 million N$ and an estimated production of 1045 GWh. The high load scenario represents the long run feasibility of the Epupa scheme with a 500 MW load level. The best results at this load level for the Epupa hydroelectric power station was achieved for a capacity of 275 MW with a annual cost of 228 million N$ and a estimated production of 1650 GWh. Depending on load scenario the average unit cost of production for the Epupa hydroelectric power station will range between 0.14 to 0.2 cent per kWh, substantially lower than that of both van Eck and the imports from Eskom.

Future Electricity Consumption

NamPower has estimated the growth of total demand at an annual average rate of 3 per cent[6]. Based on the actual figures for 1991 and with the stated average growth rate of 3 per cent, the projected consumption would be 2243 MWh in the year 2000 as shown in Table 3.1. The table shows both the actual and the projected consumption.

Table 3.1: Actual and projected electricity consumption estimated by NamPower

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual consumption	1719	1714	1551	1553	1784	1731				
Projected consumption	1719	1771	1824	1879	1935	1993	2053	2115	2178	2243

Source: Van der Linden (1993).

[5] In the pre-feasibility study different test conditions were conducted to obtain the most desirable configuration. For more information see the pre-feasibility study chapter 12.

[6] SWAWEK (1992), ”Namibia, The Energy Situation and Epupa - A pre-feasibility Report”, Windhoek.

In the Epupa pre-feasibility study projections are also made for the growth of total demand. These projections are based on the 1991 figures for total electricity demand of 1291 MWh. However, according to NamPower's annual reports the actual total electricity consumption in 1991 amounted to 1719 MWh, which leaves the projection done by NamPower as the more accurate. It is clear, however, that the actual consumption lies more than 250 MWh below the projected consumption during 1996 in Table 3.1. However, NamPower's estimates will be used in this paper since no recent and more accurate projection has been made to the knowledge of this writer.

The World Bank estimates the growth of electricity demand at around 3.5 per cent per annum until 2000 mainly due to increasing household electrification (World Bank, 1991). This compares favorably with Nampower's projections above.

Chapter 4
SUPPLY OF ELECTRICITY

In this chapter the supply decision for the Namibian electricity sector in the short run will be presented. Furthermore, a supply curve will be constructed using a stepwise procedure. This supply curve will be based on the costs and quantities of the various sources discussed in the earlier sections. A discussion of the results will conclude the chapter.

General Assumptions

The models that will be described in this chapter are based on traditional neoclassical microeconomic theory. The Namibian power market is assumed to act like a competitive market on both the supply and demand side. Given this assumption no single producer, or consumer, has the ability to, in any way, affect the price. The price is forced, by free entry of new corporations and exit by old corporations, to equal the marginal cost so no excess profit is made in the long run. In addition, it is also assumed that no single producer can affect the hiring price of the input factors by increasing or decreasing the quantity used. The price for electricity and the input factors are therefore exogenously given. Furthermore, the producers are assumed to maximize their profit. A profit-maximizing corporation chooses both its input and its outputs with the sole goal of achieving maximum economic profits. That is, the corporation seeks to make the difference between its total revenues and its total costs as large as possible[7]. These are very strong assumptions and may not fit the Namibian power market perfectly, but to make the analysis simple they are nevertheless used since they have some analytic value.

[7] Definition obtained in Nicholson (1995).

Supply Decision

The distinction between short run and long run in this paper is based on the assumption that the capital stock is fixed in the short run while in the long run all input factors, including capital, can vary.

In order to determine the equilibrium of the Namibian electricity industry it is necessary to derive both the market supply and demand curves. The supply schedule requires the determination of the supply of the individual producers, since the market supply is the sum of the supply of all the producers in the industry.

In the short run, where the capital stock is fixed, a corporations supply curve is derived from that portion of the marginal cost curve ”laying above” the average variable cost, (Ruffin, 1992). However, since it is very difficult to obtain or calculate the marginal cost for most corporations it is assumed that the marginal cost is constant and hence equal to the average variable cost. This assumption is common in empirical calculations of supply decisions. In the case of the Namibian power market this assumption holds fairly well for the Ruacana power station and the electricity import from South Africa, but for the van Eck and Paratus power stations, where fuel are an major part of the cost, it does not. Nevertheless, since sufficient data, for calculating the marginal costs for the power stations, are not collected by domestic Namibian authorities the average cost will be used as a proxy for all four major power suppliers. This can also be justified by the fact that at the point of profit maximization the marginal cost equals the average cost.

The Namibian Electricity Supply Curve

In order to study the supply side of the Namibian power market each single power station has to be considered individually[8]. By ranking the power stations according to their productions costs a supply curve for the entire power market is then derived.

The cost curves in figure 4.1 is based on figures from 1994 and presents each individual power suppliers production costs in an ascending scale, from the low to the

[8] The Paratus power station has been omitted since it only produced on average less than 0.1 per cent of the total electricity output.

high cost producers. Only variable costs are included and should therefore be interpreted as average variable costs, thus a short run supply curve. The figure shows the amount the various power stations produced and at what costs in Namibian cents. The numerous diesel generators throughout the country and the Paratus power station are omitted from the figure since no relevant data is collected. It is clear that the lowest cost producers are the hydroelectric power station at Ruacana and the future Epupa power station. This is followed by the imports from South Africa. These supplier's costs are lower than the price level for that specific year. On the other hand, the thermal power stations of van Eck operate at a cost higher than the 1994 price level.

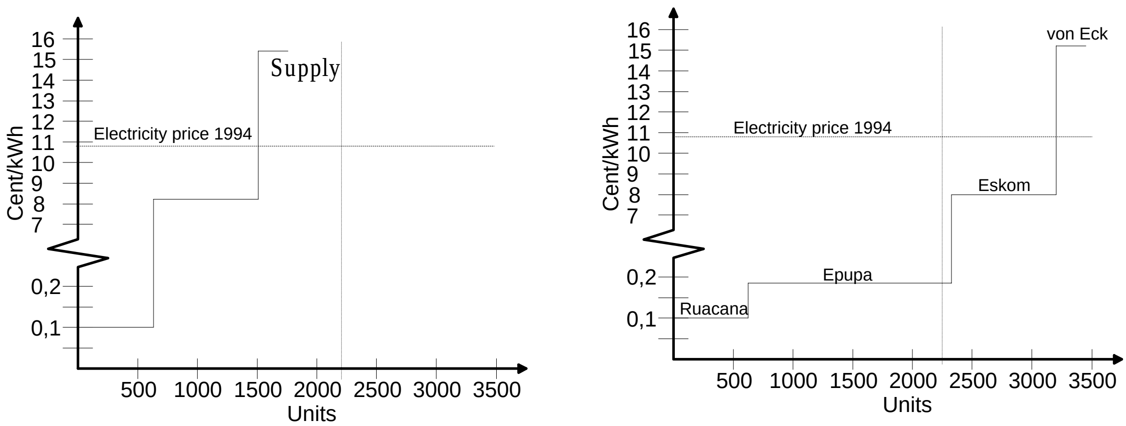

Figure 4.1: Average total costs for the four major power suppliers and 1994 electricity price

The dashed lines represent the projected consumption for year 2000 taken from Table 3.1. The left figure clearly shows that without the Epupa power station Namibia will not be able to meet the projected electricity consumption. With Epupa power station though Namibia will be able to meet this projected consumption and with domestic production.

Discussion of the Results

When comparing the average price level of electricity in 1994, 10.98 cents per kWh, with the production costs for the different power suppliers in figure 4.1 it is obvious that van Eck is a very high cost producer. Its average variable cost for producing is 15.1 cents per kWh, nearly twice the amount Namibia has to pay for its imported electricity from South Africa. However, van Eck produces only a fraction of the total amount supplied on the Namibian power market and is used merely as a backup station.

The bulk of the electricity supply comes from Ruacana power station, which is the lowest cost producer. The average variable cost for producing is 0.1 cents per kWh. Ruacana power station can however not supply the entire market itself, producing only 672 GWh in 1994. This will change if the Epupa power station comes on line. The Epupa power station is predicted to produce at an average variable cost of slightly less than 0,2 cents per kWh for each and every unit produced, which makes it the next least cost producer just above the Ruacana power station. The estimated production at Epupa is 1650 GWh for the high load scenario[9]. This production together with that of Ruacana will amount to no less than 2322 GWh.

From Table 3.1 the projected consumption in the year 2000 is 2243 GWh. If the Epupa hydroelectric power station comes on line it will, together with Ruacana power station, produce sufficient electricity to meet this demand, as shown in figure 4.1. This will make Namibia independent from electricity imports from South Africa. Electricity produced at van Eck and in South Africa will only be used to meet peak loads and during periods when Epupa and Ruacana power stations can not produce at their full capacity, i.e. during dry periods when the Kunene river is low on water.

By relaxing the assumption that the Namibian power market acts like a competitive one, a more complex situation arises. NamPower, as the single electricity utility corporation, can exercise some degree of monopoly power. However, being a national owned corporation, it is not in the interest of doing so.

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[9] Se above sections.

Chapter 5
DEMAND FOR ELECTRICITY

This chapter describes the demand side for electricity. It highlights several features associated with electricity demand. A demand curve/function for Namibian power market is derived. Its key features are then discussed in a summarizing section.

Demand Theory

From classical microeconomic theory, the demand of a good depends on the good's own price, the price of substitute/complement for that good and the consumers income level. The model's core assumption is that individuals who are constrained by limited incomes will behave in such a way as to achieve the highest possible utility. By applying the envelope theorem[10], the Marshallian demand function can be derived, yielding;

$$X = d_X(P_X, P_Y, I) \tag{5.1}$$

where X is the quantity demanded of the good, P_X is the price of the good, P_Y is the price of other goods i.e. substitutes/complements and I indicates the income level. Therefore, the consumption of electricity as a function of its own price, the prices of its substitutes/complements and the level of economic activity as a proxy for income.

Electricity is considered a normal good and it is therefore expected that consumption of electricity will increase when the price of electricity goes down, and when the economic activity goes up. Further, consumption will also rise/fall with the price of substitutes/complements. However, in the short run it may be impractical for heavy users of electricity to switch between electricity and its substitutes which indicates that the cross price elasticities is likely to be low.

[10] For detailed information about the envelope theorem se Nicholson, 1995 page 170.

It is important to remember that the consumption of electricity differs from other goods, since it is virtually impossible for humans to consume electricity directly. Rather, most people purchase electricity because it is used in conjunction with equipment to produce services that are the true object of the demand for electricity. Hence, electricity demand is therefore derived from the demand for services that involve electric equipment.

Another important feature is that the electric equipment is usually long-lived and durable. Over the life of such durable equipment the amount of electricity used is essentially fixed and dictated by the engineering design and operating procedures embodied in the equipment. This implies that movements along or shifts in the demand curve for electricity can differ considerably in the short run, when demand is tied to the stocks of existing equipment, from that in the long run, when the size of the equipment stock can be changed. It is therefore reasonable to expect that short run price elasticity of demand for electricity will be much smaller than in the long run. Furthermore, it is important to consider the price schedules when modeling electricity demand. The price schedules offered to consumers by electric utilities often contain block tariffs and increasingly take into seasonal variations in demand. An important feature of such rate schedules is that they introduce wedges between the average and marginal prices (Berndt 1990). From the viewpoint of economic theory, the appropriate price to employ in empirical demand analysis is the marginal price (Nicholson, 1995). But with a multipart tariff, several different marginal prices could exist which make the use of the average prices more convenient.

Estimated Model

The estimated model follows expression 5.1 and is fitted to time-series data over the period 1980-1996. The demand for electricity is estimated using a double logarithmic function. The estimation method of ordinary least squares (OLS) is applied. The independent variables that are included in the model consists of the price of electricity, since it is the demand for electricity that will be estimated, the price of coal, acting as complement, and the Namibian gross domestic product.

$$LnQ_{el} = Ln\alpha_0 + \alpha_1 LnP_{el} + \alpha_2 LnP_{coal} + \alpha_3 LnGDP \qquad (5.2)$$

The actual quantity of electricity consumed in kWh, Q_{el} , is the dependent variable and α_n are the independent variables coefficient. These are also the short run elasticities since the model uses a logarithmic scale (Chiang, 1993).

This model disregard that price and quantity are set jointly by the influence of both demand and supply, therefore making the estimation more uncertain. Since price elasticities are being studied this problem had to be addressed to ensure the estimates validity.

Data Sources[11]

The data for electricity consumption are taken from several annual reports from NamPower. The GDP for Namibia is extracted from varies publications published by the Central Statistics Office in Windhoek, Namibia. The coal prices are taken from IEA publications and consist of the import costs of steam coal from South Africa. However, data on the coal price for the years 1981-1983 and 1994-1996 is lacking and are therefore assumed to follow a general trend.

Test Results

The results of the OLS estimation of equation 5.2 are summarized in Table 5.1 below.

Table 5.1: Estimation of electricity demand model for Namibia

	Coefficients for Independent variables			
	Electricity Price	Coal Price	GDP Namibia	R^2
	-0.8628	-0.0042	-0.5118	78.9
(T-Ratios)	*(-4.67)*	*(-0.02)*	*(-1.32)*	

[11] All the data used are described in chapter 2.

The results in Table 5.1 are generally poor. Both the coal price and the GDP variables do not contribute in any significant way to the estimation of the demand model. In addition, the coefficient of GDP does not have the expected sign. The theory clearly states that an increase in income will generate an increase in demand. The negative sign for the coefficient of the coal price indicates that coal is a complement. The electricity price is, on the other hand, significant with a high t-ratio and an expected sign.

One reason for the unexpected sign on the GDP coefficient could be that a large part of the GDP consists of agriculture production. Since the agriculture sector is very sensitive to dry weather the GDP will fluctuate considerately, depending on the rains. Namibia is prone to prolonged dry spells which causes the agriculture sector to shrink even at times when the other components that composes the GDP are expanding. To correct for this influence of the weather, ”de-seasonisation” is undertaken using the following model (Koutsoyiannis, 1977).

$$GDP = \beta_0 + \beta_1 TIME + \beta_2 DRY \tag{5.3}$$

The variable *TIME* simply represent an ascending time scale, and *DRY* is a dummy variable. It is set to 1 in periods of no drought and to 0 when there was a drought. The result of the OLS estimation of equation 5.3 is shown in Table 5.2.

Table 5.2: Estimation of ”de-seasonalised” GDP model

Coefficients for Independent Variables				
	Intercept	TIME	DRY	R^2
	4823	86.1	355	74.8
(t-Ratios)	*(30.98)*	*(5.76)*	*(2.21)*	

Both *TIME* and *DRY* are significant with a satisfying t-ratios and in a satisfactory way explain the development of GDP in Namibia.

Using the ”de-seasonalised” GDP model, new values for GDP can be obtained by simply using the results in Table 5.2, as shown in figure 5.1.

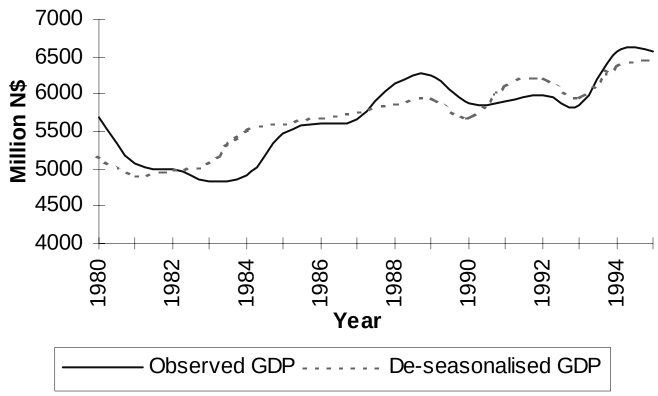

Figure 5.1: Measured and estimated GDP.

Source: National Account, Central Statistics Office.

A new OLS estimation for the demand on electricity is done using the ”de-seasonalised” GDP as a proxy for actual GDP. A double logarithmic function is used with the same independent and dependent variables based on equation 3.2. In addition, since the Durbin-Watson statistic indicated some degree of autocorrelation, a compensation for this will be done using the maximum likelihood iterative technique. The results are presented in Table 5.3.

Table 5.3: Estimation of electricity demand using ”de-seasonalised” GDP

Coefficients for Independent variables				
	Electricity Price	Coal Price	De-seasonalised GDP	R^2
	-0.342	0.191	0.891	81.9
(T-Ratios)	*(-1.15)*	*(0.807)*	*(1.27)*	

All 3 independent variables has low significant in explaining the dependent variable making the results most uncertain. Nevertheless, the short run price elasticity for electricity is –0.342, which indicates that the demand is inelastic, meaning that 1 per cent increase in the electricity price would decrease the quantity demanded with 0.342 per cent. The sign on the coal price coefficient has change from being negative to positive, i.e., now being a substitute instead of a complement. The short run estimated GDP elasticity obtained the expected sign. A one per cent increase in the GDP increases the electricity demanded by 0.891 per cent, which is consistent with the theory. The results in Table 5.3 shows that the demand for electricity is most sensitive for changes in the GDP and the least sensitive for changes in the substitute price. This is important because it shows that demand of electricity responds more to changes in economic activity than to anything else. Hence, as the economy continues to expand, it is also expected that the demand of electricity to increase as well. This justifies the construction of Epupa power station.

Discussion of the Results

Much of the empirical research on market demand behaviour focuses on obtaining estimates of elasticities. These can be used in a wide variety of applications to study how markets respond to changing circumstances. In this chapter an estimated demand function for electricity in Namibia was derived with resulting short run price and income elasticity of demand.

Using the results in Table 5.3 a demand curve can be drawn. In figure 5.2 this demand curve is shown. The demand curve is derived using equation 5.2 with 1994 years coal price and GDP. By letting the electricity price change it is possible to obtain the quantity demanded at that given price level.

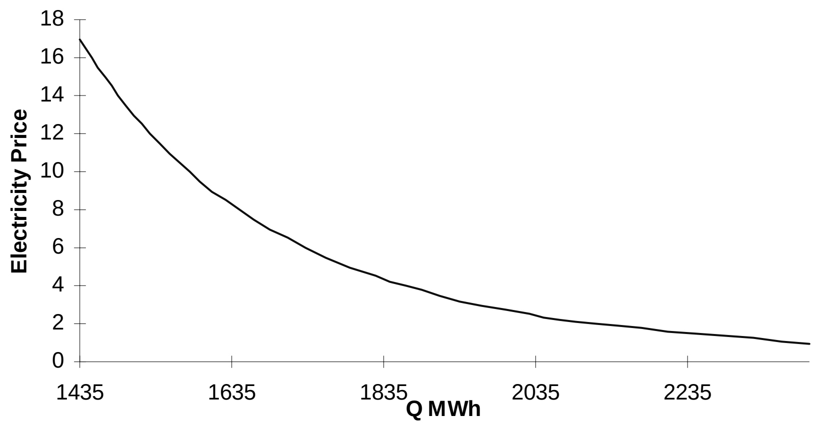

Figure 5.2: Demand curve for the Namibian power market, ceteris paribus

A change in electricity price will produce a move along the demand curve, while a change in the price of coal or in GDP will shift the demand curve. Since the GDP is expected to increase and the price of coal, following its past trend, is also expected to increase, therefore the electricity demand curve is expected to shift upwards.

Given the low short run price elasticity of demand, when Epupa hydroelectric power station comes on line, the Namibian power market will only have a small price effect in the short run. The extra output Epupa power station will produce will only slightly decrease the electricity price. The low price elasticity does not deviate much from other analysis of different power markets. However, no earlier analysis has been done on the Namibian power market for a comparison to be made.

Relatively high short run income elasticity suggests that demand is relatively responsive to level of economic activity. This is not surprising, Namibia is still undergoing a developing phase and are investing in the infrastructure and base industries, both these developing areas contribute with a major part to the economic activity and are large electricity consumers.

Chapter 6
CONCLUSIONS

The purpose of this paper was to analyse the effect on the Namibian power market, if the Epupa power station coming on line. This chapter will combine the supply and demand results obtained in earlier and draw some conclusions regarding the entire Namibian power market.

Introduction

Three hypotheses were stated in chapter one and will jointly explain the effect of Epupa coming in stream. The hypotheses were 1) That the Epupa scheme will give an independent Namibian power market 2) That the Epupa scheme will reduce the current electricity price and 3) That the Epupa scheme will make Namibia able to meet future demand with domestic electricity production. These three hypotheses will form the base for the discussions in this concluding chapter.

In earlier chapter both the supply and demand side of the Namibian power market have been analysed. By combining figures 4.1 and 5.2, an equilibrium can be derived as in figure 6.1a and figure 6.1b.

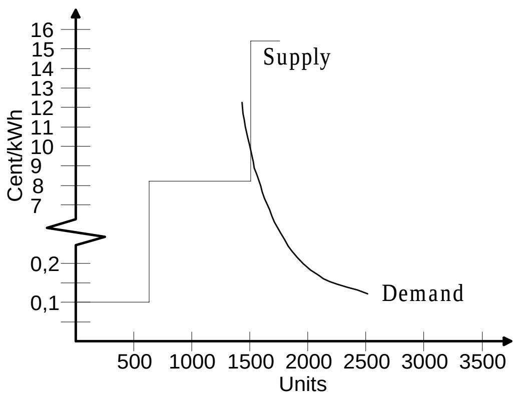

Figure 6.1a: The Namibian power market without Epupa power station.

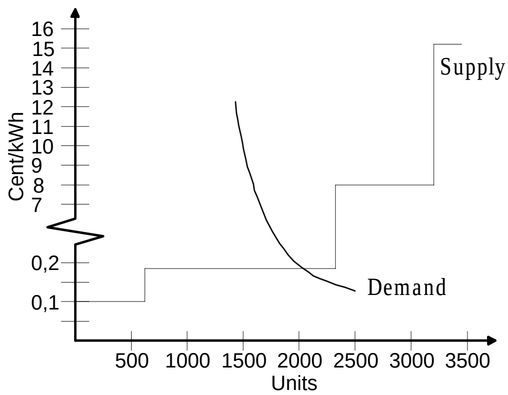

Figure 6.1b: The Namibian power market with Epupa power station.

In figures 6.1a and 6.1b the Namibian power market is shown, both with and without, Epupa power station. This is to illustrate the effect on the Namibian power market that the Epupa scheme will have. As shown, the supply curve will make a major rightward shift and drastically increase the amount of electricity produced.

Independence

Since Namibia is today heavily dependent on electricity imports, the main goal with the Epupa scheme is to make Namibia independent of these imports. Not only in the short run, but also in the long run. This is important since South Africa, as the single major electricity exporter in the region, will only have an excess capacity available for exports to the year 2003, with current production facilities (Rolén, et. al. 1996).

Depending upon the chosen construction size of the Epupa power station, figure 6.1b shows that the electricity produced at Epupa will replace that from South Africa imported electricity and at a lower production price. Since there seems to be nothing more that can be done about the vagaries of the weather, imports may still be needed to meet load peaks and during periods of dry weather when both Epupa and Ruacana cannot operate at their full capacity due to low river flows.

Electricity Price

The electricity price in Namibia is one of the lowest among the developing countries today. With the construction of the Epupa power station the electricity price may become even lower, as a result of the low generating costs. However, the price that the final consumers pay will not necessarily be lower than today since the local authorities, who buy the electricity directly from NamPower, have the final saying in the price setting. However, theoretical the electricity price could be reduced significantly and are illustrated as the equilibrium in figure 6.1b.

Future Demand

In Table 3.1 the projected consumption of electricity in Namibia is estimated to 2243 GWh. Given the past Ruacana power stations production and the expected production at Epupa power station these two power stations will be able to produce enough to meet expected demand[12].

The ceteris paribus assumption on the demand function is not a very realistic one. The demand curve in figure 6.1b is based on static figures for the GDP in Namibia and Coal prices. Given that the GDP increase, i.e. following its past trend, the demand curve will shift upwards and therefore make the analysis more uncertain.

In chapter 5 the estimation of the demand for electricity showed that the price elasticity is lower than that of economic activity, indicating that the demand for electricity is more likely to be driven by the pace of economic activity rather than by the price of electricity.

In conclusion, the Epupa scheme will give an independent Namibian power market. It will also lay the ground for a reduction in the average electricity price and it will be able to meet future demand perhaps with the exception during peak loads, in a drought situation.

[12] The production at Epupa power station depend upon chosen load scenario.

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