6.3 Small Power User Forecast

6.3.1 Introduction

The long term electricity demand forecast for Namibia, as defined for the Electricity Master Plan developed by JICA, consists of two components. The first is for Large Customers, which include all large mining and industrial concerns, as well as the proclaimed Municipalities and Towns. Large Customers also includes large state operated loads, such as water pumping stations, airports, and telecommunications facilities.

The second component covers small customers and is called Rural Electrification. This includes all small customers outside of proclaimed Municipalities and towns, and consists of rural households, rural social services, rural businesses, and commercial farms.

6.3.2 Rural Electrification Forecasting Methodology

The approaches for large and small customer forecasting are quite different. The rural electrification forecasting methodology followed includes the following steps:

- **Customer Classification**. All the small customers in Namibia were grouped together in classes that are expected to have similar consumption and demand characteristics.

- **Class Population Forecast**. The expected numbers of each class of customer for each forecast year were estimated, based on available data. This provided a potential number of customers in each class.

- **Electrification Rate Forecast**. The number of electrified customers in a class may be only a fraction of the total number, as with rural households. The number of *potential* customers includes the backlog as well as additional customers due to the growth rate. The number of *actual* customers was based

on a hypothetical rural electrification plan which was developed for the forecast and derived from assumptions about electrification priorities and available funding.

- **Class Consumption Forecast**. The expected consumption and maximum demand for typical customers of each class was determined. This was based on existing data from Namibia, as well as related experience from rural electrification programs in other developing countries.

The elements of these forecasts were combined in a model which provides estimates of the consumption and peak demand requirement for small customers in the future.

6.3.3 Customer Classification

The electricity forecast was done for each type of rural customer separately. This is because each type of customer has it's own characteristics including consumption, maximum demand, and growth rate.

The definition of 'Rural' used in this forecast is the same as that used by the Government of Namibia. The Central Statistics Office in Windhoek has defined 'Urban' to mean one of 27 proclaimed Municipalities and Towns. A few additional towns have been proclaimed since the 1991 Census and 1993/4 NHIES survey, but it was necessary to use these definitions to make use the demographic data from these surveys.

The 16 proclaimed Municipalities considered to be urban areas are: Swakopmund, Windhoek, Gobabis, Grootfontein, Karabib, Karasburg, Keetmanshoop, Mariental, Okahandja, Omaruru, Otavi, Otjiwarongo, Outjo, Tsumeb, Usakos, and Walvis Bay.

The 12 proclaimed Tows also considered to be urban areas are: Hentiesbaai, Luderitz, Okakarara, Ongdangwa, Ongwediva, Opuwo, Oshakati, Rehoboth, Rundu, Katima Mulilo, Khorixas, and Arandis.

Rural areas are defined as all areas outside these 28 Municipalities and Towns, with the exception of villages attached to and supplied by mines or large industries that are outside urban areas.

It is expected that more towns and villages will be proclaimed in the near future, giving these communities greater autonomy. Note that there is an discrepency between the NamPower definition of Local Authorities and the Government definition of urban areas. Local Authorities includes some villages that are considered to be rural areas. This discrepency has been resolved in the forecast models.

The Small Customers in Namibia have been classified as follows:

(1) Rural Households.

This is all residential customers outside of proclaimed Municipalities and Towns or mining company villages. This definition of rural is in accordance with Namibian Government policy, as used in the 1991 Census, the National Development Plan, and other documents. The large majority of these potential customers have yet to be electrified.

The rural households can themselves be divided into several types, as follows:

- **Unproclaimed villages and towns**. These are large communities with populations of over 500 people. There were approximately 500 such villages in rural areas in 1991, comprising about 80 000 households. These households when electrified are likely to consume more electricity than truly rural customers, and behave more like typical urban consumers. These communities will be termed villages.

- **Dispersed communities**, which are isolated homes in rural areas and small communities with under 500 inhabitants. The 1991 Census identified over 10 000 of these isolated localities, comprising about 100 000 households. These households, when electrified, will have typically rural low consumption patterns. A large number of these isolated communities are located on commercial farms, and most of the remainder in communal areas. It is estimated that about 7 000 of these communities are in communal areas, comprising about 70 000 households..

- **Farm workers.** There are approximately 32 600 farm workers in Namibia forming about 26 600 households. These households comprise about 125 000 people who live on commercial farms. These households should be electrified as the commercial farms are electrified.

(2) Rural Social Services.

This includes hospitals, clinics, schools, and other Government social services to rural communities.

(3) Rural Commercial Customers.

This class includes all private enterprises requiring electricity in rural communities, such as shops and petrol stations. In larger villages this includes local light industries.

(4) Commercial Farmers.

There were originally approximately 6 400 commercial farms in Namibia. Many of these have been subdivided, resulting in about 11 000 farms in 1997. Approximately 1 400 of these have already been electrified and NamPower has made provision for further expansion of the national distribution system to make electricity more accessible to commercial farmers. In addition there are several potential irrigation schemes being planned. The electricity demand for these schemes is included in the forecast.

6.3.4 National Class Population Forecast

A forecast for expected numbers of each customer class in each region was done.

(1) Rural Households

Namibia currently has some 200 000 rural households, of which under 10% have access to electricity. The goal of rural electrification is to bring electricity to the majority of these homes, and their associated businesses and social services. It was vital to know the numbers of these potential customers in order to forecast their additional demand on the electricity generation and transmission system.

The 1991 Census provided a breakdown of population distribution by Region and by District. The Regional Resources Manual gave detailed data on social services available by Region. In order to make the best use of available information, a forecast of rural population and number of households was done at a Regional level.

Initial population figures (urban and rural) for each Region were taken from the 1991 Census. The institutional population of about 90 000 in 1990 was considered to be completely urban. The figures for population per household for each Region were also taken from the Census figures. These varied from 3,8 in Erongo Region to 6,2 in Okavango Region. A major assumption is that the number of people per household remain constant in each Region over the forecast horizon.

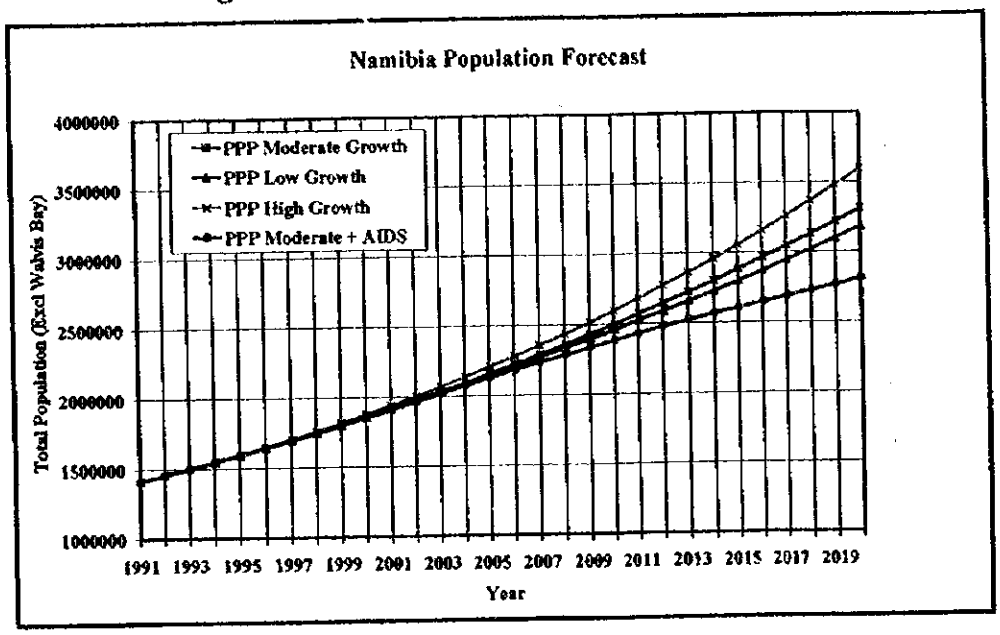
Overall population growth rates were taken from 'Provisional Population Projections 1991 - 2011' issued by the CSO in 1994. This document provided a set of three population growth scenarios, of which the medium scenario (about 3,1% per annum) was recommended for planning purposes. This is also the population growth scenario used in the 'First National Development Plan' (NDP1). The population projections extend only to 2011, and the slowly declining growth rate was extrapolated till 2020 for this forecast.

The total household population growth rate was assumed to equal the overall population rate in each region. The Urban households growth rate was estimated to be 5% due to urbanisation and the difference between total households and urban households provided a forecast for the number of Rural households in each Region each year. The model caters for migration from predominantly rural to predominantly urban regions. A figure of 5% for annual urban growth is consistent with some figures reported for developing countries. It is, however, less than the 5,44% reported by Windhoek for the period 1991 to 1996 and the 5,4% and 7% reported for Mexico city and West African countries. The NDP1 mentions an urbanisation rate of 5,5% and expects this to continue for at least ten years . (A high rate of 8% is also mentioned as a possiblility, but this is considered unlikely and unsustainable in the long term.) Both the 5% and 5,4% scenarios are considered realistic for Namibia.

The population forecast is shown in Figure 6.8. Note that Walvis Bay is excluded, but not relevant as it is an almost entirely urban area. The impact of AIDS is clearly visible in the longer term, and the use of the PPP medium growth scenario for this forecast may need revision in a few years.

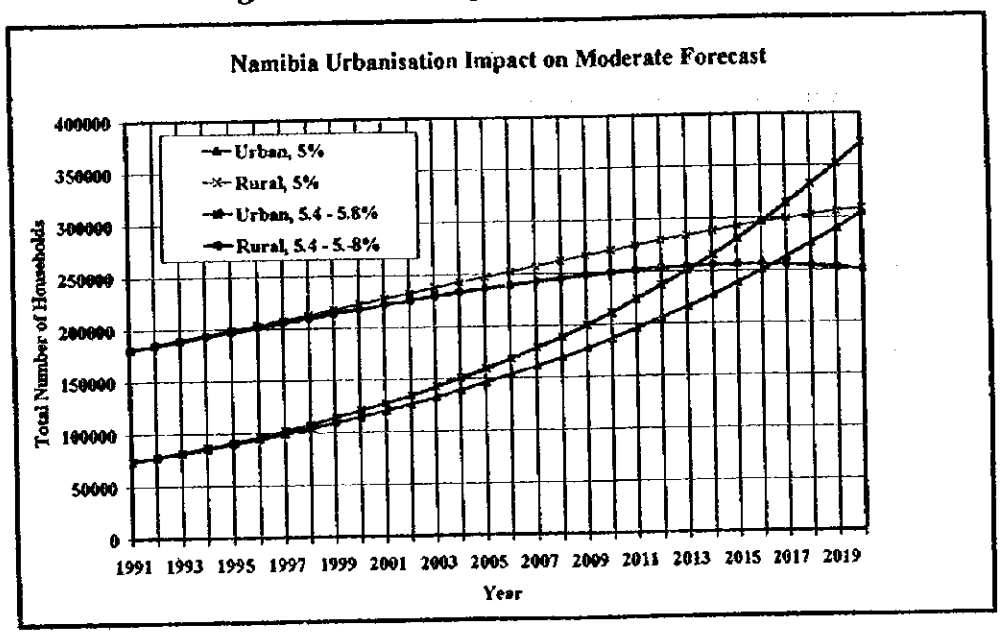
Figure 6.9 illustrates the impact of different rates of urbanisation on the numbers of urban and rural households

Figure 6.8 - Namibian Population Forecast



Source: CSO

Figure 6.9 - The Impact of Urbanisation



The final forecast numbers for Population as well as Urban and Rural households are listed in Table 6.1. This table lists figures for the medium growth scenario with a 5% urbanisation rate, which is the 'Base Case' for the electricity demand forecast.

Table 6.1 - Population and Household Forecast

Year	Total Population	National Growth %	Urban Growth %	Urban Households	Rural Households	Total Households
1991	1 409 920	3.1	5	73 870	180 519	254 389
1992	1 453 628	3.1	5	77 564	184 877	262441
1993	1 498 690	3.1	5	81 442	189 309	270 751
1994	1 545 149	3.1	5	85 514	193 813	279 327
1995	1 593 049	3.1	5	89 789	198 388	288 178
1996	1 642 434	3.1	5	94 279	203 034	297 313
1997	**1 693 349**	**3.1**	**5**	**98 993**	**207 748**	**306 741**
1998	1 745 843	3.1	5	103 943	212 530	316 472
1999	1 799 964	3.1	5	109 140	217 376	326 516
2000	1 855 763	3.1	5	114 597	222 286	336 883
2001	1 913 291	3.1	5	120 326	227 257	347 584
2002	1 972 603	3.1	5	126 343	232 286	358 629
2003	2 033 754	3	5	132 660	237 370	370 030
2004	2 094 767	3	5	139 293	242 151	381 444
2005	2 157 610	3	5	146 258	246 959	393 216
2006	2 222 338	3	5	153 570	251 788	405 359
2007	2 289 008	3	5	161 249	256 633	417 882
2008	2 357 678	3	5	169 311	261 488	430 799
2009	2 428 409	2.9	5	177 777	266 347	444 123
2010	2 498 833	2.9	5	186 666	270 778	457 444
2011	2 571 299	2.9	5	195 999	275 174	471 173
2012	2 645 866	2.9	5	205 799	279 524	485 323
2013	2 722 597	2.9	5	216 089	283 819	499 908
2014	2 801 552	2.9	5	226 893	288 048	514 941
2015	**2 882 797**	**2.8**	**5**	**238 238**	**292 199**	**530 438**
2016	2 963 515	2.8	5	250 150	295 759	545 909
2017	3 046 494	2.8	5	262 658	299 187	561 844
2018	3 131 795	2.8	5	275 790	302 468	578 259
2019	3 219 486	2.8	5	289 580	305 587	595 167
2020	3 309 631	2.8	5	304 059	308 525	612 584

Source: CSO

This model produced a total number of Rural households in 2015 of 292 199. This is the total number of potential homes by that time. The population growth was modelled with several other scenarios, with variations on overall growth rate, urbanisation rate, and AIDS impact.

An alternative urbanisation rate of 5,4% to 5,8%, as expected by Windhoek Municipality, results in a total number of Rural Households of about 256 000 by 2015.

The CSO population growth projections do not consider the possible impact of the AIDS epidemic on long term population growth. The UNDP Human Development Report for Namibia 1997 deals with the impact of AIDS in depth, and states that the population growth rate could decline to below 2% by 2010 because of AIDS. This impact is included in one of the scenarios modelled for the population forecast.

Table 6.2 lists the numbers of urban and rural households expected by the year 2015 for several of the population growth scenarios.

Table 6.2 - Household Growth Scenarios

Population Growth Forecast Scenario	Urban Households 2015	Rural Households 2015
Low, 5% Urbanisation, no AIDS	238 238	277 280
Medium, 5% Urbanisation, no AIDS	**238 238**	**292 199**
High, 5% Urbanisation, no AIDS	238 238	322 285
Medium, 5,4% Urbanisation, no AIDS	280 374	255 882
Medium, 5% Urbanisation, AIDS	238 238	244 183
Medium, 5,4% Urbanisation, AIDS	280 374	207 866

As can be seen, the number of rural households could vary considerably with different assumptions, with the AIDS impact and urbanisation rate playing key roles.

(2) Rural Social Services

The total numbers of social services were obtained from the 1996 Statistical Abstract for 1995. Social services were also classified according to their expected electricity consumption rates:

- **Hospitals** : There are currently 41 hospitals (Regional Resources Manual has 39). The Government is implementing a policy of redistribution of health resources, increasing expenditure on primary health care to provide equity in the availability of health services to all Namibians. This implies an increase in the number of clinics and health care centers, while decreasing the number of hospitals. The forecast assumed a decrease in the number of hospitals by one per year for five years, as per NDP1 intentions. All of these closing hospitals are in urban areas. The forecast used regional figures from the Regional Resources Manual to determine the numbers of rural hospitals, which total 15 in 1995.

- **Clinics and Health Centers.** There are currently 256 in the country (Regional Resources Manual has 265). Almost all of these clinics and health centers are in rural areas. The forecast used regional figures from the Regional Resources Manual to determine the numbers of rural clinics and health centers. The forecast assumed an increase of approximately 3% per year in each region in step with population growth. This is somewhat higher than the 1% per annum indicated by the Ministry of Health and Social Services.

- **Schools.** The 1996 Statistical Abstract lists a total of 1 372 schools in Namibia. The Regional Resources Manual has 1 390, excluding Childcare Centers. The total for rural areas is 1 166. As with clinics, the forecast assumed a growth rate proportional to the population growth rate.

- **Schools with Hostels** : Schools with attached hostels use substantially more electricity than those without hostels. A review of Northern Electricity's customer base revealed that about 15% of schools had attached hostels. An initial estimate of about 150 schools with hostels was used for this forecast. A growth rate of 3% per annum was forecast, in line with the population growth.

- **Other Government Social Facilities** (Post Offices, Police Stations, and local government offices) : This class excludes all parastatals, water pumping, military bases, and airports. The Regional Resources Manual was used as a source for

these figures, with a total of 134, of which 82 were estimated to be in rural areas. The billing records of Northern Electricity however indicate that considerably more government facilities have already been electrified. These included such diverse facilities as border posts, agricultural development centers, and tribal offices. Ultimately it was not possible to get reasonable estimates of the total number of these facilities in the country - or by region.

It must be noted that exact numbers of each of the above-mentioned services are difficult to establish, as each source of data often had different figures. This forecast will use the figures in the Regional Resources Manual in most cases, in order to facilitate a forecast by region, as requested by MME.

(3) Rural Commercial Customers (Businesses)

There are no accurate figures for the number of private businesses that exist or would make use of electricity. The NHIES survey estimates that 5% of rural households earn their main source of income from businesses. . Based on this, a rough estimate for the number of commercial customers in rural areas would be one per twenty households. This agrees with figures reported in an environmental study "Understanding the Oshanas". This implies about 10 400 potential customers, rising with population growth to about 15 000 by the year 2015.

(4) Commercial Farming

There were originally about 6 400 commercial farms in Namibia, of which about 1 400 already have access to grid electricity from NamPower. Many of the farms have been subdivided, resulting in an total number of about 11 000 in 1997. The government also intends relocating 100 large communal farmers to commercial land by 2000. Over 40 new commercial farms have already been established on communal land in Okavango Region. The 1996 NamPower Electricity Master Plan makes provision for extension of rural schemes to cover about 90% of the commercial farming area in Namibia over about 30 years.

(5) Irrigation Schemes

The NDP1 has a target of increasing land under irrigation by 5 000 hectares (ha) by 2000. Several new irrigation schemes are currently being planned. The following schemes have been considered in this forecast:

- Lower Orange River (Hoenfels, Koeskop, and Daberas), about 750 ha.
- Aussenkjer, a large project of about 8 000 ha on relatively high ground.
- Hakkiesdoring - Ramansdrif, about 1 500 ha in addition to present 500 ha.
- Upper Orange River, about 2 500 ha currently under development.
- Naute Dam. Increasing the present 240 ha to about 600 ha.
- Brukkaros. A feasibility study for about 1 000 ha is almost complete.
- Etunda. Currently about 50% of this 1 200 ha project is complete.
- Sesfontein. There is a potential for about 500 ha in the longer term.
- Kavango River. There is potential for about 4 000 ha in the Kangongo area and another 2 000 ha in the Dikiyo area, both vegetables and grain.
- Zambezi River. Downstream of Katima Mulilo the possibility of 12 000 ha of sugar plantations and 5 000 ha of grain farming is under consideration. The possibility of a sugar mill in the area is also under consideration.

This is a total of about 37 600 hectares of potential irrigation farming. The forecast assumed that about two thirds of this (23 000 hectares) would be put under irrigation over the forecast horizon. This was approximated by 230 farms of 100 hectares each.

6.3.5 Regional Class Population Forecast

The rural forecast was carried out on a regional basis, as per a request from MME. The population and growth per region was derived from the national population growth forecast, and varies from region to region. These variations are functions of issues like urbanisation, occupation, government policy, and regional climate and topography.

(1) The Household Forecast on a Regional Basis

The above forecast was done on a regional basis. The present and target (2015) household populations for each region are tabulated in Table 6.3.

Table 6.3 - Household Forecast by Region

	Urban Households	Rural Households	Urban Households	Rural Households
	1997	1997	2015	2015
Caprivi	3625	17672	8724	24856
Erongo	11641	5485	28016	7715
Hardap	6737	9588	16213	13485
Karas	5888	8806	14171	12386
Khomas	38482	5692	92612	8006
Kunene	2531	12166	6092	17111
Ohangwena	0	32715	0	46014
Okavango	4247	16874	10220	23733
Omaheke	2152	9085	5180	12778
Omusati	0	35540	0	49988
Oshana	8090	18589	19470	26146
Oshikoto	4039	21189	9720	29803
Otjozondjupa	11560	14347	27820	20180
Totals	98993	207748	238238	292199

(2) 'Urbanised' Rural Households

The official definition of urban areas is inadequate for this forecast, as a large proportion of rural households are in large (but unproclaimed) villages, and many have adopted an urban lifestyle and associated energy needs. The 1991 census Report B Table A02 identified over 500 towns and villages of over 500 residents, of which only a few are proclaimed and therefore officially urban areas. For the purposes of this forecast, this section of the rural population will be treated as 'Villages', to distinguish them from the truly rural residents living in communities of under 500 people.

Table 6.4 lists the distribution of localities as recorded in the 1991 Census. All of the localities of over 5000 residents are official Urban areas, as are about ten of the 475 localities of 500 to 5000 residents.

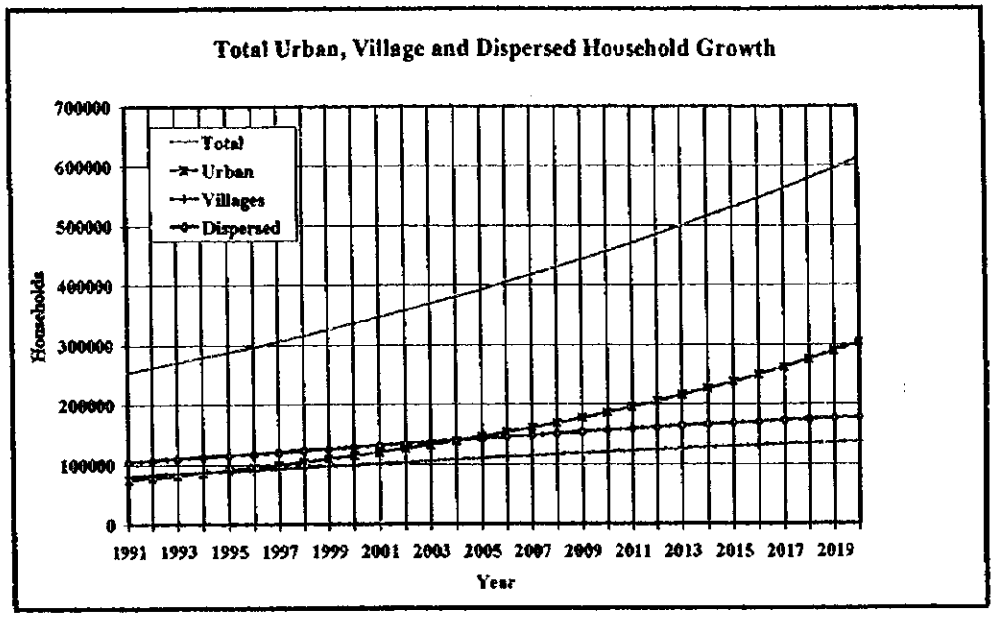
Two types of population distribution can be identified. In several regions (Ohangwena, Okavango, Omusati, and Oshana) there are about five dispersed communities for each village. The remaining regions (with the exception of Oshikoto) have over 50 dispersed communities per village. This difference highlights two totally different types of population distribution in the country. (Oshikoto has components of both types of distribution.) Similarly, the average size of a dispersed community in the north is 155 persons, while it is 22 persons in the other regions. Most of the dispersed communities in the central and southern regions are on the commercial farms. The northern regions have a more evenly spread population distribution, while the population in the other regions is concentrated in a small number of towns and villages. The projected growth in Urban, Village, and Dispersed households in Namibia is shown in Fgiure 6.10. Appendix B includes graphs illustrating the Urban, Village and Dispersed community household growth expected for the base case forecast in each region.

Table 6.4 - Regional Distribution of Villages and Dispersed Communities

Regional Distribution of Villages and Dispersed Communities				
	>5000 People 'Cities & Towns'	500-5000 People 'Villages'	1-499 People 'Dispersed Communities'	DC per Village
Caprivi	1	25	1254	50
Erongo	1	9	514	57
Hardap	2	12	1209	101
Karas	3	10	1042	104
Khomas	3	3	705	235
Kunene	1	14	1088	78
Ohangwena	0	109	493	5
Okavango	1	57	356	6
Omaheke	1	11	912	83
Omusati	0	113	426	4
Oshana	3	51	252	5
Oshikoto	1	48	676	14
Otjozondjupa	3	13	1531	118
Total	20	475	10458	

Source: CSO

Figure 6.10 - Total Urban, Village and Dispersed Household Growth



(3) Caprivi Region

This region is rather isolated from the rest of the country - both physically and electrically. The region is almost entirely rural in nature, with very little manufacturing industry and no mining activity. Most of the population lives in the East, on the floodplains and along the rivers and roads. The primary occupation in the region is subsistance agriculture, although fish are an important food source. The NHIES estimate for farm workers was about 2 000 in 1994. The main urban center of the region, Katima Mulilo, is located far to the East and is supplied with electricity by a 3 MW diesel generating set and a 66 kV line from Zambia. The NamPower grid has been extended from Rundu to Mukwa, Andara and Bagani in the West of the region. Apart from these villages (and their surroundings) there is no grid electricity in the region. NamPower intends extending the distribution system from Katima Mulilo to the Ngoma and Linyandi areas. The completion of the upgrading of the road from Rundu to Katima Mulilo (Trans Caprivi Highway) will bring opportunities for development to the region. There is potential for the development of irrigated sugar cane farming along the Zambezi, east of Katima Mulilo, along with the establishment of a co-generating sugar mill in the area.

Table 6.5 - Caprivi Region Rural Population Forecast

Caprivi Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	4964	514	6982
Dispersed Households	12708	0	17874
Hospitals	1	1	1
Clinics & Health Care	39	7	54
Schools with Hostels	18	1	25
Schools	123	11	172
Government Facilities		5	
Shops	883	57	1242
Livestock Farming	0		
Irrigation Farming	0		

(4) Erongo Region

This region, along the coast around and north of Walvis Bay, consists of desert in the West and semi-desert in the East. The region is sparsely populated, with people being concentrated in a number of towns and villages. The Eastern and central parts of the region are used for commercial and communal livestock farming. A number of mines provide employment in the region, including Rössing Uranium, the Navachab Gold Mine, and a marble quarry at Karibib. The major centers of Walvis Bay and Swakopmund, along with the Export Processing Zone (EPZ) at Walvis Bay, provide most of the employment for the urbanised residents of this region. Other urban areas are Arandis, Karibib, Usakos, Omaruru, and Henties Bay. These towns and villages all have access to electricity from NamPower. Several of the smaller villages, including Uis, Omatjete, and Okambahe, are also connected to the national grid. NamPower is currently constructing a power line to Otjimbingwe, which is expected to be completed by October 1997. The NHIES estimated about 3 000 farm workers in the region in 1994. Along with their families, this implies that about half of the rural population lives on commercial farms. The remainder live in the villages, the larger of which have already been electrified. The potential for further rural electrification includes about thirty small villages to the north and north-west of Omaruru, and the commercial farms and farm workers.

Table 6.6 - Erongo Region Rural Population Forecast

Erongo Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	1474		2073
Dispersed Households	4011		5641
Hospitals	1		1
Clinics & Health Care	6		9
Schools with Hostels	2		3
Schools	15		21
Government Facilities			
Shops	789		1786
Livestock Farming	674	200	

(5) Hardap Region

Hardap extends across southern central Namibia, from the Atlantic ocean to the Botswana border in the East. The Namib dune desert which borders the sea is not populated. East of the desert is an escarpment formed by the Naukluft Mountains and Schwarzrand. This leads to the central plains followed by the Kalk plateau in the East. Both the plains and the Kalk plateau have a semi-desert climate. Most of the land is used for livestock farming, and is sparsely populated. The large towns in the region - Mariental and Rehoboth - have been electrified for several years, as have a number of the smaller towns, such as Gochas, Aranos, Klein Aub, Stampriet, Gibeon and Maltahohe. The remaining small towns and villages are currently being electrified as a result of the Southern Namibia Rural Electrification Project. These include Kalkrand and Hoachanas which were supplied in 1996. Rietoog, Schlip, and Duineveld are planned for Phase III of the project. This means that most of the urban and village residents will have access to electricity, and the remaining rural households (about 4 000 according to the 1991 Census data) are probably all workers on commercial and communal farms.

The NHIES estimated about 3 700 farm workers in the region. Approximately 10% of the region is used for communal farming. There is a small amount of irrigation farming at Hardap and Stampriet. There is currently no mining of note in the region, although some prospecting is taking place. Small-scale manufacturing industries

are located in Rehoboth and Mariental. Most of the schools, clinics, government services and businesses are in the electrified towns, with the exception of a few schools in the communal farming areas. Electrification of the farms will therefore be the primary goal for this region.

Table 6.7 - Hardap Region Rural Population Forecast

Hardap Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	4236	846	5959
Dispersed Households	5351		7526
Hospitals	1	1	1
Clinics & Health Care	9	7	13
Schools with Hostels	5	4	7
Schools	42	37	59
Government Facilities		87	
Shops	479	94	674
Livestock Farming	2316	300	

(6) Karas Region

Karas is the largest and most sparsely populated region of Namibia. It is bordered by the Atlantic Ocean to the west and the Orange River to the South. As with the Hardap region, the Karas region has a barren dune desert between the escarpment and the sea. The remainder of the area consists of a semi-desert plateau, with the Groot and Klein Karas mountain ranges in the South-east. The density of vegetation decreases from East to West, following the rainfall patterns. Most of the land east of the desert is used for stock farming, both communal (in the Berseba area) and commercial. The large towns in the region are Keetmanshoop and Karasburg, and the port Luderitz. Industries include fishing at Luderitz and light manufacturing at Luderitz, Keetmanshoop, and Karasburg. The major industry in the region is mining, with diamonds along the coast, copper and zinc at Rosh Pinah, and marble at Aus. Semi-precious stones are also collected in the region. Future prospects for mining are good, including a copper mine at Haib and a zinc mine at the Skorpion deposit, about 20km north of Rosh Pinah. These will both provide jobs and uplift the rural economy in the region. There is irrigation farming along the

Orange River and a small amount at the Naute Dam. Several additional irrigation projects are currently being studied along the Orange River, with a total potential of about 15 000 hectares of irrigated farmland. Extension of the Naute Dam irrigation and development at Brukkaros is also under consideration. The large towns have had electricity for many years and the smaller towns are being electrified as part of the Southern Namibia Rural Electrification Project. Berseba and Kosis were electrified in 1996. Phase II of the project, currently in progress, includes Khomnarib, Klein Vaalgras, Koichas, and Blouwes. Phase III is planned to cater for Aroab, Koes, Warmbad, and Aus. This leaves only a few small villages in the Berseba communal farming area and the commercial farms with their workers in terms of rural households still to be electrified. The number of farm workers was about 2 600 in 1994.

Table 6.8 - Karas Region Rural Population Forecast

Karas Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	4511	846	6345
Dispersed Households	4295		6041
Hospitals	1		1
Clinics & Health Care	21	20	30
Schools with Hostels	4	4	6
Schools	34	30	47
Goveroment Facilities		78	
Shops	440	94	619
Livestock Farming	1819	200	

(7) Khomas Region

This region is central to Namibia in many ways. It surrounds the capital city of Windhoek and consists of a hilly countryside covered by savannah type grasslands and shrubs. The moderate, reliable rainfall makes the region ideal for livestock farming, and crop production below some of the dams is possible. Currently only one mine is operational in the region, at Otjihase. The mine extracts copper, zinc, and lead. The main town is Windhoek, the largest city in Namibia, which accomodates most of the light and manufacturing industry in the country. The only

other village of note is Dordabis, which has been targeted for electrification in Phase III of the Southern Namibia Rural Electrification Project. The large majority (90%) of the region's population lives within the boundaries of Windhoek City. Rural electrification is limited to the farms and their workers, of which there are about 2 600.

Table 6.9 - Khomas Region Rural Population Forecast

Khomas Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	397		558
Dispersed Households	5295		7448
Hospitals	0		0
Clinics & Health Care	2		3
Schools with Hostels	1		1
Schools	14		19
Government Facilities			
Shops	284		400
Livestock Farming	1192	200	

(8) Kunene Region

The Kunene Region in the north-west of the country is fairly remote and inaccessible. The Namib desert extends along the coast (the Skeleton Coast), followed by an escarpment and mountainous region which leads on to the plains on the eastern side. The region includes the Etosha National Park, which occupies approximately 15% of the total area. The desert is arid, but the mountainous region consists of shrub savannah which developes into bush savannah to the East. The towns of Khorixas, Outjo and Opuwa form the urban areas in the region, and villages include Kamanjab, Fransfontein, Sesfontein, and Ruacana. The southern third of the region is used for commercial livestock farming, and the north-western areas used for communal farming. Commercial farming employs about 700 workers. The region is rich in mineral resources, but mining activities are limited, mainly due to inaccessibility. A little manufacturing occurs in Outjo. There is irrigation farming on about 600 hectares at Etunda, with the potential of about 1 200 hectares in total. There is also a proposed irrigation farming project at Sesfontein, with a potential of

up to 500 hectares. There are about seven additional villages in the communal farming area, and a large number of dispersed small communities, centered around rural schools and clinics.

Table 6.10 - Kunene Region Rural Population Forecast

Kunene Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	3340		4698
Dispersed Households	8825		12413
Hospitals	1		1
Clinics & Health Care	14		19
Schools with Hostels	5		7
Schools	39		54
Government Facilities			
Shops	608		855
Livestock Farming	763	0	

(9) Ohangwena Region

This region, along the northern border with Angola, is characterised by flatness. The western half could be classified as grass savannah while the eastern half becomes sandy woodland as it extends into the Kalahari. The shallow depressions (oshanas) get filled annually during the rainy season and floods, and usually remain wet until June. This revives the grasslands and provides fish which come down from Angola. The population is rural, and concentrated in the west and along the main road running south from the Angolan border at Oshikongo. The entire region is communally owned land. The main occupation is subsistence farming, both with crops and livestock. Although there are a number of large towns in the region, such as Eenhana and Ohangwena, these are not yet proclaimed and as such not considered oficially urban. There are no mining or industrial activities in the region, and the transport and communications infrastructure is generally undeveloped. Many of the large towns have been connected to the NamPower grid as a result of the Ovambo Electrification Project initiated in 1991.

Table 6.11 - Ohangwena Region Rural Population Forecast

Ohangwena Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	19095	962	26857
Dispersed Households	13620		19157
Hospitals	2		3
Clinics & Health Care	22	15	31
Schools with Hostels	26	7	37
Schools	176	46	247
Government Facilities		62	
Shops	1635	111	2300
Livestock Farming	0	0	

(10) Okavango Region

The Okavango region is in the north-east corner of Namibia proper, Ohangwena and Oshikoto to the west and the Caprivi region to the east. The Okavango River runs along most of the Northern border of the region, between Namibia and Angola. The region is extremely flat and is covered by scrub savannah and dry woodland. The population, approximately 10% of the national total, is rural (with the exception of Rundu town) and concentrated along the banks of the Okavango river and the main road. The main occupations are fishing and subsistence farming, both crop and livestock. The government has allocated land for about 40 large commercial farms on previously communal land and relocated farmers to them. No mining takes place in the region. Industry is limited to small manufacturing at Rundu for local needs.There is potential for organised forestry and agro-forestry. The infrastructure in the region is limited, and access will be improved with the completion of the Trans Caprivi highway. The NamPower grid has been extended along the Okavango river from the 132 kV substation at Rundu, to Nkurenkuru in the west and to Bagani (in the Caprivi Region) in the east. A number of public and private customers have been connected to this supply since 1993.

Table 6.12 - Okavango Region Rural Population Forecast

Okavango Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	8651	1807	12167
Dispersed Households	8223		11565
Hospitals	2		3
Clinics & Health Care	38	30	55
Schools with Hostels	27	9	38
Schools	190	66	267
Government Facilities		44	
Shops	843	201	1186
Livestock Farming	46	0	

(11) Omaheke Region

This region, in the eastern central part of the country, is extremely flat and forms part of the Kalihari Sandveld. It consists of a sandy soil covered by a dry shrub savannah. The region has a higher rainfall than the southern areas of the country and is ideal for livestock farming. Communal land comprises about 35% of the region. The population, under 4% of the national total, is sparsely distributed. In communal areas the population is concentrated around water sources and the roads. There are about 900 commercial and 3 500 communal cattle farmers in the region. The main center for the region is Gobabis. There is no mining in the region, and only small-scale light industries in Gobabis. Infrastructure in the region is reasonably well developed, and there is potential for the development of industries associated with the local livestock farming as well as ecotourism. A tarred road linking South Africa to Windhoek via Botswana (Trans-Kalihari Highway), and passing through Gobabis, is currently under construction. Gobabis has been electrified for several years, and the Eastern Namibia Electrification Program has brought electricity to many of the smaller towns. These include Otjinene, Aminuis, Leonardville, Epikuro, and Witvlei. There are still a number of small communities in the Aminuis (nouth of Gobabis) and the Otjinene (north of Gobabis) communal areas without electricity. There are no plans for irrigation farming in the region.

Table 6.13 - Omaheke Region Rural Population Forecast

Omaheke Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	2202	234	3098
Dispersed Households	6882		9680
Hospitals	0		0
Clinics & Health Care	6	5	8
Schools with Hostels	3	0	4
Schools	22	2	31
Government Facilities			
Shops	454	23	638
Livestock Farming	1209	200	

(12) Omusati Region

The Omusati Region is relatively small, very flat and one of the more densely populated regions in Namibia. It consists of a plain gradually sloping down southwards to the Etosha pan depression. The northern half of the region forms part of the Oshana environment in which seasonal floods fill the shallow drainage channels (oshanas), providing water for the local inhabitants and their livestock. The northern half is a fairly densely populated rural area while the south is sparsely populated. The region is palm savannah in the north, with sandveld encroaching on the west and grass savannah to the south, where rainfall is lower and more variable. Most of the rural population are communal farmers, and both dryland agronomy and livestock farming are practised. Fishing is also practised in the larger oshanas during the rainy season. There are no proclaimed towns in the region, but the main centers of Tsandi and Uutapi are large villages. The 1991 Census listed over 100 villages and over 400 communities of under 500 persons, giving a ratio of one village per four dispersed communities. With most of the population concentrated in the northern half, this makes Omusati one of the most densely populated rural areas in the country. A large number of village centers have been electrified as part of the Ovambo Electrification Project, which has been ongoing in phases since 1991. No mining or manufacturing takes place in the region.

Table 6.14 - Omasuti Region Rural Population Forecast

Omusati Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	19486	496	27408
Dispersed Households	16054		22580
Hospitals	4		6
Clinics & Health Care	35	1	50
Schools with Hostels	29	3	41
Schools	201	21	283
Government Facilities			
Shops	1777	52	2499
Livestock Farming	1	0	

(13) Oshana Region

The Oshana Region is the smallest in Namibia. It is extremely flat, sloping gradually down towards the South and the Etosha pan depression. The region is covered by shallow depressions (oshanas) which get filled annually during the rainy season. The region is the most densely populated in the country, with the population being concentrated in the northern section. The main urban centers of Ondangwa, Ongwediva, and Oshakati are located on the main road running north to the Angolan border. The region has palm sanannah coverage in the north and grass savannah to the south. Population pressure has resulted in a decline in the numbers of trees and shrubs, leading to the threat of deforrestation in the area. As with Omusati, this region has a large number of villages of over 500 residents. Fish in the oshanas are an important source of protein, and most of the rural population is employed in communal subsistence farming, both livestock and grain (mahangu). No commercial farms exist in the region. There is no mining in the region, and manufacturing is limited to light industries at Oshakati and Ondangwa, which have been electrified for many years. A large number of village centers have been electrified as part of the Ovambo Electrification Project, which has been ongoing in phases since 1991. The Oshakati-Ongwediva-Ondangwa corridor has experienced high urban growth in recent years, and has the potential to become a strong industrial center in the north of Namibia.

Table 6.15 - Oshana Region Rural Population Forecast

Oshana Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	9133	962	12846
Dispersed Households	9456		13301
Hospitals	0		0
Clinics & Health Care	14	14	19
Schools with Hostels	12	7	16
Schools	83	46	116
Government Facilities		63	
Shops	929	111	1307
Livestock Farming	15	0	

(14) Oshikoto Region

The Oshikoto Region comprises the eastern part of the former Owamboland communal farming area and the area around Tsumeb. The northern part of the region is a flat plain sloping gradually down towards the Etosha Pan. This plain is broken by the Otavi Mountains to the south of Tsumeb. The region changes from palm savannah in the extreme north to grass savannah covering most of the area and woodland (mopani and acacia) savannah to the south. The area around Tsumeb consists of commercial crop farms growing wheat, mielies, sorghum, peanuts, vegetables and fruit. Some farms use irrigation. The communal farmers have mainly livestock with some mahango cultivation for subsistence. Copper, lead, and silver are mined at several mines in the region, which also produce small quantities of arsenic, germanium, and cadmium. The Tsumeb mine includes two smelters and a large workshop, and the town has several light industries. The rural population in concentrated in the north-west of the region, along the main road to Angola. A large number of village centers have been electrified as part of the Ovambo Electrification Project, which has been ongoing in phases since 1991.

Table 6.16 - Oshikoto Region Rural Population Forecast

Oshikoto Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	7281	962	10241
Dispersed Households	13908		19562
Hospitals	1		1
Clinics & Health Care	16	15	22
Schools with Hostels	16	7	22
Schools	107	46	148
Government Facilities		62	
Shops	1059	111	1468
Livestock Farming	369	0	

(15) Otjozondjupa Region

This region is essentially a flat plain which forms part of the Kalahari. The major exception is the Otavi Mountain range which extends from about 60 km west of Otavi to the vicinity of Grootfontein. The region has a mild sub-arid climate, and is covered mainly by thornbush savannah. Commercial farmland constitutes about 67% of the area, and extensive livestock farming is practised. Crops (maize and sunflowers) are also grown around the Otavi Mountains. Almost one third of all Namibian farm workers, about 8 500 households, are employed in Otjozondjupa. This accounts for about two thirds of the rural population in the region. Approximately half the population is urbanised, with the main centers being Okahandja, Otjiwarongo, Okakarara, Otavi, and Grootfontein. Parts of the Tsumkwe district in the east are completely unpopulated. Mining of copper, zinc, silver and associated minerals occurs at Kombat and Grootfontein. Manganese is mined at Otjosondu. Light industries are located at Otjiwarongo, Otavi, Grootfontein, and Okahandja. The Eastern Namibia Electrification Project brought electricity to several of the towns and villages in the region, including Coblenze, Otjituuo, and Okamatipati. There are still, however, several villages in the communal areas of Okakarara district and along the Omatako River in need of electricity. The villages of Tsumkwe and Gam in the far east of the region are unlikely to get grid electricity in the near future due to their extreme remoteness. (Tsumkwe currently operates a 160 kW diesel generator.)

Table 6.17 - Otjozondjupa Region Rural Population Forecast

Otjozundjupa Region Rural Population Forecast	1997 Total (Estimated)	1997 Electrified (Estimated)	2015 Total (Forecast)
Village Households	2561	235	3601
Dispersed Households	11787		16578
Hospitals	1		1
Clinics & Health Care	15	5	20
Schools with Hostels	3	2	4
Schools	26	4	37
Government Facilities		23	
Shops	717	400	1008
Livestock Farming	2470	400	

6.3.6 The Present Status of Rural Electrification in Namibia

Estimates for the current base of electrified customers in rural areas were made. This consists of the customers electrified before independance and those electrified as a result of rural electrification programs since 1990.

(1) Rural Households Electrified before Independance

Table H05 in the 1991 Census Report B reports that 10 790 Rural households used electricity for lighting. This figure is the considered the most reliable estimate for 1991, and includes households using petrol or diesel generators. Assuming that 10% of these households were supplied by diesel generators, about 9 700 rural households had access to grid electricity in 1990. About 80% of these homes were formal detached dwellings, mainly in large villages that were not defined as urban areas.

(2) The Rural Electrification Program

After independence in 1990 the Government of Namibia embarked on a rural electrification program. Data on the outcome of this program are scant, and must

be reviewed carefully to obtain an accurate picture of the current status of the national electrification program.

The program was initiated in the former Ovambo area in 1991. This was later extended to Kavango, followed by the eastern part of the country, and then to the Southern rural areas. Some villages in the west are also being electrified. The EDRC Review of the Ovambo Electrification Project describes the status of this area in late 1995. The report states that a total of 1 507 prepayment residential customers had been connected, along with 226 billed commercial customers and social services. Accurate records are not available, but it is suspected that at least 1 000 additional connected prepayment customers were not recorded at this time.

A chart from an MME presentation in late 1996 contains Table 6.18, which lists the EDRC figures for Ovambo and adds figures for the other electrified regions:

Table 6.18 - Status of Electrification - December 1996

Type of Customer	Owambo	Kavango	Eastern	Southern
Residential	1507	140	469	753
Private Shops	138	3	21	9
Schools & Hostels	66	65	4	17
Clinics & Other Public Buildings	160	81	17	18

Source: MME

A monthly report by Northern Electricity dated May 1997 lists the following numbers of customers within their supply area (Table 6.19).

Table 6.19 - Status of Electrification - May 1997

Type of Customer	Owambo	Kavango	Total
Residential Pre-Paid	2918	1038	3956
Residential Metered			920
Maximum Demand			231
Business 3-Phase			436
Business 1-Phase			270

Source: NE

In a FAX to the JICA team in June 1997, MME added to the above data with figures of 24 conventional and 571 prepayment customers in the Caprivi region.

In August 1997, MME provided the JICA team with the following Table 6.20, detailing all rural electrification customers expected by the end of 1997. The Ovambo and Okavango figures represent Northern Electricity customers, while the other regional figures represent past and current rural electrification projects. Most of the Private Conventional customers (about 930) were electrified prior to the rural electrification program

Table 6.20 - Status of Electrification - December 1997

Rural Electrification Customers in Namibia (as expected by the end of 1997)					
Region	Private Prepayment	Private Conventional	Private Total	Government	Regional Total
Ovambo	2918	557	3475	181	3656
Okavango	1038	970	2008	149	2157
Caprivi			571	24	595
Southern			1880	267	2147
Eastern			469	42	511
Totals			8403	663	9066

Source: NE

(3) Estimate of the State of Rural Electrification by Region

The data in Table 6.20, as well as an analysis of billing figures for Northern Electricity, were used to estimate the numbers of electrified customers per class in each region (Table 6.21). Since Northern Electricity claimed in their May 1997

EMC report to have exhausted their electrification funds for the following six months, it was assumed that no further connections would take place in Ovambo during 1997. The customer totals and class proportions for Ovambo and Okavango were based on an analysis of customer records from Northern Electricity for July 1997. The total number of cutomer bills was about 50 more than in the MME table. (The Northern Electricity bills include 54 Department of Water Affairs accounts, which could have been omitted from the MME table.) The Ovambo totals were divided equally between the four Ovambo regions. For the Caprivi, Southern, and Eastern regions it was assumed that 10% of the private customers were businesses. The Government customers for these regions were split according to the Northern Electricity customer class ratios. Note that these figures include about 930 households with conventional meters, and probably connected prior to the commencement of the rural electrification program. The available data indicates that no (or very little) rural electrification has taken place in the Erongo, Khomas, and Kunene regions. The commercial farm estimates were derived from the total number of NamPower rural accounts and overlaying a map of NamPower rural distribution coverage with a map detailing farm boundaries, and is only a rough estimate.

Table 6.21 - Estimated Status of Electrification by Region

Region	Household	Schools	Clinics	Business	Government	Farms
Caprivi	514	12	7	57	5	0
Erongo	0	0	0	0	0	200
Hardap	846	67	41	94	27	300
Karas	846	66	40	94	26	200
Khomas	0	0	0	0	0	200
Kunene	0	0	0	0	0	0
Ohangwena	962	53	15	111	62	0
Okavango	1807	75	44	201	30	0
Omaheke	234	2	5	23	3	200
Omusati	962	53	15	111	62	0
Oshana	962	53	15	111	62	0
Oshikoto	962	53	15	111	62	0
Otjozondjupa	235	2	5	23	4	400
Total	8330	436	202	936	343	1500

Source: MME and NE

In total, approximately 7,400 households as well as about 1,900 schools, clinics, businesses and government services have been electrified since the start of the first electrification project in 1991.

6.3.7 Electrification Rate Forecast

The rate at which rural electrification will take place is primarily a policy issue, and will be limited by resource constraints such as finance and manpower.

(1) Government Policy on Rural Electrification

The Government has placed a high social and political priority on rural electrification as a means of socio-economic upliftment and creating incentives for economic development. Namibian Government policy has been expressed as the desire to electrify 90% of all rural households by the year 2015. This is, however, a rather ambitious goal, and a more practical aim has been expressed in the recent draft Energy Policy. The draft policy clearly states that one of the challenges facing the electricity sector is improving access to electricity in a sustainable manner, particularly in rural areas. It commits Government to continue electrifying rural areas, with an emphasis on community facilities, with both grid and renewable electricity.

It also acknowledges that, due to a variety of socio-economic and cultural factors, poor rural households are likely to continue to use fuelwood for cooking and heating, even if they have access to electricity. The draft policy also mentions constraints experienced with rural electrification in 'finance mobilisation and availability of skilled human resource for proper management and operation of rural electricity systems'. A policy of ensuring the sustainable availability of fuelwood in rural areas is proposed, along with a policy of increasing the availability and affordability of alternative fuels such as paraffin and LPG, and appliances, for rural areas.

The draft policy states Government's intention to reduce dependency on donor funds for electrification, and to mobilise sustainable levels of finance, through

means such as the introduction of an electrification levy. It states an intention of completing the initial phase of rural electrification by connecting another 12 000 households by the year 2000, with a long term goal of connecting 25% of rural households to the national grid by 2010.

The initial target mentioned in the draft Energy Policy imply annual rates of about 4 000 until the year 2000. The long term target of 25% by 2010 implies a rate of over 6 000 per year for the following ten years.

(2) The Rates of Electrification in Other Developing Countries

Rural electrification programs in six countries were evaluated by Dingley prior to Eskom embarking on a national electrification program in South Africa in 1990. The countries were Brazil, Costa Rica, the USA, Hong Kong, Thailand, and Greece. These six countries had a 20 to 1 range of GNP per capita. Brazil, Costa Rica, and Thailand have GNP per capita figures similar to that of Namibia. The average rate of connections for these six countries was surprisingly consistent, with four of them electrifying 11 or 12 customers per 1000 population per year. Hong Kong (a built up, urban type area, over 5 000 people per km^2) managed 13 customers and Thailand (almost entirely rural electrification, but high density of over 100 per km^2) achieved 10. South Africa's electrification program, led by Eskom, has maintained a rate of between 10 and 12 since 1993. It would seem that a rate in this order of magnitude is the maximum that can be sustained for a long term nation wide electrification program. Constraints which will limit this rate include the following:

- Capital Finance availability
- Sourcing and transport of materials and equipment
- Trained manpower for planning and construction
- The development of maitainance, customer support, and revenue collection structures, and staffing of these structures.
- The availability of additional generation capacity
- Population density (very low in Namibia, except in Northern regions)

An annual electrification rate of 10 households per 1000 population implies a rate of about 16 000 homes per year for Namibia. Note that this rate includes both urban and rural homes. It is clear from the household forecast above that the number of urban households will grow faster than rural households, and the the rate of urban electrification will need to be at least equal to the rate of rural electrification. This implies a practical limit of about 8 000 customers per annum (increasing to 16 000 in about 20 years) for rural electrification, assuming that finance and other resources will be available. This provides an 'practical upper limit' for the rate of electrification.

(3) The Present Rate of Electrification in Namibia

In a recent report to the EMC, Northern Electricity (NE) stated that a total of 218 businesses and homes had been electrified during the first six months of operations. NE has about 5 800 customers, and pending applications for about 1 100 new customers. This base includes about 930 conventional residential customers, most of whom were electrified prior to the commencement of the rural electrification programs in 1991.

NamPower has extended it's rural distribution schemes, and has connected about 100 additional rural customers in the 1996/7 financial year. NamPower has maintained this rate of rural (farming) customer connection for several years. Commercial farmers taking advantage of NamPower's subsidised supply scheme are obliged to extend this supply to their farm workers - thus further extending electrification to rural households.

According to NamPower, the total amount spent on Rural Electrification was N$ 208 million between 1991 and 1996. About 18% of this was provided by the Government and NORAD, about 23% by customers themselves, and the other 59% by NamPower. This resulted in the electrification of approximately:

- 7 400 Prepayment residential customers
- 1 900 Non-residential customers

- 500 Commercial farms

This corresponds to an average capital cost of N$ 22 000 per connection. Since commercial farming can be considered a special case of rural electrification, they can be excluded from the calculations. Without the farms, and using the MME expenditure figure of N$ 120 million by the end of 1997, the average connection cost is about N$ 13 000. This can be split roughly into about N$10 000 for distribution extension (by NamPower) and N$3 000 for reticulation costs (local authority). Electrification was achieved at an average rate of about 1 400 connections per year. This will be assumed to be the lower limit of likely future electrification rates.

(4) A Rate Forecast Based on Constant GDP Contribution

The JICA team forecast a rate of electrification based on a constant proportion of GDP contribution to rural electrification. The total expenditure on electrification from 1991 to 1996 was calculated as a proportion of GDP. The average for the six years was 0,19% of GDP. Note that this figure was boosted by grant funding, and would be 0,15% if the grants are excluded. The GDP was forecast assuming low (2%), moderate (3,5%) and high (5%) annual growth rates. Contributions of 0,2% and 0,15% of GDP was allocated to electrification. A cost of N$ 13 000 per connection (as determined above) was used. Table 6.22 lists the annual numbers of connections that this constant GDP contribution rate would achieve.

Table 6.22 - Rate of Electrification Forecast

Year	0,2% GDP Contribution			0,15% GDP Contribution		
	2% Growth	3,5% Growth	5% Growth	2% Growth	3,5% Growth	5% Growth
1998	2308	2308	2308	1731	1731	1731
1999	2267	2369	2473	1700	1776	1855
2000	2312	2451	2597	1734	1839	1948
2001	2359	2537	2727	1769	1903	2045
2002	2406	2626	2863	1804	1970	2147
2003	2454	2718	3006	1840	2038	2254
2004	2503	2813	3156	1877	2110	2367
2005	2553	2912	3314	1915	2184	2486
2006	2604	3013	3480	1953	2260	2610
2007	2656	3119	3654	1992	2339	2740
2008	2709	3228	3837	2032	2421	2877
2009	2764	3341	4028	2073	2506	3021
2010	2819	3458	4230	2114	2594	3172
2011	2875	3579	4441	2156	2684	3331
2012	2933	3704	4663	2200	2778	3497
2013	2991	3834	4896	2244	2875	3672
2014	3051	3968	5141	2288	2976	3856
2015	3112	4107	5398	2334	3080	4049
2016	3174	4251	5668	2381	3188	4251
2017	3238	4400	5952	2428	3300	4464
2018	3303	4554	6249	2477	3415	4687
2019	3369	4713	6562	2527	3535	4921
2020	3436	4878	6890	2577	3658	5167

A base case using 3,5% GDP growth with a 0,2% contribution to rural electrification was selected for this forecast. This plan will achieve the goal of 25% of rural households connected by the year 2015, which is five years later than desired in the draft energy policy.

(5) Rural Electrification Plan for the Forecast

A rural electrification plan was developed for the purposes of the forecast. This plan was based on the 3,5% GDP growth and 0,2% contribution rate. The plan

targeted four regions in the Ovambo region, with equal connection rates in each region. Schools, clinics, government services and businesses were given priority, followed by village households. **Businesses were targeted agressively** to support development in rural centers. Dispersed households were electrified only once all other connections had been completed in a region. Commercial farms were assumed to be electrified at a rate of 10 per year in each region except Ohangwena, Omusati, Oshana, and Oshikoto, but 20 per annum in Otjozondjupa, making a total of 100 per year. This assumes that NamPower and the commercial farmers will continue electrifying farms at the present rate. The plan assumed that 70% of the irrigation projects

Figure 6.11 - Electrification Rate Forecast

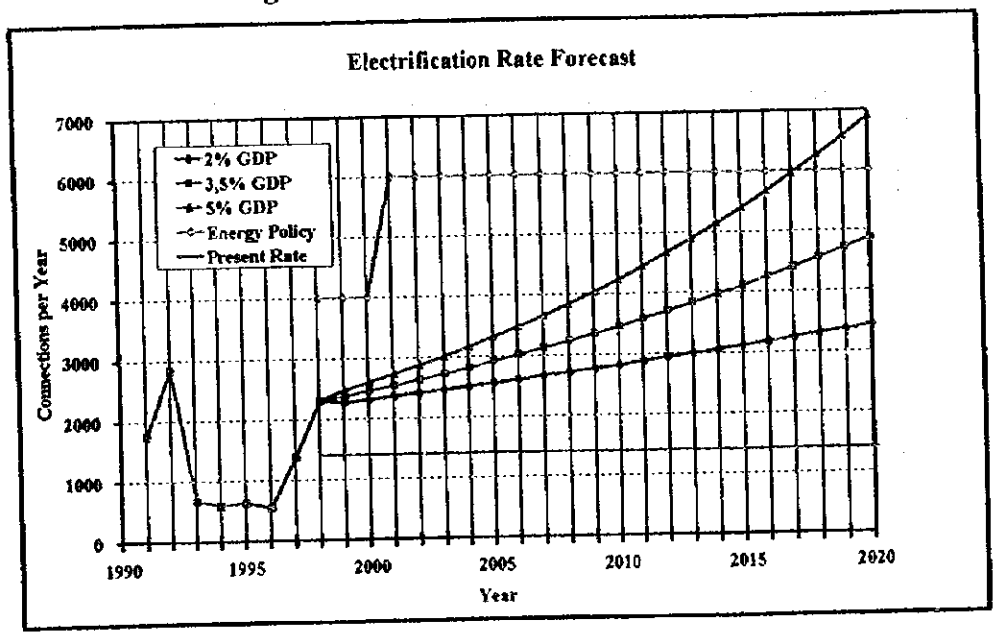
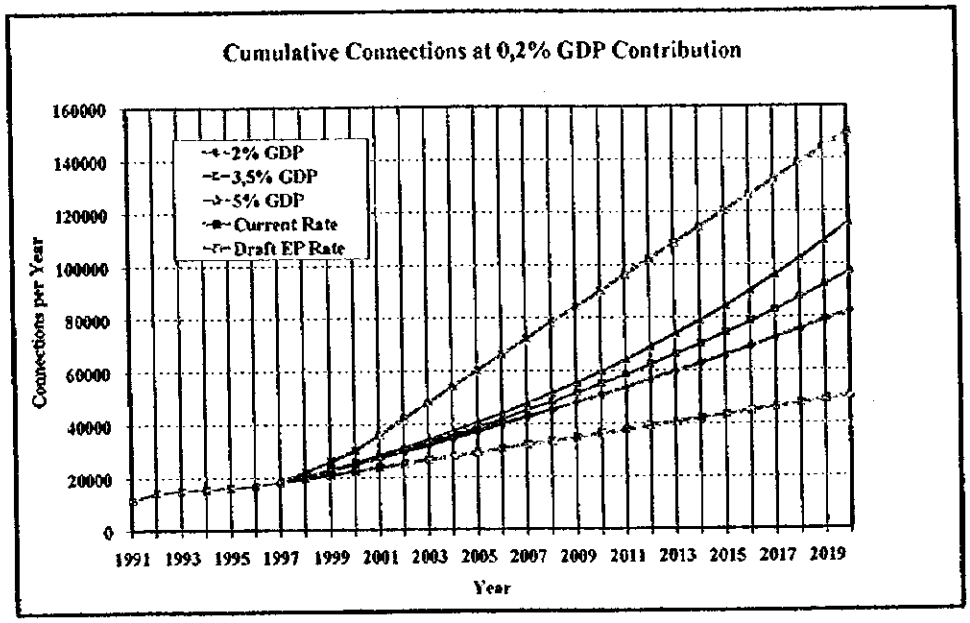
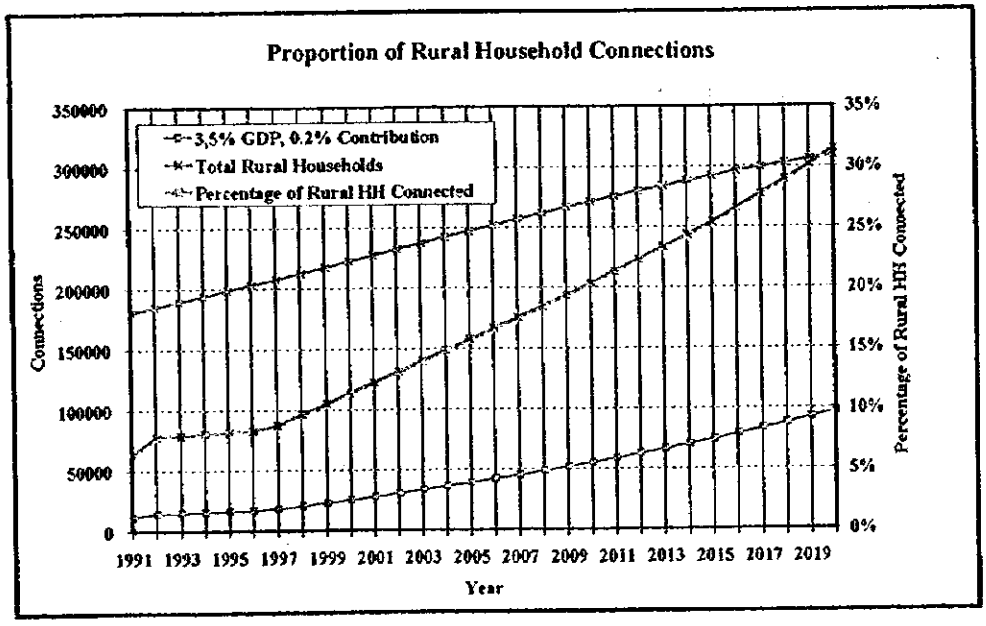


Figure 6.12 - Cumulative Connections



identified earlier would be implemented. This represents a total of 23 000 hectares by the year 2020, fed from the Orange River (Karas Region) and Okavango and Zambezi Rivers (Caprivi Region).

Figure 6.13 - Proportion of Rural Household Connections



The overall development rate was assumed to start at 600 hectares in 1998 increasing gradually over the forecasting horizon.

Connections allocated to each customer class were based on present class proportions for Northern Electricity Customers. The numbers for each customer class in the first forecast year (1998) were :

Village Households :	1 985
Dispersed Households :	0
Hospitals :	0
Clinics & Health Care :	3
Schools with Hostels :	12
Schools without Hostels :	84
Govt. Social Services :	16
Businesses :	208
Commercial Farming : 100 farms	
Irrigation Farming :	6 farms (600 irrigated hectares)

This plan was developed purely for illustrative purposes, and the actual numbers and locations of future electrification projects should be the result of detailed local planning studies. The plan does, however, provide a basis for forecasting total rural electricity demand.

6.3.8 Rural Class Consumption Forecast

A forecast for the consumption of each type of new connection was made. This was based on data from NamPower and Northern Electricity billing records, and compared to figures for similar customers in other developing countries, particularly African rural electrification projects, where possible. Growth in rural sales will be primarily due to increasing numbers of customers rather than increasing consumption per customer.

(1) Rural Village Households

The village households will generally treat electricity as the new residential energy source that replaces traditional fuels. Applications include lighting, entertainment

and refrigeration, as well as thermal applications such as cooking and water heating. This will in part be a response to the increasing difficulty and cost of acquiring fuelwood in urbanised areas, assisted by the higher proportion of cash wages in villages as compared to dispersed communities. Most of the rural households connected so far fall into this category, and it will be the primary target of future electrification programs.

The mean consumption for 928 NE conventional residential customers is approximately 300 kWh per month. These customers are 'urban' in nature and have used electricity for several years. This compares to the means in urban areas as follows:

Windhoek: 900 kWh per month
Walvis Bay: 570 kWh per month.
Swakopmund: 440 kWh per month
Otjiwarongo: 634 kWh per month.

The mean consumption for about 4 000 NE prepayment residential customers is about 200 kWh per month. According to NE, about 40% of these are formal dwellings and 60% traditional dwellings. Assuming that the formal dwellings will consume the same amount of electricity as the conventional residential customers, the mean consumption for the traditional dwellings is about 133 kWh per month. This is high compared to the following figures for rural customers in:

Rural villages in Ethiopia : 110 kWh per month.
Rural villages in Zambia : 60 - 80 kWh per month
Villages in South Africa : 80 - 120 kWh per month

The average consumption for these customers is higher than expected because the bulk of those already connected are salaried employees, representing the higher income bracket of rural villagers. Since most of the formal dwellings in the Ovambo regions have already been electrified, 80% of present Northern Electricity new connections are traditional dwellings. It is expected that the average monthly

consumption (for all rural households) will drop slowly from 200 kWh as the proportion of traditional dwellings rises, stabilising at about 150 kWh per customer.

(2) Rural Dispersed Households

The rural households which make up communities of under 500 people, rely mainly on subsistence farming for survival. A number of these small communities are comprised of workers on commercial farms, although many are in the communal areas of the northern regions. These households have low incomes and cannot afford many appliances or high expenditure on electricity. Electrified homes in these communities are expected to be characterised by low and intermittent consumption patterns. These households will generally use electricity for lighting and entertainment, and on occasion other applications. The low incomes and low cash component of these communities implies that consumption may also be sporadic. The majority of these households cannot afford electricity or electrical appliances at this stage. Average consumption for these customers is expected to be in the region of 40 kWh per month. This compares to figures of 20 kWh in Egypt, 40 kWh in Botswana, and 60 kWh in Thailand. Considerable rural development will be required before these customers are able to make more use of electricity. Their average consumption is not expected to increase over the forecast horizon.

(3) Schools

Estimates for the annual consumption in schools was derived from NamPower and Northern Electricity billing figures. Mean annual consumption for 27 schools with hostels was 400 MWh, and for over 200 schools without hostels was 12 MWh. Average school consumption is not expected to grow significantly.

(4) Hospitals, Clinics and Health Centres

Estimates for the annual consumption in health facilities was derived from NamPower and Northern Electricity billing figures. The mean annual consumption for twenty hospitals was 180 MWh, and for over sixty clinics and Health Care

centers was 21 MWh. Average health facility consumption is not expected to grow significantly.

(5) Government Social Services

Estimates for the annual consumption in social services was derived from NamPower and Northern Electricity billing figures. The mean annual consumption for government social services was about 3,6 MWh. Average social service consumption is not expected to grow significantly.

(6) Businesses

Estimates for the annual consumption in rural businesses was derived from NamPower and Northern Electricity billing figures. The mean annual consumption for businesses was about 29 MWh. The relatively high mean consumption reflects the urban development taking place at rural centers like Oshakati and Ondangwa. The potential for large energy intensive industries in the Northern regions is accommodated in the large power user section of the forecast. Average business consumption is expected to grow slowly as commercial and local manufacturing load develops in the large centers in rural areas.

(7) Commercial Farms

Estimates for the annual consumption in commercial (livestock and crop) farms was derived from NamPower billing figures. The mean annual consumption for about 1 300 farms was about 22,8 MWh. Average farm consumption is not expected to grow significantly.

(8) Irrigation Farms

Estimates for the annual consumption in irrigation farms was derived from NamPower billing figures. The mean annual consumption for about 40 irrigation farms along the Orange River in the Karas Region was about 31,2 MWh. Future irrigation projects have been planned with capacities of 2 kVA to 3 kVA per hectare. Assuming a load factor of 20%, this translates to about 3 600 kWh per hectare per annum. Actual NamPower sales to current irrigation projects at Etunda near Ruacana (600 hectares) including the canal pump, and at the Naute Dam near

Keetmanshoop (240 hectares), give figures of 800 kWh per hectare per annum and about 0,5 kVA per hectare, which are lower than the planning figures. This forecast will assume 1 500 kWh per hectare per annum at a 20% load factor for future projects. About 1000 kWh per hectare is used for pumping from dams or rivers into canals and pipelines. This is catered for in the large customer Water Pumping class. The remaining 500 kWh represents local pumping from canals to fields, and is catered for in the rural forecast.

6.3.9 The Rural Forecasts for Namibia

A spreadsheet model incorporating the above forecasts and plans was developed. This model produced expected sales for each region and Namibia.

Figure 6.14 - The Rural Electrification Forecast I

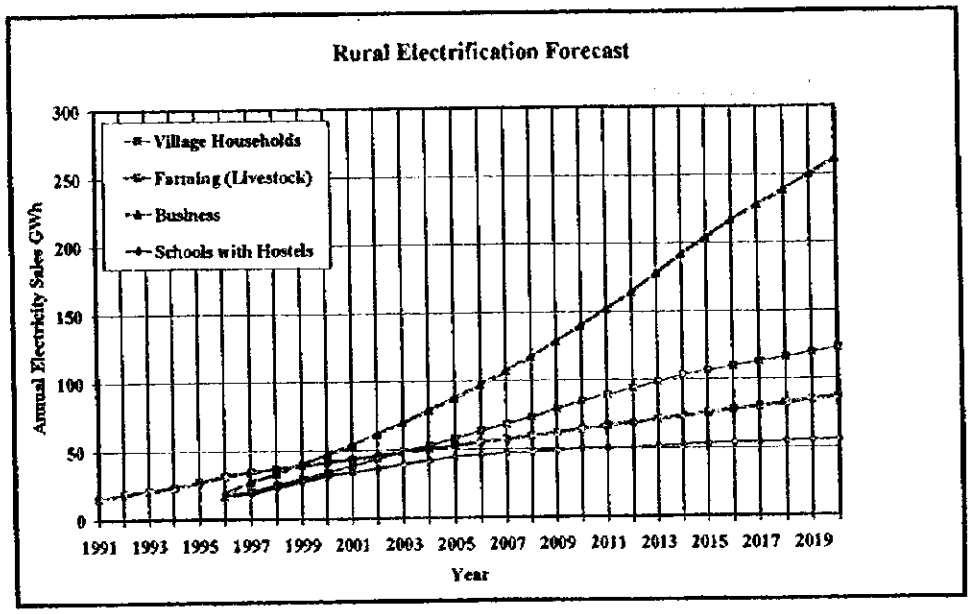
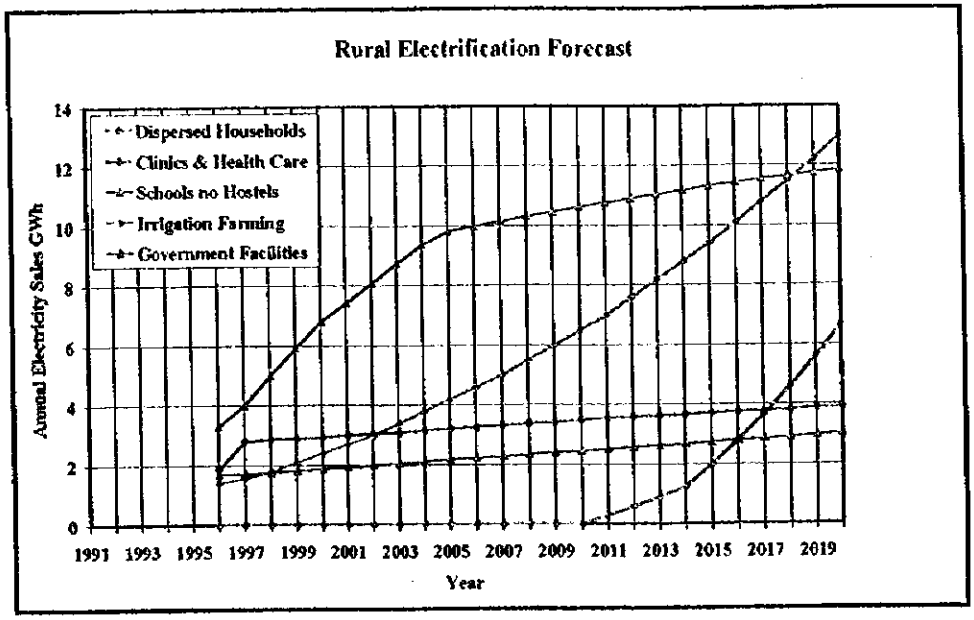


Figure 6.15 - The Rural Electrification Forecast II



Figures 6.14 and 6.15 show the increase in sales to each class of rural customer as a result of implementation of the electrification plan. Businesses will have the highest consumption as they are aggressively targeted by the plan, followed by village households.

The total sales figures for each rural customer class were then included in the sectoral model for large customers, to provide total sales forecasts for the entire country. The model is flexible, permitting the impacts of a range of different assumptions to be easily and quickly evaluated. Population growth rates, urbanisation rates, and regional electrification plans can be revised as desired. The impacts on the forecast are automatically calculated and an updated electricity demand forecast is immediately available.

Table 6.23 - Total Rural Sales Forecast

Total Rural Sales Forecast GWh			
Year	**Low Growth**	**Moderate Growth**	**High Growth**
1997	112.47	112.47	112.47
1998	131.71	131.71	131.71
1999	144.06	150.51	157.15
2000	159.98	169.60	179.65
2001	174.51	187.72	201.73
2002	188.62	205.89	224.45
2003	203.24	225.10	248.96
2004	217.79	244.78	274.64
2005	231.80	264.35	300.90
2006	244.53	282.96	326.75
2007	257.69	302.58	354.47
2008	269.92	321.61	382.22
2009	282.87	341.99	412.33
2010	296.54	363.79	444.97
2011	308.30	383.78	476.23
2012	320.90	405.33	510.26
2013	333.63	427.62	546.12
2014	346.05	450.06	583.11
2015	356.33	470.24	618.09
2016	366.63	490.94	654.64
2017	374.97	509.50	689.24
2018	383.05	528.13	724.80
2019	391.51	547.72	762.58
2020	399.46	567.07	800.96

The total sales expected to rural customers, for the three electrification rates assuming a 0,2% GDP contribution to rural electrification, are listed in Table 6.23 and illustrated in Figures 6.16 and 6.17.

Figure 6.16 - The Three Rural Electricity Demand Forecasts

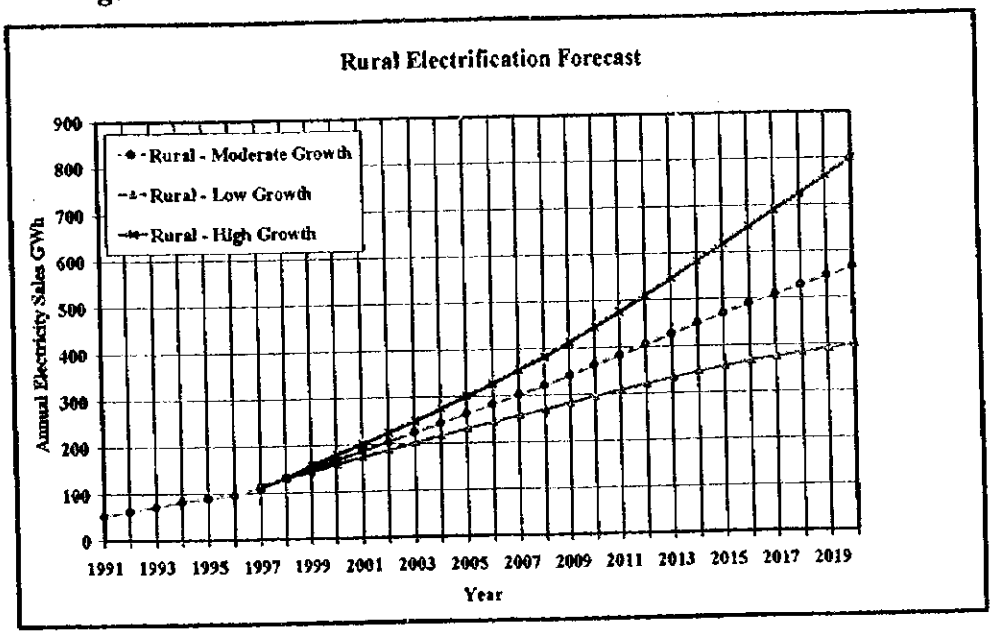
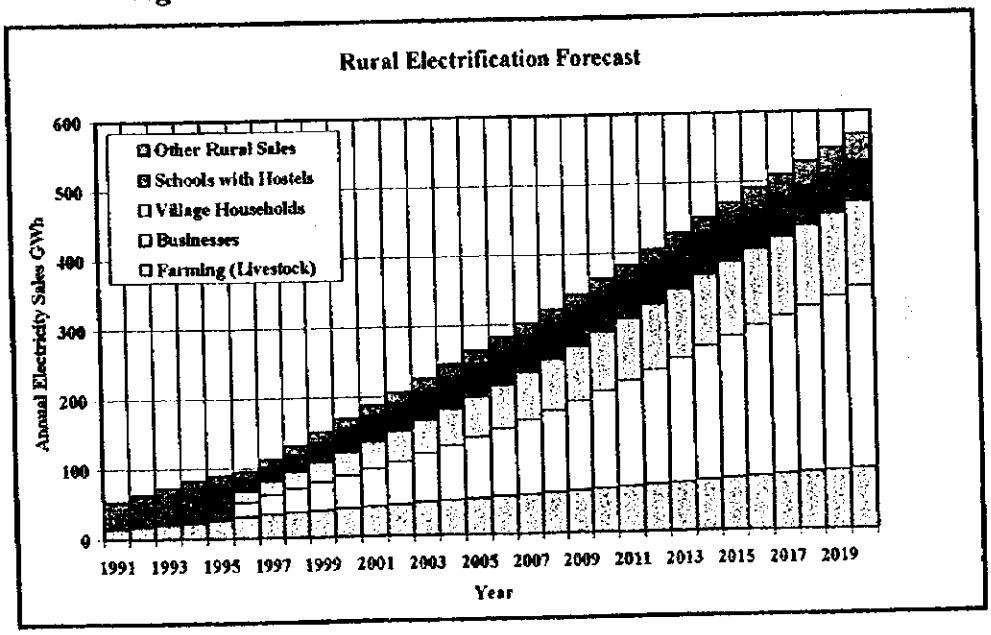


Figure 6.17 - The Moderate Growth Rural Forecast



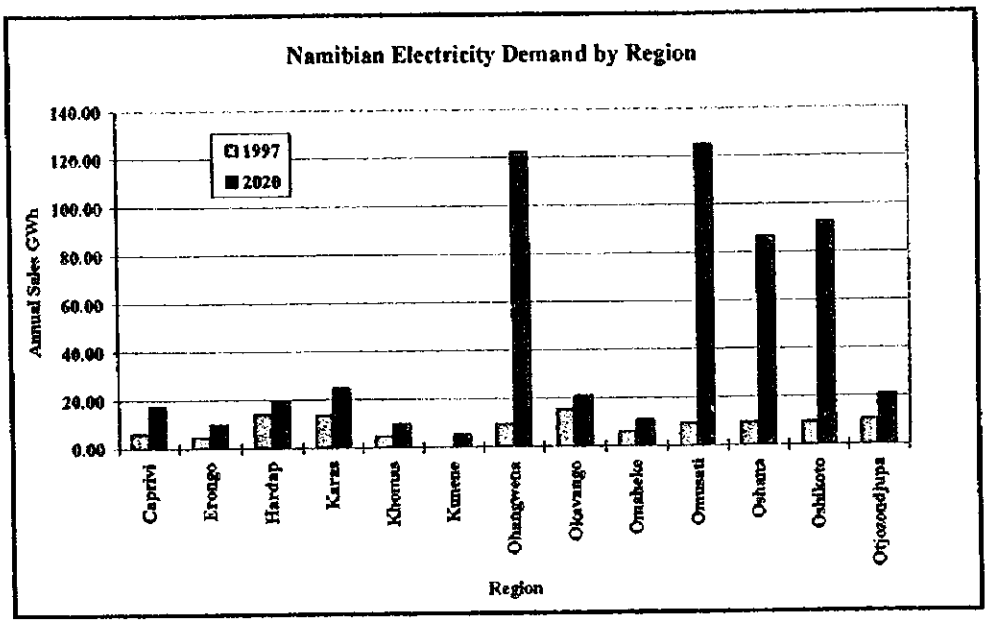
6.3.10 The Rural Forecast by Region

The model forecasts rural demand in each region separately, and Figure 6.18 shows the present and expected rural electricity demand in each region. The focus of the electrification plan on the four northern regions results in high growth in

regions. The planned irrigation schemes have an impact in the Caprivi and Karas regions, as does the higher commercial farming connection rate in the Otjozondjupa region.

Appendix B contains graphs illustrating the expected growth in sales to each class of rural customer in each region, as well as the total rural sales by region.

Figure 6.18 - The Rural Forecast by Region



6.4 Electrical Energy Forecast Results

Tables 6.24, 6.25 and 6.26 below summarise the results of the three electrical energy forecasts by category. Figure 6.19 displays the three forecasts while Figures 6.20, 6.21 and 6.22 below show each one of the three forecasts broken down by category.

Expected average annual growth of electricity consumption in Namibia over the twenty four years according to the middle forecast is 4.8% per annum. This is significantly higher than the 2.9% per annum over the past sixteen years, or the 2.2% per annum since independence. The reasons for this higher growth are strong growth in municipalities, positive growth in mining, strong growth in manufacturing (especially due to allowance for manganese smelters), strong

growth in water pumping and major growth expected in rural areas due to more emphasis on rural electrification.

The growth projected by the high forecast is 7.9%. The major factors are the inclusion of the Haib copper mine, the proposed zinc mine (at Skorpion) and the Sand Piper plant in later years. Electrification of rural areas also contributes more under the high forecast than under the middle forecast.

In the case of the low forecast, the expected growth is 2.7%. This is slightly lower than the growth over the past sixteen years.

The average electricity/GDP elasticity shows a decrease from 1.53 for the past sixteen years to 1.37 for the period up to 2020 in the case of the middle forecast. Although this indicates a more electrical energy efficient economy, Namibia is still in a process of electricity intensive economic development. Average electricity/GDP elasticity for the high forecast is 1.58, while it is 1.35 for the low forecast for the period up to 2020.

Over the past sixteen years electricity consumption per capita stayed allmost constant at about 1030kWh per capita per annum. Under the middle forecast electricity consumption per capita shows an increase from 1030kWh per capita in 1996 to close to 1600kWh per capita. The implies an average annual growth of 1.8% per annum in electricity consumption per capita.

Consumption per capita for the high forecast will increase to 3,200kWh per capita, while in the case of the low forecast it will drop to 985kWh per capita.

Results by region are shown in Tables 6.27, 6.28 and 6.29, and Figures 6.23, 6.24 and 6.25. It has to be noted that the results by region are consumption figures for that particular region. The supply of some of the load may come from substations in other regions. Furthermore, as mentioned above, the forecasts for the smaller regions will not be as accurate as those for the larger regions. As can be seen a few regions dominate the electricity market.

Table 6.24 - Namibia Electrical Energy Forecast (Middle Forecast)

Year	L.Authorities		Mining		Industry		Water		Gov.& Parast		S. P. Users		Foreign		TOTAL	
	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth
1995	842.7	5.70	645.4	3.05	8.5	4.94	53.8	-18.73	17.5	66.67	89.8	8.00	146.8	428.06	1804.5	11.44
1996	897.4	6.50	613.6	-4.93	8.1	-4.71	53.7	-0.19	19.9	13.71	100.6	11.93	30.0	-79.56	1723.3	-4.50
1997	938.5	4.58	623.0	1.53	8.3	2.47	52.5	-2.23	20.8	4.52	112.5	11.84	0.0	-	1755.6	1.87
1998	1002.3	6.80	695.4	11.62	8.8	6.02	53.6	2.10	21.9	5.29	131.7	17.11	0.0	-	1913.7	9.01
1999	1072.5	7.01	738.5	6.20	20.7	135.14	56.2	4.85	23.0	5.02	150.5	14.28	0.0	-	2061.5	7.72
2000	1158.5	8.01	759.5	2.84	311.5	1405.55	72.5	29.03	24.2	5.22	169.6	12.68	0.0	-	2495.8	21.07
2001	1238.1	6.87	760.7	0.16	422.7	35.70	81.8	12.84	25.4	4.96	187.7	10.68	0.0	-	2716.5	8.84
2002	1303.3	5.27	761.0	0.04	423.3	0.14	84.2	2.93	26.7	5.12	205.9	9.68	0.0	-	2804.4	3.24
2003	1368.3	4.99	762.3	0.17	423.9	0.14	86.4	2.61	28.0	4.87	225.1	9.33	0.0	-	2894.0	3.19
2004	1434.9	4.87	762.6	0.04	424.5	0.14	88.6	2.55	29.3	4.64	244.8	8.74	0.0	-	2984.7	3.13
2005	1504.2	4.83	763.9	0.17	425.2	0.16	104.2	17.53	30.6	4.44	264.3	8.00	0.0	-	3092.5	3.61
2006	1578.3	4.92	765.2	0.17	632.1	48.64	119.2	14.44	32.0	4.58	283.0	7.04	0.0	-	3409.7	10.26
2007	1651.7	4.65	766.5	0.17	838.9	32.72	121.0	1.51	33.5	4.69	302.6	6.93	0.0	-	3714.2	8.93
2008	1727.7	4.60	767.8	0.17	839.6	0.08	123.0	1.65	35.0	4.48	321.6	6.29	0.0	-	3814.7	2.71
2009	1806.4	4.55	769.1	0.17	840.4	0.10	125.0	1.63	36.5	4.29	342.0	6.34	0.0	-	3919.4	2.74
2010	1893.5	4.82	770.4	0.17	841.2	0.10	126.7	1.36	38.0	4.11	363.8	6.37	0.0	-	4033.6	2.91
2011	1999.2	5.58	770.8	0.05	842.0	0.10	132.9	4.88	39.5	3.95	383.8	5.49	0.0	-	4168.1	3.33
2012	2085.8	4.33	771.2	0.05	842.8	0.10	134.6	1.28	41.0	3.80	405.3	5.62	0.0	-	4280.7	2.70
2013	2174.7	4.26	771.6	0.05	843.6	0.09	136.4	1.34	42.5	3.66	427.6	5.50	0.0	-	4396.3	2.70
2014	2266.6	4.23	772.0	0.05	844.5	0.11	138.1	1.25	44.0	3.53	450.1	5.25	0.0	-	4515.2	2.70
2015	2360.2	4.13	771.4	-0.08	845.4	0.11	150.2	8.78	45.6	3.64	470.2	4.48	0.0	-	4643.0	2.83
2016	2455.4	4.04	770.8	-0.08	846.3	0.11	172.4	14.81	47.2	3.51	490.9	4.40	0.0	-	4783.1	3.02
2017	2553.3	3.98	770.2	-0.08	847.3	0.12	174.4	1.16	48.9	3.60	509.5	3.78	0.0	-	4903.6	2.52
2018	2654.1	3.95	769.6	-0.08	848.3	0.12	175.1	0.40	50.6	3.48	528.1	3.66	0.0	-	5025.8	2.49
2019	2758.4	3.93	769.0	-0.08	849.4	0.13	176.2	0.63	52.4	3.56	547.7	3.71	0.0	-	5153.1	2.53
2020	2866.1	3.91	768.5	-0.07	850.5	0.13	176.9	0.40	54.2	3.44	567.1	3.53	0.0	-	5283.3	2.53

Table 6.25 - Namibia Electrical Energy Forecast (High Forecast)

Year	L.Authorities		Mining		Industry		Water		Gov.& Parast		S. P. Users		Foreign		TOTAL	
0	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth
0	0.0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	842.7	5.70	645.4	3.05	8.5	4.94	53.8	-18.73	17.5	66.67	89.8	8.00	146.80	428.06	1804.5	11.44
1996	897.4	6.50	613.6	-4.93	8.1	-4.71	53.7	-0.19	19.9	13.71	100.6	11.93	30.00	-79.56	1723.3	-4.50
1997	940.3	4.78	623.0	1.53	8.6	6.17	52.5	-2.23	20.8	4.52	112.5	11.84	0.00	-	1757.7	1.99
1998	1008.0	7.20	695.4	11.62	9.7	12.79	53.6	2.10	22.0	5.54	131.7	17.11	0.00	-	1920.4	9.26
1999	1084.7	7.61	756.0	8.72	22.2	128.78	56.2	4.85	23.1	5.02	157.2	19.32	0.00	-	2099.3	9.32
2000	1180.2	8.81	1692.5	123.86	313.6	1313.25	79.1	40.72	24.3	5.22	179.6	14.31	0.00	-	3469.3	65.26
2001	1273.2	7.87	2372.5	40.18	425.4	35.65	108.8	37.58	25.5	5.06	201.7	12.29	0.00	-	4407.2	27.03
2002	1355.5	6.47	2583.1	8.87	426.7	0.31	116.8	7.36	26.9	5.42	224.5	11.27	0.00	-	4733.4	7.40
2003	1442.0	6.39	2584.4	0.05	428.0	0.30	119.0	1.88	28.3	5.27	249.0	10.92	0.00	-	4850.7	2.48
2004	1533.9	6.37	2584.7	0.01	429.3	0.30	121.2	1.85	29.7	5.14	274.6	10.32	0.00	-	4973.4	2.53
2005	1631.0	6.33	2691.1	4.12	430.7	0.33	142.0	17.16	31.2	5.04	300.9	9.56	0.00	-	5227.0	5.10
2006	1735.8	6.42	2801.0	4.08	638.3	48.18	162.3	14.29	32.9	5.28	326.7	8.59	0.00	-	5697.0	8.99
2007	1842.6	6.15	2897.4	3.44	845.9	32.53	179.9	10.82	34.7	5.49	354.5	8.48	0.00	-	6154.8	8.04
2008	1955.0	6.10	3010.4	3.90	847.4	0.18	181.9	1.11	36.6	5.38	382.2	7.83	0.00	-	6413.4	4.20
2009	2073.4	6.05	3011.7	0.04	849.0	0.19	183.9	1.10	38.5	5.29	412.3	7.88	0.00	-	6568.7	2.42
2010	2204.5	6.32	3013.0	0.04	850.6	0.19	185.6	0.92	40.4	5.11	445.0	7.92	0.00	-	6739.0	2.59
2011	2360.5	7.08	3013.4	0.01	852.2	0.19	191.8	3.33	42.4	4.95	476.2	7.02	0.00	-	6936.5	2.93
2012	2498.2	5.83	3153.9	4.66	853.8	0.19	193.5	0.89	44.5	4.80	510.3	7.15	0.00	-	7254.1	4.58
2013	2642.1	5.76	3504.7	11.12	855.5	0.20	195.3	0.93	46.6	4.66	546.1	7.03	0.00	-	7790.2	7.39
2014	2793.4	5.73	3925.6	12.01	857.3	0.21	223.2	14.33	48.7	4.53	583.1	6.77	0.00	-	8431.3	8.23
2015	2950.7	5.63	4135.2	5.34	859.1	0.21	257.3	5.43	50.9	4.64	618.1	6.00	0.00	-	8871.2	5.22
2016	3114.0	5.54	4134.6	-0.01	860.9	0.21	301.4	9.45	53.2	4.51	654.6	5.91	0.00	-	9118.8	2.79
2017	3284.8	5.48	4134.0	-0.01	862.9	0.23	325.3	0.78	55.7	4.60	689.2	5.28	0.00	-	9351.9	2.56
2018	3463.8	5.45	4133.4	-0.01	864.9	0.23	347.9	0.27	58.2	4.48	724.8	5.16	0.00	-	9592.9	2.58
2019	3651.9	5.43	4378.1	5.92	867.0	0.24	370.9	0.42	60.8	4.56	762.6	5.21	0.00	-	10091.2	5.19
2020	3849.3	5.41	4693.0	7.19	869.1	0.24	371.6	0.27	63.5	4.44	801.0	5.03	0.00	-	10647.4	5.51

Table 6.26 - Namibia Electrical Energy Forecast (Low Forecast)

L.Authorities		Mining		Industry		Water		Gov.& Parast		S. P. Users		Foreign		TOTAL	
GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth	GWh	%Growth
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
842.7	5.70	645.4	3.05	8.5	4.94	53.8	-18.73	17.5	66.67	89.8	8.00	146.80	428.06	1804.5	11.44
897.4	6.50	613.6	-4.93	8.1	-4.71	53.7	-0.19	19.9	13.71	100.6	11.93	30.00	-79.56	1723.3	-4.50
936.7	4.38	620.8	1.17	8.2	1.23	52.5	-2.23	20.8	4.52	112.5	11.84	0.00	-	1751.5	1.63
996.7	6.40	688.7	10.94	8.3	1.22	53.6	2.10	21.9	5.29	131.7	17.11	0.00	-	1900.9	8.53
1060.5	6.41	720.8	4.66	8.5	2.41	56.2	4.85	23.0	4.82	144.1	9.38	0.00	-	2013.0	5.90
1137.0	7.21	729.5	1.21	8.8	3.53	60.1	6.97	24.1	4.82	160.0	11.05	0.00	-	2119.4	5.29
1203.8	5.87	727.7	-0.25	9.1	3.41	61.7	2.67	25.1	4.36	174.5	9.08	0.00	-	2201.9	3.89
1252.7	4.07	727.0	-0.10	9.4	3.30	63.3	2.59	26.2	4.32	188.6	8.09	0.00	-	2267.2	2.97
1296.4	3.49	728.3	0.18	9.7	3.19	64.9	2.53	27.2	3.87	203.2	7.75	0.00	-	2329.7	2.76
1340.0	3.37	728.6	0.04	10.0	3.09	66.5	2.46	28.2	3.64	217.8	7.16	0.00	-	2391.1	2.64
1384.7	3.33	728.9	0.04	10.3	3.00	68.1	2.31	29.2	3.64	231.8	6.43	0.00	-	2453.0	2.59
1432.1	3.42	724.2	-0.64	10.6	2.91	69.7	2.41	30.3	3.78	244.5	5.49	0.00	-	2511.4	2.38
1477.2	3.15	719.5	-0.65	10.9	2.83	71.3	2.30	31.5	3.89	257.7	5.38	0.00	-	2568.1	2.26
1523.1	3.10	704.8	-2.04	11.2	2.75	72.9	2.24	32.7	3.68	269.9	4.75	0.00	-	2614.6	1.81
1569.6	3.05	696.1	-1.23	11.5	2.68	74.5	2.19	33.8	3.49	282.9	4.80	0.00	-	2668.4	2.06
1621.7	3.32	682.4	-1.97	11.8	2.61	76.2	2.28	34.9	3.31	296.5	4.83	0.00	-	2723.6	2.07
1687.9	4.08	669.8	-1.85	12.1	2.54	77.9	2.20	36.0	3.15	308.3	3.97	0.00	-	2792.0	2.51
1735.7	2.83	657.2	-1.88	12.4	2.48	79.6	2.18	37.1	3.00	320.9	4.09	0.00	-	2842.9	1.82
1783.6	2.76	642.6	-2.22	12.7	2.42	81.4	2.26	38.2	2.86	333.6	3.97	0.00	-	2892.1	1.73
1832.3	2.73	634.0	-1.34	13.0	2.36	83.2	2.21	39.2	2.73	346.1	3.72	0.00	-	2947.7	1.92
1880.4	2.63	624.4	-1.51	13.3	2.31	85.0	2.19	40.3	2.84	356.3	2.97	0.00	-	2999.8	1.77
1928.1	2.54	614.8	-1.54	13.6	2.26	86.9	2.28	41.4	2.71	366.6	2.89	0.00	-	3051.5	1.72
1976.0	2.48	605.2	-1.56	13.9	2.21	88.8	2.19	42.6	2.80	375.0	2.28	0.00	-	3101.5	1.64
2024.4	2.45	595.6	-1.59	14.2	2.16	90.8	2.25	43.7	2.68	383.1	2.16	0.00	-	3151.8	1.62
2073.6	2.43	586.0	-1.61	14.5	2.11	92.8	2.20	44.9	2.76	391.5	2.21	0.00	-	3203.4	1.64
2123.5	2.41	576.5	-1.62	14.8	2.07	94.9	2.26	46.1	2.64	399.5	2.03	0.00	-	3255.3	1.62

Figure 6.19 - Namibia Electrical Energy Forecast

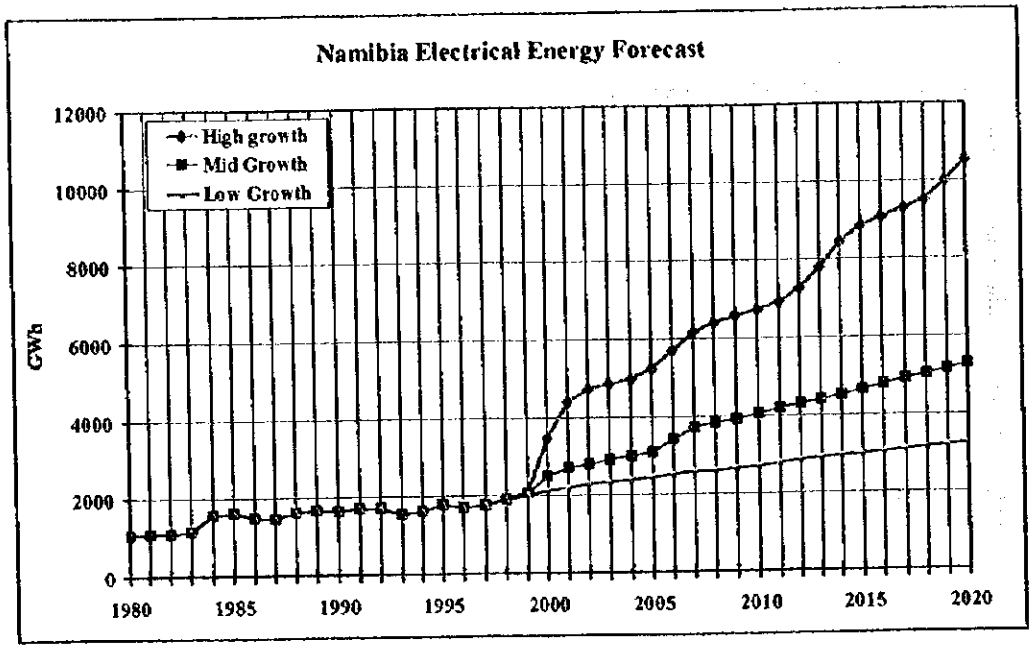


Figure 6.20 - Namibia Electrical Energy Forecast (Middle Forecast)

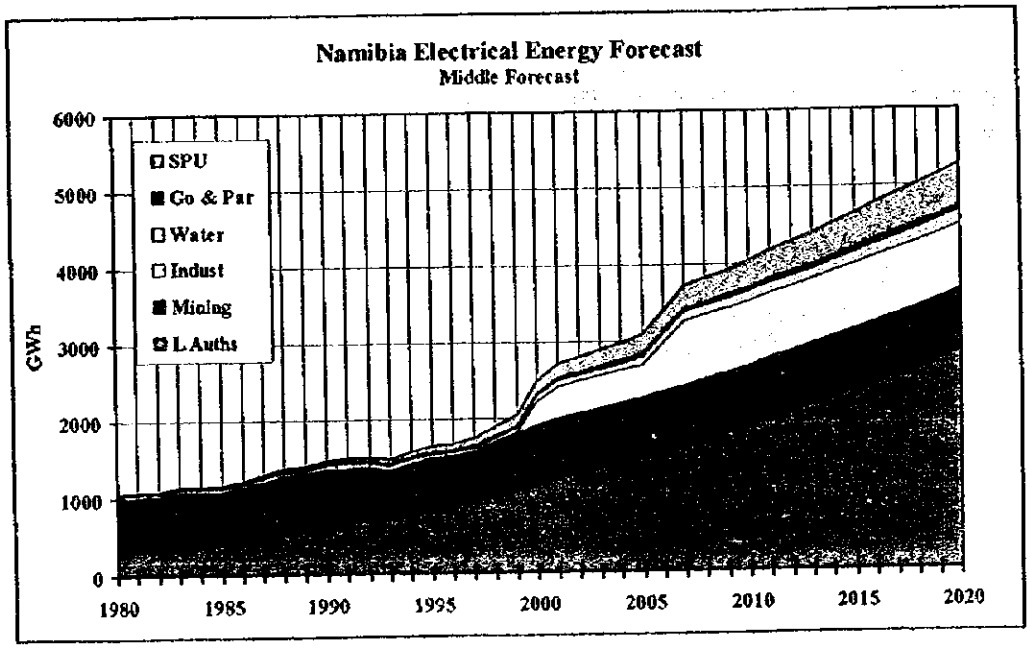


Figure 6.21 - Namibia Electrical Energy Forecast (High Forecast)

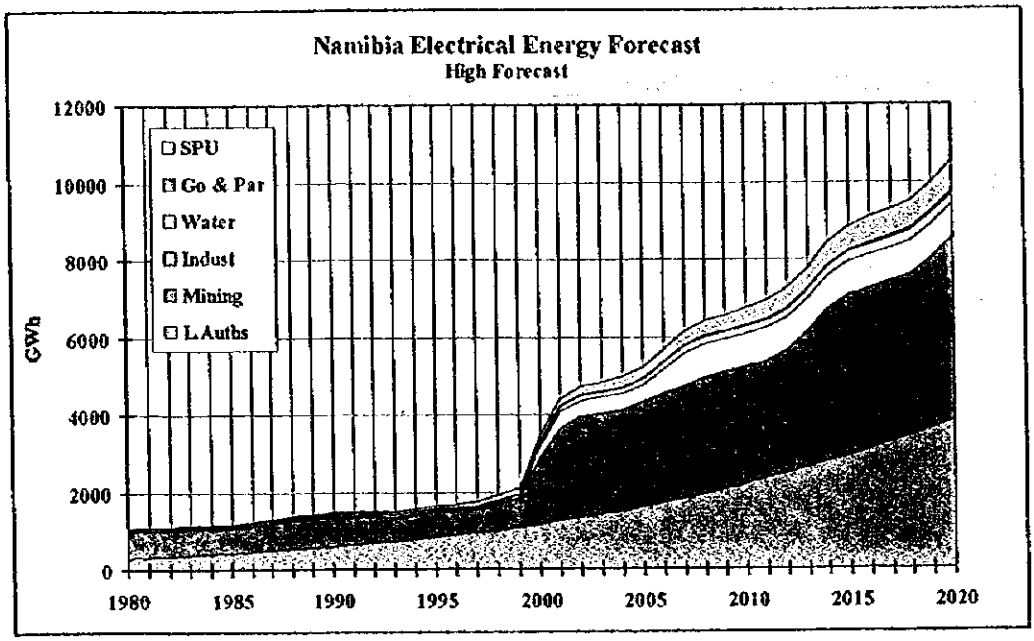


Figure 6.22 - Namibia Electrical Energy Forecast (Low Forecast)

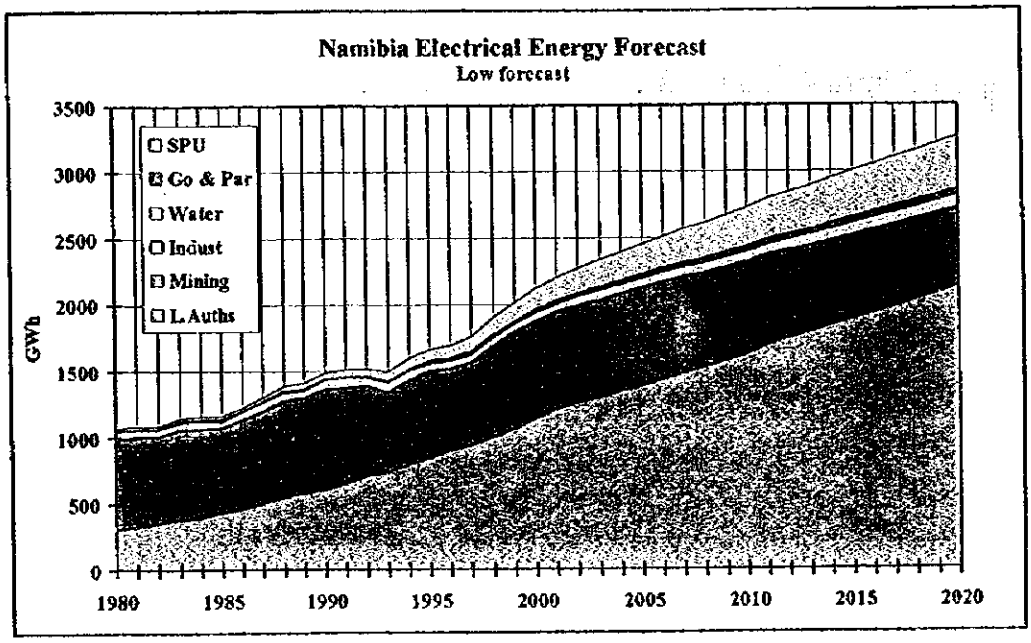


Table 6.27 - Namibia Regional Electrical Energy Forecast (Middle Forecast)

Year	Caprivi	Erongo	Hardap	Karas	Khomas	Kunene	Ohangwena	Okavango	Omaheke	Omusati	Oshana	Oshikoto	Otjozond	Total
	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh
1995	14.1	383.5	38.6	292.2	497.7	14.3	13.9	23.9	14.6	18.3	41.4	153.0	151.9	1657.7
1996	15.4	408.9	41.6	298.2	513.7	14.9	16.7	24.7	15.4	20.3	48.9	120.7	154.2	1693.3
1997	16.4	440.6	42.7	317.6	540.2	15.4	19.5	25.4	16.0	21.8	53.4	94.0	152.5	1755.5
1998	17.2	460.2	44.4	353.2	572.4	16.1	24.1	26.1	16.7	26.5	60.3	118.6	178.0	1913.7
1999	19.0	473.2	46.5	363.0	605.6	16.9	28.8	26.7	17.3	31.3	66.6	155.8	210.8	2061.5
2000	20.5	506.5	48.6	368.5	637.8	17.6	33.6	27.4	17.9	36.2	73.0	186.6	521.5	2495.8
2001	22.1	538.2	50.8	372.8	668.9	18.4	38.5	28.1	18.6	41.2	79.2	197.5	642.1	2716.5
2002	23.8	554.0	53.1	377.1	701.3	19.3	43.7	28.8	19.4	46.5	85.5	201.3	650.7	2804.4
2003	25.5	568.7	55.5	381.5	735.2	20.2	49.0	29.6	20.2	51.9	92.4	205.1	659.3	2894.0
2004	27.2	582.6	57.7	385.9	770.5	21.0	54.3	30.4	20.9	57.4	99.0	209.5	668.2	2984.7
2005	28.9	597.9	60.0	390.4	807.9	21.9	59.7	44.3	21.7	63.0	105.8	213.6	677.3	3092.5
2006	30.4	616.5	62.2	394.7	846.9	22.7	63.9	58.2	22.5	68.5	112.7	217.8	892.7	3409.7
2007	31.8	632.8	64.5	399.1	887.3	23.6	68.6	59.0	23.2	73.4	120.4	222.5	1108.0	3714.2
2008	33.3	649.6	66.7	403.6	929.8	24.4	73.1	59.7	23.9	78.4	127.9	227.0	1117.3	3814.7
2009	34.8	666.9	69.0	408.4	974.2	25.2	78.2	60.5	24.7	83.6	135.7	231.6	1126.5	3919.4
2010	36.3	690.7	71.2	413.0	1020.6	26.1	83.5	61.2	25.4	89.0	144.2	236.9	1135.7	4033.6
2011	37.7	730.4	73.4	417.7	1069.0	26.8	88.4	66.3	26.1	94.1	152.4	240.9	1144.9	4168.1
2012	39.3	748.1	75.7	422.6	1119.5	27.7	94.0	67.1	26.8	99.7	160.8	245.2	1154.1	4280.7
2013	40.9	766.5	78.0	427.7	1171.0	28.6	99.5	67.9	27.6	105.6	169.5	250.0	1163.5	4396.3
2014	42.5	785.6	80.3	432.8	1224.5	29.5	105.5	68.8	28.5	111.3	178.4	254.6	1173.0	4515.2
2015	44.2	804.8	82.7	437.0	1279.0	30.4	111.4	79.8	29.3	117.7	184.6	259.4	1182.6	4643.0
2016	45.9	824.2	85.1	441.5	1334.6	31.4	117.9	101.2	30.1	123.8	190.2	264.7	1192.4	4783.1
2017	47.6	844.5	87.7	446.0	1391.3	32.4	124.3	102.1	31.0	130.7	196.0	267.6	1202.4	4903.6
2018	48.9	865.5	90.4	450.2	1449.0	33.4	131.2	103.0	31.9	137.3	202.1	270.1	1212.8	5025.8
2019	50.1	887.6	93.1	454.7	1508.7	34.4	138.1	104.0	32.9	144.6	208.3	273.1	1223.5	5153.1
2020	51.5	910.3	95.9	459.2	1570.5	35.4	145.2	105.0	33.8	151.8	215.0	275.3	1234.4	5283.3

Table 6.28 - Namibia Regional Electrical Energy Forecast (High Forecast)

Year	Caprivi	Erongo	Hardap	Karas	Khomas	Kunene	Ohangwe	Okavang	Omaheke	Omusati	Oshana	Oshikoto	Otjozond	Total
0	GWh	GWh	GWh	GWh	GWh	GWh	GW	GWI	GWI	GWh	GWh	GWh	GWh	GWh
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	14.1	383.5	38.6	292.2	497.7	14.3	13.9	23.9	14.6	18.3	41.4	153.0	151.9	1657.7
1996	15.4	408.9	41.6	298.2	513.7	14.9	16.7	24.7	15.4	20.3	48.9	120.7	154.2	1693.3
1997	16.4	440.9	42.8	317.8	541.2	15.4	19.6	25.5	16.1	21.9	53.4	94.1	152.7	1757.7
1998	17.3	461.4	44.7	353.7	575.4	16.3	24.2	26.2	16.8	26.6	60.4	118.7	178.6	1920.4
1999	19.5	475.9	47.6	382.0	612.2	17.2	29.9	27.7	17.9	32.4	67.6	156.8	212.7	2099.3
2000	21.3	511.5	50.3	1310.5	649.3	18.1	35.3	28.7	18.7	37.9	74.6	188.3	524.7	3469.3
2001	23.3	546.5	53.2	2015.1	687.0	19.1	41.1	29.9	19.7	43.8	81.5	200.0	647.0	4407.2
2002	25.3	566.2	56.3	2236.7	728.1	20.2	47.3	31.1	20.9	50.1	88.7	204.7	657.8	4733.4
2003	27.5	585.7	59.7	2242.7	773.0	21.4	53.9	32.5	22.0	56.8	96.7	209.6	669.2	4850.7
2004	29.7	605.2	63.0	2248.9	821.2	22.6	60.7	33.9	23.3	63.8	104.6	215.3	681.2	4973.4
2005	32.0	626.7	66.5	2365.9	872.8	23.9	67.7	48.4	24.5	71.1	112.8	220.8	693.8	5227.0
2006	34.0	655.8	70.0	2482.6	927.6	25.1	73.6	63.0	25.8	78.5	121.3	226.6	913.0	5697.0
2007	36.1	774.4	73.6	2505.1	985.4	26.5	80.3	64.5	27.1	85.4	130.8	233.2	1132.4	6154.8
2008	38.3	910.9	77.3	2512.1	1047.0	27.8	86.9	66.0	28.4	92.5	140.2	239.6	1146.3	6413.4
2009	40.5	936.9	81.2	2519.6	1112.4	29.2	94.4	67.6	29.8	100.2	150.2	246.4	1160.3	6568.7
2010	42.7	971.0	85.0	2527.0	1181.8	30.6	102.2	69.2	31.2	108.2	161.2	254.2	1174.7	6739.0
2011	45.0	1025.0	89.0	2534.7	1255.1	31.9	110.0	75.1	32.6	116.0	172.0	260.6	1189.4	6936.5
2012	47.4	1194.2	93.1	2542.9	1333.0	33.4	118.7	76.8	34.1	124.9	183.4	267.5	1204.6	7254.1
2013	50.0	1575.3	97.4	2551.4	1414.2	35.0	127.5	78.6	35.7	134.3	195.2	275.4	1220.3	7790.2
2014	52.6	1607.6	101.8	3006.9	1499.8	36.7	137.2	80.5	37.4	143.6	207.6	283.1	1236.5	8431.3
2015	55.3	1640.9	106.4	3225.3	1589.1	38.4	147.0	114.6	39.1	154.1	216.6	291.2	1253.3	8871.2
2016	58.2	1675.2	111.2	3233.9	1681.8	40.2	157.9	159.0	40.9	164.5	225.0	300.4	1270.6	9118.8
2017	61.2	1711.5	116.3	3242.9	1778.3	42.0	168.9	183.0	42.8	176.2	233.7	306.4	1288.7	9351.9
2018	63.7	1749.6	121.6	3251.8	1878.6	44.0	181.1	207.1	44.8	187.9	242.8	312.1	1307.8	9592.9
2019	66.4	2035.5	127.1	3261.3	1984.2	46.0	193.3	231.3	46.8	200.8	252.2	318.6	1327.7	10091.2
2020	69.2	2393.3	132.9	3271.1	2095.1	48.1	206.3	233.7	49.0	213.9	262.3	324.1	1348.4	10647.4

Table 6.29 - Namibia Regional Electrical Energy Forecast (Low Forecast)

Year	Caprivi	Erongo	Hardap	Karas	Khomas	Kunene	Ohangwe	Okavang	Omaheke	Omusati	Oshana	Oshikoto	Otjozond	Total
0	GWh	GWh	GWh	GWh	GWh	GWh	GW	GWI	GWI	GWh	GWh	GWh	GWh	GWh
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	14.1	383.5	38.6	292.2	497.7	14.3	13.9	23.9	14.6	18.3	41.4	153.0	151.9	1657.7
1996	15.4	408.9	41.6	298.2	513.7	14.9	16.7	24.7	15.4	20.3	48.9	120.7	154.2	1693.3
1997	16.4	438.0	42.6	317.5	539.2	15.4	19.5	25.4	16.0	21.8	53.3	94.0	152.4	1751.5
1998	17.1	452.3	44.2	352.8	569.4	16.0	24.0	26.0	16.6	26.4	60.0	118.5	177.5	1900.9
1999	18.5	452.8	45.5	361.5	599.0	16.7	27.9	25.9	16.9	30.4	65.3	154.9	197.7	2013.0
2000	19.0	471.7	47.1	366.2	626.5	17.3	32.0	26.1	17.3	34.6	70.8	174.1	216.7	2119.4
2001	19.8	497.3	48.6	369.4	651.2	17.9	36.2	26.4	17.7	38.9	75.9	177.6	225.1	2201.9
2002	20.9	508.4	50.2	372.5	675.4	18.5	40.4	26.8	18.2	43.2	80.9	180.3	231.6	2267.2
2003	22.0	518.4	51.7	375.3	698.4	19.2	44.6	27.1	18.6	47.5	86.1	183.1	237.6	2329.7
2004	23.1	527.2	53.0	378.1	722.0	19.8	48.8	27.4	19.0	51.8	90.8	186.5	243.7	2391.1
2005	23.4	536.1	54.3	380.9	746.6	20.3	52.7	28.7	19.4	56.0	95.6	189.3	249.7	2453.0
2006	24.4	542.7	55.5	383.4	772.0	20.8	55.6	29.7	19.8	60.0	100.4	191.3	255.7	2511.4
2007	24.9	546.8	56.7	386.0	797.8	21.4	58.8	30.8	20.1	63.4	105.6	194.6	261.4	2568.1
2008	26.0	546.1	57.9	383.5	824.4	21.9	61.7	30.6	20.5	66.7	110.6	197.6	267.1	2614.6
2009	26.5	551.6	59.0	380.6	851.9	22.4	65.1	31.5	20.8	70.2	115.6	200.7	272.5	2668.4
2010	27.5	560.2	60.1	377.6	880.2	22.9	68.5	31.7	21.2	73.7	121.1	201.1	277.8	2723.6
2011	28.5	583.7	61.1	374.9	909.3	23.4	71.6	31.8	21.5	76.8	126.2	200.5	282.8	2792.0
2012	29.0	587.9	62.1	372.2	938.9	23.9	75.0	33.0	21.8	80.2	131.2	200.0	287.7	2842.9
2013	30.1	590.4	63.1	369.7	968.4	24.4	78.2	33.3	22.1	83.8	136.3	199.8	292.5	2892.1
2014	30.6	600.1	64.1	366.3	998.5	24.9	81.8	34.7	22.5	87.1	141.4	198.4	297.4	2947.7
2015	31.7	609.5	65.1	362.9	1028.3	25.4	85.1	34.9	22.9	90.8	144.3	197.0	302.1	2999.8
2016	32.2	618.6	66.1	359.2	1057.9	25.9	88.7	36.3	23.2	94.1	146.6	195.9	306.7	3051.5
2017	33.3	628.1	67.1	355.9	1087.3	26.5	92.2	36.4	23.5	97.9	149.0	192.9	311.4	3101.5
2018	33.9	637.8	68.2	351.7	1116.4	27.0	96.0	38.0	23.9	101.4	151.5	189.7	316.3	3151.8
2019	34.4	648.0	69.3	348.1	1146.0	27.5	99.5	39.2	24.3	105.3	154.0	186.7	321.2	3203.4
2020	35.0	658.2	70.3	344.4	1176.0	28.0	103.1	40.9	24.6	108.9	156.7	183.1	326.0	3255.3

Figure 6.23 - Namibia Middle Regional Electrical Energy Forecast

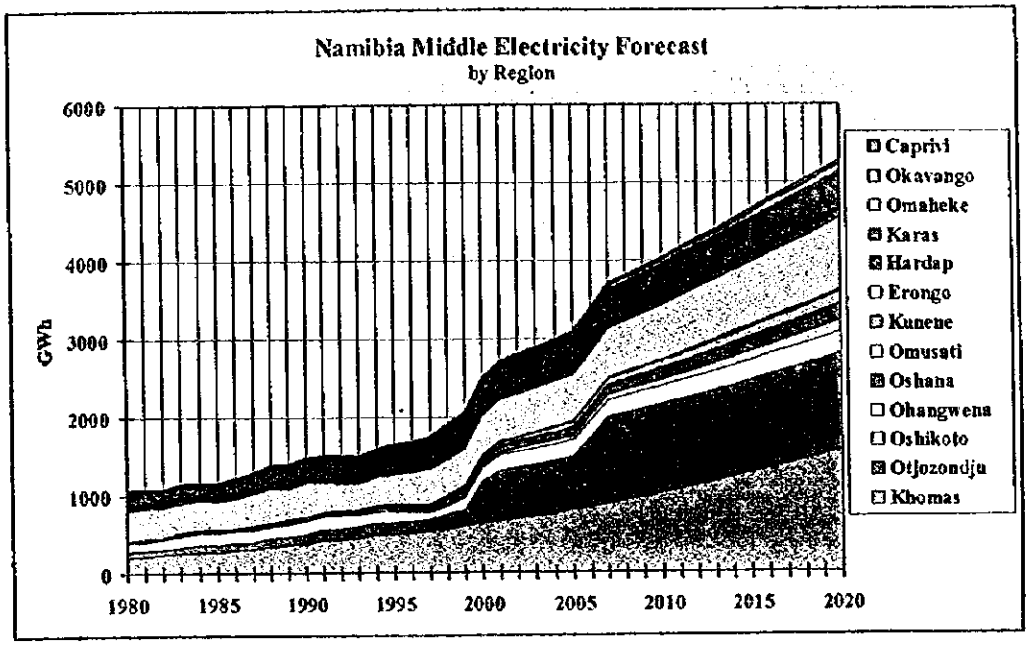


Figure 6.24 - Namibia High Regional Electrical Energy Forecast

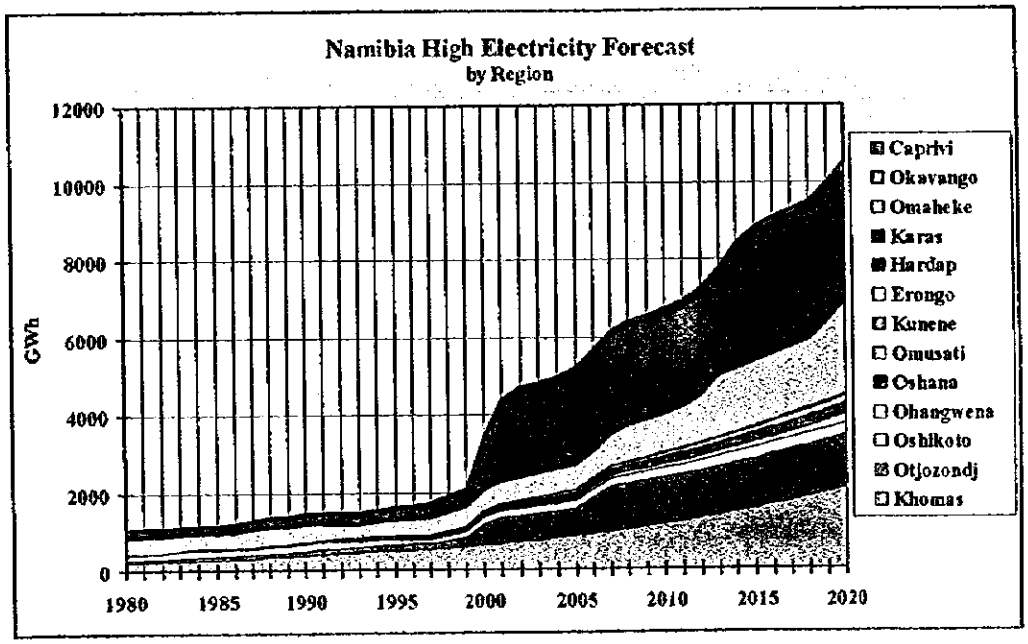
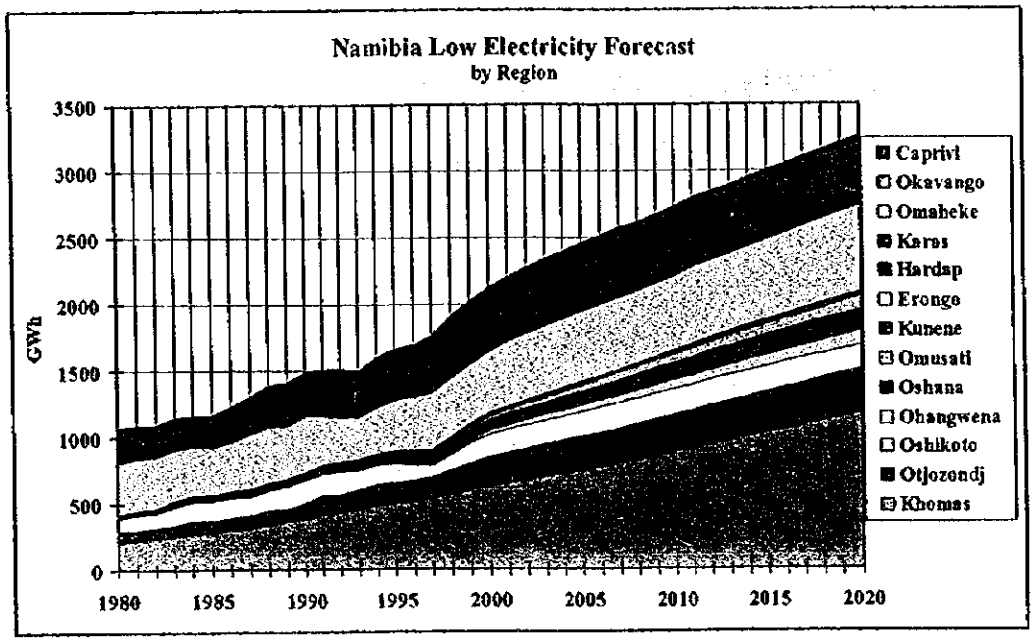


Figure 6.25 - Namibia Low Regional Electrical Energy Forecast



6.5 The Maximum Demand Forecast

6.5.1 Maximum Demand (MD) Forecast Methodology

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

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

The more sophisticated techniques, such as demand profile forecasting or probability based statistical techniques, could not be applied as there is insufficient load research data for the various customer types in Namibia. These techniques are able to incorporate the impacts of secondary MD drivers, such as weather sensitivity and Demand Side Management programs.

6.5.2 The Contribution to Load Factor Method

The CLF technique effectively disaggregates the system MD into several components, namely the coincident peak demands for each customer class. A class of similar customers will maintain it's energy to peak demand relationship for many years,

while a changing mix of several classes will not. An assumed load factor is then assigned to each class, and the class coincident peak demand calculated from the forecast energy sales for each year. The coincident peak demands are summed to obtain a total sales MD. The contribution of system losses to the peak demand is then added to produce a forecast for the sent out MD.

6.5.3 The Data used for the Maximum Demand Forecast

The CLF method requires annual sales forecasts for each customer class as well as estimates for the annual *coincident peak* load factor for each class. The sectoral model used for the energy sales forecast provides the annual sales figures required. The coincident peak load factors are estimates based on the limited demand profile data available as well as a survey of NamPower large customer billing data. Note that these load factor estimates are for the *aggregated class demand* (kW) at the time of system peak demand, which is in the evening at about 19h00 on weekdays. These load factors could be higher than those of individual customers in the class. System losses, which have varied between 8% and 12% over the last fifteen years, were assumed to remain constant at 11% over the forecast horizon.

Table 6.30 - Assumed Coincident Class Load Factors

Customer Class	Assumed Coincident Load Factor
Local Authorities	60%
Mining	80%
Industry	70%
Water Pumping	60%
Government & Parastatals	50%
Small Power Users	40%

Source: NamPower

6.5.4 The MD Forecasting Model

As with the other models developed for this forecast, the MD model is implemented as an Excel workbook. Three similar sheets were developed for the Low, Moderate, and High forecasts.

6.5.5 The Forecast Maximum Demand Results

The annual MDs indicated by the model for past years are higher than those reported by NamPower. This is because the NamPower MDs did not include the contribution to Namibian peak demand by non-interconnected supplies. These include Oranjemund, Rosh Pinah, Noordoewer and Ariamsvlei supplied from South Africa (Eskom) and Katima Mulilo supplied from Zambia (ZESCO). These loads add 10 - 30 MW to NamPower's reported MD. Table 6.31 lists the annual MDs produced by the CLF model.

Table 6.31- Forecast Maximum Demands (at sending end)

Year	Low Growth MW	Moderate Growth MW	High Growth MW
1990	271	271	271
1991	286	286	286
1992	294	294	294
1993	294	294	294
1994	303	303	303
1995	324	324	324
1996	338	338	338
1997	350	350	351
1998	380	382	383
1999	403	413	420
2000	427	497	654
2001	446	542	815
2002	461	562	875
2003	476	583	903
2004	490	604	931
2005	505	629	982
2006	519	692	1072
2007	533	752	1160
2008	544	775	1212
2009	558	799	1248
2010	572	826	1287
2011	588	856	1332
2012	601	882	1395
2013	613	909	1494
2014	627	937	1611
2015	639	966	1697
2016	652	998	1753
2017	664	1025	1806
2018	676	1053	1861
2019	688	1082	1957
2020	701	1112	2062

Note: The maximum demands include off grid 20MW.

Figure 6.26 and Figure 6.27 illustrate the growth of the annual MD and load factor.

Figure 6.26 - Forecast Annual Maximum Demands (at sending end)

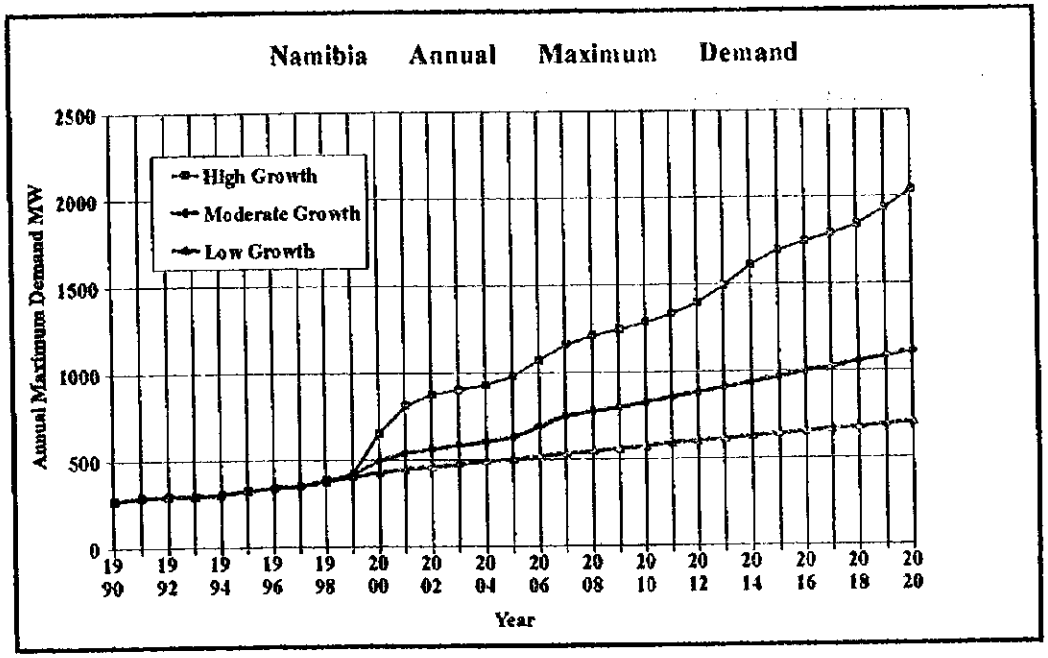
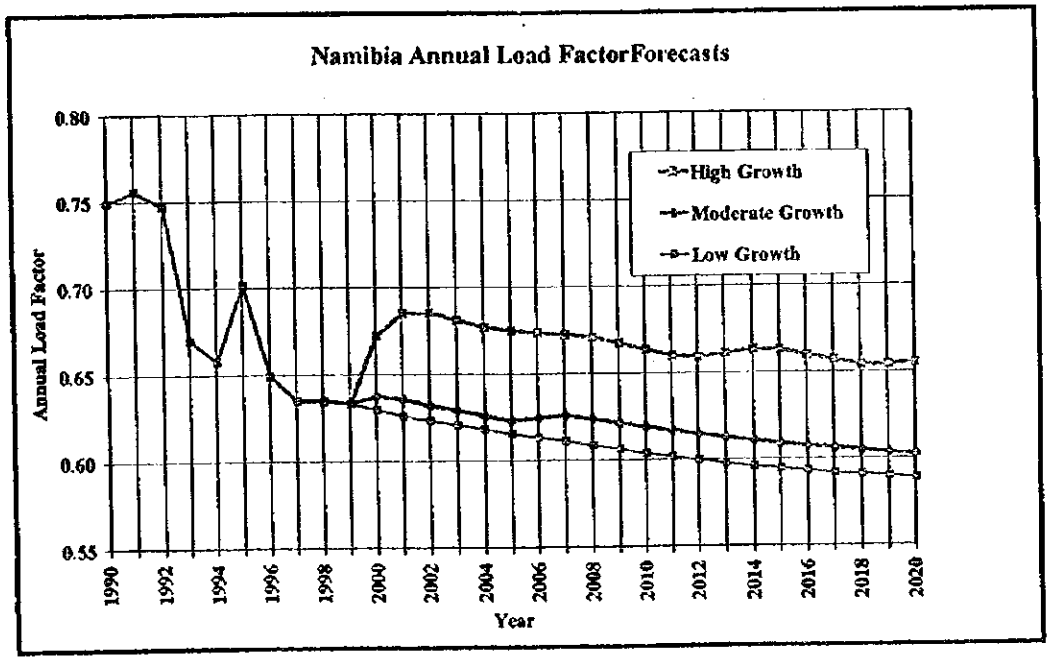


Figure 6.27 - Forecast Annual Load Factors



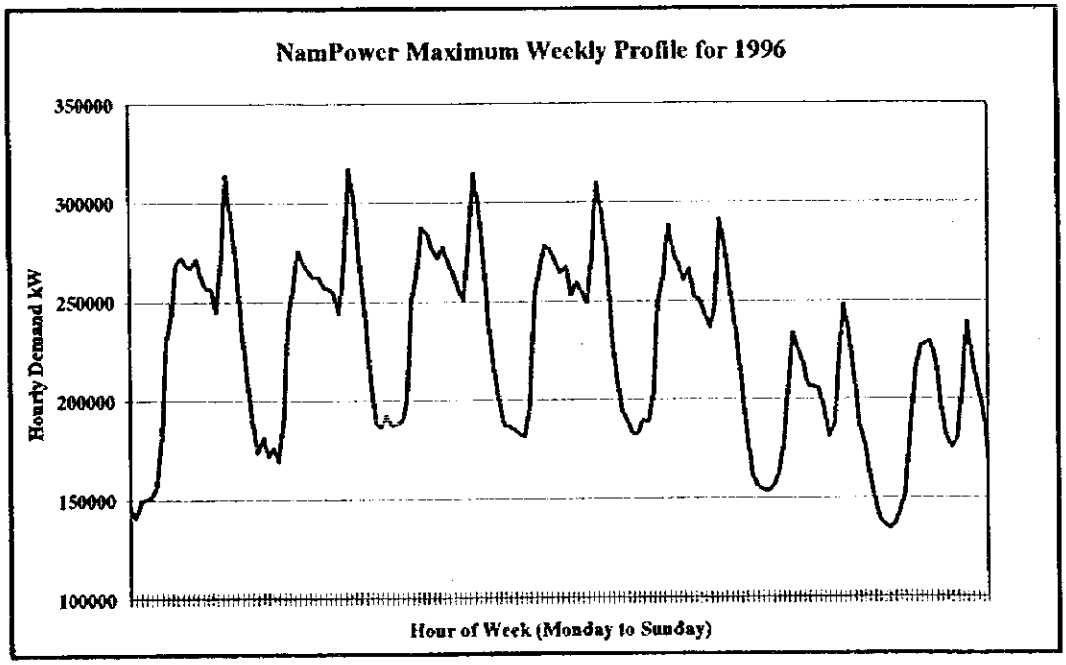
6.5.6 The NamPower System Demand Profile

The hourly demand profile for the interconnected grid system from 1987 to 1996 was provided to the JICA team by NamPower. This demand profile includes generation by NamPower power stations and the imports from Eskom from Aggeneis. The additional load supplied by Eskom and ZESCO to NamPower customers, which amounts to about 15% of the total sales in Namibia, is not included in the demand profile.

Although this is an incomplete picture of the Namibian electricity demand profile, it is sufficient to highlight changes that have taken place over the last decade, specifically since independence.

Figure 6.28 shows the demand profile of the winter week during which the annual maximum demand occurred in 1996. The recorded MD was 317 MW on Tuesday at 20h00. Note the narrow evening peak on weekdays.

Figure 6.28 - Week of Highest Demand in 1996

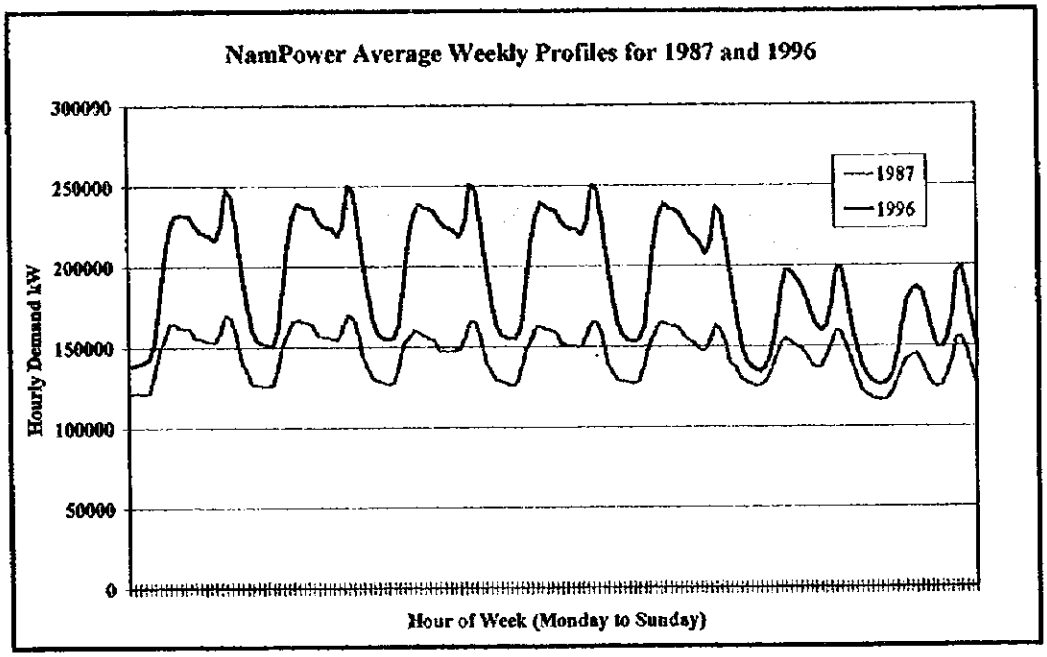


Source: NamPower

A comparison of the average weekly demand profile for 1987 and 1996 (Figure 6.29) indicates a major change in the profile shape over this period. The 1996 profile

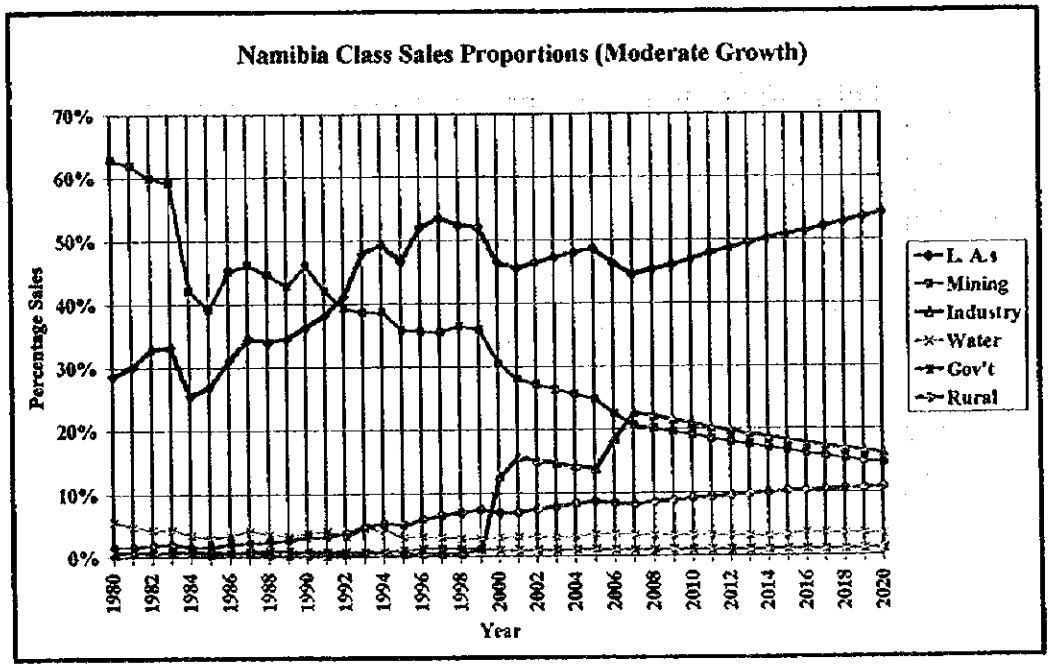
indicates a larger proportion of daytime load than in 1987. This can be explained by the changing makeup of load supplied in Namibia. This is illustrated by Figure 6.30, which shows that the peaky local authority load increased from 35% to 52% of the total between 1987 and 1996, while the flat mining component decreased from

Figure 6.29 - Average Weekly Demand Profiles for 1987 and 1996



Source: NamPower

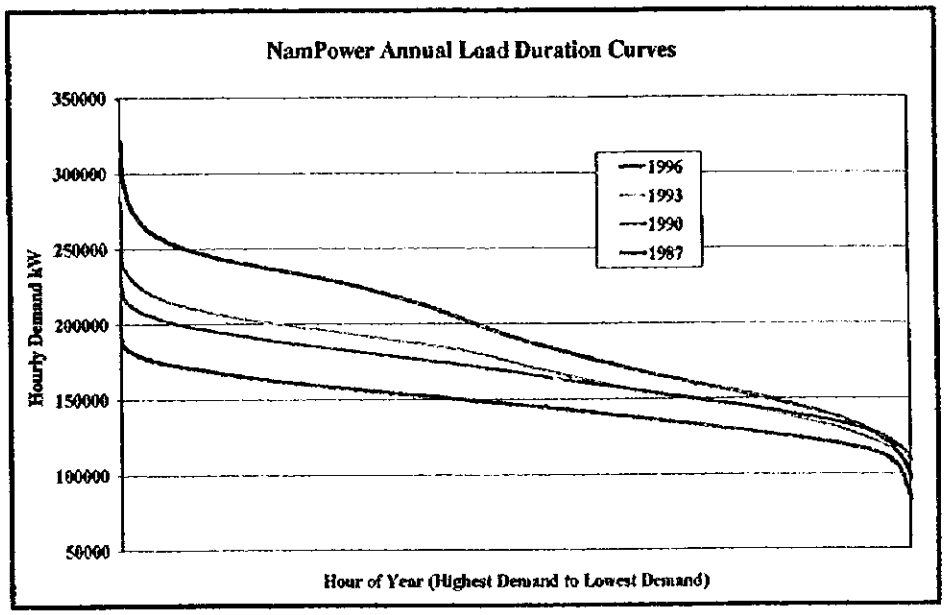
Figure 6.30 - Namibia Electricity Sales Class Proportions



about 46% to 36%. The continued high growth of the local authorities as well as the increasing rural load will continue to put pressure on the system load factor, and this impact will be reduced by expected growth in heavy industry (the manganese smelter), and mining (the Haib copper mine) in the high growth forecast.

The changes in load makeup have also altered the NamPower load duration curve, as is evident in Figure 6.31. The increase in load growth during the higher demand hours of the year can clearly be seen. The most important change is the dramatic increase during the peak demand hours. In 1987 the system demand exceeded 90% of the MD for a total of 727 hours, while in 1996 it exceeded 90% for only 60 hours. Thus 10% of Namibia's peak demand (about 33 MW) was required for under 1% of the time.

Figure 6.31 - NamPower Annual Load Duration Curves



Source: NamPower

This type of short duration peak demand is an ideal candidate for some form of demand management measure. At least one municipality (Windhoek) has recently installed a ripple control system to manage peak demand by switching off domestic storage water heaters at peak times. Windhoek Municipality could reduce their peak demand by over 10% (about 10 MW) with this system. The impacts of such DSM measures will have to be considered in future.