Energy Outlook for Mozambique

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The intent of the discussion paper series is to stimulate discussion and exchange ideas on issues pertinent to the economic and social development of Mozambique. A multiplicity of views exists on how to best foment economic and social development. The discussion paper series aims to reflect this diversity.
As a result, the ideas presented in the discussion papers are those of the authors. The content of the papers do not necessarily reflect the views of the Ministry of Planning and Development or any other institution within the Government of Mozambique.

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Acknowledgement:

This paper was mainly written during my time at the Ministry of Energy. I would like to thank for their input my colleagues at the Ministry of Energy, in particular the Department of Studies and Planning. Of course I am solely responsible for the opinions expressed here and for any remaining errors.

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Abstract (Ingles)
The energy sector in Mozambique is changing rapidly, with further growth and expansion to be expected during the next decade and beyond. This paper provides some figures and numbers to document key developments and potential scenarios with the purpose to facilitate policy making in the future. As such, this paper serves as a background document to the new Strategy for the Energy Sector 2008-2012.

Key words: Energy, Natural Resources, Outlook, Energy Policy

Abstracto (Português)

O sector de energia em Moçambique está a registar rápidas mudanças, esperando-se mais crescimento e expansão durante as próximas décadas. Este documento apresenta algumas figuras e numeros para descrever os aspectos chaves desta evolução bem como cenários potenciais com visto a facilitar a elaboração das políticas energéticas. De tal maneira, o documento serve como documento de referência da nova Estratégia do Sector de Energia 2008-2012.

Palavras-chave: Energia, Recursos Naturais, Perspectivas, Políticas Energéticas

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CONTENTS

1. Introduction

The energy sector in Mozambique is changing rapidly, with further growth and expansion to be expected during the next decade and beyond. This paper provides some figures and numbers to document key developments and potential scenarios with the purpose to facilitate policy making in the future. As such, this paper serves as a background to the new Strategy for the Energy Sector 2008-2012.

To this aim I used data from various sources as well as a software tool to develop scenarios. The energy data have been collected and processed by the Directorate of Studies and Planning (DEP) of the Ministry of Energy, in collaboration with the National Directorate of Studies and Political Analysis (DNEAP) of the Ministry of Planning and Development. Original data come from the Ministry of Mineral Resources (MIREM) and the following companies: Cahora Bassa Hydropower (HCB), Mozambique Electricity Company (EDM), Mozambique Transmission Company (MOTRACO), ENMo, ELGAS, SASOL, Matola Gas Company (MGC) and Mozambique Petroleum Import (IMOPETRO). For more details I refer to the Energy Statistics 2000-2005 and 2006 (Ministry of Energy 2007a,b). In addition, economic data on Mozambique come from the National Institute of Statistics (INE), the Ministry of Planning and Development and the Worldbank, while population data come from the United Nations (UN) as well as INE.

For the scenario development I used the software tool LEAP (Long-range Energy Alternatives Planning system), a scenario-based energy-environment modelling tool.[1] The LEAP scenarios presented in this paper are based on comprehensive accounting of how energy is consumed, converted and produced in Mozambique under a range of assumptions on population, economic development, technology, and so on. To this aim a Mozambican LEAP version was created on the basis of the data described above.

The organization of the paper is as follows. Sections 2 and 3 set the stage for the energy outlook by providing information on population growth and GDP growth, respectively. Section 4 to 9 then present the calculations and projections for the various dimensions of the Mozambican energy sector. Section 10 concludes. Finally, a number of annexes provide further quantitative details to the analyses presented in the paper.

[1] For more information see: http://www.energycommunity.org

2. Population

Any meaningful policy making for the energy sector requires information on the size and growth of the population. For example, to define and monitor the electrification ratio (the % of the population with access to electricity) one needs adequate numbers on current and future population size. Figure 1a shows 4 scenarios of the population growth in Mozambique between 2000 and 2050. The growth figures used by the National Statistics Institute INE are around 2.4-2.3% up to 2020. Whereas these numbers seem to be reasonable adequate to describe the current situation, they must be considered as too high to describe the next decade, given the impact of increasing GDP, urbanization and the HIV/AIDS pandemic. The highly respected United Nations (UN) population statistics therefore plot a more realistic picture with population growth decreasing over the next decades. In their Medium Variant, population growth is expected to gradually decrease to about 1% in 2050, while their High Variant and Low Variant forecast population growth to decrease to 1.5% and 0.5%, respectively, by 2050. **Throughout this document I work with the UN Medium Variant, unless otherwise stated.**

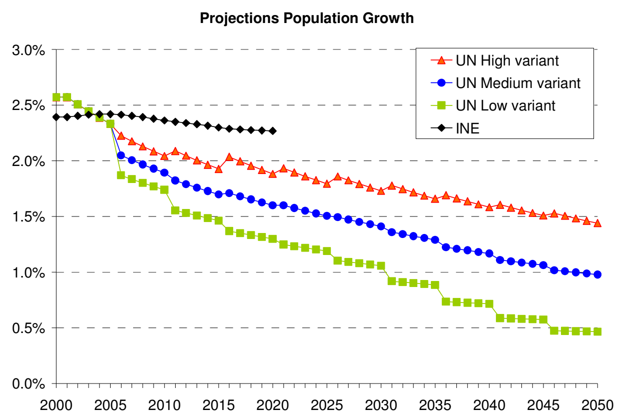

Figure 1a

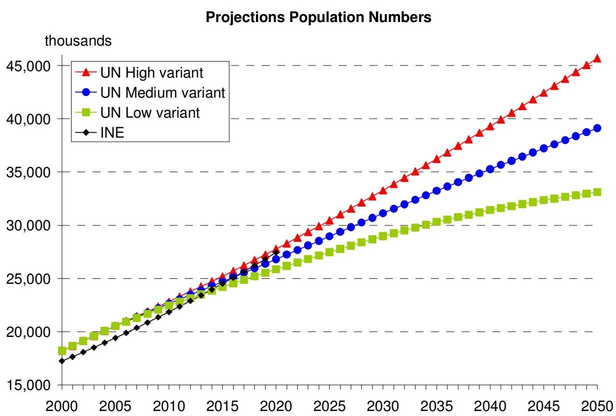

Figure 1b

As a result, in the UN Medium Variant, the population will grow from about 20 million in 2007 to 39 million in 2050. The UN High Variant and Low Variant imply a population size in 2050 of 45 million and 33 million people, respectively. Apart from the size, also the composition of the Mozambican population - in terms of Urban and Rural - is expected to change considerably over the next decades. Figure 2a shows the UN expected division in Urban and Rural population (for their Medium Variant). It can be seen that the urban population will grow considerable faster than the rural population.

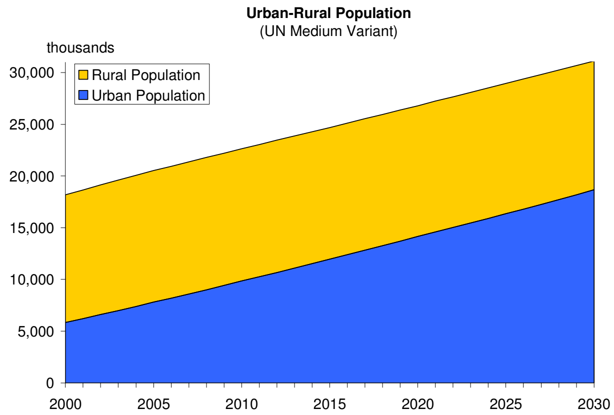

Figure 2a.

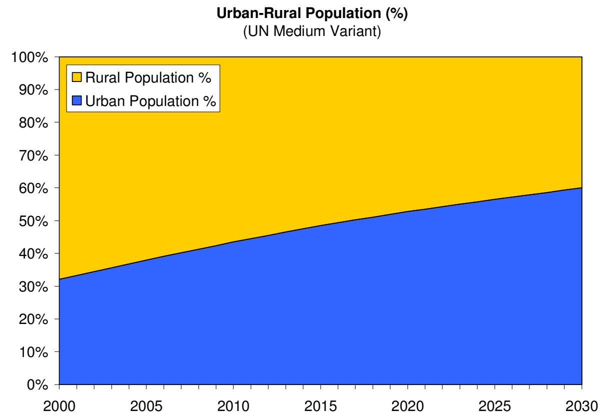

Figure 2b.

As a result of this urbanisation process, the share of the population living in urban areas is expected to increase from close to 40% in 2007 to 60% in 2030 (see Figure 2b). Given the aforementioned population growth this means a considerable increase of the absolute number of people in an urban environment: from about 8 million in 2007 to about 19 million in 2030. In other words, by 2030 the number of people living in cities in Mozambique is almost equal to the whole population at this moment.

Figure 3a shows the increase in population, expressed in number of households. Currently INE counts with an average of 5 (sometimes 4.6) people per household. However, it is expected that the average household size will gradually decrease over time. Therefore I have plotted in Figure 3a the number of households for the different population growth scenarios, assuming both 4 and 5 people per household. If we assume 5 persons per household, according to the UN Medium Variant the number of households will increase from circa 4 million in 2007 to 8 million in 2050. If we assume 4 persons per household, we are talking about circa 5 million households in 2007 and 9.8 million in 2050.

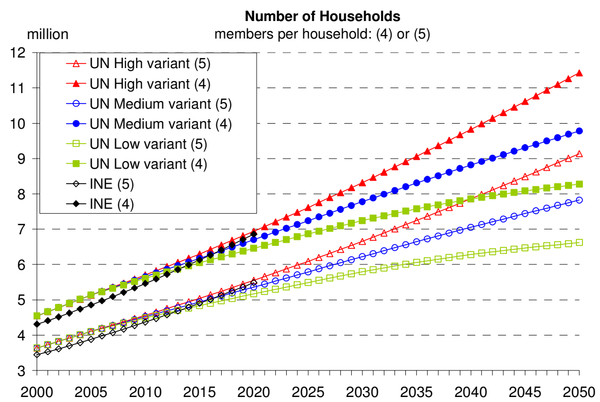

Figure 3a

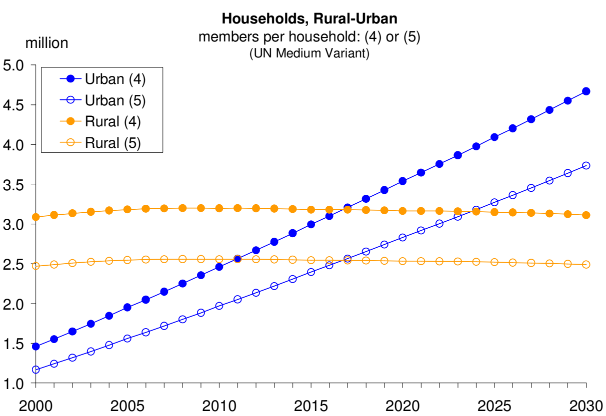

Figure 3b

As noted before, the number of households in urban areas will grow faster than in rural areas. Figure 3b shows that under the UN Medium Variant we can expect the number of urban households to increase from circa 1.6 million in 2007 to 3.7 million in 2030 if we assume 5 persons per household. If we assume a household size of 4, the number of urban households will grow to over 4.5 million by 2050. Contrary to the number of urban households, the number of rural households will remain more or less constant: around 2.5 million if we assume a household size of 5 and around 3 million if we assume a household size of 4. For more details I refer to the tables in the Annex on Population.

3. GDP growth

Apart from assumptions on the size, growth and composition of the population, meaningful energy policy scenarios require adequate assumptions on the development and composition of GDP over time. Throughout this document I work with three scenarios: a Reference Scenario as the most likely development path, a High Growth Scenario, and a Low Growth Scenario. Table 1 shows the assumptions on future GDP growth for these 3 scenarios in relation to the historical GDP growth figures for the period 2000-2005. From the Table it can be seen that in the Reference Scenario I assume annual GDP growth to gradually decline from 7.5% in 2006 to 4% in 2030. In the High Growth Scenario I assume annual GDP growth to gradually decline from 9.5% in 2006 to 6% in 2030, while in the Low Growth Scenario I assume annual GDP growth to gradually decline from 5.5% in 2006 to 2.0% in 2030. The combination of these three scenario provide an adequate framework to assess potential future developments in the energy sector between a very optimistic upper boundary and a very pessimistic lower boundary regarding economic growth expectations.

Table 1 Assumptions on GDP growth

Economy	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**Aver. 02-05**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	7.5%	7.0%	6.0%	5.0%	4.0%	4.0%
High Growth	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	9.5%	9.0%	8.0%	7.0%	6.0%	6.0%
Low Growth	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	5.5%	5.0%	4.0%	3.0%	2.0%	2.0%

More details on the growth of various sectors, like transport and services, are provided in the relevant sections below.

4. Access to Electricity

A key element of the government policy in the energy sector is to increase the % of the population with access to electricity. In this section I provide some basic calculations that may help to define goals on electrification rates and to monitor progress, under different assumptions regarding the number of new connections and the growth of the population. Electricity is mainly provided through the national grid, managed by the national power utility Electricidade de Moçambique (EdM). In addition, in rural areas a long way from the national grid (in distance and time) electricity is also provided through isolated grids, mainly driven by diesel generators. Section 4.1 deals with the national grid, section 4.2 with isolated grids.

4.1 National Grid

Currently EdM has around 400,000 residential customers. If we assume 5 persons per household, this means that about 2 million people have currently access to electricity. Given a population size of around 20 million, this implies that circa 10% of the population have access to electricity provided by the national grid. The number of new residential connections realized per year has increased from around 10,000 in 2000 to over 70,000 in 2006, reflecting the increasing performance of EdM in executing the electrification program (see Table 2).

Table 2. Number of new residential connections per year (thousands) – Historical Data & Assumptions

Access	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference (Medium Access)	10.6	15.8	0.85	22.9	38.2	51.3	70.4	70	70	70	70	70	70
High Access	10.6	15.8	0.85	22.9	38.2	51.3	70.4	100	100	100	100	100	100
Low Access	10.6	15.8	0.85	22.9	38.2	51.3	70.4	50	50	50	50	50	50

To get an idea of what we may expect of the future in terms of % of the population with access to electricity, I develop three scenarios regarding the future development of new connections: in the Reference (Medium Access) Scenario I assume a constant number of 70,000 new residential connections per year, similar to the historical high performance of 2006; in the High Access Scenario I assume 100,000 new residential connections per year; in the Low Access Scenario this number is 50,000 (see Table 2). Combining this with the number of persons per households (4 or 5) and the expected population growth, I can come up with a consistent estimate the % of population with access to electricity in the future. In Figure 4a I plot this electrification ratio for the period up to 2050, under the three aforementioned scenarios as well as an additional Scenario 'Extra High' of 150,000 new residential connections per year, and assuming a household size of 4 and 5 and the UN Medium Variant for population growth.

From Figure 4a it can, for example, be seen that in case of 70,000 new residential connections per year (Reference Scenario) and a household size of 5, by 2050 around 45% of the population will have access to electricity. The Figure also shows, for example, that if the Government wants to realise an electrification rate of 50% by 2030, and assuming a household size of 4, EdM needs to realize 150,000 new residential customers per year.

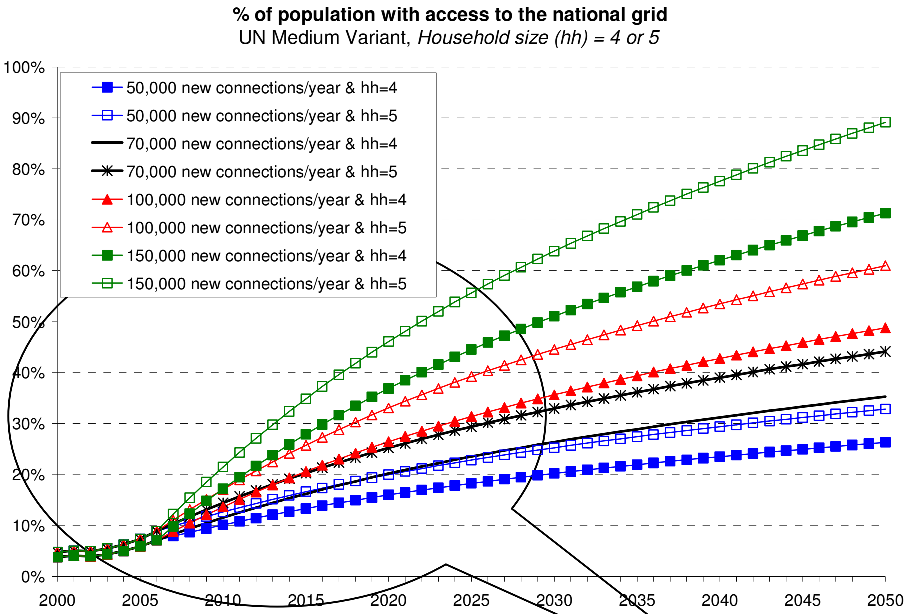

Figure 4a

Figure 4b

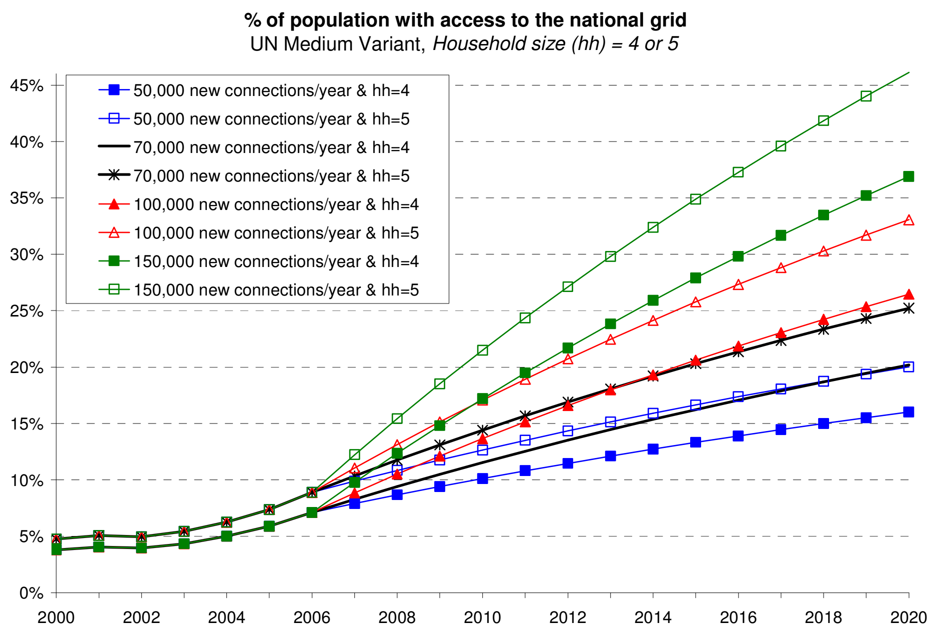

Figure 4b zooms in on Figure 4a, with a focus on the period 2000-2020. Figure 4b shows that if the Government wants to define an electrification goal of 20% by 2012, EdM has to connect 100,000 new residential customers each year if we assume a household size of 5. If EdM continues with the 2006 level of 70,000 new residential customers per year, the electrification rate in 2012 will be around 17% if we assume a household size of 5 and around 14% if we assume a household size of 4. For more detail I refer to the tables in Annex 2.

4.2 Isolated Grids

Currently, Mozambique has established 90 Isolated Grids in 9 provinces (see Table 3). An evaluation study done by FUNAE in 18 districts reports a total of 1,577 customers for these 18 isolated systems, of which 84% are residential customers (Nicolau 2007, p28). This implies on average 1,321 (=84% x 1,577) customers divided by 18 grids = 73 residential customers per isolated grid. Let me optimistically assume that the real figure for all Isolated Grids is somewhat higher (100 or 150) and that the household size is 5 or 4. This allows us to estimate the % of the population with access to electricity trough isolated grids, per province and for the country as a whole. The details are provided in Table 3.

Table 3. Isolated Grids

Number of res.clients per Isolated Grid		**100**	**100**	**100**	**150**	**150**	**150**
Household Size			**4**	**5**		**4**	**5**
Province	**Isolated Grids**	**Customers**	**Population**	**Population**	**Customers**	**Population**	**Population**
C.Delgado	21	2,100	8,400	10,500	3,150	12,600	15,750
Niassa	11	1,100	4,400	5,500	1,650	6,600	8,250
Nampula	12	1,200	4,800	6,000	1,800	7,200	9,000
Zambezia	8	800	3,200	4,000	1,200	4,800	6,000
Tete	8	800	3,200	4,000	1,200	4,800	6,000
Manica	5	500	2,000	2,500	750	3,000	3,750
Sofala	9	900	3,600	4,500	1,350	5,400	6,750
Inhambane	11	1,100	4,400	5,500	1,650	6,600	8,250
Gaza	5	500	2,000	2,500	750	3,000	3,750
Maputo	0	0	0	0	0	0	0
TOTAL	**90**	**9,000**	**36,000**	**45,000**	**13,500**	**54,000**	**67,500**
% of Population			**0.18%**	**0.23%**		**0.27%**	**0.34%**

From the Table it can be seen that if we assume 100 residential customers per isolated grid and a household size of 4, an estimated 36,000 people or 0.18% of the population have access to electricity by means of isolated grids. If we assume 150 residential customers per isolated grid and a household size of 5, this numbers increase to an estimated 67,500 people or 0.34% of the population with access to electricity by means of isolated grids.

Figure 5 shows that if each year 1000 new residential customers get connected to Isolated Grids – which is roughly equivalent to 10 new generators each year – by 2050 around 0.6% of the population will have received access to electricity via isolated systems. To reach an isolated grid electrification ratio of more than 1% by 2050, at least 2000 new customers need to be connected *each year*. In addition, it is to be noted that for various reasons (most notably lack of diesel and technical problems) the isolated systems function on average only 1,82 hour per day (Nicoalau 2007:28), instead of the foreseen 4 hours per day. In other words, the effective access to electricity by means of isolated grids is much lower than assumed in the aforementioned calculations.

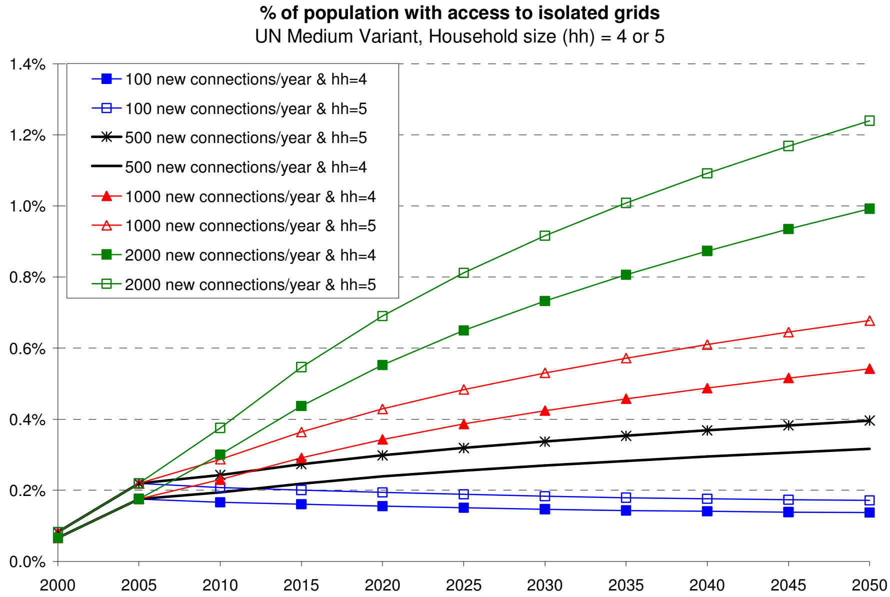

Figure 5. % of population with access to isolated grids

4.3 Demand for Electricity - Households

Demand for electricity by households depends not only on projections regarding population growth and household size, but also on the quantity of electricity consumed per household. Table 4 summarizes historical data on the amount of kWh per residential EdM customer for the period 2000-2006 with assumptions regarding its development in the future in three scenarios: Reference, High, and Low.

Table 4. Electricity Consumption per Household – Historical Data & Assumptions

Demand	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference													
kWh/person	453	468	436	387	357	353	310	320	250	250	250	262.5	275
kWh/household	2,263	2,339	2,180	1,934	1,785	1,763	1,548	1,530	1,180	1,180	1,180	1,239	1,299
High Demand													
kWh/person	453	468	436	387	357	353	310	320	300	325	350	375	400
kWh/household	2,263	2,339	2,180	1,934	1,785	1,763	1,548	1,530	1,416	1,534	1,652	1,771	1,889
Low Demand													
kWh/person	453	468	436	387	357	353	310	320	250	225	200	200	200
kWh/household	2,263	2,339	2,180	1,934	1,785	1,763	1,548	1,530	1,180	1,062	944	944	945

The Table shows that the average consumption of electricity per household has been gradually decreasing from 2,263 kWh in 2000 to 1,548 in 2006, which is due to the increasing number of relatively lower income households with access to electricity in the context of the electrification program. In the three scenarios I assume this trend to continue, at various degrees, until 2020/25 after which average electricity consumption per household is assumed to gradually increase as a result of growing energy intensity that comes along with higher incomes. To calculate electricity demand, I combine these numbers with the assumptions on new connections as listed in Table 2: 70,000 new connections annually in the Reference Scenario, 100,000 in the High Scenario and 50,000 in the Low Scenario. Figure 6 contains the resulting electricity demand by households under the various assumption regarding demand and access as described above. The Figure shows that in the Reference Scenario household electricity consumption is expected to increase from just above 500 GWh in 2006 to over 2,500 GWh by 2030. Under the most optimistic assumptions regarding access and demand per household this number will be close to 5,500 GWh by 2030 while under the most pessimistic assumptions as described above the projected demand will be around 1,500 GWh by 2030.

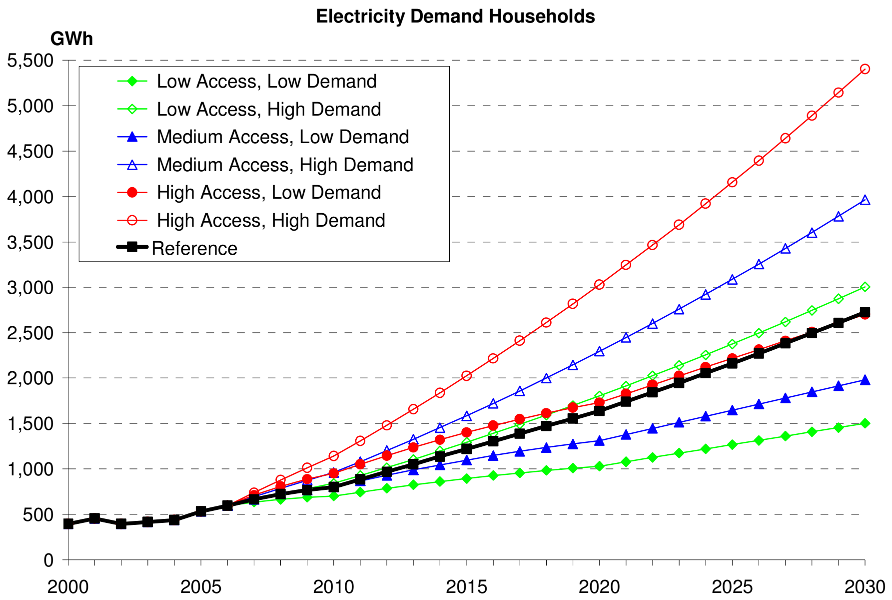

Figure 6. Projected Electricity Demand by Households

4.4 Demand for Electricity - Commercial

Demand for electricity consumption by the commercial sector depends on its size and energy intensity. I measure the size by the share of the commercial sector in total GDP, distinguishing between Services and Industry (excl. Mozal). The size of the commercial sector in the future is then determined by assumptions on overall GDP growth, as given in Table 1 (section 3), as well as by assumptions on the development of the sectoral GDP share. Table 5 provides the historical data of sectoral shares of the Services and Industry sector (excl. Mozal) in total GDP and combines these with assumptions for the future, again in threefold: Reference, High, and Low.

Table 5. Demand and Activity Level COMERCIAL SECTOR – Historical Data & Assumptions

Services	Historical Data							Assumptions					
% of GDP	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	***Aver. 02-05***	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference	39.6%	40.5%	39.5%	37.6%	36.5%	36.3%	*37.4%*	36.0%	37.5%	39.4%	41.3%	43.1%	**45.0%**
High Growth	39.6%	40.5%	39.5%	37.6%	36.5%	36.3%	*37.4%*	36.0%	38.3%	41.3%	44.2%	47.1%	**50.0%**
Low Growth	39.6%	40.5%	39.5%	37.6%	36.5%	36.3%	*37.4%*	36.0%	36.7%	37.5%	38.3%	39.2%	**40.0%**
Industry	Historical Data							Assumptions					
% of GDP	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	***Aver. 02-05***	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference	18.5%	18.4%	17.9%	18.5%	17.3%	17.3%	*17.8%*	17.5%	17.9%	18.4%	19.0%	19.5%	**20.0%**
High Growth	18.5%	18.4%	17.9%	18.5%	17.3%	17.3%	*17.8%*	17.5%	18.8%	20.3%	21.9%	23.4%	**25.0%**
Low Growth	18.5%	18.4%	17.9%	18.5%	17.3%	17.3%	*17.8%*	17.5%	17.1%	16.6%	16.0%	15.5%	**15.0%**

The Table shows that the GDP share of Services is currently around 37%, which I assume to grow until 45% by 2030 in the Reference Scenario, to 50% in the High Scenario and to 40% in the Low Scenario, respectively. The GDP share of the Industry sector (excl. Mozal) is currently around 18%, which I assume to grow until 20% by 2030 in the Reference Scenario, and to 25% or 15% in the High or Low Scenario, respectively. With respect to the energy intensity, for the Services sector I assume an annual growth rate of 0.5% in the Reference Scenario, and 1% and 0% in the High and Low Scenario, respectively. For the Industry sector I assume an annual growth rate of energy intensity of 1% in the Reference Scenario, and 1.5% and 0.5% in the High and Low Scenario, respectively. For more details I refer to the Tables in Annex 3. The resulting electricity demand under the different assumptions is shown in Figure 7. The Figure shows that in the Reference Scenario, electricity demand by the commercial sector is expected to grow from just over 1,000 GWh in 2006 to just over 5,000 GWh by 2030. In the High and Low Scenario the projected electricity demand will arrive at a little over 10,000 and 2,000 GWh, respectively.

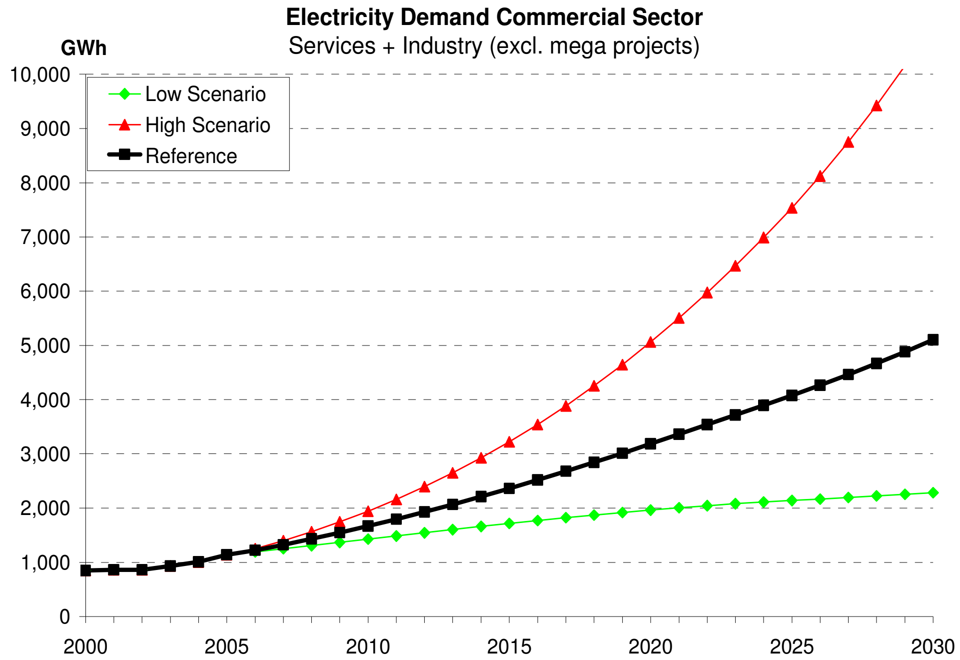

Figure 7. Projected Electricity Demand by the Commercial Sector

4.5 Demand for Electricity – Total (excl. mega projects)

Total Demand for electricity (excl. mega projects) comprises household demand and commercial demand. (Note that electricity demand by agriculture is very small (about 40 MWh in 2005), while electricity demand by Transport is also negligible small). The amount of total electricity distributed is higher since it includes transport and distribution losses as well as own consumption by EdM and electricity for public lighting. In 2005 transport and distribution losses counted for about 21% of total electricity supply while own consumption and public lighting together were about 4%. In the Reference Scenario I assume the sum of transport and distribution losses to reduce 12% by the year 2030, to 14% in the High Scenario and to 10% in the Low Scenario. Furthermore, I assume that own consumption and public lighting account for 1.5% by 2030 in the Reference case, to 2.2% in the High Scenario and to 0.8% in the Low Scenario. For more details see Table A4.1 in Annex 4. The resulting projections for Total Electricity Distributed are presented in Figure 8. The Figure shows that in the Reference Scenario total electricity distributed will grow to circa 8,000 GWh by 2030. In the Low Scenario distributed will be around 4,000 GWh by 2030 while in the High Scenario the electricity distributed will grow to circa 17,000 GWh.

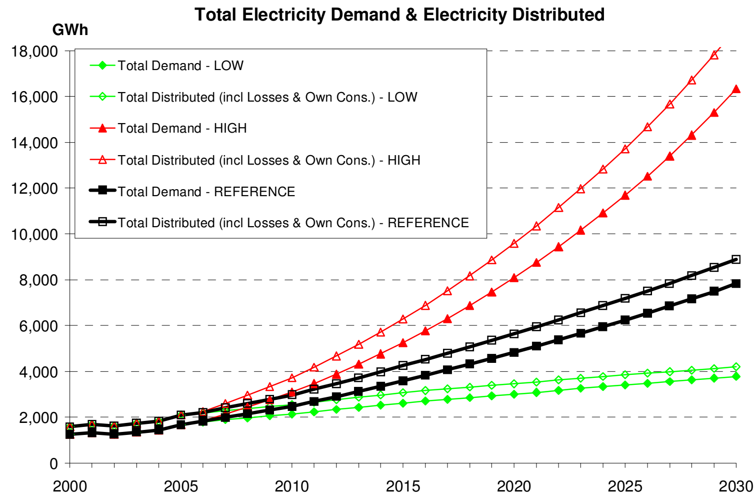

Figure 8. Projected Total Electricity Demand & Supply

Figure 9 provides a breakdown of total electricity distribution under the Reference Scenario. From the Figure it can be seen that total non-megaproject electricity demand is more or less equally divided over households, services and industry. On top of this comes 20-12% losses as well as 4-1.5% own consumption and Public lighting.

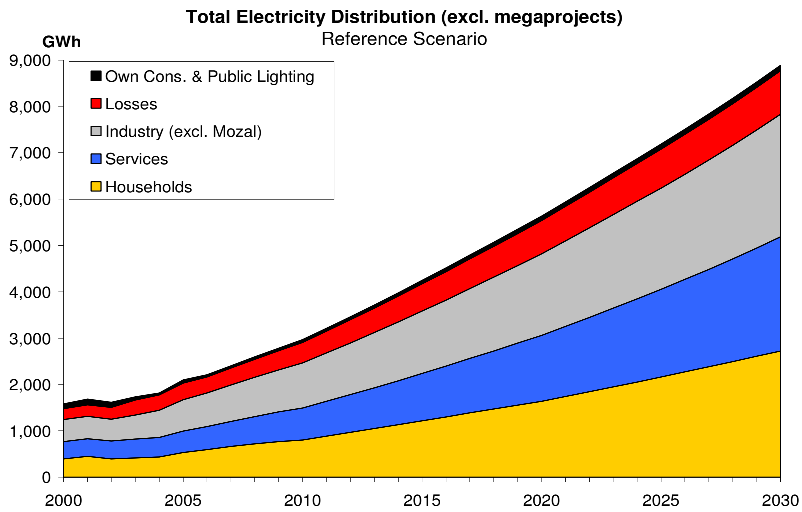

Figure 9. Breakdown of Electricity Distribution, Reference Case

Of course, growing demand for electricity implies a need for growing supply of electricity. Currently, the major part of domestic non-megaproject electricity consumption is supplied by HCB. In addition, EdM has some own capacity with the hydro dams of Mavuzi, Chicamba and Corumana. Regarding EdM's own capacity, expansion is foreseen with the rehabilitation of the Massingir dam (25MW) and the construction of the Lurio dam (120 MW), probably in 2008 and 2012 respectively. Figure 10 illustrates the total available electricity supply and contrasts this with historical and projected electricity demand for the 3 scenarios. From the Figure it can be seen that as of 2007 the country enters a situation of excess demand. The new capacity delivered by the Massingir and Lurio dams will help to ease this situation in the future but will not be sufficient to solve it. Hence, there is an urgent need to search for alternative sources of electricity supply.

The most obvious solution for EdM is to negotiate with HCB the possibility to increase the share it can acquire from this large hydro dam (2075 MW). However, the question is whether the existing long-term contracts that HCB has with its main clients, particularly ESKOM (South Africa), provide sufficient space for such a solution. If not, Mozambique runs the risk of having to import expensive electricity to meet domestic (non-mega project) demand while at the same time exporting cheap electricity from its own resources. In any case, responsible energy planning requires addressing this issue, not only regarding HCB but also with respect to new generation capacity like the new thermal plants in Inhambane and Moatize as well as the Mphanda Nkuwa hydro dam.

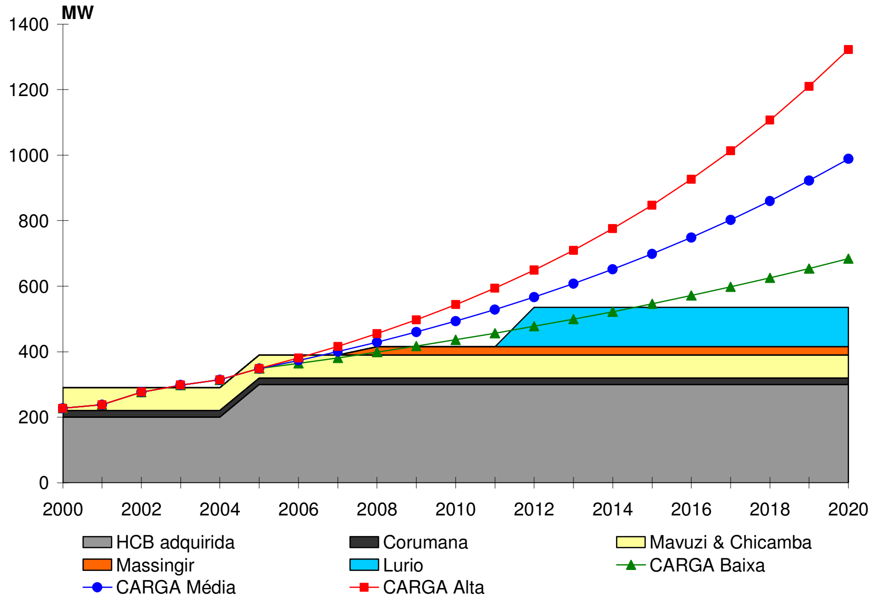

Figure 10 Supply and Demand of Electricity

4.6 Loss reduction

As noted before, currently EdM loses around 20% of its total electricity supply with transport and distribution losses. About ¾ of these losses consist of distribution losses, of which a major part comprises non-technical losses. These can in principle be avoided. Figure 11 shows that since 2003 losses are gradually, albeit slowly, reducing. Since a major part of the transport losses are technically unavoidable, a loss reduction policy needs to focus on the (non-technical) distribution losses, including theft and poor administration.

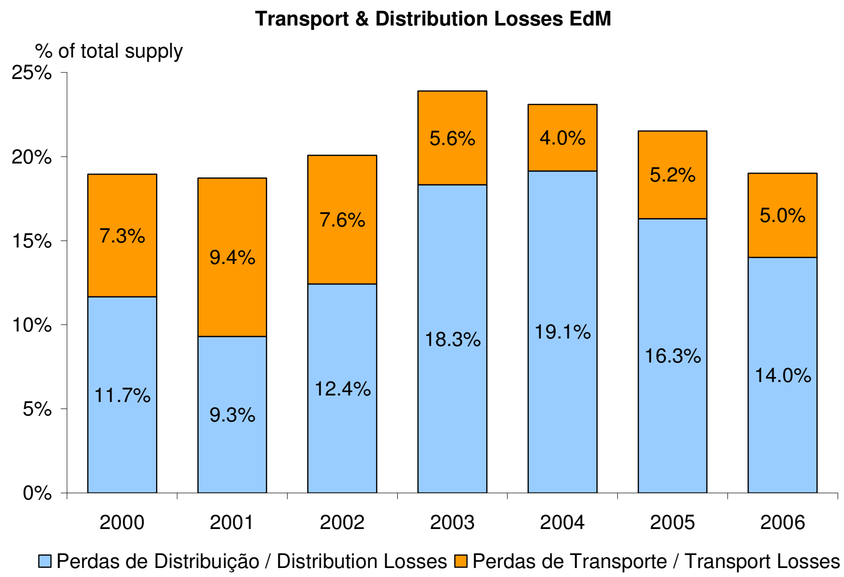

Figure 11. Transport & Distribution Losses EdM 2000-2006

Figure 12 illustrates the value of a loss reduction policy, by presenting the cumulative value of 1% electricity supply at a constant 2006 average selling price of 8.5 USDc/kWh. From the Figure it can be seen that in the Reference case, a minor 1% reduction in distribution losses will generate up to 100 million USD for EdM until 3030. In the High Scenario this value increases to circa 160 million USD while even in the Low Scenario up to 60 million USD can be saved until 3030 if only 1% loss reduction would be realised.

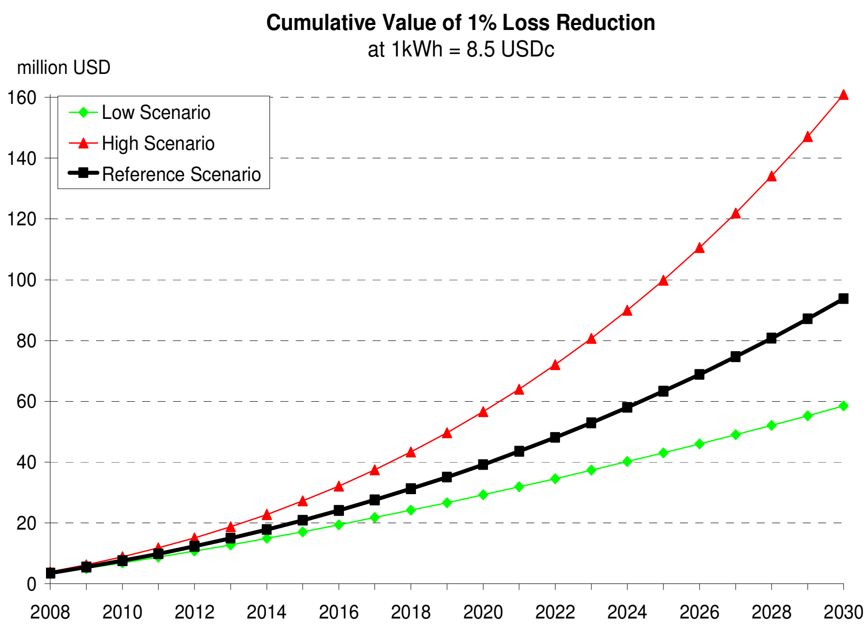

Figure 12. Cumulative Value of 1% loss reduction

5. Access to Fuels

For its fuel consumption Mozambique currently depends completely on import. Since 2002 the value of fuel imports increased with about 50% to circa 350 million US$ in 2006 (see Figure 13). This sharp increase in the value of fuel imports is ultimately caused by a considerable increase in the price of crude oil at the international market (see Figure 14). International crude oil prices have tripled since 2002. Before 2002 the oil price fluctuated for a long time between 10 and 30 US$/Barril. After 2002 the price has increased gradually to about 60 US$/Barril by the end of 2005, and have not structurally decreased since then. In other words, the current high oil prices are a structural rather than an incidental phenomenon, with a likely oil price between US$50/Barril and USD70$/Barrel for the time to come.

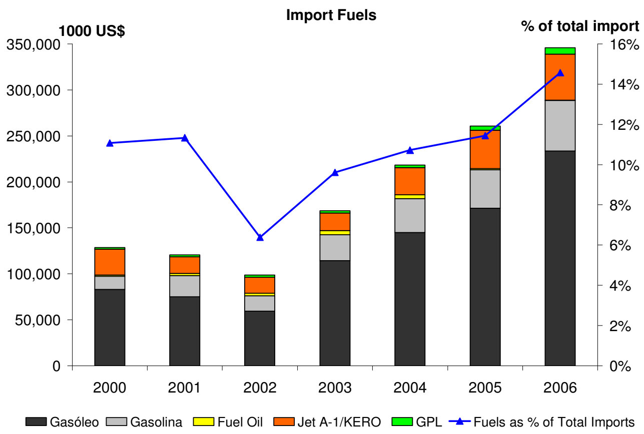

Figure 13

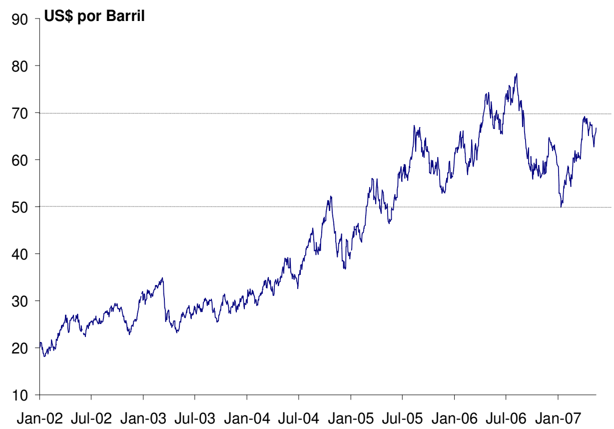

Figure 14

Since the share of oil products in total imports is high and rising - in 2006 fuels accounted for more than 14% of total imports - this has severe implications on the Mozambican economy, through a considerable negative impact on the balance of payment, the exchange rate, inflation, poverty incidence and the absorptive capacity of the economy (see Arndt et al. 2005). In sum, there are good reasons to reduce the dependency of fuel import. One way to do this is to promote the consumption of cleaner fuels, like CNG or bio-diesel. This topic is dealt with in section 7.

The vast majority of demand for fuels comes from the transport sector. Unfortunately the available data on diesel consumption do not provide a sectoral breakdown. For our calculation we therefore assume that during the period 2000-2005 90% of total diesel consumption is consumed by Transport (with the remaining 10% equally divided over electricity generators and the Agriculture sector). Future fuel consumption by the transport sector depends on its size and fuel intensity. I measure the size by the share of the transport sector in total GDP. The size of the commercial sector in the future is then determined by assumptions on overall GDP growth, as given in Table 1 (section 3), as well as by assumptions on the development of the sectoral GDP share. Table 5 provides the historical data of sectoral shares of the Transport Sector (incl. Telecommunications) in total GDP and combines these with assumptions for the future, again in threefold: Reference, High, and Low.

Table 5. Demand and Activity Level TRANSPORT SECTOR – Historical Data & Assumptions

Transport	Historical Data							Assumptions					
% of GDP	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	***Aver. 02-05***	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference	8.7%	8.2%	8.2%	8.7%	9.5%	9.5%	9.0%	9.5%	9.6%	9.7%	9.8%	9.9%	**10.0%**
High Growth	8.7%	8.2%	8.2%	8.7%	9.5%	9.5%	9.0%	9.5%	9.9%	10.4%	11.0%	11.5%	**12.0%**
Low Growth	8.7%	8.2%	8.2%	8.7%	9.5%	9.5%	9.0%	9.5%	9.3%	8.9%	8.6%	8.3%	**8.0%**

The Table shows that the GDP share of Transport & Telecom is currently around 9.5%, which I assume to grow until 10% by 2030 in the Reference Scenario, to 12% in the High Scenario or to 8% in the Low Scenario, respectively. The high growth rate of GDP in this sector is probably for most part due to fast growth in value added of telecommunication (Mcel, Vodacom). As a result, aggregate energy intensity is small and rapidly decreasing - which is thus probably mainly due to fast growth in value added of telecommunication. Since INE does not provide separate GDP figures for the transport sector I am not able to separate Transport and Telecommunication. However, it is to be noted that fuel consumption in the Telecommunication sector is likely to very small. For details on the assumption regarding energy intensity in the transport sector I refer to Table A5.1 in Annex 5. The resulting electricity demand under the different assumptions is shown in Figure 15.

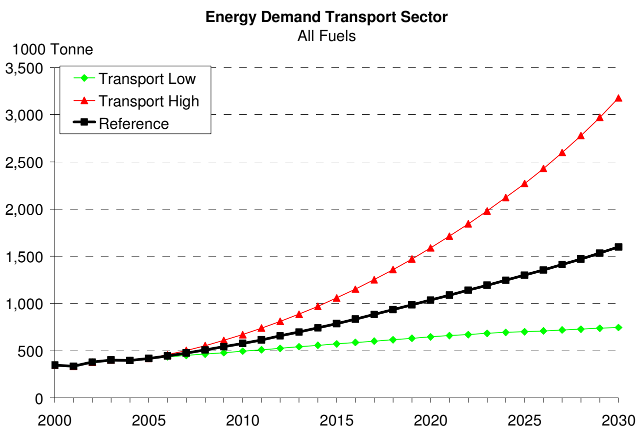

Figure 15

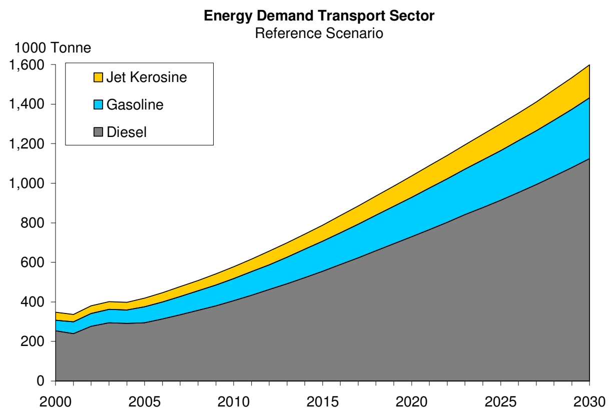

Figure 16

Figure 15 shows that in the Reference Scenario, total fuel demand by the transport sector is expected to grow from about 500,000 tonne in 2006 to over 1,500 tonne by 2030. In the High and Low Scenario the projected fuel demand will be circa 3,200 and 700 tonne, respectively. This growth is mainly a function of GDP growth. Figure 16 shows a breakdown of total fuel demand under the Reference Scenario. From the Figure it can be seen that around ¾ of total fuel consumption consists of diesel.

The LPG market is currently restricted to some larger cities (mainly Maputo, Beira, Nampula) and is monopolised by a private company, which recently has not managed to meet the demand for this product, thereby invoking sharp price increases. As a result access to this relatively clean and efficient source of energy is at present very limited. LPG consumption is stagnating at around 13,000 tonne per year (Ministry of Energy 2007a,b). Detailed data on LPG consumption per household in Mozambique are not available, but it is known that the average consumption of LPG is 22 kg per person per year, based on a weighted average based on WHO data for developing country households currently using LPG (Source: World Energy Outlook 2006, p437). I assumed that Mozambique is somewhat below this average, since GDP level is low and LPG is in Mozambique almost exclusively used for cooking (and not heating). Hence for Mozambique I assume an average annual LPG consumption of 15kg per person, which translates into 75 kg per household if the household size is 5. Finally, I assume that LPG is consumed by urban households only. Then it is possible to calculate the % of urban households with access as follows: divide total LPG consumption by 75kg, to get the number of households with access to LPG; divide this number by the total number of urban households (see section 2) to get the % of urban households with access to LPG. The result of this calculation for the period 2000-2030 is shown in Figure 17.

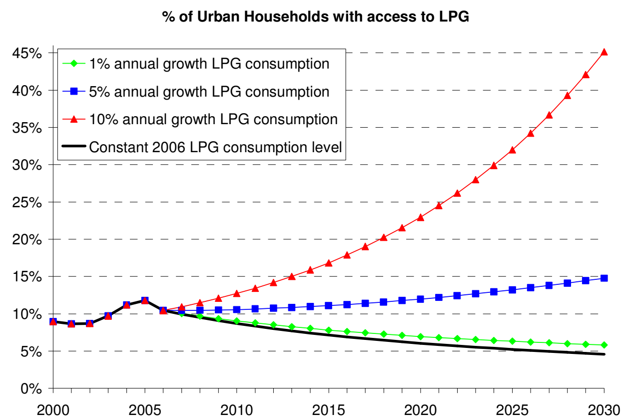

Figure 17

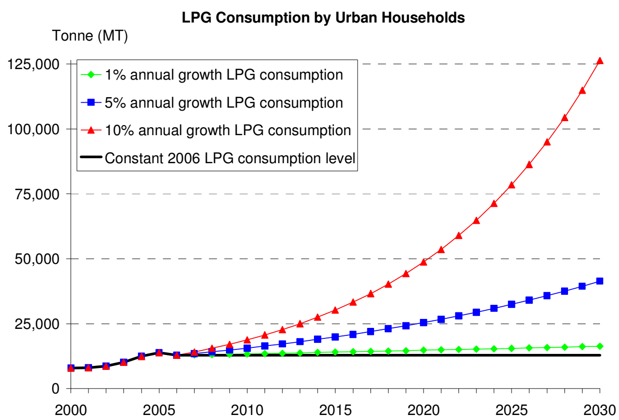

Figure 18

From Figure 17 it can be seen that currently an estimated 10% of the urban households has access to LPG. If LPG remains constant at the 2006 level[2] then this percentage will decrease to 5% by 2030 due to the rise of the urban population (see section 2). To increase the percentage of population with access to LPG, LPG consumption needs to increase with at least circa 3% per year. A 5% annual increase in

[2] Note that LPG consumption decreased from 2005 to 2006 due to supply interruptions.

LPG consumption, for example, leads to an access percentage of 15% by 2030, while an annual growth of 10% of LPG consumption implies that by 2030 around 45% of the urban population does have access to LPG.

Figure 18 shows that annual consumption of LPG under the same scenarios as in Figure 17. From the combination of Figure 17 and 18 it can be seen that an annual 10% increase of LPG consumption implies that by 2012 around 15% of the urban households would have access to LPG, which translates into a doubling of current LPG consumption to about 25,000 tonne of LPG. This result illustrates well the problem with the current LPG market: most likely it would be impossible to import 25,000 tonne from South Africa, given their capacity problems (even the current 13,000 tonne is already a problem), while it will also be very difficult - if possible at all - to import 25,000 tonne from elsewhere since this quantity does not even fill 2 LPG ships (which have a minimum capacity of 15,000 tonne). Importing by ship is likely to pay-off only in the case of 5 ships or more per year, that is by a minimum of 75,000 tonne. As compared to the 2006 consumption level, this would imply an almost 500% increase in consumption, which indeed is very unlikely to be realised in the short term. Figure 18 shows that in case of a steady 10% annual growth, it will take until about 2025 until we reach 75,000 tonne. In sum, if it is a policy objective to increase LPG consumption than the Ministry of Energy has to explore alternative ways to supply the Mozambican market, including the option of domestic production of LPG (either by realizing an oil refinery or by means of processing condensate derived from the natural gas exploration in Inhambane province) or the option to build new transport and storage infrastructure in the port of Maputo to facilitate large scale importing of LPG for re-export to the regional market (RSA, Swaziland, South-Zimbabwe, Botswana), of which a small part then may supply the Mozambican market.

6. Efficiency and Sustainability

Consuming energy resources has its price, either in terms of monetary costs and/or in terms of environmental degradation. Therefore, it is worthwhile to consume energy as efficient as possible. In this section I provide some numbers to illustrate the importance of promoting energy efficiency, in the area of electricity and in the field or traditional biomass.

6.1 Electricity

Figure 19 provides an indication of the amount of electricity that can be saved if 1% energy efficiency is realised. From the Figure it can be seen that in the Reference Scenario, 1% efficiency improvement leads to annual electricity savings between circa 15 GWh in 2008 to 50 GWh in 2030. In the High Scenario, electricity savings can be as high as 110 GWh by 2030, while even in the Low Scenario, energy savings can amount to over 20 GWh by 2030. To put this into perspective, it is to be noted that, the amount of 15 GWh electricity savings is sufficient to provide electricity to 10,000 households - given an average annual electricity consumption of 1500 kWh per household (see section 4.3).

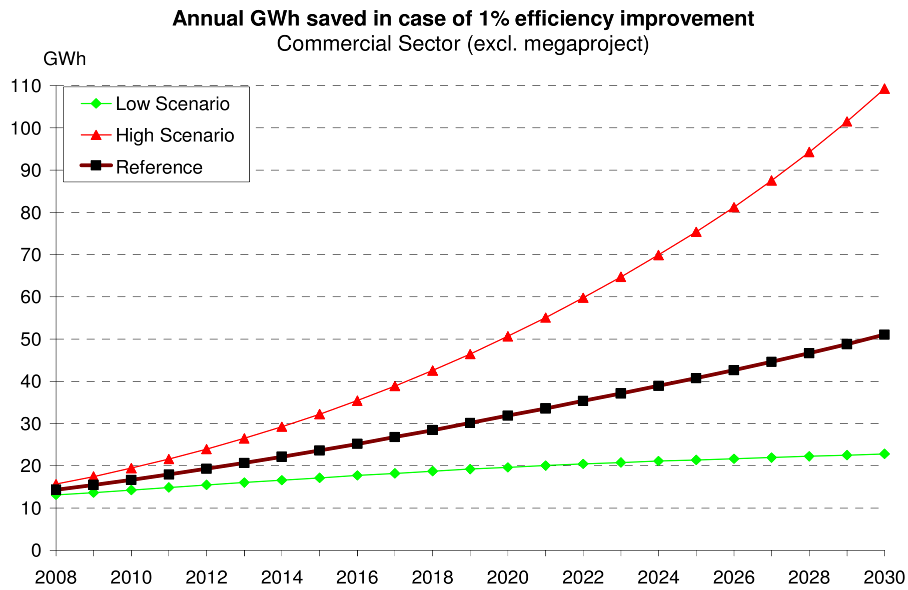

Figure 19. Total Electricity Savings in case of 1% efficiency improvement

6.2 Biomass

Figure 20 shows total expected fuelwood consumption until 2030 if no efficiency improvements in the consumption of fuelwood will take place. It can be seen that fuelwood consumption is expected to rise, which is mainly a result of population growth. In the Reference Scenario, fuelwood consumption is expected to rise from an estimated 230,000 TJ in 2007 to 260,000 TJ in 2030. In case of high population growth (see section 2) this will increase to over 280,000 TJ, while in case of low population growth (see section 2) total fuelwood consumption is expected to stabilize at around 240,000 TJ.

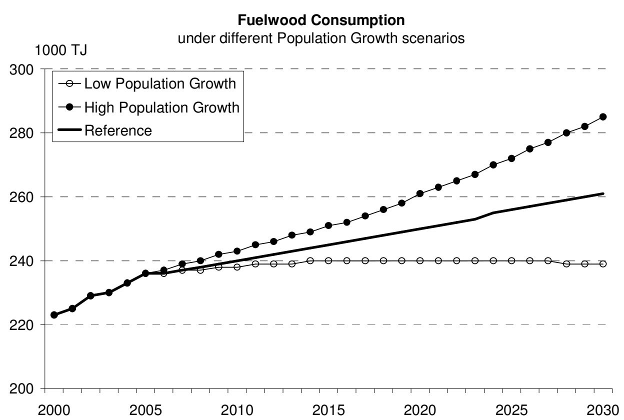

Figure 20

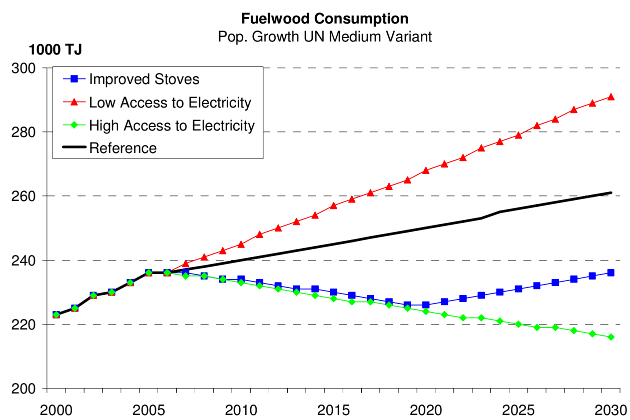

Figure 21

Figure 21 shows the impact of improved stoves distribution on expected fuelwood consumption, assuming that the use of these improved stoves induces a 10% efficiency improvement in fuelwood consumption at the household level by 2020. From the Figure it can be seen that this means that in the Reference Scenario total expected fuelwood consumption will be around 235,000 TJ as compared to 260,000 TJ without any efficiency improvement. According to Nicolau (2007, p23) Mozambique currently annually looses between 45 and 120 million trees as a result of fuelwood and charcoal production. A 10% efficiency improvement then means that Mozambique can currently save between 4,5 and 12 million trees per year. Assuming continued population growth (see figure 19), this number will increase over time.

Figure 21 also shows the impact or (rural) electrification on fuelwood consumption, resulting from the fact that electrified households reduce their consumption of fuelwood and charcoal. From the Figure it can be seen that in case of a high electrification rate (100,000 new residential customers per year), annual fuelwood savings will have more or less the same impact as a 10% efficiency improvement by means of improved stoves.

7. Cleaner Fuels

As mentioned in section 5, the share of oil products in total imports in Mozambique is high and rising (around 14% in 2006) and this has severe negative implications on the Mozambican economy. Hence, there are good reasons to reduce the dependency of fuel import and one way to do this is to promote the consumption of nationally produced cleaner fuels, like CNG or bio-diesel. Table 6 shows the quantity of cleaner fuels required over time to substitute, respectively, 1%, 3% or 5% of total diesel consumption by cleaner fuels. The Table indicates that in the Reference Scenario, 1% substitution of diesel with cleaner fuels (for example through blending of bio--diesel), requires an annual production of circa 4,000 tonne in 2010, which grows until circa 11,000 tonne by 2030 due to growth of the transport sector and thus fuel demand (see also section 5) . In the High and Low Scenario the demand for fluctuates as indicated in the

Table 6 Quantity of Cleaner Fuels under different

Tonne	2007	2010	2015	2020	2025	2030
Reference						
1% Cleaner Fuel	3,353	4,068	5,546	7,295	9,150	11,246
3% Cleaner Fuel	10,058	12,203	16,638	21,884	27,449	33,739
5% Cleaner Fuel	16,763	20,338	27,729	36,473	45,749	56,232
High						
1% Cleaner Fuel	3,536	4,734	7,459	11,188	15,981	22,357
3% Cleaner Fuel	10,609	14,203	22,377	33,565	47,942	67,072
5% Cleaner Fuel	17,681	23,671	37,295	55,942	79,903	111,787
Low						
1% Cleaner Fuel	3,169	3,488	4,029	4,551	4,937	5,246
3% Cleaner Fuel	9,507	10,464	12,087	13,652	14,812	15,739
5% Cleaner Fuel	15,845	17,440	20,145	22,754	24,686	26,232

Table, due to different assumption regarding fuel demand (see section 5). In the case of bio-fuels, it is foreseen that a major part of its production will be based on the Jatropha plant. From international experience it is known that 1 hectare of jatropha will produce on average 1892 liters of biodiesel (Source: Global Petroleum Club via Wikipedia).[3] If we furthermore assume a conversion factor from oil to biodiesel of 0.97 and a heat content of biodiesel that is 90% of petroleum diesel, we can calculate the amount of hectares needed to grow sufficient jatropha to produce the amount of bio-diesel provided in Table 6. The results are shown in Table 7.

Table 7. Hectares of Jatropha needed for bio-diesel production in Mozambique.

	Consumption of (bio)diesel in 1000 tonne					Hectares needed for Jatropha production				
	2010	**2015**	**2020**	**2025**	**2030**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference										
Diesel consumption	406.8	554.6	729.5	915.0	1,124.6					
1% bio-diesel	4.1	5.5	7.3	9.1	11.2	2,463	3,358	4,416	5,540	6,809
3% bio-diesel	12.2	16.6	21.9	27.4	33.7	7,388	10,073	13,249	16,619	20,427
5% bio-diesel	20.3	27.7	36.5	45.7	56.2	12,313	16,788	22,082	27,698	34,045
7% bio-diesel	28.5	38.8	51.1	64.0	78.7	17,239	23,504	30,915	38,777	47,662
10% bio-diesel	40.7	55.5	72.9	91.5	112.5	24,627	33,577	44,164	55,395	68,089
High Scenario										
Diesel consumption	473.4	745.9	1,118.8	1,598.1	2,235.7					
1% bio-diesel	4.7	7.5	11.2	16.0	22.4	2,866	4,516	6,774	9,675	13,536
3% bio-diesel	14.2	22.4	33.6	47.9	67.1	8,599	13,548	20,321	29,026	40,608
5% bio-diesel	23.7	37.3	55.9	79.9	111.8	14,331	22,579	33,869	48,376	67,680
7% bio-diesel	33.1	52.2	78.3	111.9	156.5	20,064	31,611	47,417	67,726	94,751
10% bio-diesel	47.3	74.6	111.9	159.8	223.6	28,663	45,159	67,738	96,752	135,359
Low Scenario										
Diesel consumption	348.8	402.9	455.1	493.7	524.6					
1% bio-diesel	3.5	4.0	4.6	4.9	5.2	2,112	2,439	2,755	2,989	3,176
3% bio-diesel	10.5	12.1	13.7	14.8	15.7	6,335	7,318	8,265	8,967	9,529
5% bio-diesel	17.4	20.1	22.8	24.7	26.2	10,558	12,196	13,776	14,946	15,882
7% bio-diesel	24.4	28.2	31.9	34.6	36.7	14,782	17,075	19,286	20,924	22,234
10% bio-diesel	34.9	40.3	45.5	49.4	52.5	21,117	24,393	27,551	29,891	31,763

From the Table it can be seen that in the most optimistic scenario of 10% substitution of diesel by bio-diesel from jathropha and high growth of fuel demand in the transport sector, one needs around 135,000 ha of jatropha by 2030. In the more realistic Reference scenario and 5% substitution, this amount reduces to circa 34,000 ha by 2030. Given the fact that the total agricultural area in Mozambique is around 48,600,000 million ha – of which currently around 6% is in use – total jatropha production for national bio-diesel consumption will even in the most optimistic scenario of 135,000ha by 2030, not exceed 0.2% of total agricultural land. Hence, bio-fuel induced crop production should in principle be no threat to food security – provided of course that current agricultural land is not substituted for jatropha production.

[3] Note that Nicolau (2007, p26) provides essentially the same number: 1380 - 2200kg.

To stimulate the introduction of cleaner fuels, fiscal policy is to be considered an important instrument. A principal aim of any fiscal policy regarding cleaner fuels is to guarantee that cleaner fuel prices remain below the conventional diesel price, for example below a factor 0.8 of the diesel price, in order to secure consumer demand and thus investments by the private sector. To achieve this, a key element of the fiscal strategy should be the introduction of a cross-subsidy mechanism into the fuel price structure such that in case of (very) low oil prices the petrol and diesel prices are topped up to cross-subsidize the price of cleaner fuels. Figure 22 shows the price of conventional diesel in Mozambique as a function of the international oil price, given the existing system of taxes and margins, in comparison with the estimated production costs of bio-diesel from jatropha and the price of CNG (excluding the specific fuel tax). The latter is calculated on the basis of information provided by Matola Gas Company and AutoGas with the assumed margins reflecting reasonable returns on their investments. The production price of bio-diesel from jatropha is calculated by assuming average production costs of 1150 US$ per hectare (Nicolau 2007, p27) and an average yield of 1892 liter per hectare (see above).

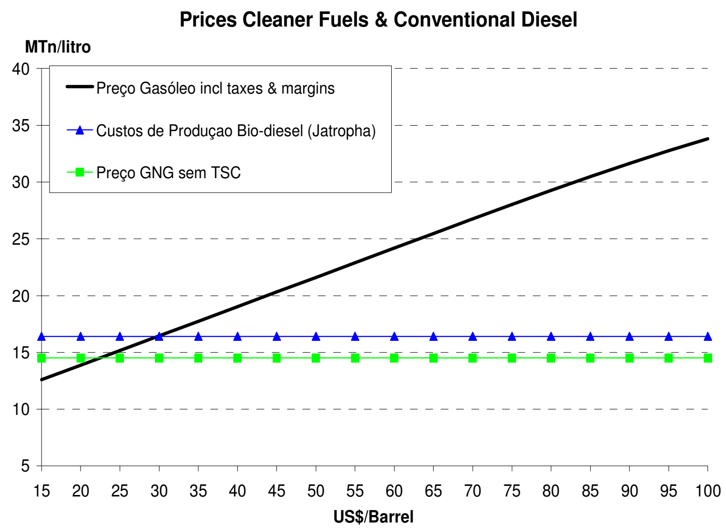

Figure 22. Price Cleaner Fuels and Conventional Diesel

From Figure 22 it can be seen that at any oil price higher than 40-45 US$/Barrel, cleaner fuels are likely to be considerable cheaper than conventional diesel. If oil prices drop below 40 US$/Barrel, than a mechanism should be in place to guarantee that cleaner fuels remain cheaper than conventional diesel. One way to do this is to introduce a cross-subsidy mechanism, such that diesel consumers pay an extra component on top of the market price which is used to subsidy the costs of cleaner fuels. A similar but slightly different option would be to include such a mechanism of compensation in either the margin of the retailer and/or distributor or in the design of the specific fuel tax. Regarding the latter, given the high price differential between diesel and cleaner fuels at oil prices of 50US$/Barrel and higher (as shown in Figure 22), one may consider the option to introduce a specific fuel tax on cleaner fuels as a function of this price differential. This means that the specific fuel tax varies with the difference between the price of diesel and cleaner fuels: if this price difference is high, than the specific fuel tax per litre is also high, if this price differential is low, than the specific fuel tax per litre is also low. In this way, the government can reap part of the consumer surplus of cleaner fuels (i.e. the benefits from a very low relative price).

8. New Energy Technologies

Currently the total installed capacity of solar energy in Mozambique is about 104kW. Figure 23 provides a percentage breakdown of this figure for the various provinces. About 25% of this is installed in the Sofala province, while the northern provinces of Niassa en Cabo Delgado together account for another 28%.

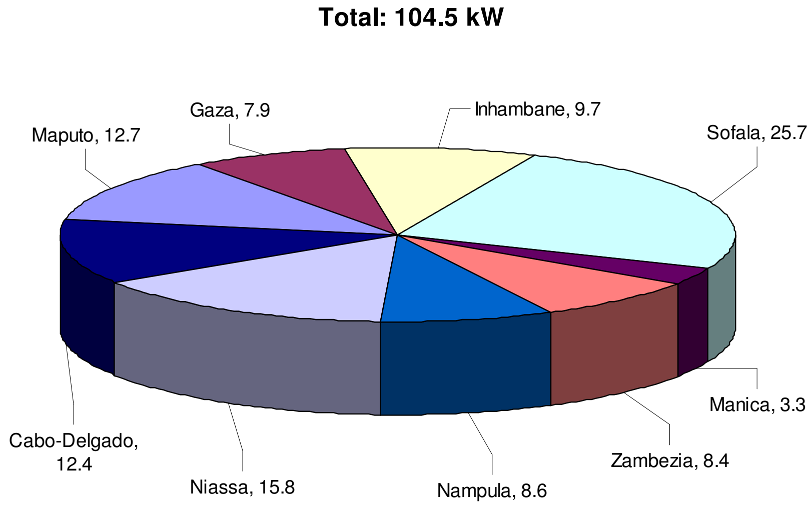

Figure 23. Installed Solar Energy Capacity Mozambique

Regarding the future, plans exist to promote new and renewable energy forms in an economically viable manner in order to increase productive capacity and social welfare in remote rural areas, through the diffusion of technologies like mini-hydro power systems, solar PV, bio-fuel based electricity generation and wind turbines. As an illustration, Table 8 provides an overview of the PARPA goals on the installation of Isolated Grids for education and health institutions in Mozambique.

Table 8. Planned Isolated Electricity Systems on basis of New Renewable Technologies

PARPA goals	**2006**	**2007**	**2008**	**2009**
# of education and health institutions	150	300	450	500

A principal challenge in promoting new and renewable energy technologies is to secure that the scale and geographical concentration of the aforementioned activities is such that this encourages the private sector to become involved in disseminating and maintaining systems that use solar power, small hydro power and wind power.

9. Megaprojects [4]

9.1 Overview

Mozambique's abundance in yet largely unexplored natural resources is attracting substantial foreign direct investments in large energy-intensive industries as well as in the mining, exploration and transformation sectors. These are projects of large dimensions, often referred to as 'mega projects'. So far, some mega projects have been realized, such as the Mozal aluminium smelter near the capital Maputo, while several new projects are planned or already under construction. It is to be expected that the recent transfer of the ownership the Cahora Bassa hydro dam from Portugal to Mozambique will accelerate the realization of various new mega projects, like for example the construction of the Mphanda Nkuwa hydro dam. Notwithstanding the importance of natural gas and coal, electricity is the key issue when talking about the development of existing and new mega projects. Figure 24 gives an overview of current and future electricity production in Mozambique, indicating a spectacular growth in production from about 10.000 GWh in 2000 to about 42.000 GWh as of 2014. [5]

Currently, virtually all electricity produced is hydro electricity generated by HCB. Since 1997 the production by HCB has gradually increased and is currently close to reach its maximum capacity (2075 megawatt). HCB is and will be the main producer of electricity in Mozambique, exporting about 80% of its production (mainly to South Africa) while the remaining 20% is acquired by the national electricity utility Electricidade de Moçambique (EdM). We may expect a second large hydro dam, Mphanda Nkuwa, to become operational in 2014 with a capacity of 1300 megawatt (MW), thereby increasing base-load hydroelectricity production capacity in Mozambique with more than 50%. Of its total capacity 650 MW will most likely go to the extension of Mozal (shortly referred to as Mozal III) while the other 650 MW will be

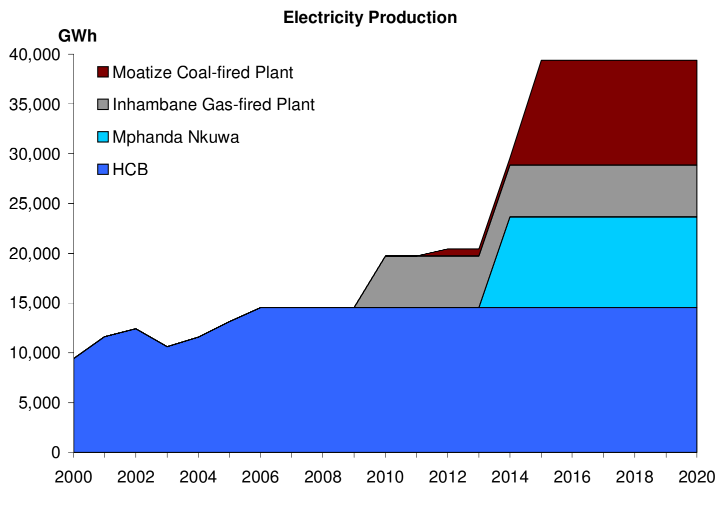

Figure 24 Electricity Production by Megaprojects

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[4] This section is based on Bucuane and Mulder (2007).

[5] Since peak-load is a very different market from base-load (and not suitable to serve base-load demand of mega projects) in Figure 21 we have not included HCB North.

exported. A third large hydro project in Mozambique with a capacity of 600 MW is HCB North, to be build at the north bank of HCB´s site. Probably to be realised somewhere between 2010-2015, HCB North is meant to meet peak-load demand in the SADC region. Another new mega project in the electricity sector is a 700 MW natural gas-fired electricity plant, fuelled by gas from the Pande/Temane fields, and expected to become operational in 2010. The most likely scenario is that initially all its electricity will be exported to South Africa, while as of 2014 about 100 MW might be acquired by EdM and as of 2017 an additional 200 MW might go to the Chibuto Heavy Sands project. Finally, the large-scale exploration of the Moatize coal mine in the near future has given rise to the possibility of constructing a coal-fired power station with a capacity of 1500 MW. It is to be expected that 1000 MW will become operational as of 2012 while the remaining 500 MW will probably be available as of 2015. We assume in this paper that about 10% of its electricity production will be consumed at the site of the Moatize coal mine itself and in the northern region of Mozambique, while 90% will be exported. In sum, the current and new electricity generation plants together account for a total base-load electricity production equivalent to 5575 MW and a total investment value of 5.7 billion US$ (for more details see Table A6.1 in Annex 6).

Most energy produced in Mozambique is exported. With respect to the coal from the Moatize mine, we expect 15% to be marketed in Mozambique, including consumption by the electricity plant, while the remainder will be exported for consumption by steel plants in Brazil (Yager, 2005). The vast majority of natural gas is and will be exported to South Africa, although domestic consumption tends to increase due to the realization in 2005 of a new pipeline to the Beleluane industrial park near Maputo and because of the natural gas-fired electricity plant to be constructed.

Also in terms of electricity, almost all production is exported. About 75% of Mozambique's major electricity generation site HCB is exported, mainly to South Africa but also to Zimbabwe and Botswana, and in the future also to Malawi. It is to be noted that this fact is due to the traditionally low domestic electricity demand as well as lack of transmission infrastructure from HCB (located in the northern Tete province) to the southern region of Mozambique – the economically most vibrant part of the country. Thus, electricity consumption in the

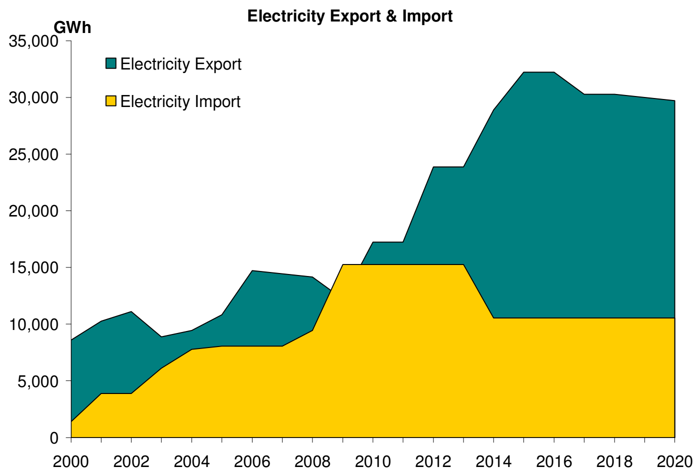

Figure 25 Electricity Export & Import by Megaprojects

southern part of Mozambique, including the large electricity consumption by Mozal has to be wheeled through South Africa, and/or imported from South Africa. As a result, we arrive at the somewhat peculiar fact that Mozambique is currently an (almost equally big) exporter as well as importer of electricity. As said before, the Moatize coal-fired electricity plant will mainly produce electricity for export (we assume 90%), implying a considerable increase in electricity exports as of 2012 (see Figure 25). As mentioned before, the new natural gas-fired electricity plant is expected to produce primarily for export (see also below), while in the long run it will presumably also deliver electricity to EdM and the Chibuto heavy sands mine.

Concerning energy imports, those consist in Mozambique primarily of oil products and electricity. Given the absence of refineries, all domestic consumption of fuels is imported. Electricity imports have been rapidly increasing since 2000, mainly due to the start of Mozal, which imports its electricity consumption from South Africa. From Figure 25 it can be seen that electricity import will increase substantially between 2009 and 2014. This is mainly due to the foreseen realization of Mozal III in 2009, which depends on electricity imports from South Africa until the Mphanda Nkuwa dam can take over electricity delivery as of 2014. The second-most likely scenario here is that Mozal III will fail to import its electricity from South Africa due to the severe capacity problems of ESKOM, in which case we may expect the natural gas-fired electricity plant to supply Mozal III until 2014 instead of exporting its electricity. Finally, we assume that the Chibuto Heavy Sands mine in Gaza province, which is expected to start in 2009, will also import its electricity initially from South Africa.[6]

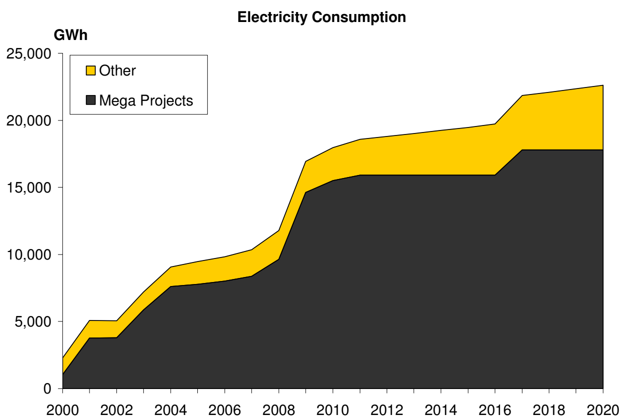

Figure 26

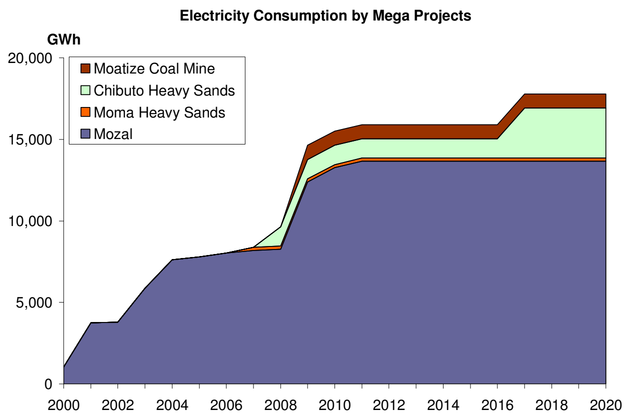

Figure 27

The various mega projects (will) consume large amounts of electricity, about 6 – 9 times as much as the rest of the country all together. This dual nature of the Mozambican electricity market is

[6] The latest news is that the most energy intensive processing part of the Chibuto mining operations will take place close to the Mozal site near Maputo (instead of in Chibuto), with electricity supplied by Motraco from South Africa.

illustrated in Figure 26. A breakdown of electricity consumption by megaprojects is provided in Figure 27. From the Figure it can be seen that by and large Mozal is and will be the main electricity consumer in Mozambique. As mentioned before, Mozal operates since 2000 (constructed in two phases, shortly referred to as Mozal I+II) while we assume that Mozal III starts to operate in 2009. Furthermore, we assume the Moma Heavy Sands mine to start in 2007, receiving its electricity from HCB through a newly constructed transmission line from Nampula. We suppose that the Chibuto Heavy Sands mine starts in 2009, with a second phase starting in 2017. Finally, we assume the Moatize coal mine to start operating in 2009. Initially they will be supplied by HCB, while the new coal fired plant is expected to take over electricity supply as of 2012. Together these mega projects account for a total electricity consumption equivalent to 1882 MW and a total investment value of 5.5 billion US$ (for more details see Table A6.2 in Annex 6).[7]

9.2 Cross-subsidy scheme and Megaprojects

To facilitate the availability and affordability of electricity in rural areas, EdM currently applies a cross-subsidy scheme consisting of two components. First, the electricity tariff applied to domestic consumers is progressive, meaning that large consumers pay a higher price per unit than small consumers. Second, there is a uniform tariff structure across the country, while costs of supplying electricity vary considerably – costs per unit are much higher in remote rural areas than in densely populated urban centers. This in effect implies a cross-subsidy from the southern and also the central region to the northern region of Mozambique. The current rural electrification program will imply that the current cross-subsidy scheme will come under great pressure over the next years because of the relatively sharp increasing number of small (poor) customers in remote areas. One way to solve this problem is to extend the cross-subsidy scheme such that it also includes mega projects. There are a number of good reasons to justify this strategy: 1) Rural electrification generates substantial positive externalities, originating from increased productivity in the private sector, freeing up time and labour for education and/or income generating activities, and improved health and environmental conditions; 2) Due to the high costs of rural electrification, without subsidies there will be underinvestment in expanding the national grid from a social point of view, given the aforementioned positive externalities; 3) Mega projects enjoy substantial private benefits from consuming large quantities of cheap electricity while their positive impact on the Mozambican is currently very limited (due to their

[7] Recently the Norwegian energy company NorskHydro relaunched the plan for a second aluminum smelter in Mozambique, most likely to be located at the port of Nacala in the northern province of Nampula. Electricity is supposed to be supplied by the Moatize coal-fired plant that presumably becomes operational as of 2012. The plan is, however, too premature to be included in our analysis.

capital-intensive character); moreover, their current tax treatment can be considered as exceptionally generous; 4) Against international standards, mega projects pay a very low electricity price, and a small mark-up on this price will by no means jeopardize the highly profitable business opportunities they are currently experiencing.

With respect to the latter, Figure 28 shows that whereas the average EdM tariff of 5.12 US$c/kWh to small and medium sized enterprises in Mozambique is already low in international perspective, Mozal pays only 1.03 US$c/kWh and the Chibuto and Moma heavy sands project are paying 2.3 and 2.05 US$c/kWh, respectively.[8] Hence, any reasonably moderate electricity tax, like for example 0.1USDc/ kWh, will not change this picture. When we look at energy taxes in domestic perspective it is to be noted that EdM's industrial and commercial customers pay a monthly fixed tax, which translates ii

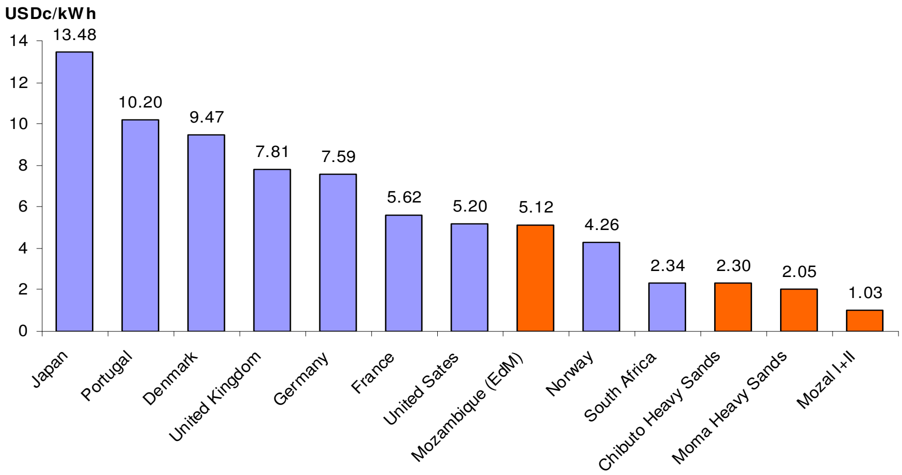

Figure 28. Industrial electricity prices of Mozambique in international perspective

monthly fixed tax implies an effective tax rate of 5-10%, depending on the level of electricity consumption.[10] Moreover, all EdM customers are due to pay an additional 17% VAT. In contrast, the mega projects currently pay no electricity tax while also enjoying (general or specific) VAT exemptions.

Since the idea behind inclusion of megaprojects into the cross-subsidy scheme is to ensure the social benefits of the presence of mega projects in Mozambique, one may consider the option that if mega projects invest themselves in transmission lines that benefit (rural) electrification by extending and

---

[8] Source: EdM 2006, personal communication. It is to be noted that the Moma Heavy Sands project pays a nominal electricity tariff of 0.9 US$c/kWh to EdM. However, Moma constructed the required 200km transmission line originating from Nampula itself at a cost of about US$ 13 milion. Given a 30-year economic lifetime of the line, a discount rate of 10% and 193 GWh annual electricity consumption this yields 1.15 US$c/kWh. Hence, the effective electricity tariff to Moma is about 2.05 US$c/kWh (0.90 + 1.15 US$c/kWh).

[9] Source: own calculations, based on Ministério da Energia (2007a,b).

[10] Source: own calculations, based on Ministério da Energia (2007a,b). Note that residential customers eligible to the social tariff are exempted from the monthly tax.

strengthening the national grid, they are allowed to deduct these costs from the additional costs they are supposed to pay as a result of their inclusion in EdM's cross-subsidy scheme.

Table 9 shows the potential benefits of including mega projects into the cross-subsidy scheme against a rate of 0.1 USDc/kWh. If all mega projects listed in the table are included, the total annual revenue will be 15.5 million US$.

Table 9. Revenue from including mega projects in cross-subsidy scheme at a 0.1USDc/kWh rate

0.1 USDc/kWh Tax	Mozal I+II	Mozal III	Moma	Chibuto I	Chibuto II	Moatize	TOTAL
Price (USDc/kWh)	1.03	1.50 / 2.70	0.90	2.30	2.30	2.50	
After Tax Price (USDc/kWh)	1.13	1.60 / 2.80	1.00	2.40	2.40	2.60	
Average Annual Tax (million USD)	7.8	5.1	0.2	1.3	1.4	0.9	15.5
Cummulative Tax 2007-2020 (million USD)	108.9	71.4	2.7	16.4	5.5	11.5	216.4
% contribution	50.3%	33.0%	1.2%	7.6%	2.5%	5.3%	

Furthermore it can be seen from the Table that the largest burden will fall on Mozal. Since Mozal I+II does not receive it electricity from EdM through the national grid, one may consider to exclude Mozal I+II from the cross-subsidy scheme. As a result, total annual revenues will fall to 7.7 million US$, which is still a considerable amount of money.

9.3 Rural Electrification Fund and Megaprojects

An other option to ensure that a fair part of the benefits resulting from the development of natural resources through mega projects is guaranteed for Mozambique, is to levy 0.1 USDc/kWh on electricity produced by large-scale electricity generation plants (>300MW) to create a Rural Electrification Fund aiming to finance the establishment and rehabilitation of small isolated grids. This means that megaprojects will subsidy the costs of electricity supply to small consumers (in rural areas) in areas where connections to the national grid will not take place within a reasonable time, thereby contributing to economic growth and poverty reduction. There are a number of good reasons to justify this strategy: 1) Rural electrification generates substantial positive externalities, originating from increased productivity in the private sector, freeing up time and labour for education and/or income generating activities, and improved health and environmental conditions; 2) Due to the high costs of rural electrification through isolated grids, without subsidies there will be underinvestment in expanding the number of isolated grids from a social point of view, given the aforementioned positive externalities; 3) Electricity production is known for its substantial negative impact on the environment, particularly in the case of fossil-fuel based electricity generation. Taxing energy is an important instrument to internalize these negative externalities, and is widely used throughout the world; 4) By and large the burden of a levy on electricity production in Mozambique will fall on neighbouring countries due to the large share of electricity generation earmarked for export. The regional electricity market provides ample space to increase electricity prices without compromising Mozambique's comparative advantage in electricity production, due to the combination of excess demand for electricity in the region and the relatively low price of electricity production in Mozambique as compared to neighbouring countries.

Regarding the latter point, in principle there is no need to tax exports of electricity. After all, Mozambique has a typical comparative advantage in producing cheap electricity, and classical trade theory suggests that increasing trade in this good will then enhance welfare. More specifically, increasing exports help to improve the balance of payment, which currently shows a considerable deficit. However, there will be no complete trade-off between export benefits and tax benefits because of the low electricity prices in Mozambique. To illustrate this point, Figure 29 compares the electricity generation costs in Mozambique, including a tax of 0.1 US$c/kWh, with those in South Africa, by far the most important buyer of Mozambican electricity.[11] The Figure shows that the relatively low costs of electricity generation in Mozambique, thanks to abundant natural resources, provide ample space to sustain its comparative advantage in electricity production, even after including a tax levy of 0.2 US$c/kWh. This is particular true for hydro electricity while room for price increases is smallest for coal based-electricity.

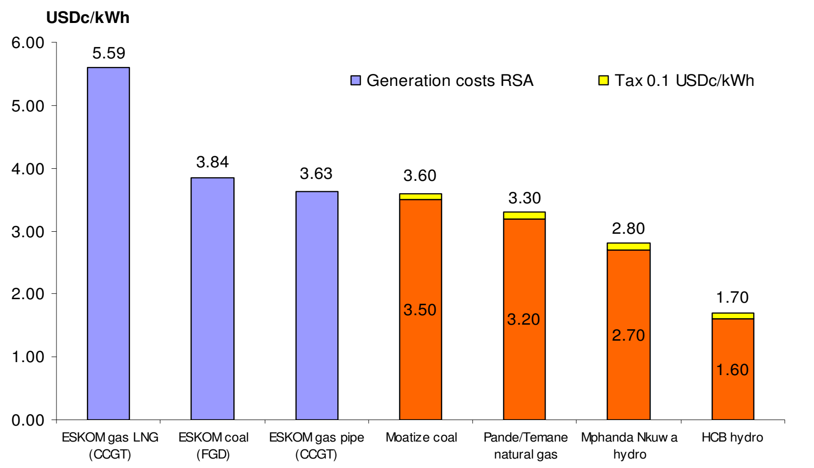

Figure 30. Electricity generation prices Mozambique and South Africa

Of course, Mozambique has to be careful with increasing its prices of electricity exports to South Africa, for the very reason that Mozambique depends on South Africa to sell its electricity, due to the combination of excess production capacity in Mozambique and the dominance of South Africa on the regional electricity market. This evidently places South Africa in a comfortable position to negotiate low prices for its electricity imports, a situation that has characterised the past and in particular the last decade during which South Africa had considerable excess capacity of its own. This situation, however, is rapidly changing with South Africa entering a situation of excess demand (NER

[11] Source: NER 2004.

2004, SAPP 2005). In spite of (a relatively cheap) increase of production capacity in South Africa until 2010 in the form of returning several mothballed units to service, South Africa continues to face excess demand that can only be satisfied by a further increase in generation capacity. As shown in Figure 27, electricity generation costs in Mozambique are (highly) competitive even after taxation, implying that Mozambique is rapidly gaining market power in the regional electricity market, also after 2010.

Table 10 shows the potential benefits of a 0.1 USDc/kWh levy on electricity production by megaprojects. If all mega projects listed in the table are included, the total annual revenue will be 31.5 million US$.

Table 10. Revenue from a 0.1 USDc/kWh levy on electricity generation by megaprojects

	Natural Gas *Inhambane*	**Coal** *Moatize*	**Hydro** *HCB*	**Hydro** *Mphanda Nkuwa*	**TOTAL**
Price (USDc/kWh)	3.20	3.50	1.43	2.70	
After Tax Price (USDc/kWh)	3.30	3.60	1.53	2.80	
Average Annual Tax (million USD)	5.2	8.4	16.4	9.9	**31.5**
Cummulative Tax 2007-2020 (million USD)	57.3	84.1	229.7	69.4	**440.5**
% contribution	13.0%	19.1%	52.2%	15.7%	

For more details I refer to Bucuane and Mulder (2007).

10. Conclusion

The energy sector in Mozambique is changing rapidly, with further growth and expansion to be expected during the next decade and beyond. In this paper I have provided some figures and numbers for the various dimensions of the Mozambican energy sector in order to document key developments and potential scenarios with the purpose to facilitate policy making in the future. The document has been written as a background to the new Strategy for the Energy Sector 2008-2012. Obviously, there is room for further exploration of the future of the energy sector in Mozambique. In my view, future research could be particularly useful in the area of new and renewable technologies and (bio-)fuels.

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ANNEX 1 – Population

Table A1.1 Population

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population (thousands)											
INE	17,241	19,420	21,854	24,518	27,439						
UN High variant	18,194	20,533	22,817	25,199	27,764	30,447	33,277	36,234	39,297	42,450	45,694
UN Medium variant	18,194	20,533	22,635	24,698	26,809	28,954	31,117	33,232	35,267	37,223	39,117
UN Low variant	18,194	20,533	22,452	24,197	25,853	27,466	28,981	30,311	31,426	32,348	33,115
Population Urban											
UN Medium variant (%)	32.1%	38.0%	43.5%	48.5%	52.8%	56.5%	60.0%				
UN Medium variant (thousands)	5,840	7,803	9,846	11,979	14,155	16,359	18,670				
Population Rural											
UN Medium variant (%)	67.9%	62.0%	56.5%	51.5%	47.2%	43.5%	40.0%				
UN Medium variant (thousands)	12,354	12,730	12,789	12,719	12,654	12,595	12,447				
Population Growth (annual %)											
INE	2.4%	2.4%	2.4%	2.3%	2.3%						
UN High variant	2.6%	2.3%	2.0%	1.9%	1.9%	1.8%	1.7%	1.7%	1.6%	1.5%	1.4%
UN Medium variant	2.6%	2.3%	1.9%	1.7%	1.6%	1.5%	1.4%	1.3%	1.2%	1.1%	1.0%
UN Low variant	2.6%	2.3%	1.7%	1.5%	1.3%	1.2%	1.1%	0.9%	0.7%	0.6%	0.5%

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Number of Households (million)											
Household size: 5 (INE)											
INE (5)	3.45	3.88	4.37	4.90	5.49						
UN High variant (5)	3.64	4.11	4.56	5.04	5.55	6.09	6.66	7.25	7.86	8.49	9.14
UN Medium variant (5)	3.64	4.11	4.53	4.94	5.36	5.79	6.22	6.65	7.05	7.44	7.82
Urban (5)	1.17	1.56	1.97	2.40	2.83	3.27	3.73				
Rural (5)	2.47	2.55	2.56	2.54	2.53	2.52	2.49				
UN Low variant (5)	3.64	4.11	4.49	4.84	5.17	5.49	5.80	6.06	6.29	6.47	6.62
Household size: 4											
INE (4)	4.31	4.86	5.46	6.13	6.86						
UN High variant (4)	4.55	5.13	5.70	6.30	6.94	7.61	8.32	9.06	9.82	10.61	11.42
UN Medium variant (4)	4.55	5.13	5.66	6.17	6.70	7.24	7.78	8.31	8.82	9.31	9.78
Urban (4)	1.46	1.95	2.46	2.99	3.54	4.09	4.67				
Rural (4)	3.09	3.18	3.20	3.18	3.16	3.15	3.11				
UN Low variant (4)	4.55	5.13	5.61	6.05	6.46	6.87	7.25	7.58	7.86	8.09	8.28

ANNEX 2 – Access to electricity

Table A2.1 Percentage of Population with Access to the National Grid, if household size = 5

Number of Residential Customers (thousands) if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	173	302	573	823	1,073	1,323	1,573	1,823	2,073	2,323	2,573
70,000	173	302	653	1,003	1,353	1,703	2,053	2,403	2,753	3,103	3,453
100,000	173	302	773	1,273	1,773	2,273	2,773	3,273	3,773	4,273	4,773
150,000	173	302	973	1,723	2,473	3,223	3,973	4,723	5,473	6,223	6,973
200,000	173	302	1,173	2,173	3,173	4,173	5,173	6,173	7,173	8,173	9,173

Access % using the INE Population Projections (2.4%-2.3%), and household size = 5

if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	5.0%	7.8%	13.1%	16.8%	19.5%						
70,000	5.0%	7.8%	14.9%	20.4%	24.6%						
100,000	5.0%	7.8%	17.7%	26.0%	32.3%						
150,000	5.0%	7.8%	22.3%	35.1%	45.1%						
200,000	5.0%	7.8%	26.8%	44.3%	57.8%						

Access % using the UN Population Projections High variant (2.6%-1.4%), and household size = 5

if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	4.8%	7.4%	12.5%	16.3%	19.3%	21.7%	23.6%	25.2%	26.4%	27.4%	28.2%
70,000	4.8%	7.4%	14.3%	19.9%	24.4%	28.0%	30.8%	33.2%	35.0%	36.5%	37.8%
100,000	4.8%	7.4%	16.9%	25.3%	31.9%	37.3%	41.7%	45.2%	48.0%	50.3%	52.2%
150,000	4.8%	7.4%	21.3%	34.2%	44.5%	52.9%	59.7%	65.2%	69.6%	73.3%	76.3%
200,000	4.8%	7.4%	25.7%	43.1%	57.1%	68.5%	77.7%	85.2%	91.3%	96.3%	100.4%

Access % using the UN Population Projections Medium variant (2.6%-1.0%), and household size = 5

if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	4.8%	7.4%	12.6%	16.7%	20.0%	22.8%	25.3%	27.4%	29.4%	31.2%	32.9%
70,000	4.8%	7.4%	14.4%	20.3%	25.2%	29.4%	33.0%	36.1%	39.0%	41.7%	44.1%
100,000	4.8%	7.4%	17.1%	25.8%	33.1%	39.2%	44.6%	49.2%	53.5%	57.4%	61.0%
150,000	4.8%	7.4%	21.5%	34.9%	46.1%	55.7%	63.8%	71.1%	77.6%	83.6%	89.1%
200,000	4.8%	7.4%	25.9%	44.0%	59.2%	72.1%	83.1%	92.9%	101.7%	109.8%	117.2%

Access % using the UN Population Projections Low variant (2.6%-0.5%), and household size = 5

if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	4.8%	7.4%	12.8%	17.0%	20.7%	24.1%	27.1%	30.1%	33.0%	35.9%	38.8%
70,000	4.8%	7.4%	14.5%	20.7%	26.2%	31.0%	35.4%	39.6%	43.8%	48.0%	52.1%
100,000	4.8%	7.4%	17.2%	26.3%	34.3%	41.4%	47.8%	54.0%	60.0%	66.0%	72.1%
150,000	4.8%	7.4%	21.7%	35.6%	47.8%	58.7%	68.5%	77.9%	87.1%	96.2%	105.3%
200,000	4.8%	7.4%	26.1%	44.9%	61.4%	76.0%	89.2%	101.8%	114.1%	126.3%	138.5%

Table A2.2 Percentage of Population with Access to the National Grid, if household size = 4

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Number of Residential Customers (thousands)											
if # of new connections per year:											
50,000	173	302	573	823	1,073	1,323	1,573	1,823	2,073	2,323	2,573
70,000	173	302	653	1,003	1,353	1,703	2,053	2,403	2,753	3,103	3,453
100,000	173	302	773	1,273	1,773	2,273	2,773	3,273	3,773	4,273	4,773
150,000	173	302	973	1,723	2,473	3,223	3,973	4,723	5,473	6,223	6,973
200,000	173	302	1,173	2,173	3,173	4,173	5,173	6,173	7,173	8,173	9,173
Access % using the INE Population Projections (2.4%-2.3%), and household size = 4											
if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	4.0%	6.2%	10.5%	13.4%	15.6%						
70,000	4.0%	6.2%	11.9%	16.4%	19.7%						
100,000	4.0%	6.2%	14.1%	20.8%	25.8%						
150,000	4.0%	6.2%	17.8%	28.1%	36.0%						
200,000	4.0%	6.2%	21.5%	35.4%	46.2%						
Access % using the UN Population Projections High variant (2.6%-1.4%), and household size = 4											
if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	3.8%	5.9%	10.0%	13.1%	15.5%	17.4%	18.9%	20.1%	21.1%	21.9%	22.5%
70,000	3.8%	5.9%	11.4%	15.9%	19.5%	22.4%	24.7%	26.5%	28.0%	29.2%	30.2%
100,000	3.8%	5.9%	13.5%	20.2%	25.5%	29.9%	33.3%	36.1%	38.4%	40.3%	41.8%
150,000	3.8%	5.9%	17.1%	27.3%	35.6%	42.3%	47.8%	52.1%	55.7%	58.6%	61.0%
200,000	3.8%	5.9%	20.6%	34.5%	45.7%	54.8%	62.2%	68.1%	73.0%	77.0%	80.3%
Access % using the UN Population Projections Medium variant (2.6%-1.0%), and household size 4											
if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	3.8%	5.9%	10.1%	13.3%	16.0%	18.3%	20.2%	21.9%	23.5%	25.0%	26.3%
70,000	3.8%	5.9%	11.5%	16.2%	20.2%	23.5%	26.4%	28.9%	31.2%	33.3%	35.3%
100,000	3.8%	5.9%	13.7%	20.6%	26.4%	31.4%	35.6%	39.4%	42.8%	45.9%	48.8%
150,000	3.8%	5.9%	17.2%	27.9%	36.9%	44.5%	51.1%	56.8%	62.1%	66.9%	71.3%
200,000	3.8%	5.9%	20.7%	35.2%	47.3%	57.6%	66.5%	74.3%	81.4%	87.8%	93.8%
Access % using the UN Population Projections Low variant (2.6%-0.5%), and household size = 4											
if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
50,000	3.8%	5.9%	10.2%	13.6%	16.6%	19.3%	21.7%	24.1%	26.4%	28.7%	31.1%
70,000	3.8%	5.9%	11.6%	16.6%	20.9%	24.8%	28.3%	31.7%	35.0%	38.4%	41.7%
100,000	3.8%	5.9%	13.8%	21.0%	27.4%	33.1%	38.3%	43.2%	48.0%	52.8%	57.6%
150,000	3.8%	5.9%	17.3%	28.5%	38.3%	46.9%	54.8%	62.3%	69.7%	76.9%	84.2%
200,000	3.8%	5.9%	20.9%	35.9%	49.1%	60.8%	71.4%	81.5%	91.3%	101.1%	110.8%

Table A2.3 Percentage of Population with Access to Isolated Grids,
if household size = 5, and number of customers per generator = 100

Number of Residential Customers if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
100	3,000	9,000	9,400	9,900	10,400	10,900	11,400	11,900	12,400	12,900	13,400
500	3,000	9,000	11,000	13,500	16,000	18,500	21,000	23,500	26,000	28,500	31,000
1,000	3,000	9,000	13,000	18,000	23,000	28,000	33,000	38,000	43,000	48,000	53,000
2,000	3,000	9,000	17,000	27,000	37,000	47,000	57,000	67,000	77,000	87,000	97,000
3,000	3,000	9,000	21,000	36,000	51,000	66,000	81,000	96,000	111,000	126,000	141,000

Access % using the INE Population Projections (2.4%-2.3%), and household size = 5

if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
100	0.09%	0.23%	0.22%	0.20%	0.19%						
500	0.09%	0.23%	0.25%	0.28%	0.29%						
1,000	0.09%	0.23%	0.30%	0.37%	0.42%						
2,000	0.09%	0.23%	0.39%	0.55%	0.67%						
3,000	0.09%	0.23%	0.48%	0.73%	0.93%						

Access % using the UN Population Projections High variant (2.6%-1.4%), and household size = 5

if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
100	0.08%	0.22%	0.21%	0.20%	0.19%	0.18%	0.17%	0.16%	0.16%	0.15%	0.15%
500	0.08%	0.22%	0.24%	0.27%	0.29%	0.30%	0.32%	0.32%	0.33%	0.34%	0.34%
1,000	0.08%	0.22%	0.28%	0.36%	0.41%	0.46%	0.50%	0.52%	0.55%	0.57%	0.58%
2,000	0.08%	0.22%	0.37%	0.54%	0.67%	0.77%	0.86%	0.92%	0.98%	1.02%	1.06%
3,000	0.08%	0.22%	0.46%	0.71%	0.92%	1.08%	1.22%	1.32%	1.41%	1.48%	1.54%

Access % using the UN Population Projections Medium variant (2.6%-1.0%), and household size = 5

if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
100	0.08%	0.22%	0.21%	0.20%	0.19%	0.19%	0.18%	0.18%	0.18%	0.17%	0.17%
500	0.08%	0.22%	0.24%	0.27%	0.30%	0.32%	0.34%	0.35%	0.37%	0.38%	0.40%
1,000	0.08%	0.22%	0.29%	0.36%	0.43%	0.48%	0.53%	0.57%	0.61%	0.64%	0.68%
2,000	0.08%	0.22%	0.38%	0.55%	0.69%	0.81%	0.92%	1.01%	1.09%	1.17%	1.24%
3,000	0.08%	0.22%	0.46%	0.73%	0.95%	1.14%	1.30%	1.44%	1.57%	1.69%	1.80%

Access % using the UN Population Projections Low variant (2.6%-0.5%), and household size = 5

if # of new connections per year:	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
100	0.08%	0.22%	0.21%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%
500	0.08%	0.22%	0.24%	0.28%	0.31%	0.34%	0.36%	0.39%	0.41%	0.44%	0.47%
1,000	0.08%	0.22%	0.29%	0.37%	0.44%	0.51%	0.57%	0.63%	0.68%	0.74%	0.80%
2,000	0.08%	0.22%	0.38%	0.56%	0.72%	0.86%	0.98%	1.11%	1.23%	1.34%	1.46%
3,000	0.08%	0.22%	0.47%	0.74%	0.99%	1.20%	1.40%	1.58%	1.77%	1.95%	2.13%

Table A2.4 Percentage of Population with Access to Isolated Grids,
if household size = 4, and number of customers per generator = 100

Number of Residential Customers	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
if # of new connections per year:											
100	3,000	9,000	9,400	9,900	10,400	10,900	11,400	11,900	12,400	12,900	13,400
500	3,000	9,000	11,000	13,500	16,000	18,500	21,000	23,500	26,000	28,500	31,000
1,000	3,000	9,000	13,000	18,000	23,000	28,000	33,000	38,000	43,000	48,000	53,000
2,000	3,000	9,000	17,000	27,000	37,000	47,000	57,000	67,000	77,000	87,000	97,000
3,000	3,000	9,000	21,000	36,000	51,000	66,000	81,000	96,000	111,000	126,000	141,000

Access % using the INE Population Projections (2.4%-2.3%), and household size = 4

if # of new connections per year:	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
100	0.07%	0.19%	0.17%	0.16%	0.15%						
500	0.07%	0.19%	0.20%	0.22%	0.23%						
1,000	0.07%	0.19%	0.24%	0.29%	0.34%						
2,000	0.07%	0.19%	0.31%	0.44%	0.54%						
3,000	0.07%	0.19%	0.38%	0.59%	0.74%						

Access % using the UN Population Projections High variant (2.6%-1.4%), and household size = 4

if # of new connections per year:	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
100	0.07%	0.18%	0.16%	0.16%	0.15%	0.14%	0.14%	0.13%	0.13%	0.12%	0.12%
500	0.07%	0.18%	0.19%	0.21%	0.23%	0.24%	0.25%	0.26%	0.26%	0.27%	0.27%
1,000	0.07%	0.18%	0.23%	0.29%	0.33%	0.37%	0.40%	0.42%	0.44%	0.45%	0.46%
2,000	0.07%	0.18%	0.30%	0.43%	0.53%	0.62%	0.69%	0.74%	0.78%	0.82%	0.85%
3,000	0.07%	0.18%	0.37%	0.57%	0.73%	0.87%	0.97%	1.06%	1.13%	1.19%	1.23%

Access % using the UN Population Projections Medium variant (2.6%-1.0%), and household size = 4

if # of new connections per year:	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
100	0.07%	0.18%	0.17%	0.16%	0.16%	0.15%	0.15%	0.14%	0.14%	0.14%	0.14%
500	0.07%	0.18%	0.19%	0.22%	0.24%	0.26%	0.27%	0.28%	0.29%	0.31%	0.32%
1,000	0.07%	0.18%	0.23%	0.29%	0.34%	0.39%	0.42%	0.46%	0.49%	0.52%	0.54%
2,000	0.07%	0.18%	0.30%	0.44%	0.55%	0.65%	0.73%	0.81%	0.87%	0.93%	0.99%
3,000	0.07%	0.18%	0.37%	0.58%	0.76%	0.91%	1.04%	1.16%	1.26%	1.35%	1.44%

Access % using the UN Population Projections Low variant (2.6%-0.5%), and household size = 4

if # of new connections per year:	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
100	0.07%	0.18%	0.17%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%
500	0.07%	0.18%	0.20%	0.22%	0.25%	0.27%	0.29%	0.31%	0.33%	0.35%	0.37%
1,000	0.07%	0.18%	0.23%	0.30%	0.36%	0.41%	0.46%	0.50%	0.55%	0.59%	0.64%
2,000	0.07%	0.18%	0.30%	0.45%	0.57%	0.68%	0.79%	0.88%	0.98%	1.08%	1.17%
3,000	0.07%	0.18%	0.37%	0.60%	0.79%	0.96%	1.12%	1.27%	1.41%	1.56%	1.70%

ANNEX 3 – Demand for Electricity - Commercial

Table A3.1. Electricity Demand and Activity Level SERVICE SECTOR – Historical Data & Assumptions

1. Elec. Demand	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**Aver. 02-05**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference													
GWh	372.6	373.5	383.7	407.6	418.6	461.1							
energy intensity growth (%)		-14.5%	-2.8%	3.9%	-1.2%	3.5%	0.9%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
High Demand													
GWh	372.6	373.5	383.7	407.6	418.6	461.1							
energy intensity growth (%)		-14.5%	-2.8%	3.9%	-1.2%	3.5%	0.9%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Low Demand													
GWh	372.6	373.5	383.7	407.6	418.6	461.1							
energy intensity growth (%)		-14.5%	-2.8%	3.9%	-1.2%	3.5%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2. Activity Level	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**Aver. 02-05**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	7.5%	7.0%	6.0%	5.0%	4.0%	4.0%
US$ (million)	1,425	1,671	1,765	1,805	1,876	2,005							
% of GDP	39.6%	40.5%	39.5%	37.6%	36.5%	36.3%	37.4%	36.0%	37.5%	39.4%	41.3%	43.1%	**45.0%**
High Growth													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	9.5%	9.0%	8.0%	7.0%	6.0%	6.0%
US$ (million)	1,425	1,671	1,765	1,805	1,876	2,005							
% of GDP	39.6%	40.5%	39.5%	37.6%	36.5%	36.3%	37.4%	36.0%	38.3%	41.3%	44.2%	47.1%	**50.0%**
Low Growth													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	5.5%	5.0%	4.0%	3.0%	2.0%	2.0%
US$ (million)	1,425	1,671	1,765	1,805	1,876	2,005							
% of GDP	39.6%	40.5%	39.5%	37.6%	36.5%	36.3%	37.4%	36.0%	36.7%	37.5%	38.3%	39.2%	**40.0%**

* At national level

Table A3.2. Electricity Demand and Activity Level INDUSTRY (excl Mozal) – Historical Data & Assumptions

1. Elec. Demand	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**Aver. 02-05**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference													
GWh	248.4	249.0	255.8	271.8	279.1	307.4							
energy intensity growth (%)		-10.2%	-2.4%	-0.3%	1.6%	1.2%	0.04%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
High Demand													
GWh	248.4	249.0	255.8	271.8	279.1	307.4							
energy intensity growth (%)		-10.2%	-2.4%	-0.3%	1.6%	1.2%	0.04%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Low Demand													
GWh	248.4	249.0	255.8	271.8	279.1	307.4							
energy intensity growth (%)		-10.2%	-2.4%	-0.3%	1.6%	1.2%	0.04%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
2. Activity Level	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**Aver. 02-05**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	7.5%	7.0%	6.0%	5.0%	4.0%	4.0%
US$ (million)	664	760	800	888	891	959							
% of GDP	18.5%	18.4%	17.9%	18.5%	17.3%	17.3%	17.8%	17.5%	17.9%	18.4%	19.0%	19.5%	**20.0%**
High Growth													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	9.5%	9.0%	8.0%	7.0%	6.0%	6.0%
US$ (million)	664	760	800	888	891	959							
% of GDP	18.5%	18.4%	17.9%	18.5%	17.3%	17.3%	17.8%	17.5%	18.8%	20.3%	21.9%	23.4%	**25.0%**
Low Growth													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	5.5%	5.0%	4.0%	3.0%	2.0%	2.0%
US$ (million)	664	760	800	888	891	959							
% of GDP	18.5%	18.4%	17.9%	18.5%	17.3%	17.3%	17.8%	17.5%	17.1%	16.6%	16.0%	15.5%	**15.0%**

* At national level

ANNEX 4 – Total Electricity Demand

Table A4.1. Electricity Distribution – Losses & Own Consumption (EdM)

% of total	Historical Data							Assumptions					
Reference	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Losses	18.9%	18.7%	20.1%	23.9%	23.1%	21.5%	19.0%	19.0%	17.8%	16.4%	14.9%	13.5%	12.0%
Public Lighting	1.7%	1.9%	1.8%	1.5%	1.7%	2.5%	1.8%	1.8%	1.7%	1.5%	1.3%	1.2%	1.0%
Own Consumption	6.6%	7.8%	6.9%	3.7%	1.3%	1.7%	0.8%	0.8%	0.7%	0.7%	0.6%	0.6%	0.5%
TOTAL	27.2%	28.4%	28.7%	29.1%	26.1%	25.8%	21.6%	21.6%	20.2%	18.6%	16.9%	15.2%	13.5%
High Scenario													
Losses	18.9%	18.7%	20.1%	23.9%	23.1%	21.5%	19.0%	19.0%	18.2%	17.1%	16.1%	15.0%	14.0%
Public Lighting	1.7%	1.9%	1.8%	1.5%	1.7%	2.5%	1.8%	1.8%	1.7%	1.7%	1.6%	1.6%	1.5%
Own Consumption	6.6%	7.8%	6.9%	3.7%	1.3%	1.7%	0.8%	0.8%	0.8%	0.8%	0.7%	0.7%	0.7%
TOTAL	27.2%	28.4%	28.7%	29.1%	26.1%	25.8%	21.6%	21.6%	20.7%	19.6%	18.4%	17.3%	16.2%
Low Scenario													
Losses	18.9%	18.7%	20.1%	23.9%	23.1%	21.5%	19.0%	19.0%	17.5%	15.6%	13.8%	11.9%	10.0%
Public Lighting	1.7%	1.9%	1.8%	1.5%	1.7%	2.5%	1.8%	1.8%	1.6%	1.3%	1.0%	0.8%	0.5%
Own Consumption	6.6%	7.8%	6.9%	3.7%	1.3%	1.7%	0.8%	0.8%	0.7%	0.6%	0.5%	0.4%	0.3%
TOTAL	27.2%	28.4%	28.7%	29.1%	26.1%	25.8%	21.6%	21.6%	19.8%	17.5%	15.3%	13.0%	10.8%

Table A4.2 Total Electricity Distribution (excl. megaprojects)

	Historical Data							**Calculations**				
GWh	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference Scenario												
Households	394	455	395	415	436	532	596	801	1,220	1,639	2,161	2,726
Services	373	374	384	408	419	462	495	694	1,019	1,424	1,892	2,463
Industry (excl. Mozal)	476	486	476	521	586	677	727	973	1,344	1,760	2,184	2,641
Losses	235	246	252	321	333	359	345	440	587	719	839	940
Own Cons. & Public Lighting	103	127	109	70	43	71	47	59	78	94	108	117
TOTAL Reference Scenario	1,581	1,688	1,616	1,736	1,817	2,101	2,211	2,968	4,248	5,637	7,184	8,887
High Scenario												
Households	394	455	395	415	436	532	596	1,141	2,025	3,030	4,157	5,404
Services	373	374	384	408	419	462	507	798	1,350	2,171	3,318	4,955
Industry (excl. Mozal)	476	486	476	521	586	677	744	1,145	1,872	2,892	4,218	5,975
Losses	235	246	252	321	333	359	351	560	899	1,302	1,759	2,287
Own Cons. & Public Lighting	103	127	109	70	43	71	48	78	128	191	267	359
TOTAL High Scenario	1,581	1,688	1,616	1,736	1,817	2,101	2,246	3,722	6,274	9,586	13,719	18,980
Low Scenario												
Households	394	455	395	415	436	532	596	701	895	1,031	1,267	1,502
Services	373	374	384	408	419	462	483	603	764	923	1,062	1,198
Industry (excl. Mozal)	476	486	476	521	586	677	710	824	951	1,040	1,076	1,084
Losses	235	246	252	321	333	359	340	372	408	412	404	378
Own Cons. & Public Lighting	103	127	109	70	43	71	46	49	50	46	40	30
TOTAL Low Scenario	1,581	1,688	1,616	1,736	1,817	2,101	2,175	2,549	3,068	3,452	3,849	4,193

ANNEX 5 – Transport

Table A5.1 Energy Demand and Activity Level TRANSPORT (incl. Telecom) – Historical Data & Assumptions

1.Energy Demand	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**Aver. 02-05**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference													
1000 Tonne	348.9	336.5	379.7	401.7	398.1	419.3							
energy intensity growth (%)		-10.9%	3.9%	-7.3%	-15.1%	-2.6%	-5.2%	-1.0%	-0.5%	0.0%	0.0%	0.0%	0.0%
High Demand													
1000 Tonne	348.9	336.5	379.7	401.7	398.1	419.3							
energy intensity growth (%)		-10.9%	3.9%	-7.3%	-15.1%	-2.6%	-5.2%	-0.5%	0.0%	0.0%	0.0%	0.0%	0.0%
Low Demand													
1000 Tonne	348.9	336.5	379.7	401.7	398.1	419.3							
energy intensity growth (%)		-10.9%	3.9%	-7.3%	-15.1%	-2.6%	-5.2%	-1.5%	-1.0%	-0.5%	0.0%	0.0%	0.0%
2. Activity Level	Historical Data							Assumptions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**Aver. 02-05**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	7.5%	7.0%	6.0%	5.0%	4.0%	4.0%
US$ (million)	311.9	337.9	366.7	418.4	488.1	528.1							
% of GDP	8.7%	8.2%	8.2%	8.7%	9.5%	9.5%	9.0%	9.5%	9.6%	9.7%	9.8%	9.9%	**10.0%**
High Growth													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	9.5%	9.0%	8.0%	7.0%	6.0%	6.0%
US$ (million)	311.9	337.9	366.7	418.4	488.1	528.1							
% of GDP	8.7%	8.2%	8.2%	8.7%	9.5%	9.5%	9.0%	9.5%	9.9%	10.4%	11.0%	11.5%	**12.0%**
Low Growth													
GDP growth*	2.8%	14.7%	8.3%	7.4%	7.1%	7.5%	7.6%	5.5%	5.0%	4.0%	3.0%	2.0%	2.0%
US$ (million)	311.9	337.9	366.7	418.4	488.1	528.1							
% of GDP	8.7%	8.2%	8.2%	8.7%	9.5%	9.5%	9.0%	9.5%	9.3%	8.9%	8.6%	8.3%	**8.0%**

Table A5.2 Fuel Consumption Transport Sector

	Historical Data						**Claculations**					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference												
Diesel	253.1	238.6	277.3	293.7	290.8	294.7	314.0	406.8	554.6	729.5	915.0	1,124.6
Gasoline	53.3	59.8	64.5	69.2	67.3	80.4	86.0	111.2	151.4	199.1	250.5	307.5
Jet Kerosine	42.3	37.6	38.5	38.5	39.4	43.2	46.0	60.1	81.7	108.0	135.2	166.2
High Scenario												
Diesel	253.1	238.6	277.3	293.7	290.8	294.7	321.7	473.4	745.9	1,118.8	1,598.1	2,235.7
Gasoline	53.3	59.8	64.5	69.2	67.3	80.4	87.9	129.0	203.7	305.6	436.4	611.2
Jet Kerosine	42.3	37.6	38.5	38.5	39.4	43.2	47.9	69.5	109.9	165.3	236.6	330.5
Low Scenario												
Diesel	253.1	238.6	277.3	293.7	290.8	294.7	306.3	348.8	402.9	455.1	493.7	524.6
Gasoline	53.3	59.8	64.5	69.2	67.3	80.4	84.1	95.3	110.3	124.3	134.6	143.9
Jet Kerosine	42.3	37.6	38.5	38.5	39.4	43.2	45.1	51.6	59.2	67.6	73.2	77.9

ANNEX 6 – Megaprojects

Table A6.1 Electricity production by mega projects

	Project	Year	MW	Location	Activity	Investor/Owner	Investment (million USD)
1	Cahora Bassa hydropower plant (HCB)	1974	2075	Tete	Production of electricity for export (85%) e domestic consumption (15%)	Portugal (15%), Mozambique (85%)	1300
2	Mphanda Nkuwa hydropower plant	2014	1300	Tete	Production of electricity for export (25%) e domestic consumption (75%)	?	2300
4	Gas fired electricity plant	2010	700	Inhambane	Production of electricity for export (30-90%) e domestic consumption (70-30%)	Siemens, Sasol (RSA)	827
5	Coal fired electricity plant	2011	1500	Tete	Production of electricity for export (90%) e domestic consumption (10%)	Companhia do Vale do Rio Doce (Brazil)	1300
	Total		**5575**				**5727**

Table A6.2 Electricity consumption by mega projects

	Project	Year	MW	Location	Activity	Investor	Investment (million USD)
1	Mozal I + II	2000/2	850	Maputo	Production and Export of Aluminium	Biliton(UK),IDC(RSA), Mitsubishi (JP)	2250
2	Heavy Sands Moma	2007	22	Nampula	Exploration and Export of Minerals	Kenmare Resources PLC (Ireland)	200
3	Heavy Sands Chibuto I	2008	155	Gaza	Exploration and Export of Minerals	SMC(RSA),IDC(RSA),WMC(Australie)	500
4	Moatize Coal Mine	2009	100	Tete	Exploration and Export of Coal	Companhia Vale do Rio Doce (Brazil)	1000
5	Mozal III	2009	650	Maputo	Production and Export of Aluminium	Biliton(UK),IDC(RSA), Mitsubishi (JP)	860
6	Heavy Sands Chibuto II	2017	105	Gaza	Exploration and Export of Minerals	SMC(RSA),IDC(RSA),WMC(Australie)	700
	Total		**1882**				**5510**