

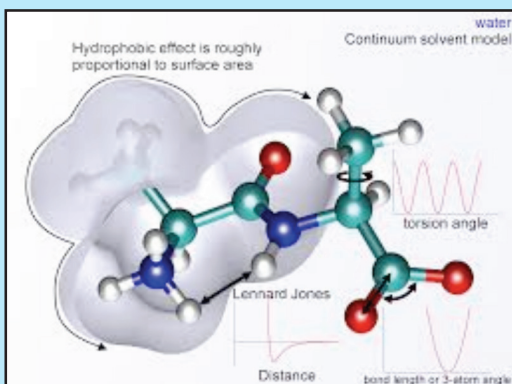
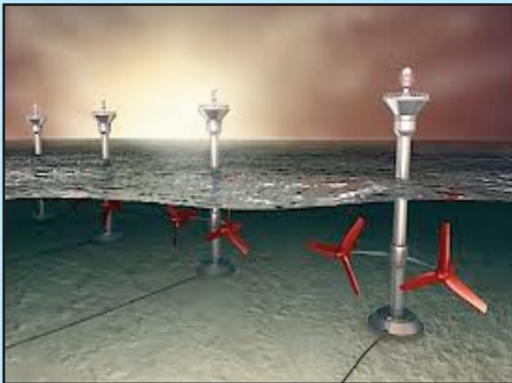


Republic of Namibia

Office of the President  
National Planning Commission

# Energy Demand and forecasting in Namibia

Energy for economic Development



2013

**National Planning Commission:  
Department of Macroeconomic Planning**

*By Ms Manuel*

**2013**

# Energy Demand and forecasting in Namibia

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## Abstract

This paper studies the relationship of energy use in Namibia to economic growth and other key development indicators such as Price, exchange rate, energy production, wages and employment. It also provides a short term energy outlook for the period of seven years (2014 to 2020). The paper applies the econometrics methodology to examine the impact of relationship between energy and other indicators mentioned. The Engle-Granger two-step and error correction method was applied to analyse the relationship between the energy consumption, GDP growth, energy productivity, employment, wages and price and exchange rates. The results indicate that there is a positive relationship between GDP growth and Energy use. There is however a negative relationship between energy consumption and energy productivity and exchange rates. The observed relationship indicate that high economic growth will increase energy demand; while the latter relationship indicates that productivity level reduces energy demand. The energy outlook shows that by year 2020 energy supply will increase by approximately 3 percent. Therefore policy makers need to take measures to increase energy supply in the country to be at par with the projected economic growth and need to encourage energy conservation, as excessive demand of energy may harm the economy.

## Acknowledgements

We would like to extend our deepest gratitude by acknowledging all those who provided us with information necessary for this study. Special thanks go to Ministry of Mines and Energy together with its agencies such as Nampower, Electricity Control Board and REEEI for making the following documents and data available which made a major contribution to this study. Documents such as the energy white policy paper of 1998, the National Integrated Resource Plan 2012 and the Energy Policy Scenarios for Namibia up to the year 2050.

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## List of Abbreviations

ADF – Augmented Dickey-Fuller

CPI – Consumer Price Index

ECB – Electricity control Board

ECM – Error Correctional Model

EDM – Electricidade De Mozambique

ESKOM – Electricity Supply Commission of the Republic of South Africa

GDP – Gross domestic products

GNI – Gross National Income

GWh – Giga Watts per hour

IEA – International Energy Agency

MW – Mega Watts

NDP – National Development Plan

NERP – National Integrated Resource Plan

NSA – Namibia Statistical Agency

OLS – Ordinary Least Squares

REEEI – Renewable Energy and Energy Efficiency Institute

VECM – Vector Error Correctional Model

WEC – World Energy Council

ZESA – Zimbabwe Electricity supply authority

ZESCO – Zambia Electricity Supply Cooperation

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## 1. Introduction

Economic activities are heavily dependent on energy input and Namibia is not an exception. Shehiel (2006) argues that, “energy is the indispensable force driving all economic activities.” The more the economy expands the more energy it will require in order to grow.

Energy comes in many different forms such as electricity, direct sun heat, mechanical and chemicals, radiant, nuclear and many more. In Namibia, energy is a composition of liquid fuels, electricity, and nuclear energy though not yet operational, geothermal energy, gas, coal, solar water heaters and cooker and charcoal (wood). The most dominant sector of energy in Namibia is the liquid fuel which includes petrol and diesel and accounts for about 63 percent of total energy net consumption, followed by electricity with 17 percent net consumption, then coal with 5 percent, the remaining 15 percent is from other types of energy such as solar, wood, wind energy among others. There is currently no oil in Namibia, though there are prospects of oil in the future, (Energy White Policy paper, 1998).

Due to the geographical location and type of infrastructure of roads in Namibia, it makes the transport sector to be one with the highest energy demand, especially the petroleum products which are imported from South Africa and other African countries. The expansion in Mining and other economic activities will lead to increase in electricity demand and it will as well

require more electricity generation within the country. The current existing three electricity power station such as the Ruacana Hydro Power, Van Eck and Paratus Oil Stations and all other source of energy generation cannot meet the required demand of energy in Namibia. The gap between the local power generation and the excess demand of energy is sourced from the neighbouring countries.

The Fourth National Development Plan (NDP4) identified three main areas of focus, namely; high and sustained economic growth, employment creation and increased income equality. All three goals contribute to achieving the high level National objective of Vision 2030, which is aimed to industrialise Namibia by the year 2030. NDP4 further emphasises that in order for Namibia to be industrialised, ‘the country needs to move from an economy dominated with agricultural activities and output to one dominated with manufacturing and value addition. The successful implementation of NDP4 programmes requires a substantial amount of energy supply in the country. Logistics and manufacturing sectors are identified as priority sectors to drive economic growth and these are sectors known to be the highest consumers of energy in the country. The country cannot become industrialised without energy, consequently that is why energy is identified as one of the important infrastructure and a primary enabler in driving economic development activities.

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## 1.1. Objectives

The NDP4 high growth scenario predicts Namibia's GDP to grow by 6.0 percent on average for the entire NDP4 span period (2012/13 – 2016/17) as Namibia looks forward to being industrialised. However the impact of energy on this growth is not exhaustively explained, though the energy white policy paper draws attention to energy as being one of the important enablers to bring about Vision 2030. This paper therefore aims to highlight the following specific objectives

- To identify energy demand, energy issues in Namibia and possible solution, in realisation of NDP4 goals and Vision 2030 and possible energy forecasting for the near future,
- To analyse the significance importance and contribution of energy to different sectors in the economy such as employment, economic growth and other socio-economic indicators, by determining relationships.
- Provide inputs to be used to expand the macroeconomic growth model in the National Planning Commission.
- Make a policy recommendation, for energy development after analysis.



## 2. Literature review

There have been many studies on the relationship between energy consumption and economic growth both for developed and developing economies. Most studies seem to agree that there is a strong relationship between energy and Gross Domestic Product. Some studies that looked at this relationship are:

Firstly, Kraft et al (1978) looked at the energy consumption in relation to Gross Domestic Product in USA, using VAR (Vector Autoregressive Model) and found out that there is a relationship between income (GNI) and energy consumption. Secondly Csereklei and Hummer (2012) examined primary energy consumption under model uncertainty and used GDP per capita as a proxy for country's wealth. The results shows that, using the country's GDP per capita, the main driving force of energy consumption is GDP. Capital and population becomes insignificant. This simply state that, for richer economies (economies with high GDP per capita), energy consumption may increase even though population is not increasing. The study also found out that taking model uncertainty into account and holding other factors constant, population growth and income becomes the main drivers of energy consumption in the future with capital playing a small role while an improvement in technology will reduce energy consumption.

Soytas et al (2001) also agreed to the relationship between Energy consumption and GDP when

they undertook a study in Turkey using the annual time series data for Turkey. The study makes use of Johansen-Juselius Cointegration Methodology and Vector Error Correction Modelling (VECM) to analyse the data. The conclusion of the paper indicates that unidirectional connections running from energy consumption to GDP strongly exist. Hence a reduction in energy consumption may negatively affect the economy.

There are other literatures that found no evidence of relationship between GDP and Energy consumption. Yu and Hwang (1984) and Yu and Choi (1985) found no evidence of relationship between Energy and GDP after using different kind of methods to analyse it. On the other hand Akarca and Long (1980) found no evidence of causality between GDP and Energy consumption when the time period of analysis is shortened to two years. Some literatures like that of Hwang and Gum (1992) and Erol and Yu (1987) also found some mixed and contradictory results.

### 2.1. Energy Demand forecasting in the developing countries

Some literature such as, Bhattacharyya et al (2009) have pointed out some specific features of energy demand modelling for developing countries, in which Namibia falls. There are various range of dissimilarity among developing countries in terms of socio economic conditions, population size, economic structure,

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human resources, energy profile and level of urbanisation. Some common characteristics such as poor performance of power sector and energy, transmission of energy from traditional to modern energies, inadequate investment decisions are found (Urban et al (2007)). In terms of lack of investments, Namibia is no exception as it is concluded in the Energy white policy (1998) to be one of the challenges in the energy sector and investment is among the policy goals to expand the energy sector.

Pandey (2002) pointed out that the existence of factors such as inequality, poverty, markets in rural areas, social and economic barriers, capital flow and technology flow are the cause of difference between developing countries energy systems to that of the developed countries.

According to International Energy Agency (IEA) (2002) data, it shows that about 25 percent of energy consumption of developing countries is from biomass and other traditional energies and this differs among countries. In Namibia consumption of biomass as energy is minimal. In most cases the use of traditional energy bring challenges during energy data analysis in modelling, as this does not provide any estimation for traditional energy demand, prices and supply as data cannot be found. Supply shortage of energy especially electricity and fuel together with inequity consumption behaviour caused by poverty is also common

in the developing countries. Lastly, inadequate capacity of statistical analysis, modelling, data management and human resource constraint remains to be a challenge among these countries.

In addition to Bhattacharyya et al (2009), which point out forecasting constraint in developing countries, there are some literatures in Namibia where studies on energy and its challenges were undertaken. Although many literatures cover a wide range of challenges facing the Namibian energy sector as a whole, little is done on the energy demand and forecasting. There seems to be a general agreement that energy shortage exist in Namibia. In 2008 the government of Namibia through its line Ministry, Ministry of Mines and Energy produced energy policy scenarios which go up to year 2050.

The Project was initiated by the World Energy Council (WEC) and used two main variables which are the level of government engagement and the level of regional and international cooperation. According to the Energy policy scenarios of 2008, variables were described as either low or high. Below are the four scenarios that the project came up with.

1. Low government engagement and low regional and international cooperation.
2. High government engagement and low regional and international cooperation.
3. High government engagement and high regional and international cooperation.

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4. Low government engagement and high regional and international cooperation.

The study concluded that Namibia needs to increase its energy generation capacity by using generation mix and renewable energy, and ensure that the government engagement and good regional and international cooperation is maintained to promote security in energy supply and for export of energy surplus. The study further recommends the use of these scenarios every five years to encourage long-term engagement of government, regional and international cooperation in energy planning.

In as much as the study outline the possible energy scenario for energy demand to year 2050, nothing is said on the demand forecasting for industries, household and the economy at large. In addition to the literature above, The World Bank and the Electricity Control Board of Namibia contracted HATCH in 2012, to develop a National Integrated Resource Plan (NIRP) for Namibia with a focus on electricity. NIRP is a 20 year electricity development plan and the purpose is to give an indication of electricity demand and supply as well as the cost of supply. The study produced some preliminary projections for electricity sales and demand, peak demand for June is 516 MW, an increase in peak demand of 1 100 MW is projected by the year 2030 with an annual growth rate of 4 percent on average. Electricity sales is projected to increase to approximately 6,500 GWh from 2,900 GWh in 2011, this represent a 4.3 percent annual growth

rate on average. These projections were based on a number of assumptions using variables such as electricity prices, population growth and economic activity projections among others, (NIRP, 2012).

The study developed the NIRP based on the mix resources which can meet the short and long-term electricity demand and supply in Namibia in an efficient, reliable and at the lowest possible cost. Estimates were developed using capital and operating costs and performance features of power generation plants using the identified mix resources.

They then came up with the generation expansion scenarios involving all generation options both single and a combination to reflect a wide range of policy options. Using a generation model, 24 scenarios were used to analyse and only seven scenarios estimated to have the lowest present value cost including one which had renewable power.

However, the study only focuses on electricity and gives no attention to other types of energy as they are not widely used in Namibia. Even though other energy is used in the generation mix to produce electricity, no strategy is reported on how a generation mix scenario could be used to increase generation of other energy apart from electricity. The impact of these scenarios on economic growth or to any other economic sectors is not analysed.

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## 3. Energy Policies

The Ministry of Mines and Energy is a policy maker of the energy sector, and in 1998 the ministry published a white paper on energy policy. The document contains detailed summarised policies that affect energy demand, energy supply for electricity, upstream oil and gas, downstream liquid fuels, downstream gas, renewable energy and other cross-cutting matters relating to economic, environment, energy efficiency and regional energy trade as well as regional co-operation. The energy white policy paper recommended the following strategies, which the government of Namibia should work towards to in order to improve and increase energy production in the country:

### *Effective governance*

Systems were to be in place to provide stable policy, legislative and regulatory frameworks for the sector.

### *Security of supply*

Namibia will achieve security through an appropriate diversity of economically competitive and reliable sources, with emphasis on the development of its own resources

### *Social upliftment*

The community will have access to appropriate, affordable energy supplies.

### *Investment and growth*

The sector should expand through local and foreign fixed investment, resulting in economic benefits for the country. Attention will be given to black economic empowerment.

### *Economic competitiveness and efficiency*

The sector should be economically efficient and should contribute to Namibia's economic competitiveness .

### *Sustainability*

The sector should move towards the sustainable use of natural resources for energy production and consumption.

These policy goals above should move Namibia from the current energy shortage situation to a goal level agreed in Vision 2030 document. In addition to the white paper energy policy, is the electricity policy, which mandates the Electricity Control Board to be the sole institute for issuing electricity licenses oversee efficient functioning and development of electricity industry and security of electricity provision, among others while Namibia Petroleum Corporation regulate the fuel oil industry. Regrettably, over the years there has been no regulator for other types of energy.

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## 4. Energy sector in Namibia

The regional power pool known as Southern Africa Power Pool (SAPP), constitute of 12 member countries within Southern Africa namely; Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. In this region, South Africa optimize 84 percent of total consumption in the region and more than 80 percent in power generation, 4 and 3 percent for Zambia and Zimbabwe respectively, while the remaining is shared among other countries within the region which include Namibia, as per regional power status in Africa Report 2010.

South Africa is leading in power exporting country in the region, followed by Democratic Republic of Congo, while the major importers are Botswana, Mozambique and Namibia representing 67 percent of total consumption and then Swaziland and Zimbabwe, (ICA report, 2011).

Namibia only have 3 major power generation stations, with the installed capacity of about 500 MW. The biggest one is the Ruacana Hydro Power station which generates about 332 MW of electricity, Van Eck Coal power station only generates 120 MW, the Paratus Diesel Power station and Anixas fuel power station at the coast with only 24 MW and 22.5 MW respectively (Konrad et al, 2013). These power stations do

not generate electricity to its full capacity at all times, the Ruacana power station depends on the water flow and weather condition while the other power stations like the Van Eck station have not been operating during 2013 due to some technical problems, these make the electricity shortage in the country to be worse and resort to imports.

According to the Regional power status of Africa 2010 report, Namibia generates about 1,305 GWh, while it consumes more than 3000 GWh. Table-1 below provides the electricity gap of what Namibia generate locally and what is consumed in the whole economy for a period of 10 years (2000-2010). Since 2000 Namibia power generation has been below 2000 GWh and average at 1,470 GWh. The total demand or consumption needed for the country started with 1,318 in the year 2000 and the trend continues to rise.

This demonstrates that as Namibia strives into becoming an industrialised nation by 2030, more economic activities will require substantial amount of power.

The gap between what Namibia generate locally and what is required for country's economic activities production is imported from the neighbouring countries such as South Africa, Zambia, Zimbabwe and Mozambique to cover the supply gap of electricity.

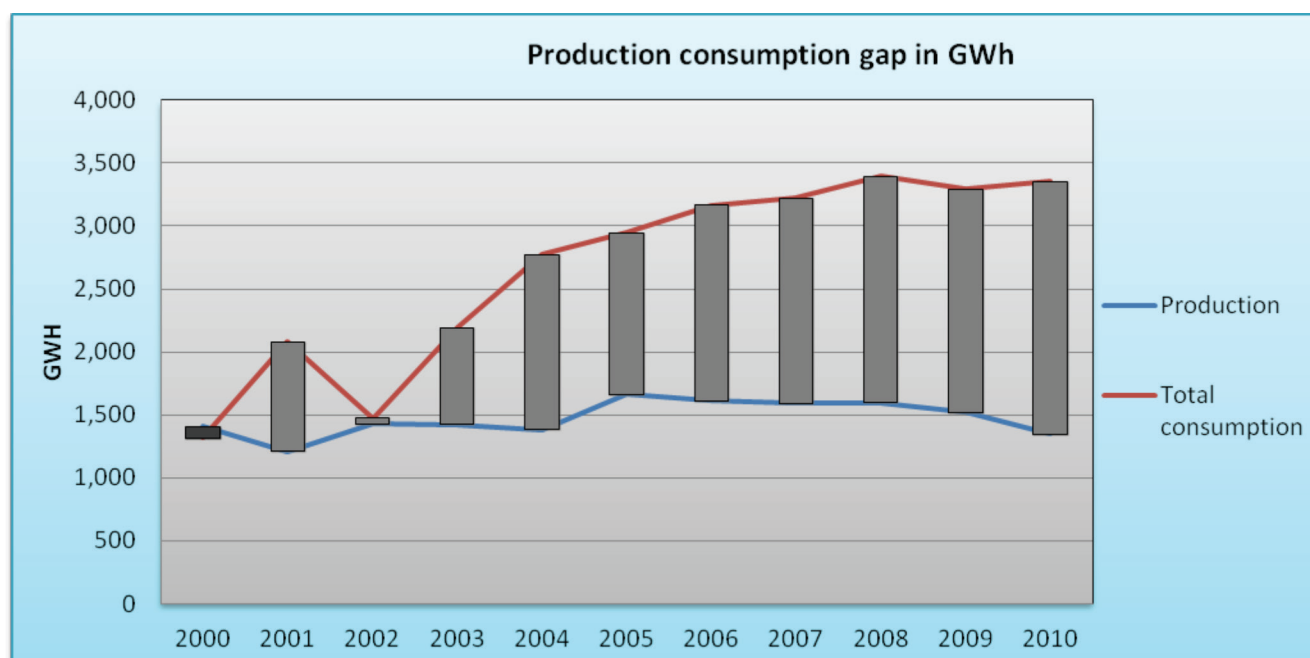
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**Table 1: Electricity Balance for the period 2000 to 2010**

	Production	Export	Imports	Supply	Gap	Consumption
<b>2000</b>	1,407	108	785	2,084	<b>-89</b>	1,318
<b>2001</b>	1,211	69	1,066	2,208	<b>871</b>	2,082
<b>2002</b>	1,429	54	942	2,317	<b>44</b>	1,473
<b>2003</b>	1,421	53	1,045	2,413	<b>772</b>	2,193
<b>2004</b>	1,380	23	1,519	2,876	<b>1,392</b>	2,772
<b>2005</b>	1,662	31	1,695	3,326	<b>1,283</b>	2,945
<b>2006</b>	1,612	36	1,867	3,443	<b>1,551</b>	3,163
<b>2007</b>	1,590	40	1,931	3,480	<b>1,629</b>	3,219
<b>2008</b>	1,595	47	2,126	3,673	<b>1,797</b>	3,392
<b>2009</b>	1,520	144	2,202	3,578	<b>1,770</b>	3,290
<b>2010</b>	1,347	294	2,462	3,515	<b>2,007</b>	3,354

*Source: ECB and NamPower's Annual Reports and Ministry of Mines and Energy Namibia data 2012*

**Figure 1: Production and consumption gap, Namibia**



*Source: Ministry of mines and energy Namibia data 2012*

In figure 1, total consumption is higher than the capacity that Namibia can produce. Both total consumption of electricity and the supply is taking an upward trend but the local generation

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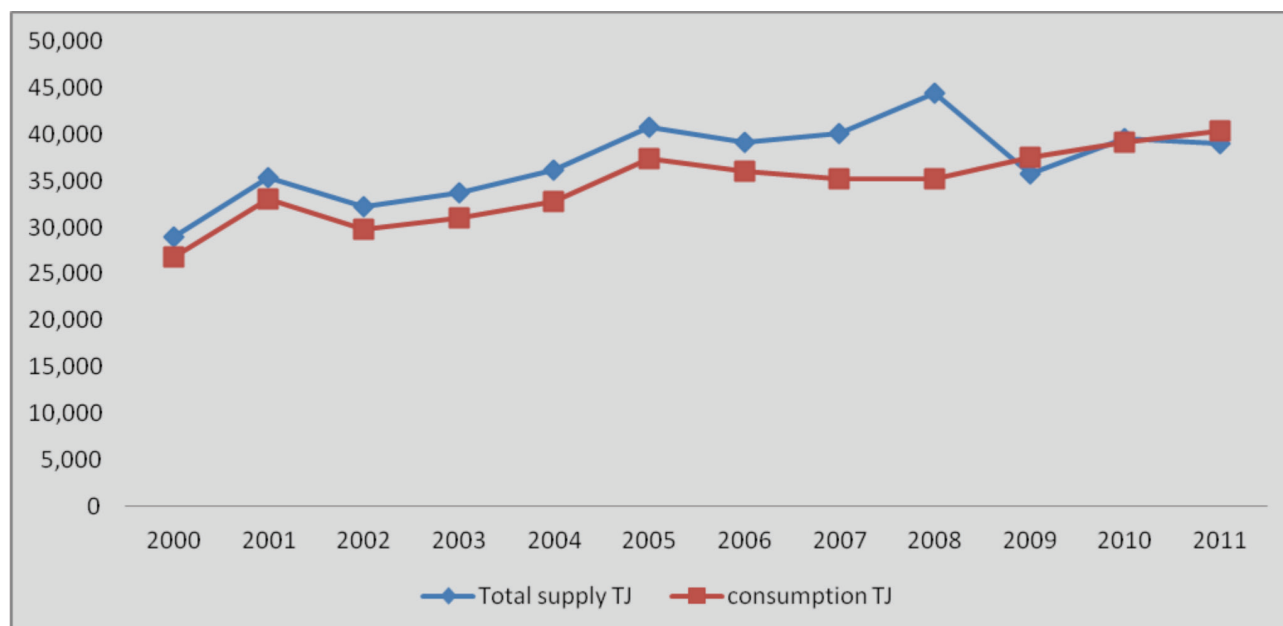
of electricity is not. The total supply includes the total local power supply plus the imports which is more than 50 percent. Namibia imports most of electricity from ESKOM South Africa which accounts for more than 50 percent of the total imports, Zimbabwe Electricity Supply Authority (ZESA) imports amounts to 23.7 percent, Electricity de Mozambique (EDM)/ Aggrekko provide 2.5 percent, Zambia Electricity Supply Corporation (ZESCO) imports varies between 0.3 and 8.2 percent while some supply from the SAPP which supply about 2.3 percent of electricity (Konrad, 2012). The amount of electricity imported may vary from year to year depending on the suppliers. In 2010/2011 financial year, 42 percent of total imports were

from ESKOM, while 39 and 19 percent were imported from ZESA and ZESCO respectively. More imports of electricity have a negative implication on the Namibian economy, it affects the trade balance negatively and as such it results in low growth in the Gross Domestic Product.

### 4.1. Liquid fuel Gas (Oil)

Liquid fuel is widely used in Namibia by both for household and industrial purposes. The liquid fuel industry is administered by the Petroleum Product and Energy Act of 1990 and 1994. The liquid fuel is in the form of diesel and petroleum which is mainly consumed by the transport sector accounting for 63 percent of total energy used in Namibia.

**Figure 2: Demand and supply of oil products in Namibia for the period 2000-2011 in TJ**



Source: Electricity Control Board data 2014

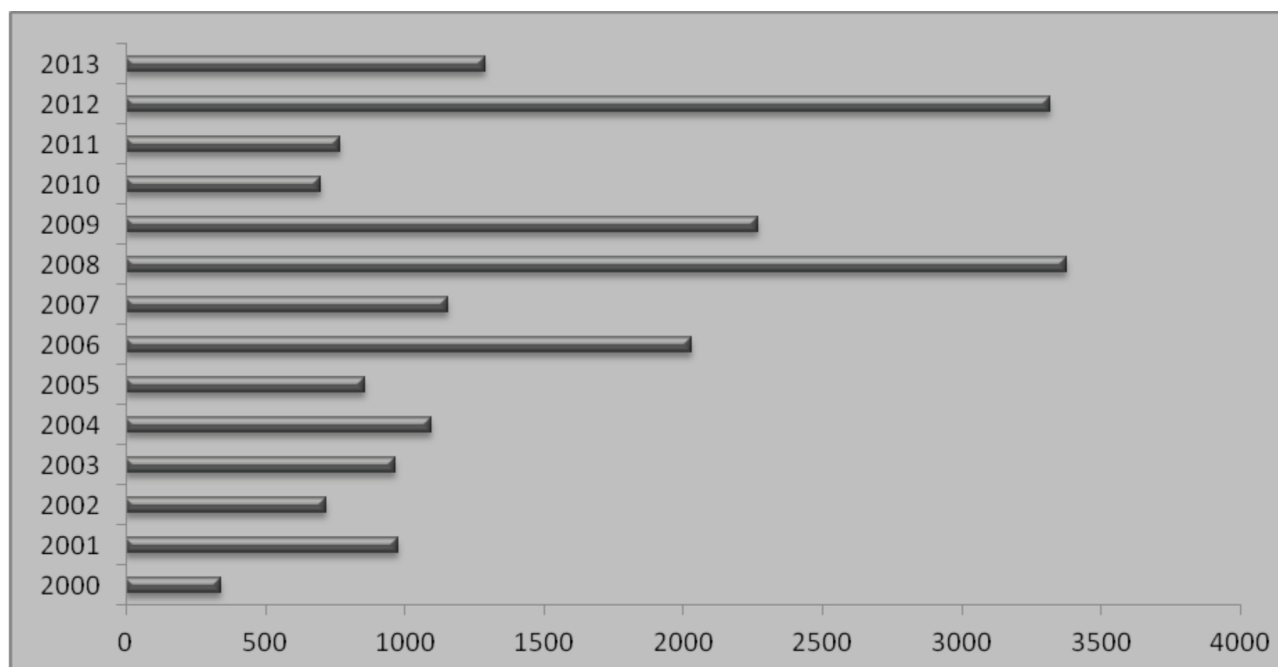
The figure above depict that the demand of oil product is on a rise, since the transport sector is prioritised to drive economic growth in Namibia, the demand for energy in the form of Oil product is also expected to take a sharp upward curve

towards Vision 2030. This will put pressure on the balance of payment as more import in the form of oil will increase thus having a negative effect on domestic output.

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## 4.2. Coal

Figure 3: Total coal imported and used in Namibia from 2000 to 2013 in TJ



Source: Electricity control Board of Namibia 2014

Coal is mined, ignited and burned to produce heat for electricity. In Namibia, coal is mainly used for the purpose of electricity generation; such power station is the Van Eck which is the single largest user of coal imported from the neighbouring South Africa. Coal is as well used for industrial boilers. According to the Energy Policy Scenarios 2050 of Ministry of Mines

and Energy, coal in Namibia is also used in the industries such as manufacturing e.g. Tsumeb Copper Smelter, Namibia Breweries and other meat processing. As the figure above depicts, more coal is needed in the country in order to support new electricity generation stations as well as for industrialisation purposes.



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## 4.3. Other sources of energy in Namibia

**Table 2: Total renewable energy supplied during 2000 to 2011**

Period	Total renewables	Hydro power	Wood charcoal	Other solid biomass	Solar CSP + PV on/off grid	Wind power On and off grid
2000	7,155	5,026	2,129	-	-	-
2001	6,489	4,360	2,129	-	-	-
2002	7,204	5,123	2,081	-	-	-
2003	7,266	5,108	2,157	-	-	-
2004	7,952	4,921	3,031	-	-	-
2005	8,984	5,962	3,022	-	-	-
2006	8,520	5,443	3,077	-	0.2	-
2007	8,943	5,551	3,392	-	0.4	-
2008	9,302	5,023	4,278	-	0.7	-
2009	9,352	5,072	4,278	-	0.9	0.6
2010	8,952	4,489	4,461	-	1.4	0.6
2011	9,260	5,058	4,200	-	1.4	0.6

Source: Electricity control Board of Namibia 2014

### 4.3.1. Solar energy

As one of the countries blessed with natural sunlight, only small amount of Namibia's solar energy resources is utilised. Namibia has the advantage of abundant solar energy which can be utilized mainly for heating water. It can be used for both commercial sector or for domestic purposes to reduce on electricity cost as well as making a substitute of electricity. However this platform is underutilised due to lack of knowledge and skills to the majority of the population in Namibia as well as the cost of solar energy equipment which is unaffordable. Most of the households' population earnings are below average to afford such utility, as a result majority of private households in Namibia are trapped to using electricity for heating water despite the fact of the country having abundance of solar energy

resources. The existing Solar Revolving Fund (SRF) under the ministry of Mines and Energy is not well marketed as most of the population are not aware of such initiative. Some people might be aware but cannot afford to take those solar energy loans because there is no subsidy from the government especially for rural community. Although efforts are made by some private households and commercial outlets to replace their hydro electricity usage with solar geyser, more still need to be done to promote solar electricity usage in Namibia. Following the Cabinet directives of 2007 which encouraged the use of solar water heater (SWH), some private institutions like Tsumkwe Solar Project for electricity production and many other government and parastatal institutions have taken

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the initiatives of replacing their electrical geyser with solar which cut their monthly electricity expenditure and at the same time provide roofing shelter to their buildings. In Namibia this energy sub sector is still small and its contribution to energy generation is petite.

### 4.3.2. Wood energy

Wood or Biomass is the main source of energy in the rural areas of Namibia, more specially in the Northern and North-Eastern part of Namibia. About 87 percent of Namibians in the rural areas use wood or wood charcoal as the main energy for cooking, heating and lighting as compared to only 16 percent in urban areas and about more than 20 percent used for lightning and heating. As more people depend on wood for energy, the resources are being exploited and leading to deforestation and causing land degradation as well as to be unproductive, this near future will result in few trees for wood, extinction of tree species and other organisms that earn their living on wood and trees.

### 4.3.3. Wind energy

Namibia is one of the countries with long coastlines measuring 1,572 km. Wind energy is sufficient to be harvested and put to good use, as it is considered to be one of the efficient and fast growing energy in the world; however in Namibia the wind energy industry is very small and minimal. Substantial wind energy found at the coastal part of Namibia is harvested on a small

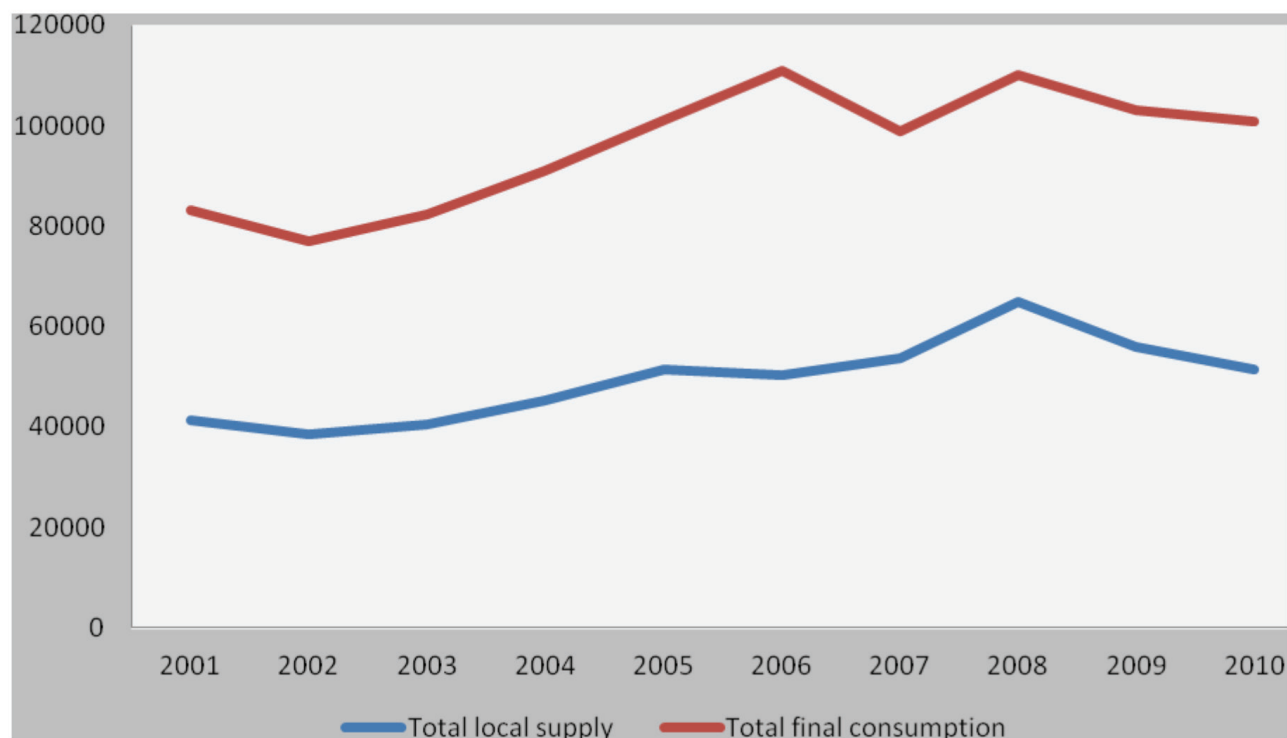
scale with wind energy converter producing 220 KW which was installed at the coast in 2005. Even though there is a potential of wind energy growth in Namibia, there is still a concern of wind fluctuations and thus the generation of electricity can be minimal and may cause disruptions, thus more investment is required to increase the efficient generation of wind energy.

### 4.4. Importance of energy on long term National Development Goals in Namibia

Energy is one of the important inputs into many of Namibia's large private and government institutions as well as in social services for economic development. However, there is an impediment on development which is caused by shortage of electricity supply, fuel and other renewable energy in Namibia. It is highly flagged in the white paper of energy policy of 1998 that energy is a very important and vital production input more especially in the productive sectors such as mining, transport, fisheries, agriculture and many other service industries. An industrialised nation has to be partially independent from foreign energy use, this is a strive for vision 2030 on energy development. Even though in the national accounts, energy is not fully shown or calculated as a sector except for electricity, other energy's value addition is calculated in the production of other goods and services that is published in the national accounts.

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Figure 4: Supply and demand of energy in Namibia, for the period 2000 - 2010



Source: Ministry of mines and energy Namibia data 2012

Figure 4 above shows the gap of capacity of local energy production and total energy consumed in Namibia during 2000 to 2010. The trend in the graph shows that since 2000 total energy demand have been higher than the local energy production. However in 2003 to 2006 demand started increasing sharply while supply remained constant. From 2009 to 2010 and going forward the supply of energy is declining while the consumption is taking an upward trend. This means that the level at which energy demand is increasing is much faster than the supply. Conversely as the NDP3 came to an end in 2012 and the Fourth National Development Plan kicked off in June 2012, energy consumption is expected to increase due to the implementation of NDP4.

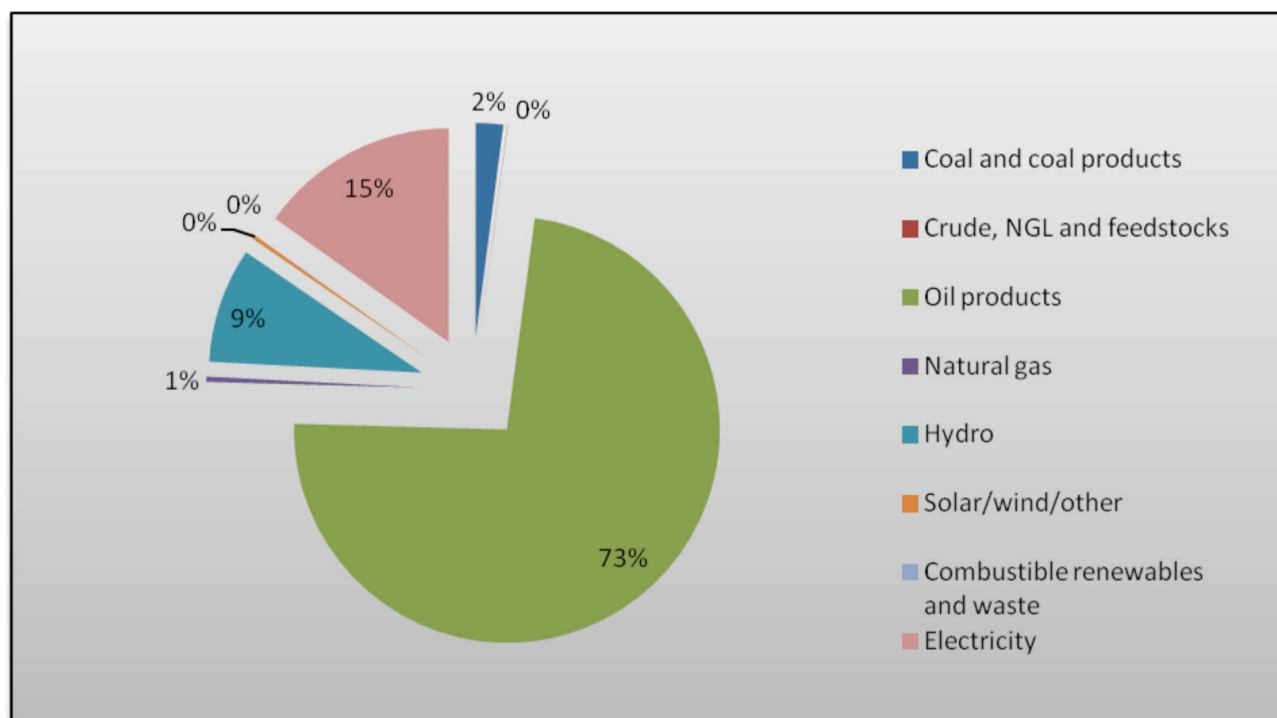
The expected increase in energy consumption is due to the anticipated increase in economic activities emanating from the NDP4 priority sectors. Transport, mining, manufacturing sectors are some of the sectors which requires more energy use.

The economy requires high energy supply in the future to cater for normal economic activities, as the economy expands with the initiative of NDPs as well as Vision 2030.

This means that the expected gap of energy demand and energy supply is expected to be wider each and every year.

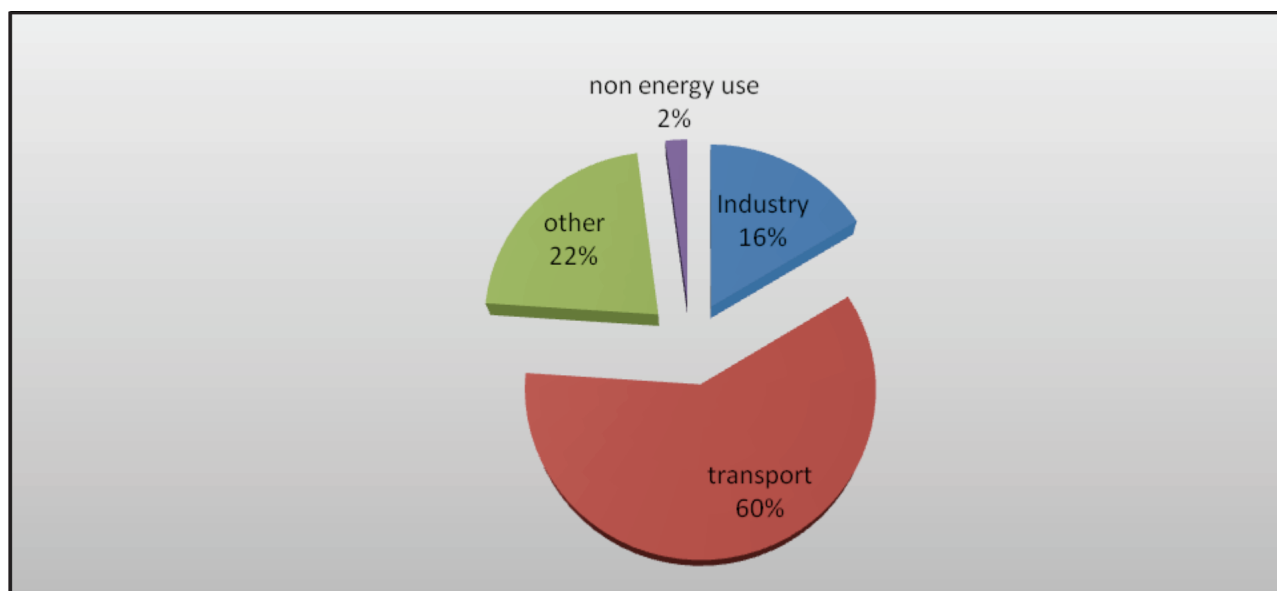
# Energy Demand and forecasting in Namibia

Figure 5: Total Energy supply in 2010



Source: Ministry of Mines and Energy Namibia data 2012

Figure 6: Total Energy consumption by sector in 2010



Source: Ministry of Mines and Energy Namibia data 2012

## Energy Demand and forecasting in Namibia

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Of the total energy supplied in the economy over the past ten years (2001 to 2010), 60 percent is utilised by the transport sector which comprise of subsectors such as road, rail, aviation and marine. Most energy used in transport sector is in the form of oil products which also takes the largest piece of total energy, 73 percent of total energy supplied in Namibia from 2001 to 2010 was from oil products. This signifies the importance of oil product as energy in the economy.

Industries which use 16 percent of total energy are composed of mining and quarrying and construction, which also include sectors that are directly involved in non-ferrous metals and non-metallic mineral and are the main sectors known to consume more electricity. Construction and mining are some of the sectors which are identified to nurture economic growth, however relating to the pace at which electricity supply is growing in the economy, growth in these two sectors will be hampered unless electricity supply increases.

Other sectors and non-energy use sector only consume 22 and 2 percent of energy respectively,

the other sector include residential, commercial and public service, agriculture/forestry and fishing. These are mostly electricity based sectors except for fishing which uses oil products.

### **4.5. Why Energy demand forecast?**

Energy demand forecasting is very important on every economy as in most cases the future is uncertain. Energy forecasting is a very important factor for development planning, formulating development strategies and also in energy policy recommendation. As the economy grows, demand for energy also increases. Thus it is very vital to know the expected energy demand as per expected economic growth. With forecasting one can prepare some policy measures for any unexpected economic shocks, it also provides relevant information whether or not there will be a shortage of energy for example electricity, fuel, gas or any other form of energy and the effects on the country's productivity level. Without energy forecasting the implementation of any National Development Plan could fail as most of the targets and priorities of NDPs require energy in order for it to be fully implemented. Forecasting will as well assist priority setters during planning of economic development.

## 5. Methodology and Data

### 5.1. General Approach

The study makes use of both primary and secondary data of which it includes desk research. Annual Gross Domestic Product, value addition for sectoral growth and population growth data were obtained from the Namibia Statistics Agency (NSA) with some assumptions from the World Bank and International Energy Agency (IEA). Energy data used in this study was collected from all main players in the Namibia energy sector by means of a survey.

Suppliers, distributors as well as end users were sampled for the purpose of data collection. A standard questionnaire was used to collect quantitative data and other qualitative information from sectors. Direct interviews during the survey were conducted. Energy balance data from the Renewable Energy and Energy Efficiency Institute (REEEI) was also used in this study which formed part of data used for forecasting. The survey collected information ranging from present energy consumption, future projection of energy supply and demand, main challenges and issues affecting the energy sector in Namibia.

### 5.2. Forecasting Approach

This section of the research paper discusses about the methodology used in forecasting the energy demand. A demand for energy is a necessity that arises in order to meet the need for energy services. Using simple indicators method of

forecasting, indicators that have direct impact on energy demand such as Gross Domestic Product, Population, Employment, Price of energy and energy supply were identified for energy forecasting purpose. Due to data limitation other variables that also have an impact on energy and GDP such as Income and location could not be used.

The econometric approach using Engle-Granger two steps and Error Correctional Model (ECM) was used for analysis and forecasting to investigate the relationship between energy consumption and economic growth, Price, Productivity and Exchange rates. There are many other methodologies that are used to test the relationship. Methods such as the Generalised Methods and Causality Tests, however due to the nature of the data used in this study the result using these methods were not consistent and satisfactory. The Engle-Granger Method produced better results compared to other methods. The study used time series data for the period of 23 years starting from 1991 to 2013. Energy Consumption is the endogenous variable, while variables such as Gross Domestic Products, Productivity, Exchange rates, Price and Employment are exogenous.

### 5.3. Model Specification

Time series data for a period of 1991 to 2013 variable used in this study is GDP, Energy

## Energy Demand and forecasting in Namibia

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Consumption, Consumer Price, Energy Productivity and Exchange rates. It was assumed that a long run relationship exists between energy consumption and Gross Domestic Product as well as price level of energy in Namibia and exchange rates. Thus the demand function was given as follow:

$$E = f(Y, P, CPI, Ex, u) \dots\dots\dots (1)$$

- Where: E = denotes total energy consumptions in KWh  
 Y = denotes Gross Domestic Products in Namibian million dollars  
 P = denotes total energy productivity which is taken as total GDP by Total energy use  
 CPI= denotes consumer price which is used as a proxy for energy price  
 Ex = denotes exchange rates, and  
 = denotes error terms (which captures the effects of the omitted variables)

Before equation (1) was estimated, all data where transformed into logarithm for comparison sake. Thus the equation (1) was transformed into natural logs given below:

$$e + \ln\beta_1 + \ln\beta_2y - \ln\beta_3P - \beta_3Cpi - \ln\beta_4Ex + \epsilon \dots\dots\dots (2)$$

Where  $\beta_s$  are the coefficient parameters and slope.

The equations given in 1 and 2 above are the most common and standard equations used in many literatures of energy forecasting. In equation two, CPI is not transformed into natural logs as they are already given in percentage change. From the model above we expect energy consumption to have positive relationship with GDP, for GDP to increase it will require a lot of energy as input to produce it. While a negative relationship is expected for CPI, exchange rate and productivity, an increase in these three variables should reduce the demand for energy. However the signs of coefficients and some variables may not be the same for Namibia, since Namibia does not produce much of the energy it uses. To further investigate these, the method of Cointegration Econometric Approach: Engle Granger two steps were used to determine the relationship of the variables in the equations above.

### 5.4. Estimation results

#### 5.4.1. Unit root tests

In most common economic analysis, the use of time series requires a need to investigate the data further before it is used. It was necessary to find out whether the data is stationary or it has a unit root. This was done by testing the variables for the presence of unit roots using Augmented Dickey-Fuller (ADF) unit root test. The results of such a test are presented in the table below.

# Energy Demand and forecasting in Namibia

**Table 3: Unit root tests-ADF**

Variables	Prob- levels	Prob-1 <sup>st</sup> difference	Stationary
<b>Energy consumption</b>	0.8957	0.0001	Stationary in first difference I (1)
<b>CPI</b>	0.0000	0.2599	Stationary in levels I (0)
<b>GDP</b>	0.9956	0.0002	Stationary in first difference I (1)
<b>Energy productivity</b>	0.0792	0.0000	Stationary in levels and First difference I (1)
<b>Exchange rates</b>	0.0000	0.8784	Stationary in levels I(0)

*All significant up to 10 percent significant level*

From table three above, CPI and productivity and exchange rates are stationary in levels, while GDP and energy consumption are only stationary in first difference as shown by their probabilities values, which is more than 5 percent in levels. Therefore, variables that are not stationary in levels are differenced to make them stationary. This is because if estimations are made with variables that are not stationary, it may lead to spurious or nonsensical results.

### 5.4.2. Long-run relationship

After the variables were tested for unit roots, it

was found that three variables where I (0) and two variables where I (1), with the dependent variable being an I (1) variable. We have a combination of the right order. So we proceeded to the estimation of a long run equation using OLS. The result of the estimation is presented in the table below.

As seen from the model, Energy consumption is an endogenous variable, while GDP, CPI. Exchange rates and productivity are exogenous variables. Ordinal Least Square was used to run a long run regression using E-views.



## Energy Demand and forecasting in Namibia

**Table 4: Regression output for a long run estimation using Engle-Granger Two steps**

Variables	Coefficient	Std. Error	t-statistics	Probability
<b>GDP</b>	0.4164	0.149	2.788	0.01
<b>Productivity</b>	-0.844	0.129	-6.563	0.000
<b>Exchange rates</b>	-0.029	0.008	-3.32	0.003
<b>CPI</b>	0.008	0.224	0.036	0.972
<b>Constant</b>	5.947	0.803	7.397	0.000
<b>R-squared</b>	0.98			

$$e = 5.947\beta_1 + 0.42\beta_2y - 0.84\beta_3P + 0.01\beta_4CPI - 0.03\beta_5Ex + u \dots\dots\dots (3)$$

The results confirm that there exists an equilibrium long run relationship (co-integration) between variables used in the estimation as the Phillips-Peron unit root test on the residual is stationary in levels at 5 percent significance level. The model in equation two is of good fit, this is evidently shown by the  $R^2$ , of which is 0.98. This means that 98 percent variation in energy consumption is explained by the model's independent variables.

The *CPI* coefficient is positive, which is inconsistency with economic theory; it implies that if price increases by 1 unit then energy consumption will also increase by 0.01 percent and vice versa. However this result is statistically insignificant at all levels. J. Asafu-Adjaye in his paper argues that “Energy and prices interact in the short-term to restore long-run equilibrium after a change in income, but the long-run energy and price effects are weak” this implies that in the long term, income and price have no effect on energy consumption.

The exchange rate coefficient is negative and it is statistically significant at all levels. This relation can be reasoned by Namibia being a net importer of energy. The lower the Namibian exchange rate, the more expensive it will be to import energy in Namibia and the impact will be passed on the price and vice versa.

*GDP* which is the main heart of this study is positively related to energy consumption, this is shown by its positive coefficient and it is also statistically significant. A one unit change in GDP will result in a 0.42 percent increase in energy consumption. GDP has an impact on energy consumption, the more the economy grows and becomes industrialized the more energy it will demand. This kind of relationship expands the neoclassical economic theory of production, in which output/GDP is a combination of Capital, Labour, and Technology and now according to the estimation results, will include energy inputs.

$$GDP_t = K_t + L_t + T_t + E_t \dots\dots (3)$$

## Energy Demand and forecasting in Namibia

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Where  $K$  is Capital,  $L$  is Labour,  $T$  is technology and  $E$  is Energy.

The use of energy as part of input in industrial production will increase productivity, this conclude that energy input plays a major role in production just like labour and capital. Thus this suggests that increasing energy production in the country should be part of economic development policies in Namibia since currently there is a shortage of energy.

Energy productivity have negative coefficient and it is statistical significant. Energy productivity is defined as using the same amount of energy to produce more output, in other words, it's using energy efficiently. Energy productivity has a positive impact on GDP; a one unit increase in energy productivity will increase GDP by a 1.40 percent. This is given by a positive relationship the two variable have, which is shown in the Appendix Table-1. Energy productivity does not only reduce energy consumption but it also reduces energy expenses as well as carbon pollution, boosts economic productivity, and improves energy security. A study by Vivid Economics 2013, found out that a 1 unit increase

in the level of a country's energy productivity causes a 0.1 percentage point increase in the rate of economic growth in that year. These findings complement recent research by the IEA, projections of energy-related CO2 report which concludes that energy efficiency will reduce energy consumption by halve. In Namibia energy productivity have a negative relationship with energy consumption, but a positive relationship with GDP. Therefore, more investment in energy efficient in Namibia will result in less energy use and will increase economic growth.

### 5.4.3. Error correctional model ECM for the short run relationship

After the long run equation was estimated, the residual was collected from the long run estimation results and tested for stationary and it was stationary in levels. Many other variables where added to the equation to run the Error Correctional Model. The error correctional model is employed to test for further co-integration between variables in the short run. Different kinds of tests are carried out with and without trends, constants and omitting some variables. After various tests, the following preferred equation was adopted for this study:

$$e = \beta_1 + \beta_2 y_{(-1)} - \beta_3 P - \beta_4 CPI - \beta_5 Ex + \beta_6 L_{(-1)} + \beta_7 Prod_{(-1)} + \beta_8 DPC + \beta_9 PGD + \beta_{10} Y + \beta_{11} EC_{(-1)} \dots\dots\dots (4)$$

Where  $EC_{(-1)}$  the lagged residuals which is also the speed of adjustment.

## Energy Demand and forecasting in Namibia

**Table 5: Regression output for a short run estimation using Engle-Granger Two steps**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<b>D(LNNOMGDP)</b>	-0.104160	0.039964	-2.606330	0.0244
<b>D(LNNOMGDP(-1))</b>	-0.102683	0.037356	-2.748768	0.0189
<b>D(LNLAB(-1))</b>	0.218606	0.115616	1.890786	0.0853
<b>D(LNPERGDP(-1))</b>	0.046247	0.013693	3.377564	0.0062
<b>D(LNPROD)</b>	-0.985629	0.025150	-39.19054	0.0000
<b>D(LNDPC)</b>	7.522149	1.238566	6.073274	0.0001
<b>D(LNCPIR)</b>	0.032027	0.008583	3.731475	0.0033
<b>D(EXRATE)</b>	-0.010570	0.002689	-3.931571	0.0023
<b>RESIDLONG2(-1)</b>	-0.285169	0.070874	-4.023620	0.0020
<b>C</b>	0.049614	0.007451	6.658346	0.0000
<b>R-squared</b>	0.995652			

*All significant up to 10 percent significant level*

After running the short run ECM model, different diagnostic test and stability tests were done to ensure that the regression equation meets the entire Linear Classical Regression Model assumptions of being BLUE. The test

ranges from Heteroscedasticity the test for non-constant variance, Normality, Serial correlation, specifications and stability of the model. The results are presented in the tables below.

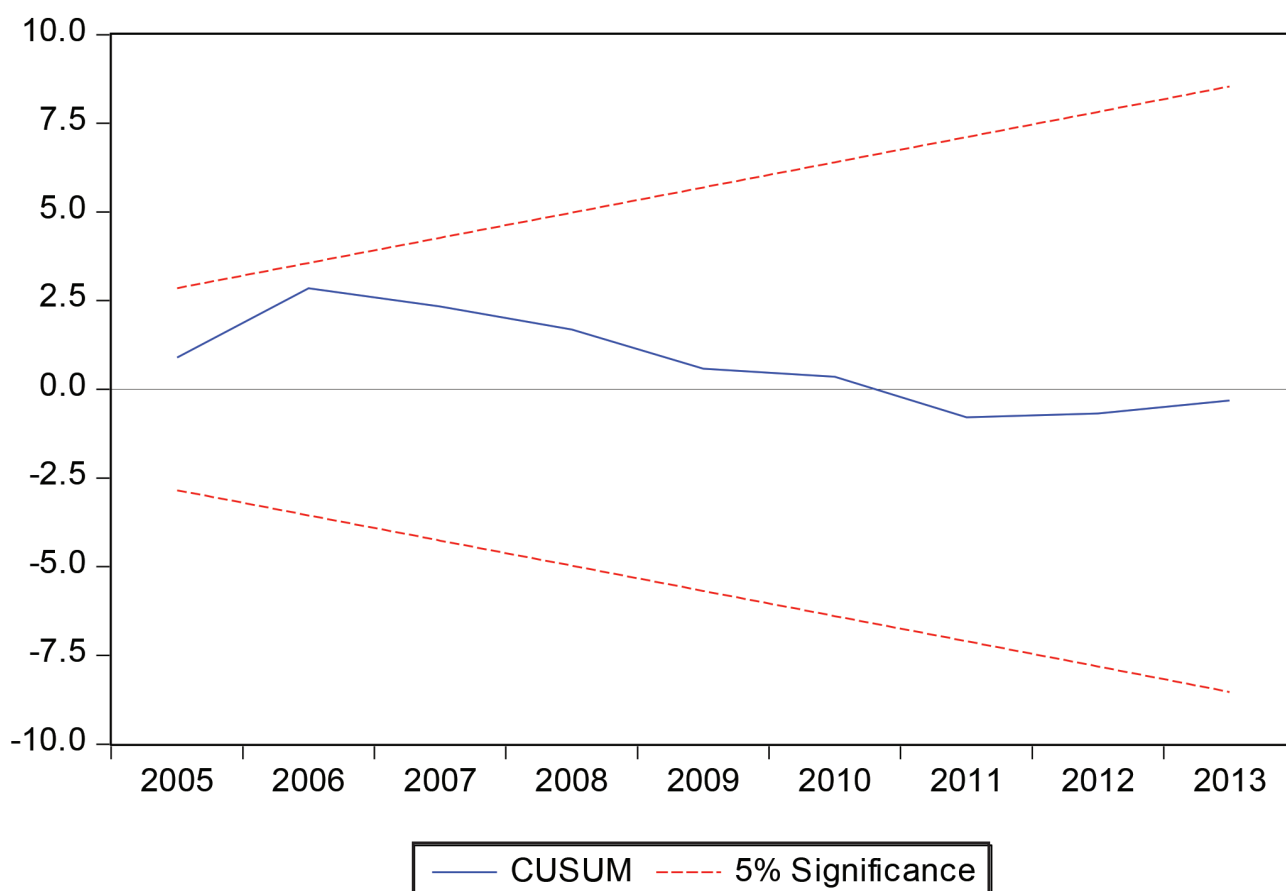
# Energy Demand and forecasting in Namibia

**Table 6: Diagnostic test of the ECM**

<i>Type Test</i>		<i>F-stats</i>	<i>Critical Value</i>	<i>R-Squred</i>	<i>DW</i>
<b>Normality</b>	Jaque-Bera	0.76			
<b>Serial Correlation</b>	Breusch-Pagan	0.71	0.35	0.07	2.01
<b>Heteroscedasticity</b>	Breusch-Pagan	1.68	0.20	0.57	1.56

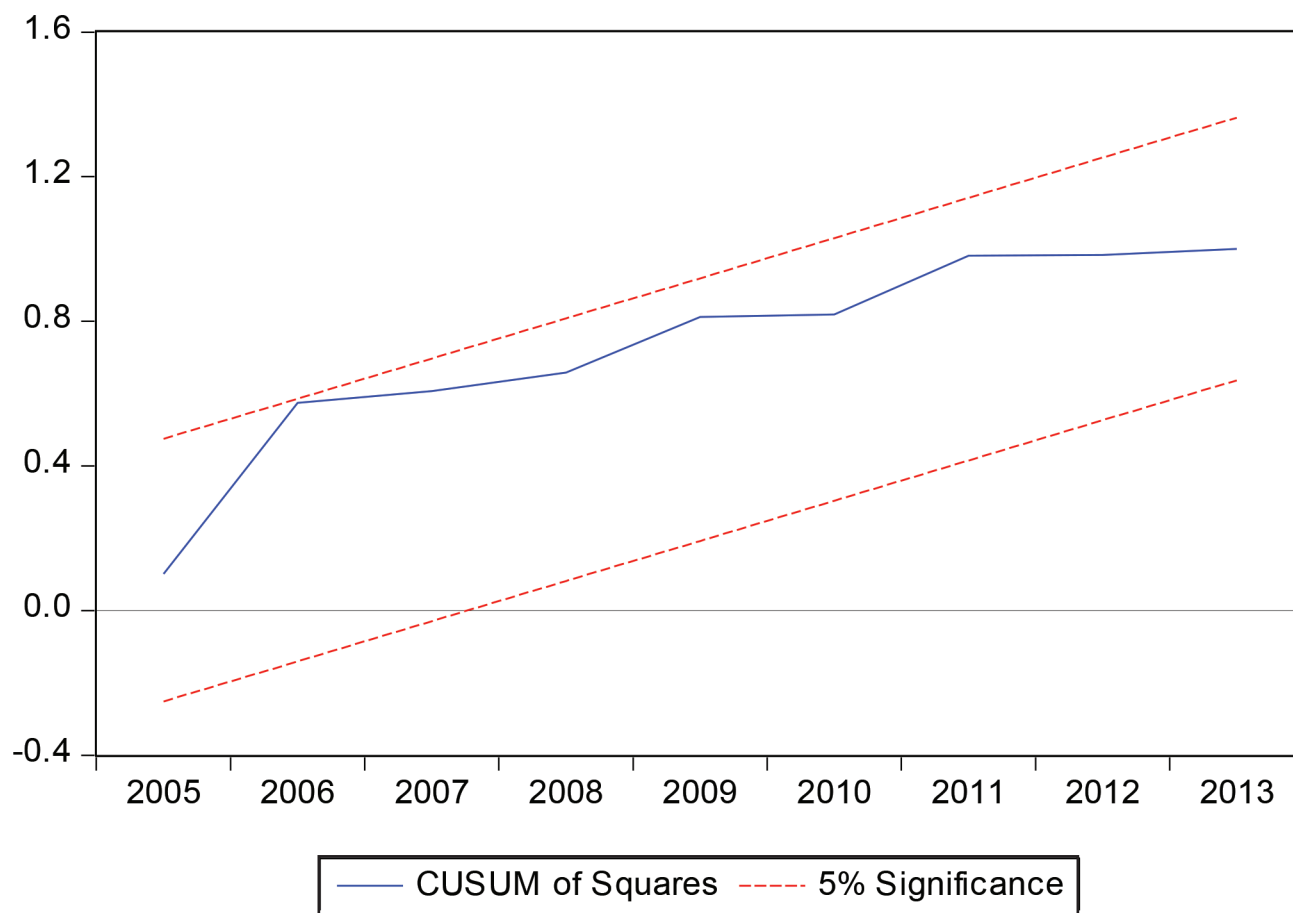
*All critical up to 10 percent significant levels*

**Figure 7: Stability test using Cusum**



## Energy Demand and forecasting in Namibia

Figure 8: Stability test using CusumQ



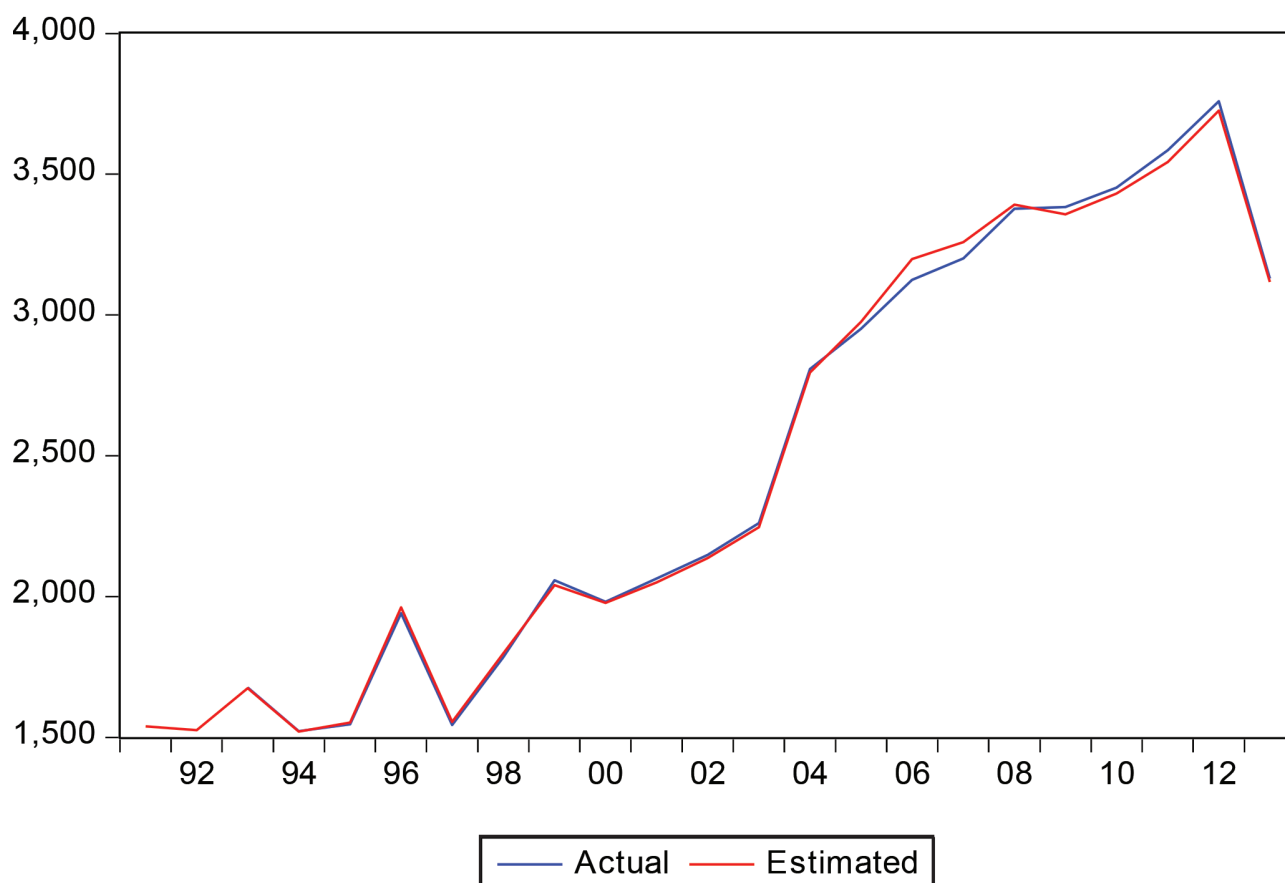
The results show that the equation is well specified and the linear classical regression assumptions are not violated. The ECM results shows that all variables are statistically significant up to 10 percent level, the residual is negative and statistically significant at 5 percent, which is signifying the deviation of energy consumption from the long run equation. The tests results in table 6 and in figures 7 and 6 shows that the model is stable over a period of time. The coefficient of the error correction implies that 29 percent of disequilibrium in energy consumption is adjusted each and every year. Other variables that are significant to impact energy consumptions in the

short run are nominal GDP, energy consumption per capita, employment levels, prices, exchange rate and energy productivity.

After the error correction equation passed all diagnostic test and stability tests. A test was done to see how well the model fit the actual data and see if the model was fit for future prediction of energy consumption using the variables in the long run equation. The graph below presents the fitted results of the actual energy consumption data from 1991 to 2013 with the estimated results.

# Energy Demand and forecasting in Namibia

Figure 9: Fitted line for Actual and estimated data on energy



## 6. Energy demand Outlook

As it can be seen in the graph above, the model is a good estimate and track well with the historical data and stable, thus it can be used to predict or forecast future energy consumption over the periods. A forecast of energy demand was done using some expert knowledge and collective assumptions collected from the field and from the key main players in the energy sector in Namibia. Some of the assumptions were based on the NDP4 targets which are GDP growth rate which will require more energy as input. Population and employment figures were also used to estimate energy consumptions. Assumptions from Nampower, REEEI, and NamCor as well

as Electricity Control Board were combined to produce the forecasts.

### Demand assumptions:

NDP4 GDP growth assumptions as well as sectoral projections growth were taken into account. Some major assumptions from the demand side are:

Transport sector: if all the planned activities in the transport sector materialise, more energy will be required. Activities such as the completion of the logistic hub, constructions of roads and railway to improve the road infrastructure as per NDP4 desired outcome.

## Energy Demand and forecasting in Namibia

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*Manufacturing sector:* the demand of energy from industry is expected to increase due to increase in demand from the smelting business (custom smelter and the anticipated new entry in the industry the iron smelting company that is to be set up in the Otavi area and other mineral beneficiation in the country.

Increase in *constructions* activities, expansion of *agricultural* activities specially the commercial farming and the green schemes, expansion in the *mining* activities as new mines open doors and all the day to day activities from all other sectors and industries which will require energy in order to realise NDP4.

### **Supply assumptions:**

Efforts have been made to ensure that the supply of energy in the economy is sustained. However, most of these efforts are not long term based.

Many of the electricity contracts from the import partners have been extended only up until 2015 and 2016, new 250 MWh plant in Walvisbay to

start by 2016, a 800MWh to be in place by 2018 and many other initiatives from the renewable energy such as the installation of solar projects and the commissioning of the concentrated solar power (CSP) in Namibia by 2017. Positive outlook on the supply side will only be realised if the Kudu gas project and all other initiatives listed above are all successful. Until that happen, Namibia will continue to experience a serious energy shortage and will have a negative effect on our developmental plans if nothing is done to increase local supply.

Using the collective assumptions mentioned above a forecast of energy consumption was made up to the year 2020. Using the co-integration equation both for long-run and short run equation all variables assumptions were collected. GDP, prices, population and employment forecast were based on the national planning macroeconomic forecasting with input from Namibia statistics agency. The following figure depicts energy demand outlook for Namibia for the next seven years.

## Energy Demand and forecasting in Namibia

Figure 10: Namibia Energy demand Outlook for 2014 to 2020

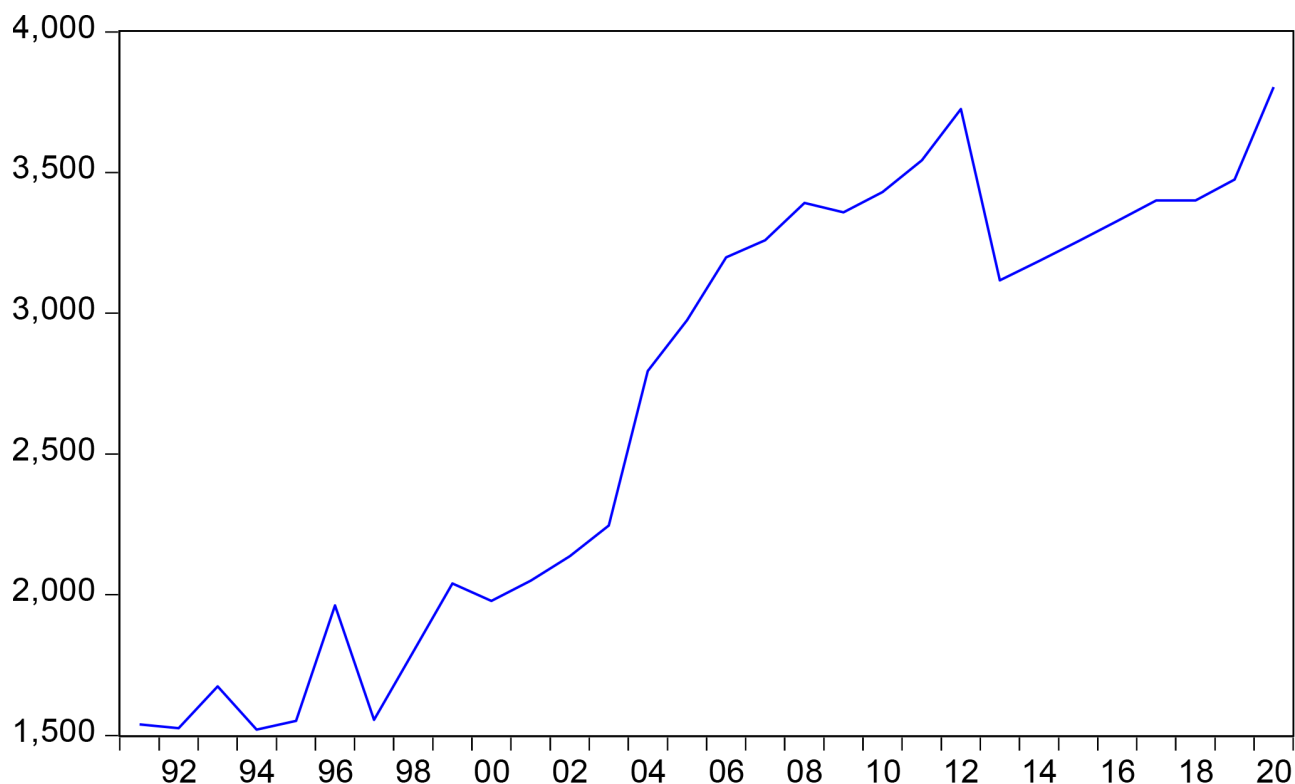


Figure 10 above shows the projected energy for Namibia from the demand side. Energy consumption for the period of 2014 to 2020 will increase by 3 percent on average this is translated into 3800 GWh. As illustrated above, energy consumption is projected to increase by 2.20 percent year on year from 2014 to 2017. It will then rise up again by 4 percent year on year from 2018 to 2020. These projections are based on the NDP4 projections of GDP growth rate, which in this study proved to have a direct relationship with the energy consumption. More economic activities such as in the mining, manufacturing, agriculture and transport sectors will put much pressure on the energy consumption. Expected positive employment growth as well as

population will also contribute to high energy consumption for the next seven years as NDP4 progress and as a result of implementing V2030 objectives.

The supply for energy is estimated to rise by 2.9 percent in the first two years and for the last three years growing at a constant by 0.1 percent. The establishment of solar generating plants in the southern towns of the country such as Keetmanshoop, Karasburg and Aranos will also contribute positively to energy supply. Growth in the oil industry will also fuel the supply for energy as it is projected to increase by 4 percent during the first two years (2013 and 2014) of NDP4 and by constant 3 percent during 2015 to 2017.



## 7. Conclusion

In this study we examined the relationship between the Namibian economic activities (GDP) and energy demand, though many studies have found a causal relationship between these two variables, there are also studies that shows negative relationship between energy demand and GDP growth. This study is in agreement with other studies such as the Kraft and Kraft 1978, Esso, 2010 and Odhiambo, who also found a relationship between GDP and Energy demand. The methodology is based on Engle-Granger two steps, which was found suitable for the type of data used in the study. The results indicate that for Namibia GDP has a positive impact on energy demand. The more GDP grow the higher the demand of energy will be. For other variables such as energy productivity and exchange rates in Namibia have a negative impact on energy use.

Energy remains to be a major important input in the Namibian economy. Future research should expand to investigate various energy sources used within each sector contributing to GDP, such as Industrial sectors, Transport and Residential. Future studies will shed additional insight on the impact of energy in the Namibian economy; however this will require quality data management from all energy players in the country as this is currently an issue.

In light with what the model and estimation results show, the following are the key conclusion of this study:

- ❖ There is a positive relationship between GDP and Energy consumption in Namibia
- ❖ There is a negative relationship between Energy consumption and Energy productivity and exchange rates

# Energy Demand and forecasting in Namibia

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## 8. Policy Recommendations

After a deep analysis of the energy demand and supply in Namibia in relation to economic growth, it will be inappropriate to conclude that energy does not have an impact on the economy. The need of energy as a contributor to economic growth cannot be underestimated. It is therefore crucial that the sector should not be side lined; the government should ensure that energy supply is increased as its demand is positively required to increase GDP. Hence, this implies that increasing energy production within Namibia should be one of the high priority objectives on economic developmental agenda, so that any economic development plan in place cannot be interrupted by energy shortage. It's highly recommended that the following recommendation be taken into consideration for policy development.

### 8.1. Increase the amount of energy supply in Namibia

It is proven in the analysis that energy consumption affects the growth of an economy, thus increasing the supply of energy will be a supplement for more economic expansion in order to industrialise Namibia and realise Vision 2030. More local energy production capacity need to be increased specially electricity and other renewable energy which could be used to reproduce other energy such as electricity. Increase in Energy supply by implementing the following:

#### 8.1.1. Sustain and improve Energy infrastructure

As emphasized in the NDP4 document, improving energy infrastructure is very vital not only for the energy sector but to the whole economy at large. This could be done through effective issuance of licences for operation that will increase energy supply.

#### 8.1.2. Expand energy research and development and also increase energy efficiency awareness

There is a need for energy innovation in the energy sector; this can only be achieved by extensive research and further development. More research is needed in the renewable energy to discover new technology of energy mix. More awareness on how to save energy need to be fostered this could be done by public education on power saving and encourage the use of renewable energy.

#### 8.1.3. Increase investment in Energy sector

Investment is the main input that can grow and develop the energy sector in Namibia. As it is a capital intensive sector, high investment would be used to increase energy production locally. This would require PPP working hand in hand to upsurge investment. The budgetary allocation from the public sector should also be allocated with energy development incentives based.

# Energy Demand and forecasting in Namibia

## 9. Appendices

**Appendix Table1: Estimation result when GDP is a dependent variable**

Dependent Variable: LNGDPE				
Method: OLS				
	<b>Coefficient</b>	<b>Std. Error</b>	<b>t-Statistic</b>	<b>Prob.</b>
LNGDPPROD	1.404793	0.044962	31.24393	0.0000
D(LNPOP)	-22.34410	4.024690	-5.551756	0.0000
DLNEMP	0.033750	0.179706	0.187807	0.8527
C	7.680417	0.167311	45.90504	0.0000
R-squared	0.987270	Mean dependent var		10.68285
Adjusted R-squared	0.985534	Durbin-Watson stat		2.075574
S.E. of regression	0.104340			
Sum squared resid	0.239510			
Log likelihood	24.04195			
F-statistic	568.7437			
Prob(F-statistic)	0.000000			

# Energy Demand and forecasting in Namibia

**Appendix Table 2: Data used in the study**

year	EXRATE	Employment	GDP	Population	Electricity	CPI	EXRATE
1991	2.8	320915	25957	1511991	1798	11.8	2.8
1992	2.9	332353	27823	1552502	2040	17.9	2.9
1993	3.3	336863	27384	1595138	1978	8.5	3.3
1994	3.6	350280	27858	1638327	2050	10.7	3.6
1995	3.6	363697	28944	1681478	2136	10.1	3.6
1996	4.3	377115	29867	1724320	2246	8.0	4.3
1997	4.5	390532	31128	1766142	2795	8.9	4.5
1998	5.5	401202	32152	1806532	2976	6.2	5.5
1999	6.1	414619	33236	1846699	3199	8.6	6.1
2000	7.0	427212	34396	1893442	3259	9.4	7.0
2001	8.6	431850	34802	1935098	3392	9.2	8.6
2002	10.5	445677	36468	1960672	3358	11.4	10.5
2003	7.5	456542	38014	1983430	3431	7.1	7.5
2004	6.5	467406	42679	2006646	3543	4.2	6.5
2005	6.4	480748	43758	2028356	3726	2.3	6.4
2006	7.0	504128	46853	2049149	3117	5.1	7.0
2007	7.1	561150	49371	2069028	3036	6.7	7.1
2008	8.1	556653	51038	2088669	2823	10.4	8.1
2009	8.4	555025	50482	2108665	2610	8.7	8.4
2010	7.6	566451	53649	2128471	2397	4.5	7.6
2011	7.2	597837	56694	2128471	2184	5.1	7.2
2012	8.6	630097	59538	2128471	1971	6.5	8.6
2013	8.2	636140	62387	2128471	1758	6.2	8.2

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