UNIVERSITY OF LJUBLJANA
FACULTY OF ECONOMICS

MASTER'S THESIS

RENEWABLE ENERGY FOR SUSTAINABLE GROWTH IN THE REPUBLIC OF SOUTH AFRICA

Ljubljana, June 2015 VANISHA HARRY

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INTRODUCTION

In order to be economically viable a country needs an electricity source. The African continent has the lowest value in electricity use per capita as well as Gross Domestic Product (hereinafter GDP) per capita. For Africa to compete against the globe and reduce poverty it needs more electricity supply. It is noted that the average consumption of electricity per person per year on the continent is only 500KWh. This amounts to only 20 percent of the world average of 2500 Kwh. Even though this is the only needs of the people of Africa, these demands can't even be met. The problem is that most of the population on the continent have minimal access to electricity. The Republic of South Africa (hereinafter RSA) and North Africa's electricity usage per capita is much higher than the rest of Africa. A start to a better life for all on the continent is to be able to meet the demand for residential energy supply of 500 kWh. The agricultural, manufacturing and other industries can only run effectively if there is ample supply of electricity (Klimstra, 2012).

The availability of electricity or energy is often taken advantage of; at a flick of a switch we have light, hot water, food to eat and are able to move around. RSA is sitting with a major problem as it cannot meet the ever increasing need of the people with regards to energy supply. Partly due to the fact that since gaining democracy in 1994 government failed to build new energy plants and adequately maintain the current energy plants. During the course of this research the aim is to understand what options are available to RSA to meet the energy supply of its population. In the recent months RSA has been experiencing major power shortages, the national monopolist supplier has enforced strong loadshedding[1] across the country, effecting many households and industries. The challenge facing RSA is finding alternate sources of energy supply, how to properly invest and plan so that this problem will be dealt with. Fortunately, it is a worldwide problem and not that alone of RSA. Each country has different problems but the global challenges are experienced by all.

The goal of the research is to gain insight into the developments in the renewable energy sector of RSA and the potential of renewable energy as well and the role of renewable energy supply in RSA. The thesis will focus on the contribution of government to help the struggling energy sector, the development of the industry and the way renewable energy can assist. The purpose is to understand if renewable energy is a sustainable way to provide energy to the millions of people in RSA and to provide guidelines that would enable RSA to do so.

Main research questions that this thesis will try to answer are:

- What are the general characteristics of the energy sector developments in RSA since 1994 on the supply and demand side and what are the main problems of the sector?

[1]When there is not enough electricity available to meet the demand Eskom would interrupt supply to certain areas, it is a form of balancing electricity supply and avoiding complete collapse of the energy supply grid.

- Which are the main policy objectives for the progress of the energy sector?
- Is RSA ready to move away from coal powered power plants and what are the policy measures planned to support the increasing share of other types of energy?
- What is the role and what are the characteristics of the renewable energy sector in RSA?
- How can the energy problems be solved and what is the role of green energy in this context?
- What are the main policy objectives and strategic development goals for the green energy sector?
- Is the sector attracting enough foreign direct investment?
- Does Eskom have what it takes to turn around this crisis?

Methodologically, primarily qualitative approach will be used. It will rely on literature mainly sourced from South African sources, articles with international recognition related to the topic at hand. The literature will be used for background information, insight and evaluation. The main methods used will be description, analysis and synthesis.

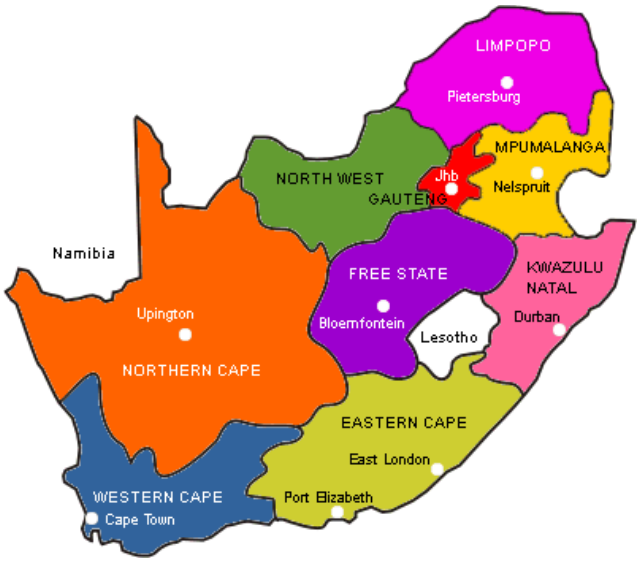
The main data source will be from online sources such as websites, journals and online articles. Primary data collection will be conducted with the interviews planned with various members in the industry.

1 SOUTH AFRICA IN BRIEF

RSA with a population just over 54 million inhabitants is divided into 9 provinces; each province has its own legislature, premier and an executive council, namely Eastern Cape, Free State, Gauteng, Kwazulu Natal, Limpopo, Mpumalanga, Northern Cape, North West and the Western Cape as represented in Figure 1.

Prior to 1994 RSA was only broken into 4 provinces namely Transvaal, Orange Free State, Natal and the Cape. The provinces are not of equal size, Gauteng finds itself crowded and much smaller and boast the highest population, while the Northern Cape is more arid and has the smallest population. Each of the nine provinces has its own provincial government and provincial premier. The premier is elected by the legislature and the President and serves a two to five year term. The premier is responsible for appointing the executive council, which serves as cabinet at the provincial level (SouthAfrica.Info, 2014).

Figure 1. South Africa

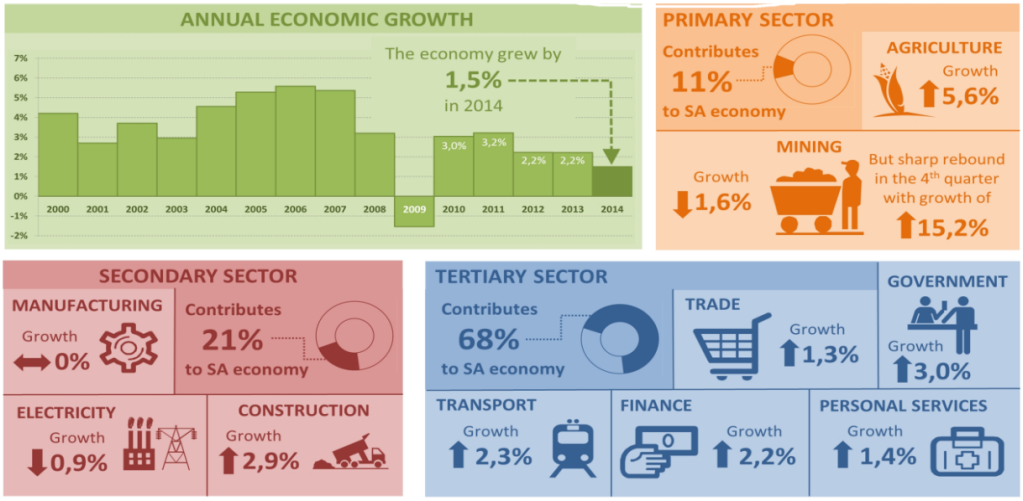


Source: *Pininterest*, 2015.

Economically, RSA had a recorded annual percentage of GDP of 0.6 percent in 2013, compared to 0.7 percent in 2012 and 1.7 percent in 2011. Annual percentage change of consumer prices also gradually increased from 2.2 percent in 2012 then increasing to 3.3 in 2013 and in 2014 making a big leap to 5.6 percent. Year 2011 saw inflation at its highest 10.9 (World Bank, 2015). During the years from 2004 to 2007 RSA growth rate was at 5 percent in real terms and decreased to just above 2 percent during 2008 – 2012 due to the global economic crisis. RSA has nine provinces as mentioned above and the three that add the most value added are Gauteng, Kwazulu Natal and the Western Cape averaging just above 60 percent. GDP increased by 1.4 percent during the fourth quarter of 2014 compared to only 0.5 percent in the second quarter. The economy in 2014 experienced growth of 1.5 percent compared to 2.2 percent 2013. Two industries had a tough time and experienced reduction in their size, while eight of the ten industries experienced growth. Mining and electricity sectors were the two industries that experienced the reduction in their size, with mining decreasing by 1.6 percent and electricity 0.9 percent. Manufacturing remained unchanged during the year.

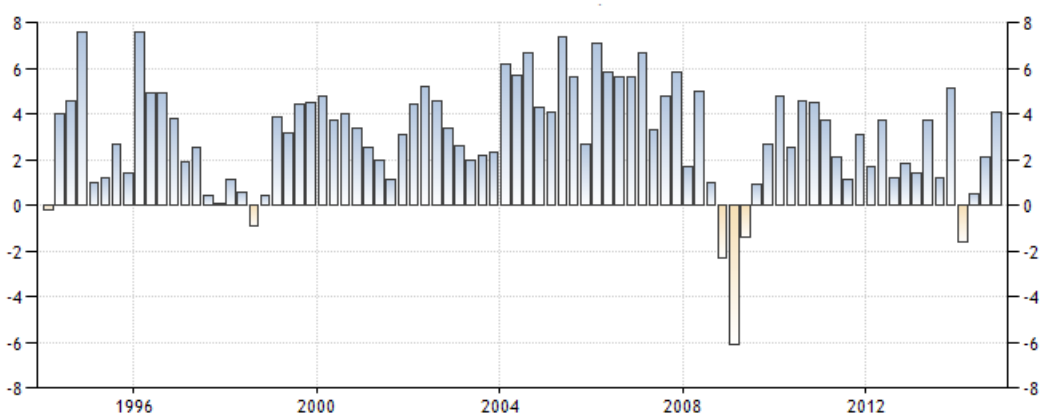
The mining industry suffered great loss in 2014 due to many strikes in the first quarter of the year, leading to losses in the first and second quarters, by the fourth quarter it picked up to 15.2 percent. Agriculture was fortunate enough to grow the fastest in 2014 increasing by 5.6 percent, followed by government services with a growth of 3 percent (Statistics SA, 2014). Figure 2 gives further insight into the 2014 economic performance. Figure 3 gives an indication of the GDP growth rate from 1995- 2015.

Figure 2. Economic Performance of RSA in 2014



Source*:* Statistics SA, *Economic Growth Slows in 2014*, 2015.

Figure 3. GDP Growth Rate Since 1994 - 2015



Source: *Trading Economics*, 2015.

Due to its history and the current growth performance, RSA has a very diverse structure to its economy. The manufacturing sector occupies the biggest share in the economy even though it has declined significantly from 19 percent in 1993 to 17 percent in 2012. Due to structural changes in the economy, the finance, real estate and business services sector grew from 17 percent in the year 1993 to 24 percent in 2012. Since democracy was obtained in 1994 these are amongst the few sectors that showed significant growth (Statistics SA, 2015).

RSA has always relied heavily on its primary sectors due to its large amount of mineral resources and attractive agricultural landscape. In the early 1990's shift in sectors had taken place and RSA became more reliant on the tertiary sectors such as wholesale, retail, tourism and communication. Key industries in RSA include automotive industry and mining, tourism and information and communication. The automotive industry contributes 6 percent to GDP, and 12 percent to exports. The mining sector which is the fifth largest in the world, contributes 18 percent to GDP and 20 percent to investment. RSA is fortunate to have good

reserves of the manganese and platinum group metals and gold, diamond and chromite ore. The Information and Communication Technologies (hereinafter ICT) sector is the most advanced and one of the biggest in Africa, RSA domestic IT industry is well known for its sound electronic banking services as well as its mobile software sector. IT spending in 2010 reached $10.6 Billion and managed along with telecommunications to generate $29 Billion in revenues. The South African Electrotechnical Export Council estimated the ICT sector contributes at least 8.2 percent to GDP, the South African ICT is estimated at $42.6 Billion in 2013 (South Africa.Info, 2014).

Agriculture is also important, contributing 2.2 percent to GDP, reflecting a major decrease over the past four decades. In terms of the Industrial Policy Action Plan for 2014/2015-2016/2017 Agro Processing has been identified as a sector with a number of macroeconomic objectives. The sector has strong up and downstream movements. On the downstream, agro processing outputs are intermediate products which add value, create employment and decreases the poverty scale. In the third of quarter of 2013 agro –processing percentage of GDP in manufacturing contributed to 7.7 Billion ZAR (16 percent) (Department of Trade and Industry, 2014).

The growing economy has resulted also in increased energy supply, which represents a challenge for current and future growth RSA is heavily dependent on its manufacturing, automotive, mining and ICT sectors which are all dependent on the energy. Constant and sufficient supply of energy is therefore crucial for the future growth of the economy.

2 CURRENT ENERGY SUPPLY AND CONSUMPTION

Electricity is produced at the coal powered station then transported to the national grid to municipalities and large industries then purchase it at wholesale price. Municipalities are the re-distributors, they supply end-users of electricity needed for domestic, commercial and industrial usage. Income is generated by municipalities by offering this service to end users, these funds are then used to subsidise for other services such as water and waste.

During the 2012/2013 financial year Eskom[2] sold over 216 541 Gwh of electricity, the sales were broken down as follows 3 000 industrial customers, 1 000 mining customers, 50 000 commercial customers and 84 000 agricultural customers. March 2013 saw Eskom net profit for the year being R 5.1 billion ($ 4 171 80000.00) which was much lower than the R 13.2 billion ($1 079 760000.00**)** generated in 2012. Sales for electricity declined by 3.7 percent to 216 561 Gwh for year ending 31 March 2013. Even though the sales decreased, some positive outcomes were also experienced, revenue improved by 12.2 percent, total number of customers improved from 4.9 million to 5 million, 150 unemployed graduates were provided with an internship. Budgeted sales for 2013 for Eskom was quoted at 222 083 Gwh but they

[2] Eskom was established in 1923 and is a state owned company that supplies electricity to RSA.

only managed sales of 216 561 Gwh. Drop in sales that was experienced in 2013 was similar to that of the energy crisis that was experienced in 2008. Over the past three years electricity prices have doubled in value, electricity consumption decreased by 206 percent in 12 months of 2012. The main consumers who decreased their consumption were residential and municipalities. Many have blamed the reduction of consumption on the heavy price increases (Mahomedy, 2013).

The RSA economy has shown vast improvement and that electricity consumption declined, proved that industry has been more cautious on how it used power, this is one explanation of what could have happened, the other is that many of the big consumers couldn't compete with the rising costs and where forced to shut down. Large industrial users and municipalities account for atleast 70 percent of Eskom's sales; this could be the reason for the huge decline that was experienced. Eskom increased prices heavily in 2010, 2011 and 2012 with prices increasing by 24.8 percent, 25.8 percent and 25.9 percent respectively. National Energy Regulator (hereinafter Nersa) rejected the price increases in 2013 of 16 percent annual tariff increase and allowed them only a 8 percent tariff increase for the next five years (Mahomedy, 2013).

2.1 Energy Supply

RSA depends heavily on its large coal supply to fuel the energy needs of the country. The reserves of oil and natural gas are very limited. Oil consumption in RSA is largely used for transportation; oil is imported from Middle East and West Africa and is refined locally. RSA managed to develop a sophisticated synthetic fuels industry, and produce gasoline and diesel fuels (Energy Information Administration, 2014).

For the oil and natural gas exploration and production the Petroleum Agency of South Africa (hereinafter PESA) provide public data. In the electricity sector, natural pipelines industries and petroleum pipeline industries Nersa is responsible for regulation. Nersa is also responsible for electricity prices regulation and encourages the private sector to participate in investment in independent power producers and off grid technologies to meet energy needs of the rural developments. Eskom is owned by government and is responsible for approximately 95 percent of the electricity needed by RSA and is responsible for operating the national electricity grid (Energy Information Administration, 2014).

Petroleum Oil and Gas Corporation of South Africa (hereinafter PetroSA) is also owned by government and is responsible for the upstream oil and natural gas sectors while the downstream oil sector and petrochemical industry is diversified and operated by international companies such as British Petroleum (hereinafter BP), Chevron, Total, Engen and Shell. PetroSA has operations in oil and gas in Africa including Ghana, Democratic Republic of Congo, Egypt, Nigeria, Gabon, Equatorial Guinea and Namibia. Sasol is an international integrated energy and chemicals company operating in Secunda (Mpumalanga), where one of

the world's largest coal based synthetic fuel plants operates. Sasol is involved in the mining of coal and promotion of natural gas and oil products. The company mines about 40 million tons of saleable coal per annum and resells about 2.8 tons per annum. Sasol imports natural gas from Mozambique via a pipeline. There are several other companies operating as well in RSA in the coal sector they include Anglo American, BHP Billton and Xstrata Coal. A South African owned coal company is one of the. top produces and trades under the name Exxaro (Energy Information Administration, 2014)

2.1.1 Coal Energy Supply

RSA is ninth in the world when it comes to recoverable coal reserves and for the African continent it has 95 percent of these reserves. Based on reports by BP Statistical Review of World Energy 2013, RSA coal reserves were estimated at 30.2 billion short tons (2012) and this should last between 60 - 70 years. The electricity sector is responsible for more than 50 percent of the coal consumed in RSA, they are followed by Sasol petrochemical industries, metallurgical industries and domestic heating and cooking. Coal production and consumption levels have been constant over the last decade. During 2012 288 million short tons (hereinafter MMst) was produced and 202 MMst was consumed (Energy Information Administration, 2014).

RSA's usage of coal is not expected to decrease anytime in the future as Eskom has expansion plans in its coal fired electricity capacity to meet the needs of the country. RSA exports around 25 percent of the coal produced. In Kwazulu Natal the Richards Bay coal terminal is the county's main coal export terminal and is one of the largest globally. In the year 2013 alone the terminal received and exported 70 million tons of coal for the first time in its history, India and China being their biggest customers (Energy Information Administration, 2014).

RSA coal production supply is dependent mainly on the domestic power use. RSA still has an abundant supply of coal that should last quite some time and is relatively cheap to produce energy from it will mean that coal generated power will always be the most suitable way to produce electricity. In order to have the supply of coal in the future it is crucial that RSA develop new mines before they are fully exhausted. Demand for coal in the future will also be impacted by increased prices, short term contracts and carbon taxes charged (Eberhard, 2011).

Table 1. RSA Energy Statistics (2000-2001)

Year	**Electricity Production from Coal Sources (percent of total)**	**Electric Power Consumption (mil Kwk)**	**Electricity Production from Renewable Sources (mil Kwt)**
2000	93.1	205 959	1 408

table continues

continued

2001	93.7	196 053	2 292
2002	93.3	209 009	2 695
2003	94.1	213 029	1 013
2004	93.9	217 064	1 265
2005	94.6	222 019	1 650
2006	94.7	228 964	3 219
2007	94.8	238 314	1 192
2008	94.2	232 230	1 583
2009	94.1	223 520	1 783
2010	94.2	232 658	2 519
2011	93.8	237 460	2 465

Source: *World Bank*, 2015.

The first indicator in Table 1 gives an indication how dependent RSA is on the production of energy from coal sources, since the year 2000 it has been over 90 percent of the energy supplied. RSA has an abundant supply of coal and is one of the largest exporters of coal. Eskom is the utility responsible for providing the country's energy needs. Thirteen coal fired power stations are in operation which includes three that have been recommissioned. These stations operate 24 hours a day providing power to the country. The Integrated Resources Plan for Electricity (hereinafter IRP) foresees RSA needing a further 6 250 MW of new coal before 2030 and coal is the best low cost option available. RSA has an abundance of supply of coal and coal fired powered stations are cheaper to build than a new nuclear plant. It is estimated that at least 8 GW of new coal capacity is needed to achieve higher levels of economic growth which is vital for RSA future economic, social and political strength, sustainability and stability. In order for this to happen there has to be some sought of security that energy sources are available at competitive prices (Jeffrey, Falcon, Kinghorn, 2014).

2.1.2 Natural Gas Supply

RSA has a limited supply of proved natural gas reserves; shale gas resources are much higher. PetroSA has numerous projects planned for the future for natural gas, presently constraints makes it difficult for natural gas to contribute to the electricity sector. RSA has 390 Tcf of shale gas resources that can be recovered. In 2011 government brought forward a moratorium for issuing new licenses for shale gas exploration. The moratorium was lifted in 2012 after research put forward that it was safe to continue exploration. RSA has a large gas-to-liquid plant built in 1992. The plant is operated by PetroSA, and is responsible for converting natural gas into synthetic liquid fuels. More than half of the synthetic liquid fuel produced is unleaded gasoline and the remainder kerosene (paraffin), diesel, propane, liquid oxygen and nitrogen, distillates, eco-fuels and process oils. The natural gas is imported along a 535 mile gas pipeline. The pipeline is owned by Mozambique and RSA governments through a joint venture. The project was started in 2004 and has a peak capacity of 524 million cubic feet per day of natural gas, and is worth $1.2 billion (Energy Information Administration, 2014). In

2013 RSA produced 14 billion cubic feet (Bcf) of dry natural gas (US Energy Information Administration, 2015).

2.1.3 Petroleum and Other Liquids

At the end of 2013 RSA crude oil reserves were 15 million barrels. These reserves are located offshore in the Bredasdorp Basin and off the West Coast of RSA, near the maritime border with Namibia. After Egypt, RSA is the largest consumer of petroleum in Africa. RSA imports crude oil from OPEC countries in the Middle East and West Africa. Domestic refineries are responsible for most of the crude oil imported. RSA has the second largest crude oil distillation after Egypt. Government has plans to implement tougher fuel standards by 2017, this will require all of them to upgrade facilities, and refinery operators are hesitant to conduct upgrades due to the low return on investment. Tariffs recently increased as government needed funding for a new fuel pipeline that will be constructed from Durban to Gauteng (Energy Information Administration, 2014).

2.1.4 Nuclear Energy

In 2013 437 nuclear reactors where in operation worldwide, the concern over nuclear energy developed after the accident at Fukushima (Japan). Many countries across the globe have decided to move away from nuclear energy in the medium to long run. As some countries take in the decision to phase nuclear energy out, others are doing the complete opposite and looking into ways to expand their nuclear energy capabilities (Van Wyk, 2013). The Koeberg Nuclear Power Station is the only one on the African continent. Construction started in 1975 and Unit one joined the grid in 1984 and Unit 2 by 1985. Koeberg has installed capacity of 1 800 MW and is situated in the Western Cape (Eskom, 2014). The plant provides 5 percent of electricity supply to the country and is owned and operated by Eskom with twin pressurised water reactors. Government has put in place plans to extend the life of the plant from 30 to 40 years (World Nuclear Association 2015).

In 2014 RSA signed an agreement with Russia a large scale nuclear power plant procurement and development program. The reactors will have installed capacity of 9.6 GW or a total of 8 units. The agreement opens doors for other collaboration in different areas such as construction of the Russian based technology based multipurpose research reactor, assistance of development of RSA nuclear infrastructure and training of specialized staff at Russian universities. The agreement assists in RSA plans to have a new nuclear plant by 2030 of a 9.6 GW of nuclear energy capacity. Further inter government agreements will be signed later and the bidding process will be complete in mid-2015 before any final contracts are signed (World Nuclear News, 2014).

2.1.5 Renewable Energy

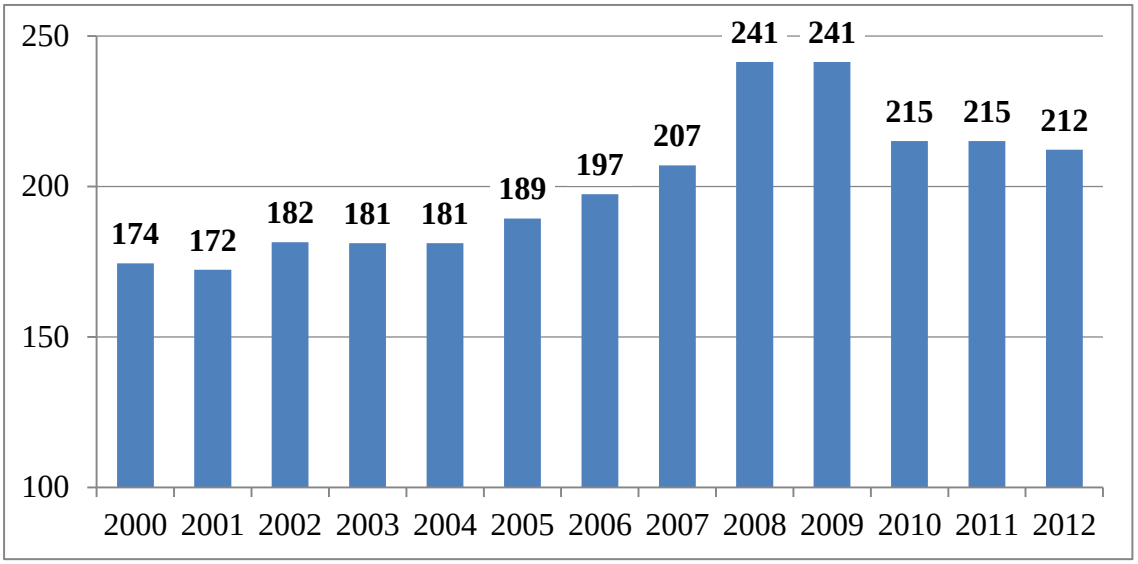
The 2003 White Paper on Renewable Energy set targets for 2013 that at least 10 000 GWh of energy needed to be procured from renewable sources. No accurate data has been made available as to the actual contributions from renewable energy (Banks & Schäffler, 2006) (I am providing available estimates in Table 1). Along the West Coast of South Africa, 37 wind turbines are already present, by the end of 2014 it was estimated that at least 400 turbines would be working throughout the country. Currently, there are five wind farms in productions, fifteen are being constructed. It is estimated that 1 983 MW of power will be produced from the 700 turbines that will be installed. Around 120 MW of power is already being produced from the three utility scale wind farms. The three farms are scattered across South Africa, some are located in the Western Cape, others in the Eastern Cape. A wind farm located in the Eastern Cape with 60 wind turbines, assisted with energy supply during the recent loadshedding the country is experiencing. The farm spreads over 3 700 ha, and is estimated to provide 460 000 MWh/y, this is enough to power 100 000 South African home and reduce carbon footprint by 420 000t (Cloete, 2014).

2.2 Energy Consumption

The demand for electricity in the country has significantly increased over the past few years, as new homes, more homes with access to power and new industrial factories come up has all lead to increased demand for power.

The second indicator from Table 1 is an indication of the electric power consumption by the millions who are connected to the energy grid. Electric power consumption is the measurement of the production of power plants and the combination of heat and power plants less the transmission, distribution and transformation losses and own use by heat and power plant. In 2012 data from the Department of Energy, 74 percent of households had access to electricity. RSA energy consumption per capita is much higher than the world average. From the period 1990 – 2002 total energy consumption experienced growth of 1.1 percent/ per year, that has increased majorly to 4 percent/ year. In 2009 data indicates that RSA electricity consumption per capita was at 4,150 kWh compared to the world average of only 2,550 kWh, this roughly 60 percent more. Total energy intensity between the period from 1990 and 2009 experienced slow growth of 0.4 percent/year and in 2000 experienced faster reduction of 1 percent/year. These changes in the trends are due to the rapid growth of the consumption of electricity and the generation of electricity from coal (Enerdata, 2011).

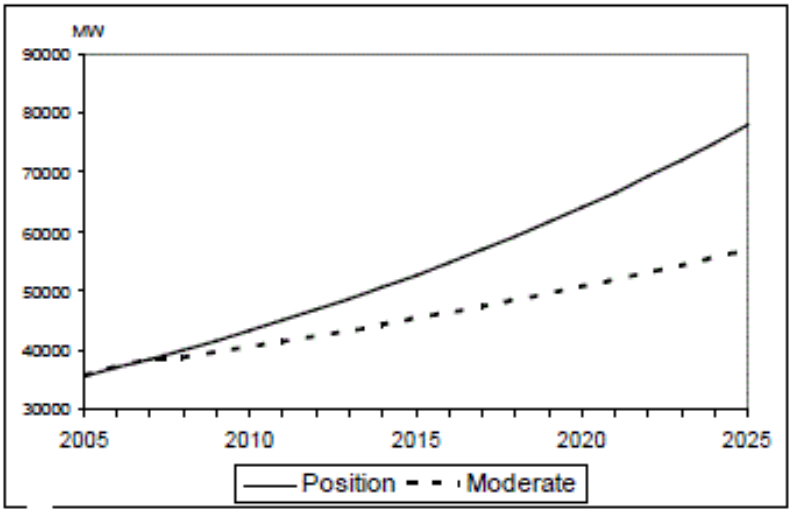
Figure 4. Electricity Consumption by Billion Kwh (2000-2012)



Source: *Indexmundi*, 2015.

In 2008 Eskom presented to parliament some challenges including ensuring continuous supply, successful execution of the capacity expansion programme, maintaining the financial stability of Eskom, dealing with climate change, implementation of Electricity Distribution Industry restructuring, building public confidence in Eskom. Eskom presented that growth of electricity demand was only dependent on economic growth. This is not correct and has many consequences. A number of studies have been done to understand the relationship between electricity consumption and economic growth, no evidence can be shown that this relationship is the correct way to measure demand (Inglesi & Pouris, 2010). Data available from 2011 and 2012 indicate that in 2012 consumption decreased by 2.6 percent compared to 2011. By December 2012 a year on year decrease of 3.8 percent was estimated. Seasonal adjusted electricity also decreased by 1.1 percent in December 2012 (Statistics SA, 2015).

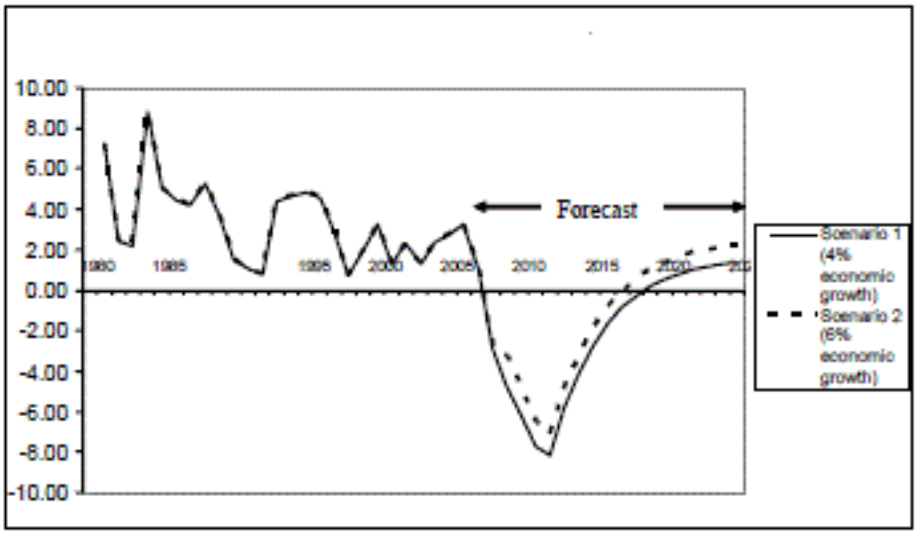
Figure 5. Eskom Long Term Demand Forecast (2005-2025) in MW



Source: Inglesi, R & Pouris A, *Forecasting Electricity Demand in South Africa: A critique of Eskom's Projections*, 2010, Figure 1, Page 2.

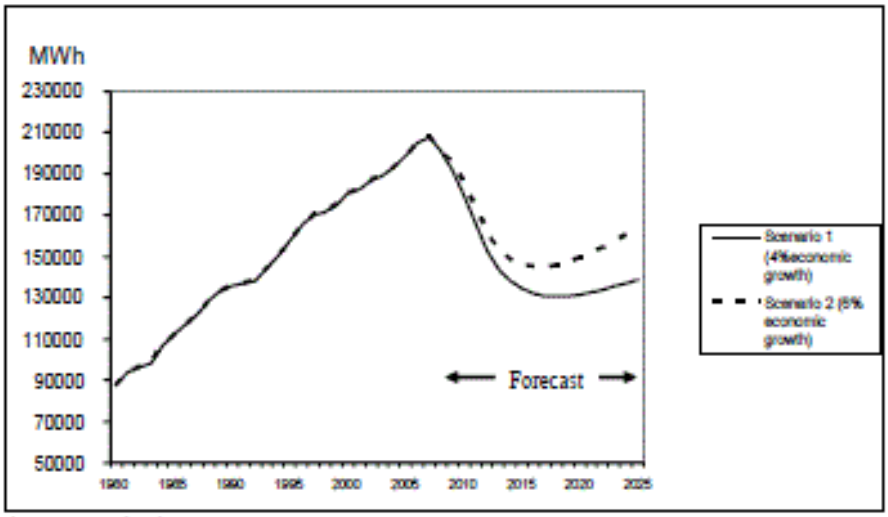
Two scenarios were used to estimate electricity use till 2025. The first assumed that economic growth will be on average 4 percent from 2009 -2025 and population growth will remain at 1 percent per annum. The second scenario measured growth at 6 percent over the same period. The figure 6 below indicates that growth is negative when prices are increasing. When prices remain constant growth moves positively. This forecast indicates that demand for electricity will decrease by 31 percent (2008-2025) in Figure 6 and 18 percent in Figure 7 (Inglesi & Pouris, 2010).

Figure 6. Yearly Electricity Demand Growth for RSA (2008-2025) in Percent



Source: Inglesi, R & Pouris, A, *Forecasting Electricity Demand in South Africa: A critique of Eskom's Projections*, 2010, Figure 2, Page 3.

Figure 7. Electricity Demand (Forecast from 2008- 2025) in MWh

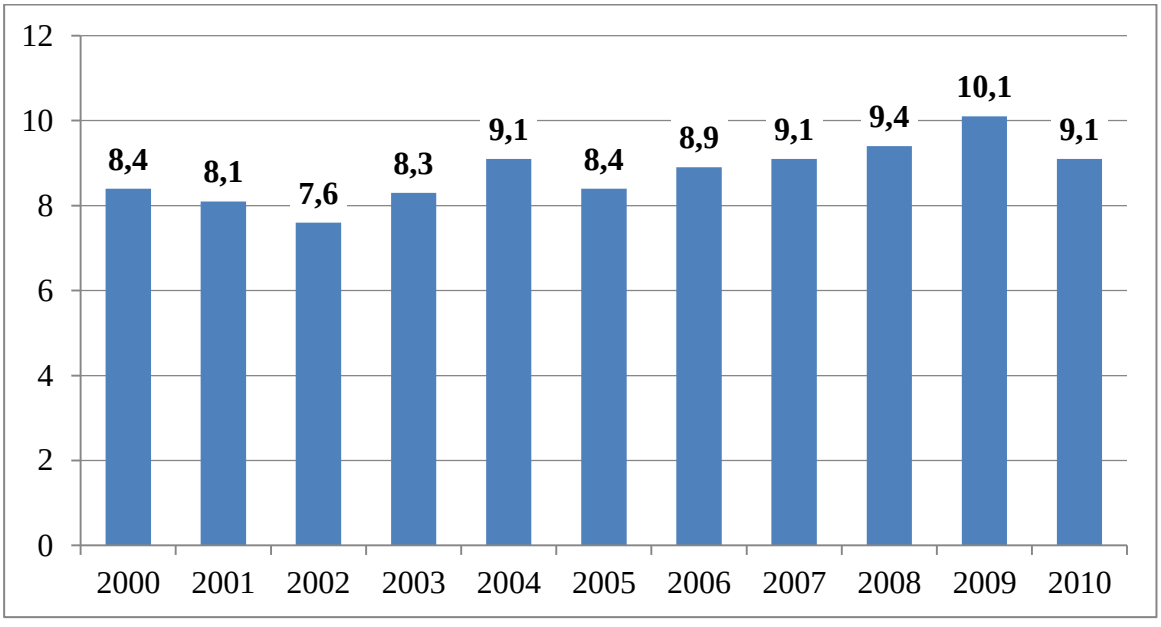


Source: Inglesi, R & Pouris, A, *Forecasting Electricity Demand in South Africa: A critique of Eskom's Projections*, 2010, Figure 3, Page 3.

2.3 Characteristics of Energy Use and the Impact on the Environment

From the period 2002 – 2012 the amount of pollution produced has increased considerably. The annual ton of pollutants is measured, these pollutants include nitrogen dioxide (hereinafter NO_2) and sulphur dioxide (hereinafter SO_2) and all emitted from electricity power plants. Over a period of 10 years these emissions of NO_2, SO_2 and particulars (hereinafter $PM_{10)}^3$ have increased by 44 percent, 22 percent and 74 percent respectively. These numbers are likely to increase even more as RSA depends heavily on coal fired electricity. In the province Mpumalanga, where most of the coal power stations can be found, pollution levels are the highest. In 2010 it was estimated that 79.8 tons of mercury was emitted by the coal powered stations accounting for 77 percent of mercury emissions for the country. The mercury emitted from the coal fired power stations was 75 percent of anthropogenic sources in RSA. The reduction of this alone will significantly improve the environmental health of the country. Countries regulate air ambient air quality through ambient air quality standards, which aims for protecting the wellbeing of humans, the broader eco systems and air quality management. The air quality standards of RSA were gazetted in 2009 with relevant standards for $SO_{2,}$ NO_2 and $PM_{10.}$ The Department of Environmental Affairs monitors air quality at ground level focusing on areas with higher risk. RSA legal standards are also behind the $20\mu g/m^3$ of the World Health Organisation. Seasons seem to affect the amount of pollution that occurs; these are mainly due to atmospheric changes. Pollutant levels seem to be higher during the winter months due to the atmospheric diurnal patterns (McDaid, 2014).

Figure 8. CO_2 Emissions Metric Tons per Capita in RSA 2000-2010



Source: *World Bank*, 2015.

Around 70 percent of the population in Sub-Sahara Africa mainly those in rural areas are dependent on wood fuel (firewood or charcoal) to meet domestic energy needs. Even though more people will be connected to some electrification programme many will still rely on this

type of energy production. RSA provides electricity supply at subsidised rates is expected to be an alternative to fuelwood but even though electricity is provided, many homes in rural areas prefer to use fuelwood due to it being more cost effective and many households being unable to afford to purchase electricity. The little amount of money they do have is rather used for essentials like education, food and clothing. Due to these conditions of poverty all over RSA the energy policy needs to consider these in their strategy so that they can break the existing energy poverty cycles linking high fuelwood use to bad socio economic conditions (Matsika, Erasmus, Twine, 2012).

In the last ten years Greenhouse Gas (hereinafter GHG) emissions in RSA have increased by 25 percent. In 2010 the total GHG emissions increased by 24 percent compared to 2000. The sectors include Energy, Industrial Processes and other product use (hereinafter IPPU), Agriculture, forestry and other land use (hereinafter AFLOU) and Waste. It is evident that the energy sector has the biggest role in GHG emissions. In 2000 this figure was at 82.3 percent to the total GHG inventory and this moved up to 85.1 percent in 2010. Electricity production dominates the emissions with 67.8 percent, transport 9.3 percent and manufacturing and construction industries 8.5 percent. In the industrial processes, an emission is released from physically or chemically transforming raw materials, as well as emissions that are released from refrigerators and aerosol cans. Metal industries are the largest contributors to GHG emissions and ranged between 73.5 and 80.3 percent over the ten year period. GHG emissions were also on the increase due to the economic growth of the country during the period 2003 and 2006 which reflected a 10.3 percent increase, and during the times of the recessions and shortages of electricity between 2006 and 2009 19.7 percent decline was experienced. Agriculture, forestry and other land use, this sector was responsible for 40.76 increase in 2010 compared to 2000. Livestock and animal waste emissions have declined by 7.3 percent in 2010 due to the decline in the cattle, sheep and goat population. In the waste sector emissions are released from disposed solid waste and waste water treatment and discharge. GHG emissions increased by 59.8 percent from 2000 to 2010 (Shah, 2014).

Many homes are impacted by the air quality they inhale because of burning fuels inside their home. Many RSA homes still burn paraffin, coal or wood indoors even though they are connected to the electricity grid. Government programmes to bring about cleaner coal techniques can reduce air pollution and the impact that it has on people's health. Air quality of RSA is affected not only by the power plants, there are other factors that also contribute these include, transport and industrial/manufacturing plants. A study was done in three different provinces in RSA and the respiratory hospital admissions were compared to mortality (premature death). The study presented results that indicated that in Mpumalanga there are higher deaths and hospital admissions due to poor families burning coal in their homes to generate electricity. Added to this the ambient air quality related health risk due to Eskom coal power plants being in the area emissions are increased three times than the health risk from indoor coal combustion. Therefore 51 percent of hospital admissions and mortalities were due to outdoor air pollution related respiratory illnesses. In other provinces this number

is much lower. Tshwane in the northern part of the Gauteng province, domestic coal burning has a higher impact on health risk than electricity generation and also in Cape Town (Western Cape) domestic wood burning was the main cause for hospital admissions and high mortality rates. Amongst the highest affected are children and infants to outside pollution, due to their lungs developing as they grow into adulthood and because children love being outdoors. In Mpumalanga the children are not only affected by air pollution from the power plants but also from coal being burnt in their homes. 26 percent of households rely on coal as an energy source. According to the Department of Energy this is four times the national average of 7 percent. Life expectancy is also affected due to coal burning. Evidence indicates that in China and India life expectancy is reduced by 2.5 and 3.5 years due to coal burning. In RSA, specifically in Mpumalanga where a high number of coal plants are found the life expectancy is 50.3 years for men and 51.6 years for females, which is below the national life expectancy of 53.3 for males and 55.2 for females. HIV/Aids are still the main cause of death, with 770 deaths per day estimated in 2010/2011, as well as cardiovascular disease (McDaid, 2014).

RSA coal reserves are on average about 53 billion tonnes, if production continues at the current rate. The process of production with coal starts when coal is crushed in huge mills to form a powder, then its goes in a huge kettle known as a boiler. The immense heat in the boiler causes the coal particles to burn to produce heat to make steam from the water that is boiled. This steam is used to turn the turbine. The generator which has a copper coil is turned by the turbine. The generator is what produces the electric current which is then distributed via the power lines. There are some advantages of using coal fired plants these include: the abundance of coal available, the reliability of coal fired plants, RSA well established infrastructure that is already in place, the most cost effective and energy efficient way to produce electricity. Disadvantages are also present and include waste products after the production including sulphur and nitrogen oxides, organic compounds, heavy metals, radioactive elements, greenhouse gas and ash, the construction of a coal fired plant is lengthy and has high costs, Most of the plants are built in the Mpumalanga area, and therefore is limited (Eskom, 2014).

Koeberg Nuclear Plant has three separate water systems from which it operates. The fact that there are three water systems means that the water in the reactor which is radioactive and forms part of a closed system does not interact with the remaining two systems and meaning that no contamination takes place. Koeberg operates using a three loop system (primary, secondary, tertiary). The primary loop is responsible for taking heat away from the fuel in the reactor to the tubes in steam generators. The water is then transported back to the reactor with the assistance of a pump, at no point is any contact made with the secondary and tertiary loop. The secondary loop system is also a closed system and here the water is pumped to a steam generator where it boils and forms steam, this steam is responsible for driving the one high pressure turbine, three low pressure turbines which drive the generator. Through this generator 930 MW of electricity is produced. In the tertiary loop the cooling water system uses sea water to cool down the steam in the two condensers. Water is then returned to the sea

once it has been used. The plant is one of the most well maintained plants in the country and contributes roughly 5 percent of energy produced (Eskom, 2014).

Pollution levels are on the increase due to RSA heavy dependence on coal generated power supply. Towns/cities located closer to these coal plants suffer the most due to pollution and the release of mercury from the power stations. Many South Africans are still reliant on fuelwood as a source of energy due to high costs of electricity. Electricity production is the main cause of greenhouse gas emissions and the health of many residents is severely impacted by these pollutants as explained above. Coal is the main way the demand for energy is solved, the nuclear power plant only contributes 5 percent while coal is around 95 percent.

3 ENERGY POLICY IN RSA

3.1 A Short History of Energy Policy

Prior to 1994 energy policies were to provide energy to a certain race group only. The "white" population which was only 11 percent of the population received energy services which were modern while the rest of the population was restricted to limited or no services at all. The industrial sector was prioritized because of economic and political interests of the country. In the 1950's the decision was made to concentrate on the production of liquid fuels for political and economic reasons. Until 1954 most of refined oil products had been imported and distributed by companies like BP, Caltex, Mobil and Shell and due to large demand for these fuels refineries were developed. In 1954 the production of liquid fuels began at Sasol and the Mossgas plant in 1992. These plants were heavily aided with the help of government. In 1987 major changes took place in the form of the Escom Act of 1987 and the Electricity Act of 1987. The Escom Act was drawn up to set out the role of Escom to providing electricity in a cost effective manner (Winkler, 2006). The aim of the Eskom Act was to provide for till its existence, functions and the management of the affairs of Eskom and for matters connected to it (Republic of South Africa, 1987). The Electricity Act of 41 of 1987 was put forward to provide for the continued existence of the Electricity Control Regulator and for the control of the generation and supply of electricity and for matters connected. The object of the regulator who in this case is the National Energy Regulator is subjected to the provisions of this Act to have control over the electricity industry to ensure the generation and efficient supply of electricity. The act also states the functions of the regulator which include license issuing for the generation, provision and within the area determined, distribution of electricity, price determination and conditions for electricity to be supplied by the licensee, at the request of any licensee or its consumer settle disputes among themselves or between licensees and the consumers or prospective customers, collect information which is needed, conduct inspections of the equipment (Republic of South Africa, 1987).

The abolishment of apartheid in 1994 led to significant changes and the decision was made to amend the energy policy as well. Stakeholder based forums took shape within the energy sector to begin negotiations. Policy development in the energy sector has to follow the procedure namely, recognising the problem, identifying underlying causes, identifying personal solutions and making decisions, upon implantation monitoring and evaluation needs to continue. The approach taken when drawing up this policy was to be transparent, building public trust, defining organisational roles, communicate policy changes effectively and to integrate these processes.

The process began with the drawing up of an Energy Policy Discussion Document by a selected group. The document covers the energy sector and identifies 111 major energy policy issues. These are then divided into different sections including energy governance, energy demand, energy supply and cross cutting issues. In August 1995 the "Green Paper" was released by the Minister for review and comment, a team of experts was then assigned to draw up the white paper and after a lengthy process was approved by Cabinet in July 1998.

In continuing, a discussion of the document and the considerations that had to be met in order for the energy policy plan to be prepared will be explained.

First, the policy context and the sectors challenges need to be identified. These aspects include economic, social and environmental forces and policies, the nature of the RSA energy sector and its link with broader forces and the goals of the sector. The energy sector is one that is heavily influenced by international pressures.

The sector is divided into demand and supply. Different demand and supply sub sectors are identified and analysed in the policy preparation process. RSA demand is analysed by energy needs of households, industry, commerce, mining, transport and agriculture. During the apartheid era international relations influenced the energy sector. RSA learnt to be self – sufficient because they needed oil imports for transport needs and were influenced by a UN led oil embargo and faced an international ban on all nuclear materials. Huge unprofitable investments were made in synthetic and nuclear fuels. These actions forced many tough challenges to the sector including a very expensive nuclear industry which used up two-thirds of the Department of Minerals and Energy's budget, and the petroleum sector filled with confusion and intricate set of controls. Even though the apartheid regime has ended does not mean the international influence has stopped. RSA faces global competition now and that means that it has to ensure abundant supply, ease of availability and competitively priced oil and nuclear fuel.

The post oil crisis has brought about significant changes to RSA, the opportunity now arose to learn from international counterparts. The most important lesson learnt was that commercial energy supply will not be limited for the future. Energy security was becoming stronger through the understanding of diversification, the flexibility of supply, and energy trade across

the borders. This new trend brought through the realisation that those uneconomic industries (e.g. chemicals industry, (South Africa.info, n.d.) were no longer protected. To see developments in the energy sector more reliability had to be placed on cost effective or market based pricing. The developments also forced the energy sector to rethink government's role in energy sector. Emphasis needed to be placed on commercialisation, corporatisation and privatisation. Global financial markets also have experienced many changes over the years, in the past developing countries relied heavily on funding from the World Bank and other such lending agencies but these days private funding has become more crucial and has an enormous effect on the sector and its financial position. The problem government faces is making the market attractive for both domestic and international investors by proving that RSA has a sound legal, fiscal and proper regulatory regimes. The issue of Greenhouse Gases are also important, energy policies are forced to how the reduction of gases will happen. Research and development has shifted to show how sustainable renewable energy is in the drive to these GHG emissions (Department of Minerals and Energy, 1998).

3.2 Energy Policy for the New Millennium

The new government who took over after the apartheid system introduced many new social and economic policies. The first of such policies was the Reconstruction and Development Programme (hereinafter RDP) which gave way for white papers by the Government of National Unity. The main objectives of RDP were to achieve faster growth of the economy and the development of it to diminish poverty. The Growth, Employment and Redistribution (hereinafter GEAR) strategy was used to help achieve the goals put out in the RDP. GEAR had two main objectives, first on its plan was to expand economic growth with the help of exports and investments, secondly the promotion of redistribution for job creation and reallocating funds in the budget. A key objective set out in the RDP base document was the goal to connect 2.5 million households to the national grid by the year 2000 (Department of Minerals and Energy, 1998).

The energy policy set to meet certain objectives these include:

- Increase access to affordable energy services
- Improving energy governance
- Stimulating economic development
- Managing energy related environmental and health impacts
- Securing supply through diversity

The first goal, to **increase access to affordable energy services**, was targeted at the disadvantaged communities, small businesses, small farms and community services. The RDP base document notes that even though energy is a basic need many citizens use other means for electricity production. Future policies need to focus on the provision of energy services to

meet simple needs of the poor, engage in productive capacity and prioritize the energy needs of community centres. Since the publication of the RDP the national electrification programme was able to reduce this backlog (Department of Minerals and Energy, 1998).

At the time of this publication according to (Department of Minerals and Energy, 1998) many South Africans were without electricity still and affordable options were not yet available. In the case where options have been made available, consumption still remains very low and do not have the desired effect. This needs to be addressed by providing complimentary factors to maximise the benefits of access to fuels. The government will encourage access to low cost energy services for disadvantaged households, small businesses, small farms and community services. Achieving this goal is crucial for the RDP plan and to improve social development in the country (Department of Minerals and Energy, 1998).

It is crucial that government understands that providing the energy is not enough, the energy needs to be affordable to the disadvantaged and sustainable, provide safe, convenient, easily accessible information to all providers as well. By addressing all these issues government realises the role woman play in utilising these services and therefore encourage woman empowerment. During the period 1978 and 2008 the real average price of electricity dropped by more than 40 percent from 39.7 c/kWh in 1978 to 22.7 c/kWh in 2008. From 2008 – 2011 electricity prices increased drastically due to power shortages in 2008 and Eskom was forced to look at expansion plans (Deloitte, n.d.).

Improving energy governance. During the era of apartheid the energy sector was under a lot of secrecy, therefore public debate on the policy was not possible. Example the Petroleum Act of 1977 did not allow the publication, broadcast, disclosure or communicating to anyone information or submitting any comment regarding the source, manufacture, transportation, destination, storage, consumption, quantity or stock level of any petroleum product acquired or manufactured or being acquired or manufactured for RSA. The punishment was harsh therefore nobody wished to go against them. These restrictions were lifted in 1993 with the United Nations oil embargo. It was unfortunate that due to these regulations that no data was published or collected. Due to the high demand of secrecy in the sector government was found it difficult to integrate policy formulation and merge departments and the various levels of government.

Stimulating economic development. In developing economies expansion of infrastructure is dependent on the huge investments in energy projects. Apartheid affected the structure of the energy sector and left a terrible past. For example because electricity distribution was linked to certain races only it made the task of providing those without electricity very difficult. The electricity, nuclear and petroleum sectors are all monopolist and government has all control measures. The task of the new government was to correct the wrongs that the apartheid regime brought to the sector, and this is possible by restructuring some sub sectors and strive for efficiency so that they can be add valuable contributions in terms of social, economic and

environmental goals that need to be achieved. RSA energy pricing are much lower than global comparisons especially in sectors such as industry and mining (Department of Energy, 1998). Prices would have been even lower if better investments were made in the past. According to 2013/2014 International and Natural Gas Report RSA is ranked 15th with the highest electricity prices (see Table 2 below for top 18 countries). The highest tariffs are recorded in Italy at 21.01 US cents per kWh and Sweden being the lowest at 7.87 cents kWh. These countries unlike RSA are seeing a reduction in their fees, RSA is experiencing major price hikes (BusinessTech, 2014).

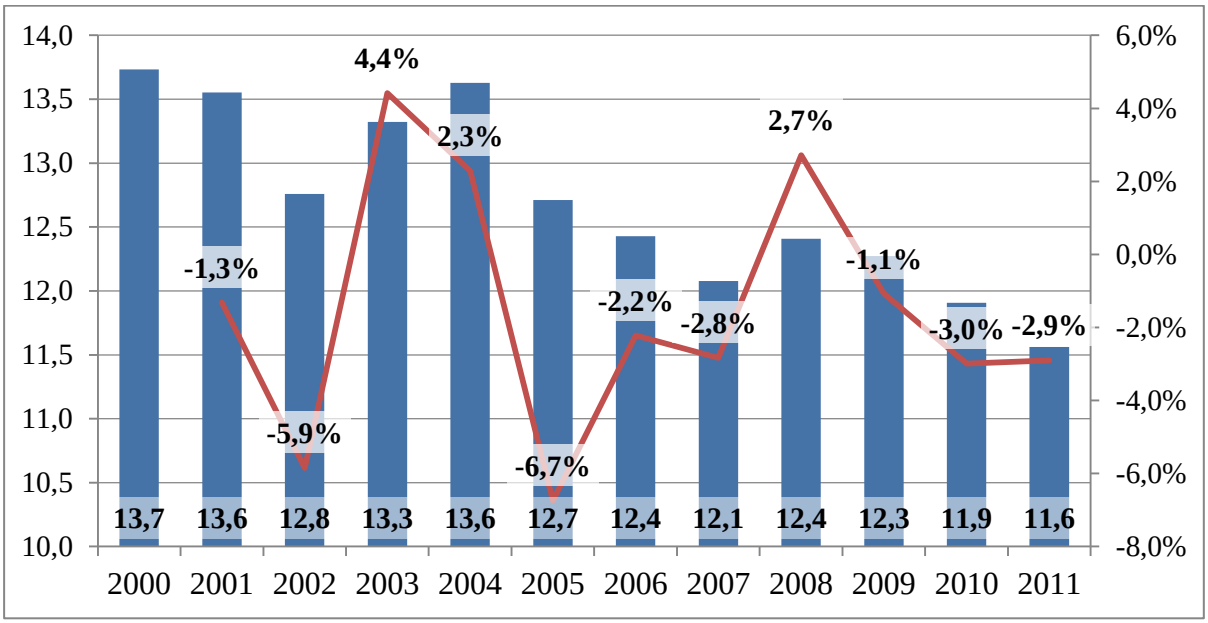
Table 2. Electricity Tariffs in Selected Countries, Year 2014

Rank	Country	Cost (USc/KWh)	YoY percent change
1	Italy	21.01	-1.7
2	Germany	19.21	-1.7
3	United Kingdom	15.40	3.5
4	Portugal	13.84	0.1
5	Spain	13.64	-7.0
6	Belgium	12.68	3.6
7	Slovakia	12.55	-2.9
8	France	10.74	3.8
9	Czech Republic	10.47	-7.7
10	Poland	10.46	5.5
11	Austria	10.44	-5.5
12	Netherlands	10.08	-8.5
13	United States	10.00	7.1
14	Australia	9.71	-23.3
15	South Africa	8.97	7.5
16	Finland	8.59	-1.8
17	Canada	8.11	2.5
18	Sweden	7.87	-2.4

Source: *BusinessTech*, South Africa Electricity Prices vs the World, 2014, Table 1, Page 1

RSA is very energy intensive, meaning that more energy is used per unit of economic output than in other countries. In fact only ten countries have higher commercial primary energy intensities. The high energy intensity is as a result of the structure of the economy and its reliance on coal for production of electricity and liquid fuels. Both of these energy processes are not capable of proper conversion of energy (Figure 9). Furthermore, industry has yet to introduce technological developments in energy efficiency and government energy policy has favoured supply-side actions, rather than promoting better use of energy. The following goals have been set to improve operation of energy markets: Government encourages competition within energy markets, if failures occur government will intervene to make sure effective delivery of services the consumers, government policy is to remove distortions and encourage energy prices to be as cost-reflective as possible.

Figure 9. Energy Intensity in RSA 2000-2011 in Btu per Year in Thousand U.S. Dollars (RHS) and Year-Over-Year Change in Percent (LHS)

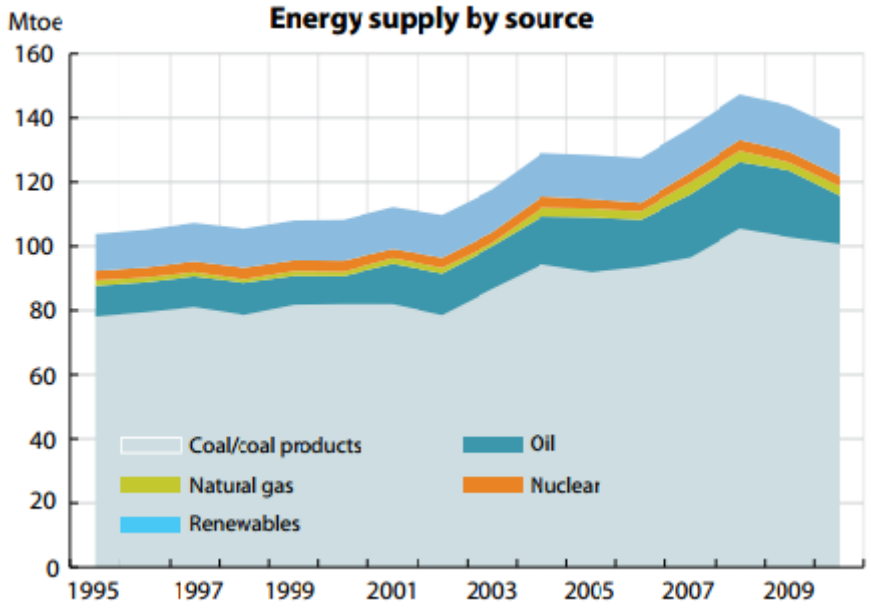


Source: *Knoema*, 2015.

Managing energy related environmental and health impacts. Studies have indicated the harsh effects on the health of the poor communities as a result of indoor and outdoor air pollution. The percentages of people suffering from respiratory illnesses are on the increase and even more in houses that do not have access to electricity. These numbers need to be reduced (See Figure 8 for CO_2 emissions). Government has set the following goals promotion of access to basic energy services for poor households, in order to reduce the impact on the health of consumers from the use of certain fuels, government will work towards reducing energy-related emissions that are harmful to the planet.

Securing supply through diversity. As previously mentioned under apartheid the energy policy goal was energy security and major investments were done in synthetic fuels and in nuclear energy. Even though this took place RSA was never self-sufficient on nuclear or petroleum. This proves that whatever the apartheid government meant to achieve did not take place it was a major failure. Therefore government shifted its goal towards increasing opportunities for energy trade, particularly within the region it will try to pursue energy security by encouraging a diverse supply of sources and primary energy carriers. The objectives set out are not easy and careful consideration has to be taken in policies, every detail needs proper planning. Many of the goals have been divided in to short term or medium term goals. Short term goals being 1-2 years and medium 3-7 years (Department of Minerals and Energy, 1998). Figure 10 below gives indication from 1995 – 2009 how energy supplied from various sources varied.

Figure 10. Energy Supply by Source 1995 -2009



Source: OECD, *South Africa Highlights*, 2013 Figure 1, Page 4.

The plan first of all had several medium term policies in order to attain long run goals. These have been set as follows (Department of Minerals and Energy, 1998):

- Increase access to affordable energy services - encourage the use of alternative sources of energy, promote improvements to those who rely on traditional fuels, encourage capacity building.
- Improve energy governance – mediate the development of research strategy so that improvements in research and development takes place, restructure state assets, new regulations need to be implemented in nuclear sector, clarification of legislation regarding nuclear energy, encourage the establishment of statistical and database systems.
- Stimulate economic development – restructure market to achieve effective competition, regulate liquid fuels industry, promote energy efficiency, legislative and regulatory arrangements is needed for natural gas industry, standards and codes of practice needs to be established for renewable energy.
- Manage energy related environmental impacts - clear and sound policy is needed for nuclear waste management, facilitation in the monitoring and evaluation of clean energy technologies is needed, keep a watch of international development in climate change and participate in the negotiations, consider implementing levy on the sale of energy to fund other developments in the sector.
- Secure supply through diversity – carefully evaluate future energy supply options, encourage the use of other sources of energy.

The plan included also several short-term priorities that were expected to contribute to the overall plan fulfilment (Department of Minerals and Energy, 1998):

- Increase access to affordable energy services – improve energy services delivery to households, development of national electricity policy, with a sound planning and financial system, equal treatment of off-grid and grid electrification.
- Improve energy governance – increase capacity of government, energy policy formulation needs to be improved, restructuring of national budget to facilitate all changes, new and improved statistical and database systems need to be implemented in all areas.
- Stimulate economic development- SMME's and previously disadvantaged should be empowered and given opportunity to contribute to energy sector, committees need to be established to oversee all activities and help with achieving the goals set out, restructuring of energy assets of the state need to take place. Energy trade barriers[3] need to be abolished; special levies need to be introduced to fund regulatory and energy development.
- Manage energy impacts on the environment – improve air quality, reduce severity of stoves, research and development needs to be emphasised.
- Secure supply through diversity- develop a Southern African Power Pool to benefit all, pursue cooperation with international bodies, research and development needs to be encouraged between local and international agencies.
- Certain sectors depend heavily on the energy supply were given special attention. fires stared by the use of candles and paraffin, improve safety standards for paraffin
- These include:

    - Households – During the time of the previous Government the focus was on the privileged white community and to create modern industrial urban society. Society members who fall on the lower end of the income bracket always look for less convenient and unhealthy fuels to provide energy. The effect on the environment from the rural poor has always been a growing concern and efforts to reduce these are high on the plans. Many rural homes use fuelwood as an energy source. Government plans to set minimum regulations for household energy services.
    - Industry, commerce and mining – Previous government focused little efforts on industry, mining and commerce energy efficiencies. Energy efficiency could save between 10 and 20 percent of current consumption. In order to achieve this, they need to address the following obstacles: inappropriate economic signals, lack of awareness, information and skills, lack of technology developments and high capital costs. International environmental standards will be followed and monitored, and from this the policy will be adjusted.
    - Transport – The focus will be to diversify fuel within the fuel sector. More affordable means of transport need to be invested into. The previous Government land policies ended with the disadvantaged all being located far from their place of work. The

[3] Unfortunately detailed data is not available for the trade barriers that were in place during the apartheid regime.

Government with its new policy needed to integrate transport, energy, land use, economic development, environment and other policies.

- Agriculture – the energy used by this sector will be reviewed in terms of commercial use and use in the traditional way. Agriculture on smallholdings needs more focus, these holdings require more services such as schools, medical facilities, roads, communication facilities and qualified staff.

- The suppliers were also studied with focus and challenges were identified:

  - Electricity – The biggest challenge is to continue to provide affordable, equitable priced electrification to end users. Government aims to keep electricity tariffs cost effective at all levels across the different industries. The debate around competition within the electricity sector is also a concern and Government supports a competitive electricity market.
  - Nuclear Energy – When this policy was drafted in 1998 the future of nuclear energy was a growing concern, the impact on the environment and economy was the concerning factors.
  - Oil and gas: Exploration and production – Concerns on whether Government should introduce dedicated oil and gas legislation are growing concerns within the industry.
  - Liquid fuels – In order for the sector to be successful minimal intervention from government is required. Government foresees international competitiveness and investment in a growing economy as a contribution to low cost products.
  - Gas – Natural gas has vision for a very attractive option and government is committed to this development.
  - Coal – They envision that coal will be the biggest provider of energy for a long time. The aim will be to reduce the environmental impacts.
  - Renewable Energy sources – renewable energy has its advantages especially in areas where it is difficult to connect them to the energy grid. When it comes to social and environmental costs, renewable energy is the most feasible. Government will invest more in the development and research of home solar panel systems especially for schools, clinics and homes for those in rural areas (Department of Minerals and Energy, 1998).

The formulation of the new White Paper for the Energy policy was not an easy task. RSA becoming a democratic country meant that it tried to make things more transparent and elected officials were held accountable for their actions (Department of Minerals and Energy, 1998).

Out of the Energy Policy of 1998 it can be seen that 5 main objectives have been highlighted and these include: increases access to affordable energy services, improving energy governance, stimulating economic development, managing related environmental impacts and securing diversity through diversity. The last objective is addressing the need for alternative sources of energy example renewables. It was evident that the government who took over

after apartheid no longer left power planning entirely up to Eskom. The new plan was that the Department of Energy provide the electricity plan (Integrated Resource Plan). Once this was obtained the Minister of Energy issued statements about how much new power generation was needed and how it would be sourced. Soon after the publication of the Energy Policy of 1998 a 70:30 split was announced between Eskom and private sector with the aim to produce a competitive wholesale power exchange. This was abandoned in 2004 due to talk of power shortages Eskom was likely to face and was taken over by single buyer model (Eberhard, Kolker, Leigland, 2014).

3.3 The Current Energy Crisis and the Energy Security Masterplan

In 2007 the Energy Security Masterplan defined energy security as ensuring that various energy resources, in sustainable quantities and at affordable prices, are available in RSA in support of economic growth and poverty alleviation, taking into account environmental impacts . The definition places emphasis on resources at the centre of energy security and the economy as the recipient. The World Energy Council outlined 3 A's to extend the definition. The three A's are:

- Accessibility. Accessibility refers to the minimum level of commercial energy services that must be available at affordable and sustainable prices. Affordable in this context means that the price should be affordable to the less fortunate and sustainable refers to the full marginal costs of the energy production, transmission and distribution should be such that it supports the financial ability of the suppliers to maintain and be able to develop these services.
- Availability. Availability refers to continuous availability in the future as well as quality of service. Disruptions in energy have a significant effect on economic development. It is vital that a diversified portfolio of domestic and imported trade fuels and energy services is available.
- Acceptability. Acceptability refers to the thoughts and attitudes of the public, they cover a vast range of issues ranging from deforestation, pollution, land degradation, greenhouse gas emissions, climate change, nuclear safety and waste management (Trollip, Butler, Burton, Caetano, Godinho, 2014).

The Department of Energy acknowledges that RSA did not make significant investments in the sector over the past twenty years. In the commercial and industrial sectors they moved from having over capacity, low priced reliable supply to one of under capacity, unreliable supplies of coal, electricity and liquid fuels. Added to this was the rise of the prices by significant numbers. Many households in the last five years were connected to the energy grid but this has been compromised by the big increase in prices and the downfall of the sector and the lack of infrastructure development and investment. The energy crisis RSA find itself in one is not a crisis that started recently, as far back as 2008 RSA started experiencing its first share of loadshedding across the country. The question remains how RSA moved from a

country with an abundant supply of electricity to a situation where industry and households face regular black outs? The answer to this question was not a sudden high demand but because no new capacity was added to the system. By the year 2003 the reserve of 40 percent was depleted, RSA demand and supply of energy was very tight. Despite the situation RSA found itself in, no new plans were made to increase capacity. Demand continued to grow and the reliability of the system worsened. The mines had no other option but to close its doors as electricity supplies could not be guaranteed. Eskom (state owned electricity utility) 10 years prior to 2008 crisis warned of electricity shortages in the future, the problems varied from government not investing in new plants, loss of skilled workers in Eskom, coal being drenched by rain water, rumours of bad planning and mismanagement. As mentioned earlier energy consumption is much higher than world averages. 2009 data indicated RSA electricity consumption per capital to be 4 150 kWh compared to the world average of 2 550 kWh (Trollip et al, 2014).

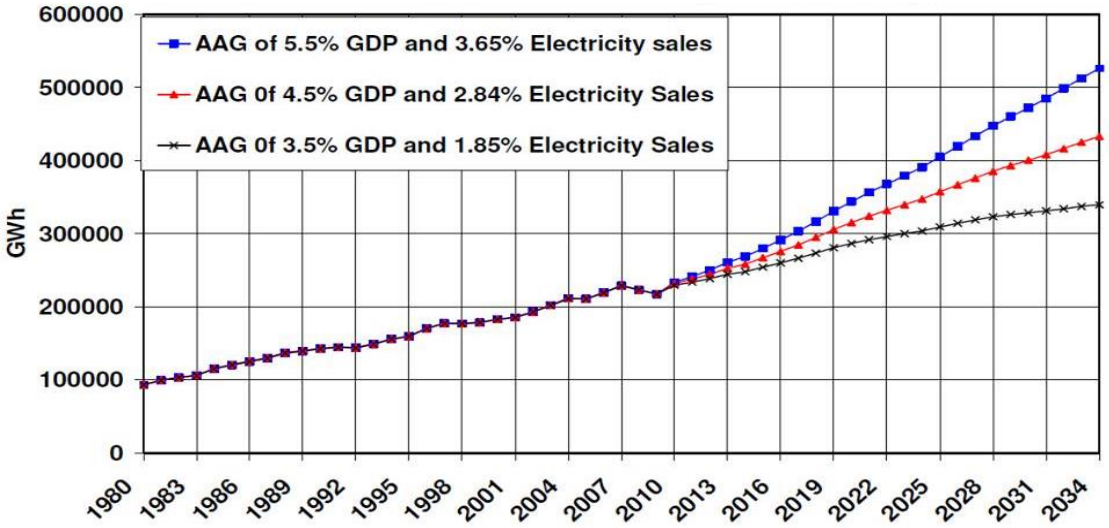
The Department of National Treasury in 2008 explained it as exponential growth and the implications of this growth. It was explained as follows, that the economic strategy of the country was to achieve a 6 percent growth rate. In the 2005 Annual Report of Eskom, electricity sales in all categories increased by 20 percent in a fifteen month period until March 2005. Eskom sales growth has been at the same rate as the growth of real GDP. Economic growth is only possible with a sustainable supply of electricity. For this reason Eskom put forward a plan to ensure long term alignment with the forecasted amounts. Data observed from the 15 month period was made that during the off peak electricity demand was at 22 000 MW, and gradually increased to 25 000 MW in peak periods (observation during summer). In winter these numbers changed, in off peak periods the demand was at 24 000 MW increasing to 32 000 MW in peak times. It was also noted that peak demand of 34 195 MW was recorded against generation capacity of 39 810 MW, which was much higher than the previous year, where peak demand was only 31 928 MW. The reserve margin which is the extra reserve required in case of emergency decreased from 16.9 percent in 2003 to 8.5 per cent in 2004. Due to these developments Eskom made the decision to bring two non-working stations back into service. These two stations would add 3 451 MW to the energy supply of RSA (Department of National Treasury, 2001) This was estimated at the rate that employment needs to be created, the increase in population, levels of poverty across the country and some other factors as well.

Each growth experienced had a ripple effect on other things, example if GDP doubles, that means production needs to increase which includes raw materials and of course energy as well. It was estimated that in the next 11 years double the amount of energy will be needed. Louw (2008) explains it as follows: the doubling time of anything that is growing constantly can be determined mathematically (Doubling time = 100 x ln(2)/ growth rate). This means dividing by 70 by the rate of growth. This basic calculation is used constantly with respect to calculating financial return, but rarely to calculating the rate at which we are growing our need for electricity or the rate at which we are depleting resources. He further explains that

each doubling cycle (11 years in this case, at 6 percent growth) is greater than the sum of all previous doubling cycles combined. In the next 11 years we will consume more than in the entire history of RSA. In order to double the size of the economy, which we will do at 6 percent growth in 11 years will require more resources than we have required during RSA history which includes electricity. Each time doubling takes place example 1 to 2, 2 to 4 etc. the last doubling cycle is greater than the sum of all previous cycles. Due to these increases it can be explained why Eskom has been unable to keep up electricity demand. In Eskom 2007 Annual Report it estimated that its plans was to double its capacity by 2024 to 80 000 MW, which was then in 16 years' time with an annual growth rate of 3.64 percent. For this to be achieved coal burning levels need to exceed what has already been burnt, imagine the effects on the environment this would have? At present RSA is one of the largest polluters of the world. Eskom did not have an easy task ahead of them, and currently in 2015 that is still the problem (Louw, 2008).

The removal of sanctions against RSA after 1994 was the main reason behind the economic growth from 1994 to 1997. This also affected the growth of in the Eskom Re-Distributor category (municipalities) which caused high annual average growth rates in sales for the sector. The Department of Energy System Operations and Planning Division (SO) forecasted some values up to the period 2035 by using three GDP assumptions, high of 5.51 percent, moderate 4.51 percent and a low of 3.51 percent. Estimated electricity growth at 3.65 percent, 2.84 and 1.84 percent, are presented in Figure 11. Sales for calendar year 2009 were at 211 Twh. It is estimated that sales till 2035 will grow at an estimated 433.3 Twh that is an average of 8.5 Twh per year. If electricity prices increase by an estimated 25 percent per year for the next three years the effect will lead to energy efficiency improvements and therefore increase sales (Department of Energy, 2010).

Figure 11. RSA Total Sales Forecasts (Including Foreign) 1980-2034



Source: Department of Energy, *IRP 2010 Energy Forecast Revision2 Report*, 2010, Table 1, Page 2.

Growth in the forecast is driven by the following areas: Electrification in rural developments to ensure the entire population has electricity. Growth in Eskom Industrial category as an impact of the increase in demand in ferro-chrome, steel, ferro- manganese and the growth in petroleum industry. In the mining sector, demand from global partners will not decline any time soon and relationships will remain strong (Department of Energy, 2010).To get a better understanding of consumption of electricity one has to take a look not at things from a broader level but more from each sectors point of view.

Table 3. Decomposition of South Africa's Electricity Consumption by Sector 1993- 2006 (GWh)

Sector	**Production Effect**	**Structural Effect**	**Efficiency Effort**	**Aggregate Effect**	**Aggregate Ranking**
Transport	9 168	6 805	-9 705	6 268	(4)
Iron & Steel	14 767	4 291	-6 031	13 027	(2)
Mining & Quarrying	3 081	-16 973	- 3 603	- 17 496	(14)
Wood & Wood Products	248	6	-437	-183	(13)
Machinery	31	-14	-98	-81	(12)
Construction	16	-1	27	42	(10)
Textiles & Leather	85	-199	45	-69	(11)
Transport Equipment	31	13	56	100	(9)
Paper, Pulp, & Print	769	-28	117	857	(7)
Food & Tobacco	200	-142	192	250	(8)
Non-metallic minerals	715	-326	927	1 316	(6)
Agriculture	1 563	-1 172	1 170	1 562	(5)
Chemicals & Petrochemical	5 082	1 385	1 982	8 449	(3)
Non-ferrous Metals	8 834	1 683	3 572	14 089	(1)
Total Manufacturing	30 761	6 667	326	37 755	

Source: Inglesi-Lotz, R & Blignaut, J, South Africa's Electricity Consumption: A Sectoral Decomposition Analysis, 2011, Table 2, Page 10

Table 3 represents the results of the various sectors, they are represented according to their efficiency effect and the sector with efficiency improvements in absolute terms with the highest is listed first. The last column sector ranking with regard to aggregate effect on electricity from 1993 – 2006 is provided. Most of the sectors have experienced increased consumption levels except for mining and quarrying, wood and wood products, machinery and textiles and leather. During this time period the largest contributors of energy consumption were non-ferrous metals (14 0889 GWh), iron and steel (13 027 GWh) and chemical and petrochemical (8 449 GWh) (Inglesi-Lotz & Blignaut, 2011).

The problems faced with regards to energy were meant to be an eye opener in 2008 and a sustainable path was meant to be planned and thought of. The consequence of the loadshedding shed a negative light to potential investors in the country but also forced government to look at other sources of energy example renewable energy and better forms of energy conservation. The sad reality of the problem is that electricity tariffs will never be lower again. Pricing increases was estimated of between 14 and 20 percent per annum for the next years. The hardest effected will be the millions of disadvantaged people in the rural communities. We are well aware that close to 95 percent of RSA energy source comes from coal fired power plants, and around 6 percent from the Nuclear Power Station in Koeberg, Cape Town. Hydroelectricity and solar sources where limited back in 2008. The decision Eskom and the government are faced with is whether to centralise or decentralise energy production.

Would matters be better if energy sources where centralized or decentralized, with all the power cuts that depending on one utility for energy made the country very vulnerable. Consumers have taken their own initiatives and installed solar panels at their homes; many have purchased generators (Louw, 2008). The problem unfortunately lies with Eskom, bad planning, mismanagement are all contributing factors as to why the country is left in darkness. Government has even suggested that shale gas and more nuclear energy should be invested in. Many of the power plants were built before 1994 when the apartheid government was still in charge. Investment in new plants did not happen in time, and now it's the responsibility of the people of RSA to reduce their consumption, Eskom has urged all to reduce their consumption especially during peak hours. These include switching swimming pool pumps off, turn off boilers at certain times during the day etc. They went so far to ask ferrochrome smelters to shut down for up to three months, and even offered to pay them for lost production (Times Live, 2014). During the year 2008 the coal powered stations experienced very low capacity. Many factors played a part in the reduction of capacity including coal being drenched by the heavy rainfall experienced, low stock supply due to the new short term purchase strategy and terrible planning during the Christmas holidays. Eskom knew of the problems facing them and the rapid decrease in the energy reserve which would be very low by 2007 already. Instead of making provisions to increase capacity, government connected more and more of the population to the electricity grid. In 2004 government decided to implement an investment plan as the reserve margin were hitting all-time lows. The costs involved in the loadshedding during November 2007 and January 2008 amounted to $6.6 Billion. Economic growth dropped to less than 4 percent in 2008. The sector with the hardest hit was the mining industry, in January 2008 mines closed for an entire week due to safety reasons. Eskom was unable to promise them a continuous supply of power. Once production started again mines promised to decrease their usage by 10 percent in the coming years. The electricity intensive sectors like manufacturing and mining are the highest contributors to export revenues, these sectors alone contribute 85 percent of total exports. The effect of the closure of mines had adverse effects on the commodity prices, platinum prices soared, RSA is responsible for 80 percent of production of platinum worldwide (Maasdam, 2008).

November 2014 saw the coal silo[4] at the Medupi Power Station collapsing. The stations capacity dropped from 3 600 MW to 1 800 MW and by the following day at 600 MW. The power plant was only 13 years old and the most recently built. Senior engineers came to the rescue and got the plant running at half the capacity by authorizing the transport of mobile coal feeders to manually load coal in five on the units. The situation forced Eskom to launch Stage 2 loadshedding and saw 2 000 MW being cut from the grid. The Finance Minister in his 2014 midterm budget speech highlighted the situation with Eskom, he mentioned that Eskom will borrow 250 million South African Rand (hereinafter ZAR) ($ 20 303 910.00) over five years with support guarantees from government. The state will also provide at least 20 billion ZAR ($20 268 115.00) of funding raised through the sale of non-strategic assets. The years ahead for Eskom seem very difficult; Professor Anton Eberhard from the University Of Cape Town Graduate School Of Business suggests a commission of inquiry to help understand what Eskom is going through and the origin of its crisis (Nicolson, 2014).

January 2015 the Medupi Power Station experienced technical problems while the commissioning of Unit 6. All these problems have made it difficult for the testing of the first Hitachi boiler at the station. Public Enterprises Minister, Ms Lynn Brown, as well as Eskom CEO Tshediso Matone along with Medupi management gave assurance that the first synchronisation of unit 6 would occur by 24 December 2014. This was already a year later than already promised. In November 2014 Eskom further announced that the December 2014 deadline was unreachable. The problems faced at the Medupi power plant are of a very technical nature, and for purposes of the research will not be gone into great detail (Yelland, 2015).

Eskom CEO, Tshediso Matone firmly believes Eskom can deliver positive results in 18 – 24 months' time and has vowed to keep the nation informed about the developments at Eskom. He mentions in a recent interview that Eskom is trying to finalize a deal with regards to "bridging finance" worth 3 Billion ZAR ($243 458 100.00). This injection of money will be used for the purchasing of diesel that is needed for February and March 2015 to allow the open cycle gas turbines to operate. The Western Cape does not look like it will manage by burning diesel in the months' ahead. Diesel plants are running on some days 12 hours a day, the diesel budget increased to 10.5 Billion ZAR ($852 577 530.00) in 2013/2014, the same figures are estimated for 2015 as well. Rumours were spreading across the media that Eskom was selling some of its assets to raise funds, but those were denied by the CEO in a recent interview. The CEO plans to encourage accelerated transition to cost effective tariffs. Further research and planning is needed so that it does not damage the economy or constrain growth in any way. April 2015 sees the tariff increasing by 12.7 percent because of mismanagement of funds and the continuous financial burden Eskom finds itself in (Creamer, 2015).

[4] Tall tower on a farm or coal plant used for storage (Oxford Dictionary, 2015)

The RSA government has admitted that they have not done enough in terms of investment into the future of energy supply. Growth is expected in the next few years due to further electrification in rural areas. Mining is a key industry in RSA and electricity is needed to ensure the smooth running of the mines. The task government has ahead for itself is to decide whether to centralise or decentralise energy sources. Eskom being monopolist operating in the RSA does not make matters any easier added with their bad management and insufficient planning is one reason for the energy crisis currently being experienced. Eskom believes it needs 18-24 months to better the situation.

4 RENEWABLE ENERGY IN RSA

Africa faces electricity supply shortage; the limited access across Sub-Sahara Africa is far from uniform. RSA has 40 000 MW and 54 million people the rest of Sub-Sahara Africa has 20 000 MW and over 800 million citizens. Nigeria is one country that has the worst shortages. It has roughly 3000 – 4000 MW that works for its population of 200 million people. Renewable energy offers one way of bridging the gap. The major sources could come from solar power and onshore wind. There are many reasons why renewable energy can reduce the power supply gap, they include extensive renewable resources. Secondly the comparative advantage, diesel fuel is what most relies on for electricity generation. Diesel power generation is expensive as Africa has limited refining capacity and very few pipeline networks. Thirdly ease of deployment, installation can be done faster for renewables. Solar power can be set up on a small scale and be effective. Research indicates that solar is most suitable for rural, off grid application. Lastly it is sustainable way forward, RSA is determined to reducing its greenhouse gas emissions. In 2009 it made a commitment to cut carbon emissions by 34 percent by the year 2020 and a further 42 percent by 2025 (Baker & McKenzie, 2013).

Baker and McKenzie (2013) put together a report based upon a survey of 140 senior executives as well as interviews with industry members globally. The question was asked why solar, wind and hydro is the most appropriate way forward. In the case of solar power the reasons include technology matches Africa's renewable resources (88 percent), technology is suitable for rural, off grid application (85 percent), technology is well proven (77 percent), technology can be well proven (77 percent), technology can deployed quickly (71 percent) and technology is relatively cheap to deploy (40 percent) (Baker & McKenzie, 2013).

With onshore wind the results from the survey proved the following reasons, technology matches Africa's renewable resources (81 percent), well proven technology (66 percent), technology is suitable for rural, off grid applications (38 percent), technology is cheap to deploy (33 percent), technology can be deployed quickly (25 percent). For hydro the numbers are not so high, the technology matches Africa's renewable resources (77 percent), technology is well proven (69 percent), technology is suited for rural, off grid application (33

percent), technology is cheap to deploy (22 percent) and the technology can be deployed quickly (9 percent) (Baker & McKenzie, 2013).

4.1 Types of Renewable Energy Sources

Renewable energy is defined as energy that is obtained from natural processes (e.g. sunlight or wind) that is replenished at a quicker rate than it is consumed. Familiar forms of renewable energy technologies include solar, wind, geothermal, hydro and biomass. According to the International Energy Agency in 2012 the world relied on renewable resources at a rate of 13.2 percent of its primary total primary energy supply and that figure in 2013 increased to 22 percent reflecting a 5 percent increase (International Energy Agency, 2012).

Solar Energy. Developing technologies in solar panels have made solar energy a very cost effective means of energy production. Solar energy was mainly used in the beginning to provide energy to satellites, telescopes and then moved its way into households, office buildings and warehouses. It is expected that solar energy could become the cheapest way to produce energy and at the same time create many jobs. Solar power works in that the suns energy is captured to generate electricity or heat through a big set of panels/mirrors. These solar or photovoltaic cells directly convert sunlight into electricity. The photovoltaic cells are made of silicon, and when the sunlight falls on the cell, the energy knocks the electrons free of their atoms and thus allowing them to flow into the material. Solar thermal collectors have heat absorbing panels and circulation tubes to heat up water or buildings. Solar concentration panels are made up of mirrors they are set up in such a way to absorb as much sunlight as possible (Natural Resources Defence Council, 2014).

Wind Power. This source of energy has gained popularity due to its pollution free and cost competitive compared to coal or gas powered plants. Wind energy is growing at a rapid pace all over the world. In USA alone in 2011, 3 464 turbines were installed and wind energy generates power to reach 11 million homes. The added advantage is the job creation brought by this type of farm brings, an average 250 MW wind farm with about 100 wind turbines creates jobs for 1 073 people over the plants lifetime. Wind energy works by taking the kinetic energy produced, it then rotates a turbine blade which then transfers energy through a hub to a generator. The generator then converts the mechanical energy into electrical energy that is then sent to the energy grid (Natural Resources Defence Council, 2014).

Hydropower. The energy created from moving water is referred to hydropower. Over the past few years many rivers and streams have been used to produce hydroelectricity. The water in these dams/rivers is natural resources but hydroelectricity has an effect on the ecosystems of these natural environments. A lot of the hydroelectric plants make use of the dams to trap the water in a reservoir, and then release it to rotate a turbine and produce electricity (Natural Resources Defence Council, 2014).

Biomass. This energy is created from plants, crop, forest residue etc. Biomass in the USA alone accounts for almost half the amounts of energy produced from renewables and are the biggest consumers of biomass energy. Biomass has very unique qualities in that it can help decrease global warming pollution or it can have the opposite effect. Many methods used today are not sustainable. The challenge is to find alternative ways of producing biomass energy that has positive effect on the environment. Biomass energy is generated from many plants substances like corn, soybeans, agriculture leftovers, rice husks, pressed sugar cane as well as wood, including trees. These plant material can used in many ways to make energy and fuel, it can be burned in power plants to produce heat/electricity, fermented to produces fuels like ethanol for vehicles and trucks, digested by bacteria to produce methane gas for rotating turbines, heated to break down into a mix of gases that can be used for electricity (Natural Resources Defence Council, 2014).

Biogas. Is used mainly by farmers who take the animal manure and convert it into energy. By doing this they combat water contamination, odour pollutions and global warming emissions. Biogas can be produced by decomposing manure with the aid of bacteria. No oxygen is present and it then turns into a gas which contains 60-70 percent methane. This is then used to produced hear, hot water and even electricity and the left over manure is then reused as fertilizer and potting soil (Natural Resources Defence Council, 2014).

4.2 Potential for Renewable Energy in RSA

RSA's potential for alternate renewable energy sources are good due to its vast landscape and various natural conditions that it consequently can offer in order to exploit various types of renewable energy sources. The Department of Energy plans to bring 17 800 MW of energy from renewable sources by 2030. RSA introduced a renewable energy independent power producer (IPP) procurement programme. This programme allows private power producers to submit tenders. In the year 2012 alone 47 billion ZAR ($5.4 billion) of contracts were signed for 1.4 GW of renewable energy. The process has also done extremely well in attracting foreign investment.

$9.3 billion was invested in debt and equity in African renewable projects in 2012 and $5.7 billion debt and equity was invested in RSA Window 1 of the renewable energy procurement programme, which indicate that 61 percent of total investment into Africa was done in RSA alone in 2012. Africa is attracting investors for many reasons these include attractive return, there is a need for global diversification as "traditional" markets decline, certainty of increasing energy demands, speed of increasing energy demand, the speed at which Africa economy is growing, the desire to gain experience in future lucrative African markets, meeting corporate and social responsibilities objectives. Research suggests that renewable projects like solar, wind, hydro and biomass is the key to Africa's growing power needs. These tenders offer much reward to investors but also involve risks as well that include and

are not limited to challenges in the legal environment and limitation of debt finance (Baker & McKenzie, 2013).

RSA has 4 500 dams which of least 1 100 has the potential to be retrofitted to become mini and small generators. Hydro has the potential to replace 6 000 tonnes of fossil fuels with a 1 MW plant and supply 1 000 sub urban homes with electricity. With the help of hydro Eskom would expand its margin by adding around 7 200 MW in the next ten years from all type of hydropower options (Mawson, 2013).

Below, each of the types and the current utilization is explained. Table 4 briefly summarizes the type of energy, the capacity it has, which region on RSA is most suitable for this of renewable energy and what the general characteristics of that type of energy are.

Table 4. Overview of Renewable Energy Sources in RSA: Capacity, Main Characteristics

Type of Energy	Capacity	Region with most potential	Characteristics
Solar Power	Annual PV assembly capacity of 5 MW	Northern Cape	- High costs - Good foreign investment potential - Ripple effect on manufacturing sector - Industrial Action Plan includes Green Economy - Most readily accessible resource
Wind Power	500 -5 000 MW	Western and Eastern Cape	- Private sector driving force - Economic stimulation in province located - Great job opportunities - Creating economic opportunities in manufacturing sector - Special economic zone created in Atlantis, Western Cape - Clean energy
Biomass	170 MWe	Kwazulu Natal (Sugar cane plantations) Any farming area	- Lack of policy - Low interest from government - Huge logistical issues - 97 percent of biogas exported - Sugar cane burgasse and wood sawdust biomass used by mills to generate own electricity

table continues

continued

Hydro Electricity	8 360 MW potential per annum	Eastern Cape and Kwazulu Natal	- Limitation: season drought, ecology of river impacted, RSA low rainfall
Wave Power	18 000 MW	Western and Eastern Cape	- Clean energy - Ocean current can be used - Security of supply guaranteed - Travel long distances but no energy lost - RSA has 2 500kms of coastline

Own analysis, 2015

Few renewable resources have the potential to contribute to RSA energy supplies, these include solar, wind electricity, biomass, hydropower and wave power.

Solar Power. Areas in parts of RSA have on average 2 500 hours of sunshine annually and average solar radiation levels between 4.5 and 6.5 kWh/m2 in a single day. RSA and Africa are fortunate enough to have sunshine throughout the year. Solar energy in RSA is the most accessible resource. The capacity of photovoltaic (hereinafter PV) panel is about 5 MW (Department of Energy, 2010). Northern Cape has the most solar resources in the country. Most provinces will suit well for solar power generation due to high levels of sunlight (Edkins, Marquard, Winkler, 2010).

International companies are witness to the development of the solar power potential of the country and beginning to start opening production facilities in the country. August 2014 saw New York Stock Exchange listed company Jinko Solar open its doors in Western Cape. They opened up in RSA because of the South African Renewable Energy Independent Power Producers Programme (hereinafter REIPPP). Jinko Solar has done well for themselves by achieving 30 percent of the market share already. Not only is this launch an addition to the energy sector but it increases RSA manufacturing sector as well, and creates much needed jobs in the city, as well as the country. The country's Industrial Policy Action Plan focus area includes green economy as well, which aims for job creation, localisation and the growth of the economy. This launch is indicative to other investors the attractiveness of RSA as an investment destination and improves the status of renewable energy (Energy Blog, 2015).

Wind Power. Developing countries are showing the most advancement in wind power than other countries. China has shown the most improvement with 13 800 MW wind power being installed in 2009 alone, China has also grown to be the global manufacturers of wind turbines (Edkins et al, 2010). RSA coastal regions and certain areas in the Northern Cape are seen as great potential for wind energy generation, with wind potential of 500 MW to 5000 MW. In RSA the private sector is the main investors involved in the development of wind energy generation. In 2008 saw the development of the first wind farm in Darling (Western Cape), it

has installed capacity of 5.7 MW for phase I and phase II will see a total capacity of 13 MW. Eskom funded the second project at Klipheuwel as part of it research and development project. The project used three types of wind turbines to test the viability of wind energy in RSA. Each of these three wind turbines gave different outputs of electricity power. A few other wind projects were not able to reach implementation stages. RSA government made a commitment to reach 700 MW of wind generated energy by 2013, then it was thought that 5 000 MW could be developed in five years, these projects are competing against other renewable projects being developed. All decisions are based on affordability, broad based black empowerment majority shareholding companies. The aim till 2030 is to reach 8 400 MW of wind generated power (Musango, Amigun, Brent, 2011).

The development of wind power in certain areas has increased the developments at certain ports around RSA as well. As the number of wind farms increase in the Eastern Cape, this has brought a hive of activity to the province. Ngquru Port in the Eastern Cape has become a major port for receiving components of the wind turbines. The Port of Saldanha which on the West Coast (Western Cape) is the second port that is being used to bring in components. Components are sourced from all over the world including, China, Germany and India. This newly developed green economy is providing many job opportunities in the economy. The renewable energy sector has no choice but to localise as much as possible. The government is encouraging such action all over the country. In May 2013 the construction began for a local subsidiary for an international company that will provide towers in the future for all wind projects. Turbine blades will still be imported as plans to build such a factory has not been given much thought (Energy Blog, 2013). Setting up large megawatt based electricity generation plants are costly. Developers are concerned about the readiness of the grid for wind power generation. The problem lies with that the grid was never designed for decentralised power production. Major investment is needed to take in energy from decentralised locations and transport it to consumption centres. An area called Atlantis, in the Western Cape has been given the go ahead to be the Special Economic Zone for manufacturing of renewable energy parts like wind turbines. The technical issues regarding grid connections are not easily solved, the problem lies with who will be paying for the infrastructure and how much (Kraemer, 2015).

Biomass. Human and natural waste is used for biomass. A few sources are largely categorized for the production of biomass energy and these are wood, waste, alcohol fuels, crops and landfill gases. The timber industry, agricultural crops and raw materials from forestry are seen as the main contributors to woody biomass resources. Biomass is major contributor to renewable energy in RSA. Indication is given that almost 18 million tonnes per annum of agricultural and forestry residues are produced (Banks & Schäffler, 2006). Various sources are used as fuel for biomass energy production and usually things considered as garbage are used to create biomass. The process is rather simple to create energy, the waste is gathered and delivered to biomass plant, then it is put in a huge furnace where it is burnt. Heat generated is used to boil water and the steam is used to move turbines and generators. The

second method is called landfill gas. The waste is then given time to decompose and then methane gas is given off. Pipelines are then connected and the methane gas produced is collected. There are a few advantages from using biomass that should be taken into account they include, biomass can be used as fuels, power production and products that would otherwise be made from fossil fuels, CO_2 is not added to the atmosphere as the same amount is of carbon is absorbed as it grows as when it released when consumed with fuel, electricity can be generated with the same equipment or power plants that are burning fossil fuels, sensible to use waste products, biomass is really cost effective, less demand is placed on earth's resources, it has a huge impact on the reduction of greenhouse gas emissions, reduction on the dependence of foreign oil is increased. Disadvantages include, collection of waste can be difficult, and certain materials aren't always available (EnviroTech, 2015).

Cooking and agricultural growth in rural parts of India is provided by biomass energy. Households with their own cattle use the dung to produce gas which is used for fuel for cooking. The leftover dung is then used as fertilizer. Sugarcane is also used to make electricity in the sugar mills, it has an added benefit that it cleanses the environment, cuts down power costs and additional revenue is also obtained. The juice is extracted from the sugarcane and the pulp that is left behind (bagasse) is sold to power plants. The power plant then burns the bagasse and the energy produced is used at the sugar mills. It is a very reliable and efficient source of energy as it uses resources available to them (EnviroTech, 2015).

RSA has large sugar cane crop and from this about 7 million tons of bagasse is left behind. Part of the bagasse is used for the production of paper but the majority is used to produce steam for electricity generation and to process heat (Davidson, Winkler, Kenny, Prasad, Nkomo, Sparks, Howells, Alfstad, 2006). Sawmills also use their sawdust for kilns. Eskom has not been keen on biomass as a means of energy production. RSA has not tapped into the market of biomass, producers of biomass feel that government has not shown must interest in biomass. Government also lack policies, subsidies and relative incentives needed to put the sector into action. The biggest barrier in the eyes of the producers and analysts are the lack of interest shown by government and feel that this is the reason it feels it has not made a meaningful contribution to the demand for energy. Interviews done with private sector individuals indicate that they feel incentives are needed so that investment into production and market development and better logistics and infrastructure is needed. Logistics is the most expensive part of biomass production. Due to the lack of support as mentioned before, more than 97 percent of RSA production of biomass is exported. So much is exported due to the lack of support from local government and because biomass production for energy is of such a small scale. Bagasse from sugarcane is estimated to yield 5 500 gigawatt hours (hereinafter GWh), timber biomass waste 2 722 GWh, sawmill waste 2 122 GWh and pulp and paper 2 542 GWh. These figures represent the potential yield and the real figures are much lower. Exporting of biomass is not ideal as the logistics costs involved are very high and the international price squeeze leaves a small margin for higher costs (Petrie, 2014).

Hydropower. Rivers can be used to generate hydroelectricity. The success of hydroelectricity is dependent fully on the geographical terrain through which the river passes through. The energy produced is reliant on the water flow rate and the height as it flows downstream. Options are limited in RSA as they are water stressed country (Banks & Schäffler, 2006).

The Orange River and the Limpopo River are the two major river systems that flow through the country. The Orange River flows in westerly direction into the Atlantic Ocean which borders with Namibia and the Limpopo River flows in a easterly direction into Mozambique towards the Indian Ocean. The rainfall averages 500mm which in comparison to other countries is rather low. RSA experiences seasonal drought and floods which limits hydropower. The potential for hydropower is limited in certain places on the eastern part of the country. An investigation looked into all hydropower types in RSA and took into account conventional and unconventional approaches. Unconventional hydropower can occur in rural and urban areas by making use of hydropower from irrigation canals, bulk water supply pipelines and deep mining undertakings. The present installed hydropower is about 2 267 MW generating an annual amount of 4 368 GWh and this only represents 2.3 percent of the total energy output. The potential of hydropower was estimated at 8 360 MW per annum (Klunne, 2015).

The Intergrated Resource Plan (hereinafter IRP) was approved by cabinet in 2011, which set out that by 2030 diversification of sources of fuel was to be done and that 6 percent of future power mix was to be obtained from pumped storage and 12 percent from base load imported hydropower. RSA current operational capacity is Gariep's maximum capacity of 360 MW, Vanderkloof 240 MW, Colley Wobbles with nominal capacity 42 MW, First Falls with nominal capacity 6 MW, Ncora with nominal capacity of 2 MW and Second Falls with nominal capacity of 11 MW. It is the aim of the IRP to reduce the reliability on coal powered stations and looking for alternative sources of energy which should add 40 000 MW by 2030 (Mawson, 2013).

Hydropower has certain limitations that should be taken into account these include, susceptibility to drought, RSA as mentioned above is a water stressed country, on many occasions the river and dam levels are at a very low rate. Similarly to other African countries to much reliance on hydropower is not recommended as RSA also experiences many dry periods. Secondly the consideration of the environment is also equally important, large scale hydropower projects impact the ecology of the rivers and river basins and for this reason hydropower is very limited as well (Banks & Schäffler, 2006).

Wave Power. Wave energy is created by wind as it travels on the surface of the sea. Energy is then moved from the wind to the waves. Wave energy is thought of its potential for renewable energy options because it is clean energy. Other benefits include it offers countries the benefit of security of supply, waves travel immense distances with very little energy loss over big areas of ocean, satellite measurements and forecasts from meteorology allows waves

to be predicted and allows for good planning. Seasonal load is good for regions where electricity demand increases during winter. The World Energy Council has estimated market potential for wave energy to be around 2 000 TWh/year, this is equel to existing deployed markets for nuclear and hydroelectric power. Regions with strong wave resources will offer lowest cost of energy from wave power because the fuel sources for these projects are free. These regions include RSA, Western Europe, North and South America and Australia (Enerlogy, 2015).

The potential in RSA for wave energy is good considering that RSA has a coastline of 2 500 km and a good manufacturing economy. Research at University of Stellenbosch Centre for Renewable and Energy Studies has indicated that the Western Cape has the highest kw/m along the RSA coast ranging from 35 to 40kW/h. Along Kwazulu Natal the annual mean was only at 15kW/h. Another option for RSA is to use the ocean current as an energy source. Two ocean currents are flowing on the RSA coastline these include the Agulhus which travels on the east coast and the Benguela Current which is found on the west coast. The Agulhus current has been noted for its power, speed and the consistency at which it flows and therefore been identified as one of the major ocean currents. To capture the energy from the ocean currents you need to capture the kinetic energy from the flow of these two currents (Ramayia, 2012).

It would appear from the research conducted that wind and solar plays the most important role in RSA renewable energy capabilities. So far the four bidding rounds that have taken place and 46 327 MW has been obtained from these projects. 53 percent for wind, 36 percent for solar PV, and 10 percent for concentrated solar power. There is still potential for another 6 300 MW. These projects are only bringing positive upliftment to the communities where they are based. These benefits are the form of better socio economic conditions, reduction of the green gas emissions and placing RSA on the global map for being a country that is taking renewable energy seriously. That being said there is a slight problem, the point of implementing economic development criteria has proven to be a bit more challenging. This goes beyond the core competence of most developers, those who are struggling are investing in socioeconomic development consultants and community liaisons to assist them. Companies who have worked in RSA before have found it easier while others are relying on the local counterpart to handle it. The disadvantage that is if it is not dealt with their purchase agreements will be cancelled (Baker, 2015).

4.3 Current Projects in Place

Currently RSA has 91 energy plants either awaiting construction, close to completion; planning and financing approved or fully operational (see Appendix A). Appendix B gives indication of how the plants are scattered across RSA and these indicate the plants from the four windows so far.

As can be seen from the Appendix A there are many plants that are fully operational already and providing energy, while others are at construction stage and approval, planning phase. RSA in 2014 was ranked among the global top ten in terms of solar power production. As can be seen from the table above that we do have a lot of solar power plants amongst the list of renewable energy plants. The current programme being run in RSA has been named as one of the most well run programmes in the world. All plants are privately owned and Eskom merely provides the grid connection and purchase the power (Energy Blog, 2014).

Eskom Sere Wind Farm. (Figure 12) On the 31 March 2015 the wind farm in the Western Cape obtained full capacity. It is a 100 MW wind farm and is estimated to reduce 6 million tons of greenhouse gas emissions over its lifespan of 20 years. Sere is Eskom's first large scale renewable energy project and forms part of the commitment for reducing the carbon footprint. Over the 20 year lifespan it is expected that the annual energy production will be about 298 000 MWh which is estimated to supply about 124 000 standard homes. There are a total of 46 wind turbines and a 44 kilometre 132 kV distribution line connected. The first wind turbine was set up in December 2013 and by December 2014 7 turbines were erected and producing energy. Since coming online already from the first wind turbine the Sere Wind Farm has contributed over 90 GWh of energy to the national power grid. Eskom has proven itself with this wind farm that it is committed to move over to renewable energy and that it can construct a wind energy facility that meets world standards (Energy Blog, 2015).

Figure 12. Eskom Sere Wind Farm

Source: *Energy Blog*, 2015.

Jeffreys Bay Wind Farm. (Figure 13) This wind farm has a total of 60 wind turbines which will reach 11 000 homes on average and avoid 420 000 tonnes of carbon dioxide emissions annually. Mark Pickering General Manager at Jeffreys Bay Wind Farm says they are one of the first wind farms to be linked to the national power grid. The wind farm is based over 3 700Ha and is one of the first projects developed under the Renewable Energy Independent Power Producer Procurement Programme. The site is very favourable for wind farming due to its good wind conditions and limited environment constraints (Meier, 2014).

Figure 13. Jeffreys Bay Wind Farm, 2014

Source: *Meier,T*, 2015.

Jasper Solar Power. (Figure 14) This is a 96 megawatt photovoltaic solar power project in the Northern Cape. It is fully operational and took around 1 million man hours during construction and took about 800 construction workers to work on the project. The plant consists of 325 000 PV modules and delivers 180 000 megawatt hours annually to RSA, this will power 80 000 households through its 20 year purchase agreement it has with Eskom. The project was developed by a very qualified group of companies, and the equity investment and ownership is a mix of international and RSA shareholders who have joint experience in various aspects of development, funding and operations (SolarReserve, 2014).

Figure 14. Jasper Solar Power

Source: *SolarReserve*, 2014.

Droogfontein Solar Power. (Figure 15) This plant was completed in May 2014. The Northern Cape is very favourable for solar energy therefor many of the plants are located in this area and is expected to attract massive investments, the strategy of the province was to unlock existing potential and make the province attractive to both local and foreign investment. The plant has a 20 year operational plan and plans socio economic upliftment for the communities within a 50 km radius. The main initiative the plant is focusing on for the communities is in the form of education and training this will include early childhood development, numeracy and literacy inventions at primary school level, mathematics and

science at secondary scold and scholarships for engineering related studies at tertiary level. The plant is estimated to produce 85 458 MWh annually and meet needs of 19 000 homes. The plant is setup on 100 hectares of land and is running at full operation (Meier, 2014b).

Figure 15. Droogfontein Solar Power

Source: *Meier, T*, 2014.

De Aar Solar Power.(Figure 16) This plant is located 6 kilometres outside of the town of De Aar in Northern Cape and will have an operation phase of 20 years, the plant will also be used to encourage socio economic development within a 50 km radius of the farm. They intend doing by means of job creation, skills transfer, infrastructure development and economic development. The plant consists of 167 580 photovoltaic panels that covers 100 hectares of land and produces 85 458 Mwh annually and is expected to reach 19 000 home on average. The plants construction started in December 2012 and took 373 local employees at the peak point of construction and took about 17 months to complete. Due to the fact that these plants are located in small rural villages, the companies involved feel that the communities can benefit from educational assistance and therefore have made this their focus (Meier, 2014a)

Figure 16. De Aar Solar Power

Source: *Meier, T*, 2014

Redstone CSP Plant. (Figure 17) This 100 Mw plant with full load energy storage of 12 hours, it is estimated to give power to 200 000 homes during peak hours of demand even when the sun has set. The plant has a 30 year life span and is due to be in operation by 2018. The plant is the first of its kind on the African continent and uses SolarReserves molten salt energy storage technology in a tower configuration and will meet energy demands day and night (MyBroadband, 2015). It is powered completely by the sun and no backup fuel is required, it minimises the use of water because it uses dry cooling. The plant plays an

important role in technology advancement for RSA. Kevin Smith who is the CEO of Solar Reserve says that because of the fully integrated thermal energy storage the plant provides dispatchable power on demand just like conventional coal, oil, nuclear or natural gas fired power plants but without bad emissions or hazardous material and without any fuel cost, the electricity price is the lowest of any Concentrating Solar Power project in place. The plant will create 800 direct jobs during construction, as much as 40 percent of the project total value will be provided by RSA suppliers (PR Newswire, 2015).

Figure 17. Redstone CSP Plant

Source: *PR NewsWire*, 2015.

The **Cookhouse Wind Farm** has a total of 66 wind turbines and is generating 138 MW of clean power and has been doing so since 2014. RSA reliance on coal is not going to change overnight but slowly RSA is creating one of the most global progressive alternative energy progress. As many of these plants start operating it assists the very strained electrical grid and reduces the carbon emissions into the air. The other benefit coming out of all these renewable plants is the transformation it is offering to these rural communities where the plants are being set up. Healthcare, education, job creation and many other initiatives is what these privately owned plants are offering to them and at the same time providing affordable prices for electricity. Prices for electricity from wind farm cost only $ 0.05 per KWH half the cost of that obtained from coal. Even though RSA is trying to steer away from coal powered stations they constructed Medupi which is set to the largest dry cooled coal fired power station in the world. Construction started in 2007 and only recently has been completed. RSA has added 4 322 MW of renewable energy in less than four years and Medupi is said to produce 4 764 MW. Renewable energy has passed the output Medupi can offer in half the time frame. RSA has "rocket launched" with its renewable energy capabilities after a very slow start. The country's economic infrastructure has also benefited considerably from the renewable plants and an estimated $16.8 billion has already been injected (Barbee, 2015).

4.4 National Strategies on the Development of Renewable Energy Sector

The RSA government thought of the White Paper on Renewable Energy to work together with the White Paper on Energy Policy. Objectives of this paper are to clearly plan the government's vision, policy principles, strategic goals and objectives for the promotion and implementation of renewable energy in RSA. Its purpose is for RSA to move away from its strong reliance it has on coal powered energy. By reducing the amount of coal used this will also reduce the greenhouse gas emissions. A commitment to try to reduce the greenhouse gas emissions was undertaken in 2002 at the World Summit on Sustainable Development in Gauteng.

The essential elements for renewable energy implementation include:

(1) Firstly sustainable development; if renewable energy is produced from sustainable natural resources it will assist development. This is maintained because most sources are naturally available and therefore not influenced by international crisis or limited supplies.

(2) Secondly enabling the environment is important; RSA has an abundant supply of renewable energy resources that can be converted to productive energy uses. The problem lies that these resources are not utilised to be cost competitive compared to the use of fossil fuels. This mainly due to use of fossil fuel does not fully account for the impact that it has on the environment, for that reason government needs to create mechanisms that support both fiscal and financial support within a legal and regulated framework to offer some competition with fossil based technologies. In order for renewable energy to increase its share in the market and be viable support from the government is needed.

4.4.1 Goals

Vision and Purpose of the Policy. Government's vision for the role of renewable energy in its energy economy is to have an energy economy where modern renewable energy increases the share of energy consumed and provides affordable access to energy throughout RSA therefore contributing to sustainable development and environmental conservation.

The purpose behind constructing this policy is to plan government's principles, goals and objectives for renewable energy. It also proves government's commitment for renewable energy and how it will impact the energy portfolio over the coming years. Renewable energy sources will be developed in a systematic way and the challenge that government faces is to provide sufficient incentives for renewable energy industries to be able to grow, develop and be sustainable. The problem RSA faces is the lack of sufficient financial resources for renewable energy, the little that it has needs to be properly utilised. Government aims to set boundaries that will enable the industry to grow and positively contribute to the RSA economy and even globally. In order for this to take place, certain changes need to be made in

the way energy is produced, sold, traded, transferred and bought. In the long term the goal is to have the renewable energy industry have a Black Economic Empowerment (hereinafter BEE) share.

The strategic goals and objectives of the White paper were put forward to have four strategic areas including financial instruments, legal instruments, technology development and awareness, raising capacity building and education.

- **Financial Instruments.** Correct financial instruments need to be used to achieve the following objectives (1) Try to ensure that an equitable level of national resources is invested in renewable technologies, (2) Set targets for the directing of public resources for the implementation of renewable energy technologies in combination with international sources of funding for this purpose. (3) Adequately introduce appropriate fiscal incentives for renewable energy. (4) Extend existing state financial support systems and institutions and introduce innovative approaches to the establishment of sustainable structures and financing mechanisms for delivering renewable energy systems. (5) Facilitate the creation of an investment climate for the development of the renewable energy sector, which will attract foreign and local investors.
- **Legal Instruments**. The legislative system needs to be consistently maintained, implemented and continuously improved to ensure renewable energy is promoted. The objectives include to develop appropriate legal and regulatory framework for pricing and tariff structures to support the integration of renewable energy into the energy economy and to attract investment, to develop an enabling legislative and regulatory framework to integrate Independent Power Producers into the existing electricity system, develop an enabling legislative framework to integrate local producers of liquid fuels and gas from renewable resources.
- **Technology Development.** The enhancement and development of technologies is needed for the successful implementation of sustainable development. This will be done through the promotion of development and implantation of appropriate standards and guidelines and codes of practice for the appropriate use of renewable energy technologies and the promotion of the appropriate research and development and local manufacturing to strengthen renewable energy technology and optimise its implementation.
- **Awareness raising, capacity building and education.** Here the goal is to develop mechanisms to raise the public awareness of the benefits and opportunities of renewable energy. This will be done by promoting knowledge of renewable energy and energy efficiency and increase the use of it, promote and stimulate the renewable energy market through the dissemination of information regarding economic, environmental, social and trade benefits of renewable energy technologies and their applications. By persuading the appropriate government and government funded institutions to implement training and education programmes with regard to renewable energy and finally to improve communication between national provincial and local government institutions on renewable energy policies.

In the White Paper certain barriers to the implementation are highlighted they include the enormous costs behind renewable energy technologies, initial investment and long term support is needed before some profits are seen, consumers lack the knowledge to see the, long term benefits and opportunities of renewable energy, the economic and social system of energy services is based on centralised development around conventional sources of energy, specifically electricity generation, gas supplies and liquid fuels, certain barriers in financial, legal, regulatory and organisational need to be overcome, the lack of non-discriminatory open access to energy infrastructure like the national energy grid need to be addressed.

The paper also provides a summary of renewable energy options that have been discussed in previous section. For RSA it is important to identify technologies that are applicable for application over a greater area. Renewable energy plants on average need approximately 3 years lead time compared to a coal fire plant whose lead time is approximately 5 years.

Table 5 below gives further evidence which renewable energy type is more suitable than others.

Table 5. Renewable Energy Power Plants

Type of plant	**Physical characteristics**	**Economic characteristics**	**Role within system or typical running regime**
Hydroelectricity (pump storage)	Extremely flexible	High capital costs, high marginal costs	Rapid response in either direction and "peak shaving"
Hydroelectricity (+Storage)	Flexible	High capital costs, low running cost	For base load and capacity following
Hydroelectricity range (run of river)	Inflexible intermittent	High capital costs, low running cost	Base load, intermittent renewable generator. Wide of capacity factors
Wind	Inflexible intermittent	High capital costs, low running costs	Base load, intermittent renewable generator. Capacity factors 25-40 percent
Energy crops and biomass waste	Capable of flexible operation	High capital costs, medium running costs. Energy from waste plants running regime dictated by need to deal with waste stream	Base load, steady output renewable generator. Around 80 percent capacity factor

table continues

continued

Landfill gas	Limited flexibility	Low capital costs, medium running costs	Base load renewable generator – 95 percent capacity factor
Municipal solid waste	Flexible	High capital costs, low running costs. Energy from waste plants running regime dictated by need to deal with waste stream	Base load steady output capacity factor around 80 percent
Solar thermal	Flexible intermittent on backup fuel storage	High capital costs medium running costs	Base load intermittent

Source: *White Paper Renewable Energy*, 2003, Table 5

In 2003 when this paper was drafted certain limitations for the implementation was already predicted to make things more difficult, these include the regulations around electricity, liquid fuels and housing and building markets, the growth in electricity pricing structure, incentives provided, the availability of supportive international finance, donor and private including government funding, the fiscal treatment of renewable energy, final operational structure of the power sector and the ease of accessing the national electricity grid and getting power to everyone, detailed feasibility evaluation results for individual projects, private investment in renewable energy, public awareness and building a demand for green energy in different sectors, affordability of renewable energy technology and the market uptake of renewable energy technologies.

Growth for the sector with deliverables like social, economic and environmental benefits to RSA; Implementation of such a programme will only be beneficial to RSA in the long run as it attracts investment. The target for future growth in the renewable energy industry was set for ten years and to have 10 000 GWh renewable energy contribution to final energy consumption by 2013 and will be mainly produced from biomass, wind, solar and small scale hydro. The renewable energy is to be used for power generation and non-electric technologies such as solar water heating and bio fuels. This is approximately 4 percent (1667 MW) of the estimated electricity demand (4 1539 MW) by 2013. This is equivalent to replacing two (2 x 660 MW) units of Eskom's combined coal fired power stations.

4.4.2 Essential Elements of Renewable Energy Implementation

Essential elements of this approach to implementation are sustainable development, enabling environment, institutional arrangements, information and technology.

Sustainable development can be defined as "integration of social, economic and environmental factors into planning, implementation and decision making so as to ensure that

development serves present and future generations" (University of Pretoria, 1998). If renewable energy is produced from sustainable natural resources it contributes to sustainable development. Climate change is the biggest challenge facing the world as we know it and by reducing the amount of fossil fuels will help reducing emissions into the air.

Enabling Environment The high capital costs involved in renewable energy makes it rather uncompetitive in the short to medium run. An established environment of fiscal, financial and legislative instruments is needed to simulate the utilisation of these technologies. Government's role also needs to be clear so that market share and open access is available to the national grid. Investors are not keen to investment in so called risky investments that is why it is critical that demonstration of the projects is done with investors so that they are familiarised with the options.

Financial Instruments Funding will be guided by moving pass the initial high capital costs and increasing the commercialisation of technologies in renewable energy with a market driven economy. Funding shall be obtained through fiscal and financial measure e.g. budgetary allocation, subsidies, levies, tax rebates etc. It is important that this be evaluated and monitored. Table 6 below indicates what instruments have been used in other countries

Table 6. Renewable Power Approached in Other Countries

Country	**System**
Australia	RE certificate (obligation)
Denmark	RE feed in tariff
France	RE fixed price
Germany	RE feed in tariff
Japan	RE certificates (obligation)
Philippines	Renewable Portfolio Standard (set aside), RE levy
Spain	RE feed in tariff
United Kingdom	Renewable Obligation Certificates
United States of America	Renewable Portfolio Standard (Set aside), RE IPP tax credits

Source: *White Paper on Renewable Energy*, 2003, Table 6

The most successful of the above instruments include investment incentives, production incentives and set asides. Investment incentives are direct subsidy and/or tax credits to encourage investment in renewable energy technology e.g. in USA the Renewable Energy generator tax credit. Production incentive is when the electricity distributor is obliged by law to purchase at a certain minimum feed in tariff electricity from every grid connected renewable energy generator. Sources of funding are to enable the distributor to buy at the grid feeder tariff including direct subsidies and/or cross subsidy from the electricity consumer, this is for example how Germany's feed in tariffs operate. Set aside is the when the block of energy supply that has been earmarked by law for capacity for renewable energy. Tenders are put in for renewable energy generators to provide the renewable energy supply. Who is

fortunate to win the tender received financial support; this was done in the USA and known as Renewable Portfolio Standard (Department of Minerals and Energy, 2003).

Options for RSA: The current position in RSA leaves the option of a combination of a set aside mixed with investment incentive as the basis for utilising energy funding for an initial programme in renewable energy. A Tradable Renewable Energy Certificate would be obtainable which will allow the trade nationally and internationally. The final decision of which option is best suited would be made once macro-economic analyses have been completed (Eberhard et al, 2014).

In 2009 the exploration into feed in tariffs took place by government but these were then changed for competitive tenders instead. The program now in place is known as the Renewable Energy Independent Power Producer Procurement Program (REIPPPP), this program has channelled private sector enterprise and investment into renewable energy in RSA at very competitive prices. 91 projects have been tendered so far to the private sector. Rural communities have seen the most improvement in economic development since the launch of the program (Eberhard et al, 2014).

In November 2011 53 bids for 2 128 MW of power generating capacity was received for Window 1, 2, 3 of these bidders were selected with a total of 1 416 MW for an investment of $6 billion. A second round of bidding was announced the same month with a reduced amount of power and other procurement changed to strengthen and increase competition. By March 2012 79 bids were received and only 19 were selected. In May 2013 the third round of bidding was open. By August 2013 93 bids were received with a total of 6 023 MW. 17 of these were given by October 2013 with a total of 1 456MW (Eberhard et al, 2014).

The three rounds of bidding attracted a huge number of various investors both locally and internationally. The REIPPP had a senior manager at the forefront that had been working for the National Treasury. The management style followed was different from the way things were normally run, in this program the key was open dialogue regarding design and implementation issues was present from the beginning. Many of the deadlines set were strictly abided to, which caught many by surprise. It was also very crucial that advisors from local and international to assist with the design and management of the program (Eberhard et al, 2014). Table 7 provides a summary of the three rounds of REIPPP.

Table 7. Summarized Results of REIPPPP Windows 1, 2, 3

	Wind	PV	CSP	Hydro	Biomass	Biogas	Landfill	Total
Window 1								
Capacity offered (MW)	1 850	1 450	200	75	13	13	25	3 625
Capacity awarded (MW)	634	632	150	0	0	0	0	1 416
Projects awarded	8	18	2	0	0	0	0	28
Average tariff (Sac/kWh)	114	276	269	n/a	n/a	n/a	n/a	n/a
Average tariff (USc/kWh) ZAR8/$	14	35	34					
Total investment (ZAR mill)	13 312	23 115	11 365	0	0	0	0	47 792
Total investment (USD mil) ZAR 8/$	1 664	2 889	1 421					5 974
Window 2								
Capacity offered (MW)	650	450	50	75	13	13	25	1 275
Capacity awarded (MW)	563	417	50	14	0	0	0	1 044
Projects awarded	7	9	1	2	0	0	0	19
Average tariff (Sac/kWh)	90	165	251	103	n/a	n/a	n/a	n/a
Average tariff (USc/kWh) ZAR7.94/$	11	21	32	13				
Total investment (ZAR mill)	10 897	12 048	4 483	631	0	0	0	28 059

table continues

continued

Total investment (USD mil) ZAR 7.94/$	1 372	1 517	565	79	0	0	0	3 534
Window 3								
Capacity offered (MW)	654	401	200	121	60	12	25	1 473
Capacity awarded (MW)	787	435	200	0	16	0	18	1 456
Projects awarded	7	6	2	0	1	0	1	17
Average tariff (Sac/kWh)	74	99	164	n/a	140	n/a	94	n/a
Average tariff (USc/kWh) ZAR9.86/$	8	10	17		14		10	n/a
Total investment (ZAR mill)	16 969	8 145	17 949	0	1 061	0	288	44 413
Total investment (USD mil) ZAR 9.86/$	1 721	826	1 820		108		29	4 504
Totals								
Capacity Awarded (MW)	1 984	1 484	400	14	16	0	18	3 914
Projects awarded	32	23	5	2	1	0	1	64
Total Investment (ZAR mill)	40 590	42 130	33 797	631	1 061	0	288	120 263
Total Investment (USD mill)	4 683	5 085	3 806	79	108	0	29	14 011

Source: *PPIAF Report*, 2014, Table 2

From Table 7 above for window 1 it can be noted that 28 bidders were identified in the first round. Total investment adding up to $ 5.97 billion and offering 1 416 MW of total energy, the initial amount procured was 2 128 MW. From these eighteen of the projects were for PV technology, with a capacity of 632 MW, while two were for CSP technology with a capacity

of 150 MW. Wind technology was given to eight projects with a total of 632 MW. Sponsors and lenders were from RSA and as well as international, local banks were involved in the financing with some of the balance from Development Finance Institutions. Construction on most of these projects commenced and the first were set to be ready by March 2015 (Eberhard et al, 2014).

Window 2 opened in November 2011 and the amount of power to be procured was 1 275 MW. By May 2012 a total of 19 bidders were selected and these included 9 solar PV projects, 7 wind projects, 2 small hydro projects and one concentrated solar project (Eberhard et al, 2014).

Window 3 opened on May 2013 with a total of 1 473MW of power needed. Of the 93 bids received only 17 were awarded in October 2013. The bids totalled 1 456 MW and consisted of 787 MW wind energy, 435 MW PV, 200 MW CSP, 18 MW landfill gas, and 16 MW biomass energy (Eberhard et al, 2014). Aggressive price decreases were seen in this round with wind averaging 74 c/kWh and 99 c/kWh for solar PV and 1.64 ZAR/kWh for concentrated solar power. Low prices were achieved by developers being able to finance a larger proportion of projects from equity, thus reducing the cost of debt. This may seem good in the short term from a pricing point of view but it does not contribute to broadly based emerging renewable energy industry (Forder, 2013).

Window 4 began in July 2014 and with 77 application received, out if these 77; 13 (indicated in Table 8) were accepted as preferred bidders with a total of 1 121 MW of installed capacity.

Table 8. Window 4 Summary

Technology	**MW Available to be allocated in the Fourth Bid Submission Phase**	**Number of recommended preferred bidders in Fourth Bid Submission Phase**	**Total Contracted Capacity for all the recommended Preferred Bidders for the Fourth Bid Submission Phase**	**Average fully indexed Price (April 2014 terms)**
Onshore Wind	590 MW	5	676 MW	R619/MWh
Concentrated solar power	n/a	n/a	-	-
Solar photovoltaic	400 MW	6	415 MW	R786/MWH
Biomass	40 MW	1	25 MW	R1450/MWh
Biogas	n/a	n/a	-	-

table continues

continued

Landfill gas	15 MW	-	-	-
Small hydro (<40 MW)	60 MW	1	5 MW	R1 117/MWh
Total	**1 105MW**	**13**	**1 121MW2**	

Source: *Department of Energy media statement,* 2015, Table 1

Almost 62 percent of the preferred bidders in the fourth window are from the Northern Cape Province as can be seen in the Table 9 below Most of the contracts capacity in the Northern Cape consists of Solar Photovoltaic Projects and partially to Onshore Wind. The Eastern Cape has 35 percent of total proposed capacity in the fourth window for the Onshore Wind category and the Hydro and Biomass bides are located in the Free State and Mpumalanga. All these successful bids has a direct impact on employment in the country with a total of 7 071 full year jobs during construction and permanent operational employment of over 1 000 of the Window 4 projects and over 20 years 27 365 direct full year employment will be made available. The amount estimated of full year work opportunities for RSA citizens who have committed in the Window 4 submission phase is 26 246 jobs which is an increase from the Window 3 submission phase which was only at 26 143 jobs and double from Window 1 which was 16 034 jobs and Window 2 which was 13 000 jobs. The manufacturing sector of RSA also sees the impact from these bids and strengthens economic and employment relations in the sector (Department of Energy, 2015).

Table 9. Window 4 Bidders According to Province

Province	**Total Project Cost (ZAR Millions)**	**Total Project Value (ZAR Millions)**	**Local Content Value (ZAR Millions)**
Eastern Cape	7 439	6 648	2 944
Free State	246	202	80
Mpumalanga	1 195	902	431
Northern Cape	14 531	11 569	6 521
Total	**23 411**	**19 321**	**9 976**

Source: *Department of Energy media statement*, 2015

4.4.3 Foreign Direct Investments to the Renewable Energy Sector

In 2012 the renewable energy independent power producing bidding programme did very well by attracting 70 billion ZAR ($ 5 760 512 800.00) over a 12 month period. As the windows for bidding to open even more investment is expected in the projects ahead. In 2013 RSA was in 13th place according to AT Kearney FDI confidence index and improved by two places from previous years. 300 of the world's leading multinational companies participated. A vital connection between foreign investment, economic growth and higher fixed investment which ensure the higher growth rates that can be achieved on a sustainable basis exists. RSA has been lacking in attracting investments this is due to lack of protection of investment rights,

good governance, consistent policies and a stable economy. The top countries attracted $1.4 trillion in 2012 while in RSA $10 billion was obtained in 2013 which is six times less than what Brazil attracted (Pickworth, 2014). In 2014 RSA climbed two places to 13, as the most attractive country for foreign direct investment. This is a positive sign as it gives indication that momentum is being gained with foreign investors. The commitment RSA has made to Renewable Energy Independent Power Provider Programme has influenced the improvement on the ranking of RSA (Department of Government Communications and Information Systems, 2014).

Global foreign investment inflows declined by 18 percent in 2012 this was mainly due to global macroeconomic instability and uncertainty regarding policies. 2012 had seen the second largest decline in Greenfield FDI since 2008. Countries that experienced strong growth included Chile, Spain, Indonesia, Poland and Oman. Chile had the most renewable energy investments. The BRIC countries (excluding RSA) had 17.6 percent of global FDI projects. The Middle East and African region experienced decline of 11.78 percent in 2012 to only 1 370 projects this influenced capital investments to decline to 43.31 percent and job creation by 23.32 percent. USA, UK, Japan, France, China, South Korea, Spain and Switzerland were the world's top net investors. The USA is the largest source of FDI if you look at the number of projects invested which amounted to 30 033 altogether. The USA invested in 22 876 more than Germany who are the second largest investors with 7 157 projects. Table 10 below indicates the top 15 FDI investors for FDI from 2008 – 2012 (Wesgro, 2013)

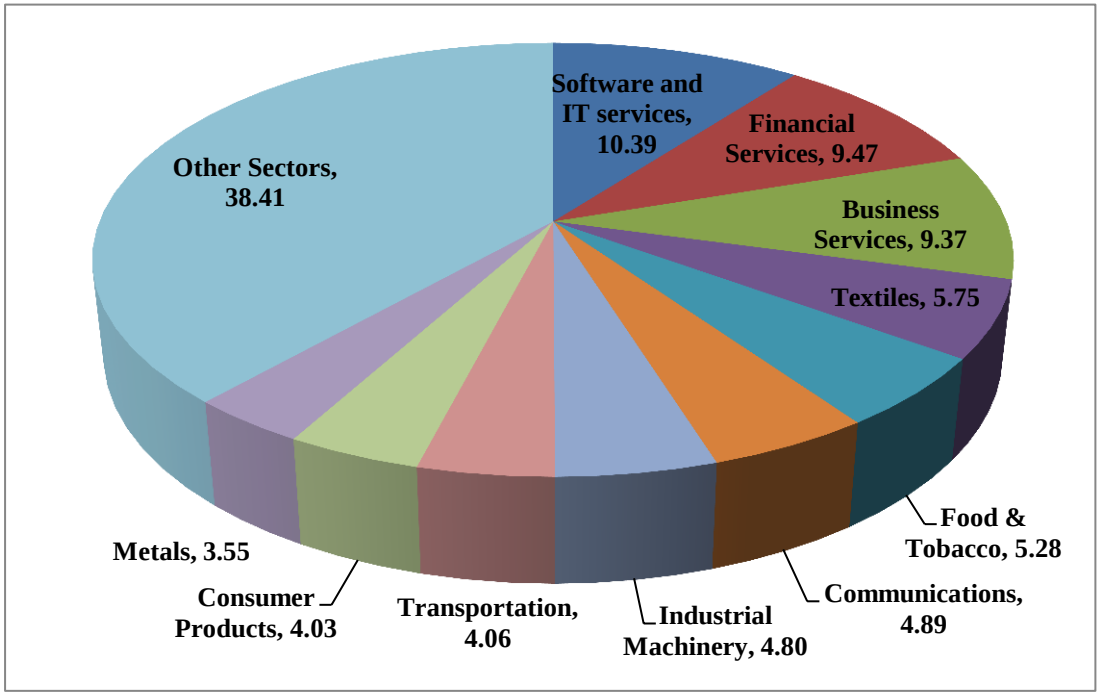
Table 10. Top 15 Global Sources Market for FDI and Top Recipients for FDI 2008-2012

Top 15 Global Source Markets For FDI 2008 -2012			**Top 15 Recipient Countries For FDI 2008 -2012**	
Rank	**Country**	**Projects**	**Country**	**Projects**
1	USA	30 033	USA	20 452
2	Germany	7 157	China	6 684
3	UK	7 097	UK	4 944
4	Japan	4 997	India	4 249
5	France	4 491	Germany	3 566
6	Spain	3 043	Russia	2 176
7	Switzerland	2 513	France	2 158
8	Italy	2 146	Spain	2 111
9	Netherlands	2 071	UAE	1 960
10	Canada	1 842	Brazil	1 897
11	India	1 763	Singapore	1 758
12	China	1 732	Poland	1 554
13	Sweden	1 608	Australia	1 527
14	UAE	1 297	Mexico	1 498
15	South Korea	1 194	Canada	1 471
Other countries		17 132	Other Countries	32 111
Total		90 116	Total	90 116

Source: *FDI Intelligence*, 2013, Table 1 & 2

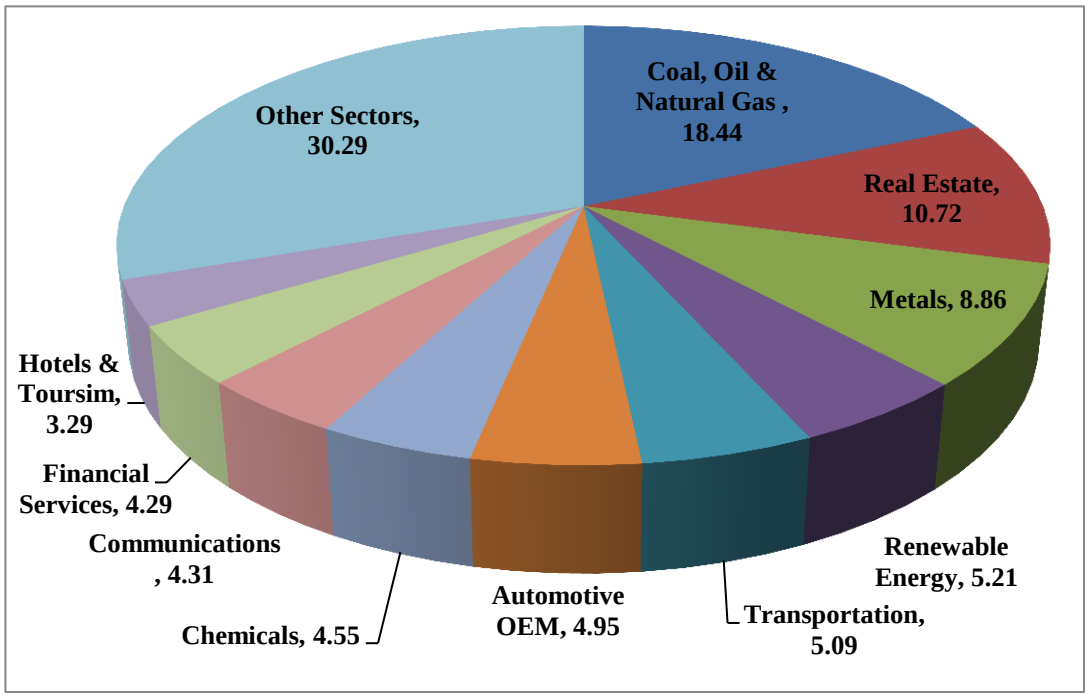
The sectors attracting the most FDI globally include software and IT, financial services, business services and textiles. Coal, oil and natural gas, state sectors have been attracting the most high value investments as well as metals, renewable energy and transportation as indicated in Figure 18 (Wesgro, 2013).

Figure 18. Top 10 Global Sectors for FDI, by Number of FDI Projects 2008 -2012 in Percent



Source: *FDI Intelligence*, 2013

Figure 19. Top 10 Global Sectors for FDI by CAPEX 2008-2012 in Percent



Source: *FDI Intelligence*, 2013.

March 2015 Ernest and Young released the renewable energy country attractiveness index. The index gives special mention to certain countries including the African continent. India has had ambitious solar targets and policy reforms in recent months giving indication why India plays a major role in renewable energy and how they aim to climb to the top of the index. Sub-Sahara Africa has been experiencing great achievements in growth and making its name known for foreign investment.

4.5 Broader Benefits of Renewable Energy Sector Development

Globally the benefits of using renewable energy are spread to encourage others who have not looked into these concepts to consider the move. These benefits are seen in all spheres including economic impact as well as the benefit it has on the planet. The benefits are briefly (explained later):

- Macroeconomic benefits (jobs, growth)
- Direct demand side effects (energy consumption patterns)
- Direct effects on supply side effects.
- Indirect effects.

Macroeconomic benefits are created through various spheres including direct, indirect and induced economic effects. These macroeconomic benefits are felt directly to the individuals, businesses and institutions who get involved directly with the investment while other benefits occur in the economic sectors and society through direct and ripple/multiplier effects (United States Environmental Protection Agency, nd). Proven research has given sufficient evidence that when countries make cost-effective investments in energy efficiency that their economy will reap the benefits. Renewable energy technologies have economic benefits for two reasons firstly they are labour intensive meaning they create more jobs than the money invested than normal electricity generation technologies and secondly they use indigenous resources, so much of the money invested can be kept in the country (United States Environmental Protection Agency , n.d.).

Direct effects on the demand side effects are felt through the energy consumption patterns for business and residential consumers particularly. Initiatives include the usage of cost effective technologies, this is done with the help of new appliances that are efficient, better lighting devices, better design and improvement in construction of new homes and businesses. The energy efficiency initiatives come from the costs for goods and services used to put in place these and include energy and other cost savings from these initiatives. These cost savings range from the money saved by households and businesses from reduced usage of energy, low maintenance costs, increase in property values from new energy saving equipment, as well as household and business expenditures, money used by companies and homes for purchasing and installing new energy efficient equipment and sector transfers that experienced increased flow of cash to corporations that design, manufacture and install these

new technologies. Economic shifts are experienced due to these effects described above. These are experienced through the effect on purchasing power of participating consumers, profitability of participating businesses and profitability of conventional power generators. These shifts together affect income, employment and overall economic output by reducing residential energy costs and making consumers have more disposable income for other goods, rise in income, employment and output, increasing income and employment with the help of stimulation in the production and sale of energy efficient equipment by existing businesses within the state, increasing income, employment and output by expanding the in state market for energy efficiency and bringing in new business and attracting investments, decreasing (United States Environmental Protection Agency, n.d).

Direct effects on supply side effects. The energy policies and programs for the supply side impact the fuel/generation mix of energy resources or the operational characteristics of the energy supply system. These measures assist the development of utility scale renewable energy and combined heat and power applications. These effects are felt through the costs of manufacturing, installing and operating the renewable energy and combined heat and power equipment. These savings are experienced through displacement savings, money saved from the decrease in purchase of fossil fuels and reduced operation and maintenance costs from the current resources, waste heat savings, money is saved by industries using waste heat for cooling and heating, program administrative costs, money spent on operations, labour. It is crucial to be aware how the costs of a program will be funded, construction costs, money spent on purchasing equipment, installation costs, costs of grid connection and on site infrastructure. The supply side of clean energy shifts economic activity with the purchases of fuels, business activity and generation of clean energy. These shifts increase income, employment and economic output in the economy through construction and operation of new renewable energy power facilities, stimulation of economic activity for both local and the export markets, expansion in the industry and attracting new business and investment (United States Environmental Protection Agency, n. d.).

Along with direct effects there are also **indirect effects**, this result from upstream in business activity changes from supplying goods and services to industries directly involved in the renewable energy initiatives. The downstream indirect effects are experienced in the local economies as they have lower energy costs, better dependable energy supply and a much better economic environment that has expansion opportunities and attracts new business. The economy of any country is the key in being able to provide the goods and services needed to implement the initiative. The larger and more diverse an economy is the more suitable it will be for indirect purchases within the country (United States Environmental Protection Agency, n.d.).

The 2012 data indicates that approximately 5.7 million people around the world have been employed in the renewable sector directly and indirectly (International Renewable Energy Agency (hereinafter IRENA). More jobs were obtained in the biofuels and solar photovoltaic

sectors. The numbers are around 1.38 million and 1.36 million respectively in each sector, while biogas, geothermal energy, small hydropower and concentrated solar power have much lower employers. The trend globally is for policy makers to pursue technologies in renewable energy for many reasons such as greater energy security, socio economic benefits and environmental considerations. Countries such as Brazil, China, European Union, India and the United States have seen the most employment in the energy sectors. These countries are also the major manufacturers of renewable energy equipment, bioenergy feedstock and installers of production capacity. The rest of the word is picking up on this trend and also making major investments and adapting policies and implementing policies with regards to renewable energy. The trends in employment in the sector have varied considerably over the years. The increases in biofuels have given light to growth in employment while the mechanism of feedstock operations is reducing the labour needs. The employment in the industry shows regional shifts in renewable energy manufacturing, manufacturing overcapacities and industry realignments, growing export competition and the impacts of austerity and policy uncertainty. Although a decline in costs is being experienced in solar and wind equipment, suppliers face new challenges and it is affecting manufacturing, they are seem to be driving deployment and corresponding jobs in installation and operations and maintenance. These shifts therefore need to be understood and the effect on relative shares of employment and overall occupational and skill patterns in renewable sector need to be monitored. The forecast for future employment depend greatly on assumptions and capacity additions, which also depend on supportive policies that are created, the trends in the cost of renewable energy technologies and labour productivity. IRENA Remap 2030 options, direct and indirect global employment in renewable energy that will be used for power, buildings, transport and industry in the year 2030 would create 16.7 million work places. They estimate that 9.7 million jobs would be in bioenergy, 2.1 million in wind energy, 2 million in solar photovoltaic, 1.8 million in solar water heating, 0.6 million in small hydropower and 0.5 million in other renewable energy technologies. If these predictions are correct this would amount to 9.2 million jobs which is huge increase from the current amount of 5.7 million (International Renewable Energy Agency, 2013).

Like in most cases of collecting statistics on employment data the renewable sector suffers the same problems. Very few countries are successful at gathering the relevant data, others rely on various sources example heterogeneous methods, assumptions and time frames. Due to these the data currently is rather uneven. The data on employment is essential to make informed policy choices. The information collected will be used to offer support to policy makers in communicating the benefits of these policies to the public with reliable facts and figures. IRENA also forecasts that by 2030 4.5 million jobs can be created in off grid renewables based electricity sector as well, this indicates the potential that exists in job creation potential if the end users sectors (heating/cooling, transport are included. The aim is to achieve universal access to modern energy services and by doing so uplifting socio economic conditions (International Renewable Energy Agency, 2013). A global initiative like the United Nations Sustainable Energy for All Initiative is one such way up-lift of the socio

economic conditions is trying to do this. This initiative brings all sectors of the society business, government, investors, community groups and academia. The objectives of the initiative include ensuring universal access to modern energy services, double the rate of improvement in energy efficiency and double the share of renewable energy in the global energy mix. The aim is to achieve these goals by 2030 (United Nations, 2015).

The four windows (Refer to Table 7 and Table 8) above which proved to be rather successful for the Renewable Energy Independent Power Producers Procurement Programme will see Window 5 opening in the near future. The fourth window results were delayed due to investigations whether the grid was reliable to accept the new access. This problem was addressed by national project developers as well as international developers. The fifth window call should be open near the end of the first quarter of 2015 and will be redesigned accordingly. Nersa will also be contacted in order to add an additional 6.3 GW in the future calls. These projects have added significantly to environment and to financial industries, these projects are estimated to save $450 million, the payments to these renewable projects with feed-in tariffs at $390 million and net profit to the economy at over $600 million (Chadha, 2015).

Besides the benefits mentioned above skills development is another advantage that renewable energy brings to the table. It is vital that a workforce be developed that can sustain the industry in the future so that the industry does not rely on experts from outside the country. Jeffrey's Bay Wind Farm in the Eastern Cape has adopted this strategy he says job creation cannot be viewed in isolation and skills development is an essential component for the farm. Their workforce is 80 percent South Africans; they have also focused on the community and try to ensure employment and development benefits are kept within a 50km radius. The Eastern Cape has been identified as primary region that has been able to capitalize on employment opportunities, this started during the construction phase of the many wind farms projects. During the busiest period of the construction 602 people were working on the Jeffrey Bay Wind Farm site, with around 45 percent from the local communities in the area (Meier, n.d.).

A national renewable technology centre has been set up in Cape Town in the Western Cape. The centre will offer specialized training to the renewable energy sector with short courses as well. This type of facility is the first on the African continent and will provide training to technicians (Saratec, 2014). According to Mr Sven Pietrangeli the training centre was set up due to the growing industry and the amount of foreign direct investment coming in. RSA has a skills shortage in the sector and they hope to address this issue. The centre offers long term training for wind turbine service technician, solar PV technician, energy efficient technician (under development) and biogas technician (under development). They are also having short courses which cover multiple disciplines and are industry specific. Currently because it is relatively new industry in RSA all types of skills are needed from engineers to technicians.

The Department of Higher Education in South Africa and the training via the national skills fund is part of this initiative.

4.6 Challenges in Renewable Energy Sector

Although there are challenges of controlling renewable energy sources and the challenge of being able to deliver renewable power supply to energy grids worldwide, many believe that wind and solar are the solutions for the world to move away from its need for the use of fossil fuels. Energy has evolved in many ways and now it's up to the global economy to move to a continuous renewable energy supply (Mclamb, 2011).

The challenges of renewable energy in RSA are first related to global challenges in the sector and also, second, to specific challenges pertaining to the situation in RSA. Let us first briefly discuss the global challenges. The power of economic recovery is essential for how markets will evolve over the coming years. Fossil fuels suffer risks of being depleted and the ever increasing expenditures of providing energy from them, means that renewable energy is the only sustainable and economic way forward. According to Tanaka (2011), the Executive Director of the International Energy Agency (IEA) he feels that energy sectors are experiencing unprecedented uncertainty they need to use energy more efficiently and slowly move away from fossil fuels by adopting technologies that leave a much smaller carbon footprint (Mclamb, 2011).

The IEA New Policy Scenario which is responsible for the plans and commitments given by countries worldwide assumes that the world primary energy demand increases by 36 percent between 2008 and 2035 or 1.2 percent per year on average. China finds itself leasing in plans to increase the share of low carbon energy technologies, including alternative motor vehicles which will assist in lowering the costs through faster rates of technology learning and economies of scale and boost their deployment worldwide. The IEC believes it is hard to emphasise the growing importance of China in global energy and it is important to monitor how they deal with threats to global energy and climate posed by the ever increasing fossil fuel usage and how they deal with this will impact on other countries in the world. Non OECD countries are responsible for 93 percent of the projected increase in world primary energy demand. Data indicates that in 2009 China overtook the United States of America to be the largest energy user worldwide even though it has low per capita energy use, contributing only 36 percent to the projected growth in global energy use. Oil will always remain the leading fuel in the whole energy mix, Oil prices are predicted to rise reflecting the growing insensitivity of demand and supply to price (Mclamb, 2011).

Many national budgets of countries are tight, industry is looking at private capital as key for funding energy and climate related infrastructure. There has been thought given to institutional investors such as pension funds, insurance companies and long term investors

who have large amounts of assets and whether these investors could be the answer to assisting funding for renewable energy where needed. The possibilities that institutional investors can be a crucial source of capital for the sector are highly possible if attractive investment and policy barriers were reduced, which could also be of great relevance to RSA. The flipside of the debacle is that there is enough investor's available but limited amount of potential investment. Nelson and Pierpont (2013) identify the barriers to achieving these goals, participants in the study involved 25 pension funds and insurance companies across North America, Europe and Australia, consultants, bankers, renewable energy developers, analysts and academics.

The constraints that institutional investors face include the following firstly managing liquidity issues, the limitations on investing in illiquid assets, secondly institutional investor scale and direct project investment, the scale at which to directly invest in renewable projects and thirdly diversification and limiting exposure to an industry or investment theme, fourthly policy barriers to investing in renewable energy and lastly investment practices of institutional investors (Nelson & Pierpont, 2013).

The other common myths and challenges that renewable energy face include renewable energy is all clean and all green, renewable energy assists in reducing carbon dioxide emissions but solar and wind generation need large amounts of land to produce small amount of electricity compared to fossil fuels. Example natural gas well that produces 60 000 cubic feet per day is responsible for producing more than 20 times the amount of energy per square meter that a wind turbine does. Moving towards renewable energy will allow an energy sprawl that will implicate the conservation of biodiversity (Kiersecker, 2011).

The other myth that exists is that renewable energy does not work unless there are subsidies to go along with it, government incentives are appreciated in the sector. Example in 2007 the USA subsidies for wind power development were at $700 million and $800 million in coal energy development. Third problem facing is the number of birds killed by wind turbines. The number birds injured or killed due to the blades of the wind turbine but analysts predict that these numbers are less than 1 million birds annually (Kiersecker, 2011).

There is the possibility to make coal cleaner, coal is responsible for than 50 percent of electricity that is used in the USA, and they also have more than enough to last a long time. Coal is responsible for 60 percent of sulphur dioxide pollution, 50 percent of particle pollution and 40 percent of CO_2 emissions. Clean coal technology is being developed that collect and store pollutants instead of it being released. CO_2 emissions will be pumped down wells to oil fields that are depleted or other geological formations deep underground. Research is not complete just how efficient this will be and if it is the solution (Kiersecker, 2011).

It's important that the challenge of overcoming the disparity in energy density, fossil fuels remains a concentrated form of energy. Gasoline has 80 times more energy by weight as a lithium ion battery. Over the past few decades shifts in energy were driven by the exploitation of better concentrated forms of energy, the issue with renewable energy is that it is less dense form of energy and will be a continuous challenge due to the inherent high resource and land footprint. The final challenge that renewable energy faces is that there is a lack of patience to wait for alternative energy to mature. Fossil fuels cannot be disregarded completely, in the USA coal is responsible for 70 percent of energy production, and RSA is 95 percent reliant on coal as well. Projections in the USA indicate by 2030 these numbers will not change much. Many consumers fear rising energy costs and therefore are not always open to new innovative ways of producing energy (Kiersecker, 2011).

There are also **challenges that are specific to RSA**. In RSA the challenges/barriers that we face in the implementation of renewable energy begin with political, then legislative issues, economics and financial problems and then lastly the development of the industry and the energy grid. These problems need to be dealt with so that RSA becomes more attractive for investors (Gets, 2013).

Political challenges. The heavy reliance RSA placed on coal is its biggest barrier to renewable energy. This as mentioned before is not the problem RSA alone faces but many countries are fighting for coal and nuclear to remain the main source of power generation. The aim of the Department of Energy is to have 17.8 GW of renewable energy by 2030. Not much has been approved with the 4 windows that have taken place and if RSA is indeed serious about making investment in renewable energy then state owned Eskom needs to start investing more in renewable energy than in coal. Eskom is publicly funded and therefore there duty to make sustainable investments in energy production. The bad side of the programme in place is that it relies solely on private sector and therefore less responsibility falls on government to take any initiatives. Local governments are also at fault as they are taking no steps in investing in renewable energy, municipalities relied on selling electricity as part of their funding model (Gets, 2013).

Legislative challenges. The policy adjusted plan for 2030 by the Department of Energy indicates 42 percent of electricity generation should come from renewable energy (17.8 GW), 38 percent from coal and nuclear (15.9 GW). Issues such as trading agreements, land access, environmental requirements, licencing and power purchase agreements have to be handled with care so that they do not add to the barriers hindering movement to renewable energy. The current bidding system only allows renewable projects with corporate and international funding to be able to participate. Reform in this legislature is needed so that small and medium scale for households and municipal projects. Currently the cost and procedures in place make it impossible for uptake from small to medium projects. Many feel that legislative barriers are the biggest problem that renewable projects face. RSA should take lead from

Germany where a lot of renewables are obtained from small projects and households; this would help considerably with renewable energy capacity (Gets, 2013).

Economic and financial challenges. Coal and nuclear including mining and related large corporations have been subsidised. A report by G20 estimates that more than R71.1 billion ($8 billion) has been awarded in consumer subsidies in coal fired electricity which causes an economic barrier for renewable power. It has been proven that the best way to deal with this is having feed in tariff systems, this means that renewable energy operators are paid a fixed price for every Kwh of electricity they feed into the grid. Taxpayers are responsible for the additional costs or by electricity consumers and has time goes by when more renewable energy is fed in the costs start to decrease. In RSA this would assist in levelling the playing field for cleaner technology. Energy security would also be increases with feed in tariffs by delivering large amounts of local generation. The biggest benefit feed in tariffs offer is its simplicity and better planning that it encourages. Germany had been able to reduce political risk by using the system and guaranteed payments for 20 years (Gets, 2013).

Renewable energy industry development. The last two limitations RSA face is the minimal amount of national expertise and the grid system. The current programme in place for bidding for renewable projects conditions include that 30 percent of the bid scoring has to be allocated in economic development. This is limited due to the fact that there is no procurement plan for the long term and the small allocation of capacity per technology that would help to promote example wind turbine blade manufacturing. Wind power is limited in RSA because there is no wind power industry. And there is a large distance between areas of high wind potential and areas of electricity demand. The RSA government needs a better long term policy to bolster investment in renewable energy manufacturing and installation across the country. Nowhere is there any public knowledge whether government has any plans to improve the national grid. There is no real technical or economic barriers to implement the Energy evolution the lack of political are to blame for the slow progress so far. Committed help from the RSA government is urgently needed to set policies and processes in place to have smooth uptake of renewable energy (Gets, 2013).

In order for RSA to tackle these challenges stricter and tighter control over legislative issues need to be taken. The Department of Energy needs to offer better assistance and make RSA more attractive by making legislature smoother. RSA has an abundant supply of coal and yes it is cheaper to produce energy from here than from renewable resources, but perhaps more effort is required into researching and investing into cleaner ways of producing electricity from coal. RSA needs to look at other countries and take lead from them on how they are making coal powered electricity generation cleaner so that greenhouse gas emissions are reduced.

There is plenty of room for renewable energy opportunities in RSA. Most of the current investments are all privately funded. As more and more countries invest in renewable energy

the costs of setting up these plants decreases, there are continuous improvements in technologies used. Onshore wind energy is an example of such a plant that has already seen significant cost decreases over the past few years. Collaboration is needed between private investors and government so that adequate support is offered to those who are interested in setting up renewable plants in the country. Incentives and subsidies are crucial to keep investors interested. Added to this long term energy planning, funding and continuous research and development is needed. RSA also has to realise that the rest of Africa is taking lead from our actions, being the most developed and having one of the largest economies on the African continent makes the rest look to us as role models in renewable energy developments. The current programme in place for bidding to have renewable plants being set up has been successful but I feel the turnaround time from biding to announcement of the tenders is far too long. They have had four successful rounds already; things should be running smoother by now. The other challenge of the national grid needs to be addressed fast.

Problems with the national grid need to be resolved from within first, meaning that the national utility Eskom needs to put in place proper guidelines and develop standards to support renewable energy connections to the grid. Eskom also has to invest significantly into research and development and encourage collaboration with members of industry. Eskom needs to determine the grids capacity for the intake of renewable energy supply and ensure that it has the capabilities to accept as much as possible as the industry grows. Eskom also needs to work together with various bodies to determine standards that all renewable energy plants can adhere to especially those in wind and solar.

More initiatives is needed from government to encourage electricity consumers to move to cleaner and news way of obtaining electricity supply like that done by the Department of Economic Development Green Economy Accord launched in 2011. This is the launch of a green partnership which will assist in creating numerous jobs and assist in creating a sustainable future. The accord covers 12 commitments these include;

Commitment One. The rollout of solar water heaters, the parties involved in the accords believe that the installation of solar water heating systems can assist with climate changing conditions and assist more South Africans with access to hot water. The aim was to have on million units installed, along with ensuring everyone has heated water the aim is also that all parts will be available locally as well.

Commitment Two. Investment in green economy, new investment is needed to continuously grow and improve the industry. Suitable investment projects need to identified as well as commitment from organise labour units is needed to create jobs.

Commitment Three. Rollout of renewable energy, the procurement of renewable energy projects is needed to expand the capacity of electricity generation.

Commitment Four. Energy efficiency assists many objectives of government which include competitive business, strengthening energy security, job creation, reducing RSA energy intensity and improving our environmental footprint.

Commitment Five. Waste recycling, re use and recovery, a number of industries are already involved in ways to reduce, reuse and recover waste for recycling.

Commitment Six. Biofuels, the production of biofuels for the blending in petrol and diesel national fuel is contributing to lower carbon emissions, more fuel supply and assisting job creation as well. Many regulations have been set in place with regard to biofuels.

Commitment Seven. Clean coal initiatives, government is supporting initiatives to help provide cleaner energy produced by coal.

Commitment Eight. Retrofitting, ways need to be identified to improve energy efficiency in workplaces, homes and power stations. Small changes like encouraging consumers to not use incandescent light bulbs but rather switch to energy savings light bulbs has seen many advantages already.

Commitment Nine. Reducing carbon-emission on our roads, government has been trying to encourage road users to switch to public transport as a means of reducing carbon emissions. Improvements in the transport system are being made so that the number of private vehicles on the road can be reduced.

Commitment Ten: Electrification of poor communities and reduction of fossil fuel open fire cooking and heating, many South African still rely on candles and firewood in rural areas as a means of energy. Government is working on initiatives to bring them alternative means such as gas as an improvement.

Commitment Eleven. Economic development in the green economy: promotion of localisation, youth employment, cooperative and skill development, the critical importance of localisation strategies for the promotion of industrial manufacturing of components, inputs and technologies is noted. The youth will be encouraged to educate themselves to be able to work in the green initiatives.

Commitment Twelve. Cooperation around the United Nations Cop 17 and its follow up, RSA is the host for the talks on climate change and all parties will work together to make realistic plans.

This accord is an important partnership between government, business community, trade union members and the community (Department of Economic Development, 2011). This

journey of renewable energy successfully being implemented is relationship that needs its roots in all aspects of the country youth, business, communities and the general public.

CONCLUSION

Through in depth research into the various energy and renewable policies of RSA, the following analysis was able to be made.

To answer the first research question, what are the general characteristics of the energy sector developments in RSA since 1994 on the supply and demand side and what are the main problems of the sector, it is noted from the research presented that RSA is extremely reliant on its abundant supply of coal for its energy production. RSA has enough coal to last it a while. Consumption has increased heavily over the past few years as the population is growing and more industrial facilities are set up. One of the key sectors in RSA is manufacturing and they are reliant upon electricity to ensure smooth running of their facilities and when production stops the ripple effect is that it impacts our economy. Many new homes have been added to the national grid since the abolishment of apartheid which has added tremendous strain on the energy supply. Government failed in investing in adequate infrastructure plans for the energy supply of the country. The other major problem facing RSA is the large amount of green gas emissions that are released due to the heavy reliance on coal energy supply. In cities/towns where the coal powered stations are situated mercury levels in the air are it highest and cause severe respiratory problems in adults, infants and children. Many citizens in the rural communities simply cannot afford to purchase electricity and rely on fuelwood to provide energy.

The main policy objectives set out in the White Paper on Energy Policy of 1998 included the following increase access to affordable energy services, improving energy governance, stimulating economic development, managing energy related environmental and health impacts and securing supply through diversity. It is evident throughout this research that the RSA government has been actively implementing energy policies to move energy efficiency forward. The continuous rollout of loadshedding as it known has forced government to look at alternative sources of energy production as well as the commitment made to reduce carbon emissions. The strategy of the RSA government has changed due to the low price of energy in RSA in the past and due to market failure, hiked prices so that a cost reflective electricity tariff can be established. Along with this strategy an environmental levy also came into effect to provide funding for the Energy Efficiency Demand Side Management Program.

The question remains is RSA ready to move away from coal powered power plants and what are the policy measures planned to support the increasing share of other types of energy. RSA is reflective of a pioneering emerging economy that has made itself transparent and has a systematic mechanism to fund energy efficiency. The successful bidding that has taken place in the Renewable Energy Independent Power Producer Programme has seen the construction

and operation of many successful renewable energy plants. The National Energy Regulator (NERSA) has the handy task of determining tariff increases and the goals for energy efficiency. Over the past ten years total cumulative savings estimated by Eskom have been around 3 072 MW through their incentive programmes. These savings have materialised due to simple changes like encouraging consumers to use CFL light bulbs instead of incandescent bulbs. Evidence would present itself that if RSA moved completely away from coal powered energy would be very difficult because so much has been invested in restoring and maintaining current plants. The challenge Eskom and government have is to ensure that sufficient research and development is done to ensure that cleaner methods of coal powered energy generation is done. RSA has an abundant supply of coal as mentioned above, but it can share the energy production with renewable energy plants, as it is doing currently.

It is evident that in order to prevent any future crisis Eskom and the RSA government need to continue to make profound changes in energy both in terms of technological and institutional ways. RSA needs to reduce its reliance on coal and move to cleaner more efficient means of energy supply.

It is also evident from the number of successful renewable energy plants that have been established that RSA certainly has the potential and means to set up this energy plants. Due to privately funding more support of government is needed in the form of policy changes, incentives and legislature to make the process a much smoother one. An interview conducted with Mr Rafael Esteban Fernandez De Cordoba from Acciona Energy which is a Spanish company, indicate that his company saw RSA as an attractive destination due to its reliable renewable energy program and the need for energy. His negative feedback was that no assistance is being received from government at all. The company is running a 138 MW wind and 74 MW solar plant that is feeding energy into the Western Cape and Northern Cape respectively and took only 18 months to set up. It is also noted that RSA is not doing enough to attract FDI into the various sectors as well as into the country.

Energy problems can be solved by government doing more to find alternative sources of energy supply and making RSA more attractive for foreign investment. Government needs to make it attractive for foreign investors to want to invest in RSA and they can do so by improving policies, legislatures and by providing subsidies to those who are involved. Sufficient research and development needs to be done so that cleaner ways of producing coal powered energy is developed. The role of green energy in is very important for future power generation. Yes RSA has the means and capabilities to develop good renewable energy plants, most of them currently in place are all privately owned and just need some support from government. RSA needs to uphold this reputation because other countries on the African continent are looking to us as examples of how to introduce renewable energy into the system. Investment into the infrastructure of the national grid also needs to be addressed; the grid needs to be able to accept more renewable energy plants.

The main policy objectives and strategic development goals for the green energy sector include financial instruments, proper financial instruments need to be used so that equitable level of national resources is invested into renewable technologies, legal instruments need to be continuously maintained, implemented and continuously improved to ensure renewable energy is promoted. Strict regulatory framework for pricing and tariff structures is needed to support renewable energy and make it attractive for investment. Technology development is needed to ensure successful implementation for sustainable development; this can be achieved by the promotion of the appropriate research and development and the development of local manufacturing to strengthen renewable energy technology. Raising awareness of renewable energy technologies to the public is also very important. Promotion of renewable energy for its economic, environmental, social and trade benefits will educate consumers as to why this is the correct way forward for RSA.

The renewable energy power producing bidding programme has done well in assisting this development of investment. RSA has not favoured well regarding foreign investment due to its lack of protection of investment rights, good governance, consistent policies and a stable economy. RSA was ranked 13th place in the AT Kearney FDI confidence index in 2013. RSA needs to do more to advertise itself as a suitable investment destination. One such organization that is trying to do is Wesgro, they are responsible for attracting FDI into the Western Cape. The Western Cape is seen as an inspiring destination to conduct business in due to its young, professional workforce and world class infrastructure Wesgro has highlighted certain key sectors to attract FDI for the province and these include agri-business, hotel and real estate investments, creative industries, information and communication technology, oil and gas, renewable energy, pharmaceuticals and biotechnology and metals, tools, niche engineering and manufacturing. According to data provided by Wesgro's Investment Promotion Manager Renewable Energy, the Western Cape alone has seen job creation of 1 090 and FDI to the value of 2 612 946 600 ($212 105 783.00) ZAR in the renewable energy sector alone, he feels that renewable energy is a sustainable way forward for RSA even though it at present only contributes small amounts of energy to the national grid. These are the developments in one province alone, imagine what is happening in the others and are indicative that RSA is on the way forward to make renewable energy a sustainable means of producing energy.

Eskom is capable of turning this energy crisis around if works smarter. In recent months many changes have already been made in the management structure of Eskom. Several top executives have been asked to step down due to mismanagement of the state owned facility. This is only one of its problems; others include lack of capacity, problems at its power stations and ongoing maintenance problems,

Eskom needs to improve its capacity and this can be done with the assistance of renewable energy plants. The current coal powered power plants that are under construction also need to be completed urgently, the Medupi power plant should have been up and running a year ago,

but there seems to be light at the end of the tunnel, as it reaches completion hopefully to go online by June 2015. Eskom is also struggling to make ends meet because it is short of funds, news early in June 2015 shoes that Eskom is putting forward an application to Nersa to have electricity tariffs increased by 25.3 percent. Many have lobbied against this request from Eskom but Eskom is leaving it in the hands of Nersa to decide.

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APPENDIXES

TABLE OF APPENDIXES

Appendix A: Current Renewable Energy Plants

Table 1. List of Renewable Energy Plants in RSA

	Name	Type of Plant	Town / City	Capacity (MW)	Window Approved	Current Status
1	Adams Solar PV 2	Solar	Hotazel	82.5	Window 3	Awaiting Construction (approved and financed)
2	Aggeneys Solar Project	Solar	Aggeneys	40.0	Window 4	Approvals planning and financing
3	Amakhala Emoyeni (Phase 1)	Onshore Wind	Bedford	134.4	Window 2	Construction
4	Aries Solar Project	Solar	Kenhardt	9.7	Window 1	Fully operational
5	Aurora	Solar	Aurora	10.4	Window 2	Construction
6	Bakamoso	Solar	Leeudoringstad	68.0	Window 4	Approvals, planning and financing
7	Bokpoort CSP Project	Concentrated Solar Theral	Groblershoop	50.0	Window 2	Construction
8	Boshoff Solar Park	Solar	Boshof	60.0	Window 2	Fully Operational
9	Chaba	Onshore Wind	Komga	20.6	Window 2	Construction
10	Cookhouse Wind Farm	Onshore Wind	Cookhouse	135.0	Window 1	Fully Operational
11	Copperton Windfarm	Onshore Wind	Copperton	102.0	Window 4	Approvals, planning and financing
12	Darling Wind Farm	Onshore Wind	Yzerfontein	5.2	Other	Fully Operational
13	Dassiesklip Wind Energy Facility	Onshore Wind	Caledon	26.2	Window 1	Fully Operational
14	De Aar Solar Power	Solar	De Aar	50.0	Window 1	Fully Operational
15	De Wildt	Solar	Brits	50.0	Window 4	Approvals, Planning and financing

table continues

continued

16	Dorper Wind Farm	Onshore Wind	Molteno/Sterkstroom	97.0	Window 1	Fully Operational
17	Dreunberg	Solar	Dreunberg	75.0	Window 2	Fully operational
18	Droogfontein 2 Solar	Solar	Kimberley	75.0	Window 4	Approvals, planning and financing
19	Droogfontein Solar Power	Solar	Kimberley	50.0	Window 1	Fully Operational
20	Dyason's Klip 1	Solar	Upington	75.0	Window 4	Approvals, planning and financing
21	Dyason's Klip 2	Solar	Upington	75.0	Window 4	Approvals, planning and financing
22	Electra Capital Paleisheuwel Solar Park	Solar	Clanwilliam	75.0	Window 3	Construction
23	Eskom CSP	Concentrated Solar Thermal	Upington	100.0	Other	Awaiting Construction (Approved and financed
24	Eskom Sere Wind Farm	Onshore Wind	Koekenaap	100.0	Other	Fully operational
25	Excelsior Wind Energy Facility	Onshore Wind	Swellendam	32.0	Window 4	Approvals, planning and financing
26	Garob Wind Farm	Onshore Wind	Copperton	136.0	Window 4	Approvals, planning and financing
27	Golden Valley	Onshore Wind	Cookhouse	120.0	Window 4	Approvals, planning and financing
28	Gouda Wind Facility	Onshore Wind	Gouda	135.2	Window 2	Construction
29	Grassridge	Onshore Wind	Port Elizabeth	59.8	Window 2	Fully Operational
30	Greefspan PV Power Plant	Solar	Douglas	10.0	Window 1	Fully Operational
31	Greefspan PV Power Plant No 2 Solar Park	Solar	Douglas	55.0	Window 4	Approvals, planning and financing
32	Herbert PV Power Plant	Solar	Douglas	19.9	Window 1	Fully Operational
33	Hopefield Wind Farm	Onshore Wind	Hopefield	65.4	Window 1	Fully Operational
34	Jasper Power Company	Solar	Postmasburg	75.0	Window 2	Fully Operational

table continues

continued

35	Jeffreys Bay Wind Farm	Onshore Wind	Jeffreys Bay	138.0	Window 1	Fully Operational
36	Johannesburg Landfill Gas to Electricity	Landfill Gas	Johannesburg	18.0	Window 3	Partially Operational
37	Kalkbult	Solar	De Aar	72.5	Window 1	Fully Operational
38	Kangnas Wind Farm	Onshore Wind	Springbok	137.0	Window 4	Approvals, planning and financing
39	Karoshoek Consortium	Concentrated Solar Thermal	Kimberley	100.0	Window 3	Awaiting Construction (Approved and financed)
40	Karusa Wind Farm	Onshore Wind	Sutherland	140.0	Window 4	Approvals, planning and financing
41	Kathu Solar Energy Facility	Solar	Kathu	75.0	Window 1	Fully Operational
42	KaXu Solar One	Cocentrated Solar Thermal	Pofadder	100.0	Window 1	Fully Operational
43	Khi Solar One	Concentrated Solar Thermal	Upington	50.0	Window1	Construction
44	Khobab Wind Farm	Onshore Wind	Loeriesfontein	138.0	Window 3	Awaiting Construction (Approved and financed)
45	Konkoonsies II Solar Facility	Solar	Pofadder	75.0	Window 4	Approvals, planning and financing
46	Konkoonsies Solar	Solar	Pofadder	9.7	Window 1	Fully operational
47	Kruisvallei Hydro	Small Hydro	Bethlehem	4.5	Window 4	Approvals, planning and financing
48	Lesedi Power Company	Solar	Postmasburg	64.0	Window 1	Fully Operational
49	Letsatsi Power Company	Solar	Bloemfontein	64.0	Window 1	Fully Operational
50	Linde	Solar	Hanover	36.8	Window 2	Fully Operational
51	Loeriesfontein 2 Wind Farm	Onshore Wind	Loeriesfontein	138.0	Window 3	Awaiting Construction (Approved and financed)

table continues

continued

52	Longyuan Mullo De Aar 2 North Wind Energy Facility	Onshore Wind	De Aar	139.0	Window 3	Awaiting Construction (Approved and financed)
53	Longyuan Mullo De Aar Maanhaarberg Energy Facility	Onshore Wind	De Aar	96.0	Window 3	Awaiting Construction (Approved and financed)
54	Metrowind Van Stadens Wind Farm	Onshore Wind	Port Elizabeth	27.0	Window 1	Fully Operational
55	Mkuze	Biomass	Mkuze	16.0	Window 3	Approvals, planning and financing
56	Mulilo Prieska PV	Solar	Prieska	75.0	Window 3	Awaiting Construction (Approved and financed)
57	Mulilo Renewable Energy Solar PV De Aar	Solar	De Aar	9.7	Window 1	Fully Operational
58	Mulilo Renewable Energy Solar PV Prieska	Solar	Prieska	19.9	Window 1	Fully Operational
59	Mulilo Sonnedix Prieska PV	Solae	Prieska	75.0	Window 3	Awaiting Construction (Approved and financed)
60	Neusberg Hydro Electric Project A	Small Hydro	Kakamas	10.0	Window 2	Construction
61	Ngodwana Biomass Power Station	Biomass	Ngodwana	62.0	Window 2	Approvals, planning and financing
62	Noblesfontein	Onshore Wind	Noblesfontein	72.8	Window 1	Fully Operational
63	Nojoli Wind Farm	Onshore Wind	Cookhouse	87.0	Window 3	Awaiting Construction (Approved and financed)
64	Noupoort Mainstream Wind	Onshore Wind	Noupoort	79.0	Window 3	Awaiting Construction (Approved and financed)
65	Nxuba Wind Farm	Onshore Wind	Cookhouse	140.0	Window 4	Approvals, planning and financing

table continues

continued

66	Oyster Bay Wind Farm	Onshore Wind	Oyster Bay	140.0	Window 4	Approvals, planning and financing
67	Pulida Solar Park	Solar	Kimberley	75.0	Window 3	Awaiting Construction (Approved and finance)
68	Red Cap – Gibson Bay	Onshore Wind	St Francis Bay	111.0	Window 3	Awaiting Construction (Approved and financed)
69	Red Cap Kouga Wind Farm – Oyster Bay	Onshore Wind	St Francis Bay	80.0	Window 1	Fully Operational
70	Roggeveld	Onshore Wind	Sutherland	140.0	Window 4	Approvals, planning and financing
71	RustMo1 Solar Farm	Solar	Rustenberg	6.8	Window 1	Fully Operational
72	Sirius Solar PV Project One	Solar	Upington	75.0	Window 4	Approvals, planning and financing
73	Sishen Solar Facility	Solar	Sishen	74.0	Window 2	Fully Operational
74	Slimsun Swartland Solar Park	Solar	Swartland	5.0	Window 1	Fully Operational
75	Solar Capital De Aar (Pty) Ltd	Solar	De Aar	75.0	Window 1	Fully Operational
76	Solar Capital De Aar 3	Solar	De Aar	75.0	Window 1	Fully Operational
77	Soutpan Solar Park	Solar	Mokopane	28.0	Window 1	Fully Operational
78	Stortemelk Hydro (Pty) Ltd	Small Hydro	Clarens	4.3	Window 2	Fully Operational
79	The Soetwater Wind Farm	Onshore Wind	Laingsberg	139.0	Window 4	Approvals, planning and financing
80	Tom Burke Solar Park	Solar	Lephalale	60.0	Window 3	Construction
81	Touwsrivier Project	Solar	Touwsrivier	36.0	Window 1	Fully Operational
82	Tsitsikamma Community Wind Farm	Onshore Wind	Tsitsikamma	94.8	Window 2	Construction
83	Upington Solar PV	Solar	Upington	8.9	Window 2	Fully Operational
84	Vredendal	Solar	Vredendal	8.8	Window 2	Fully Operational

table continues

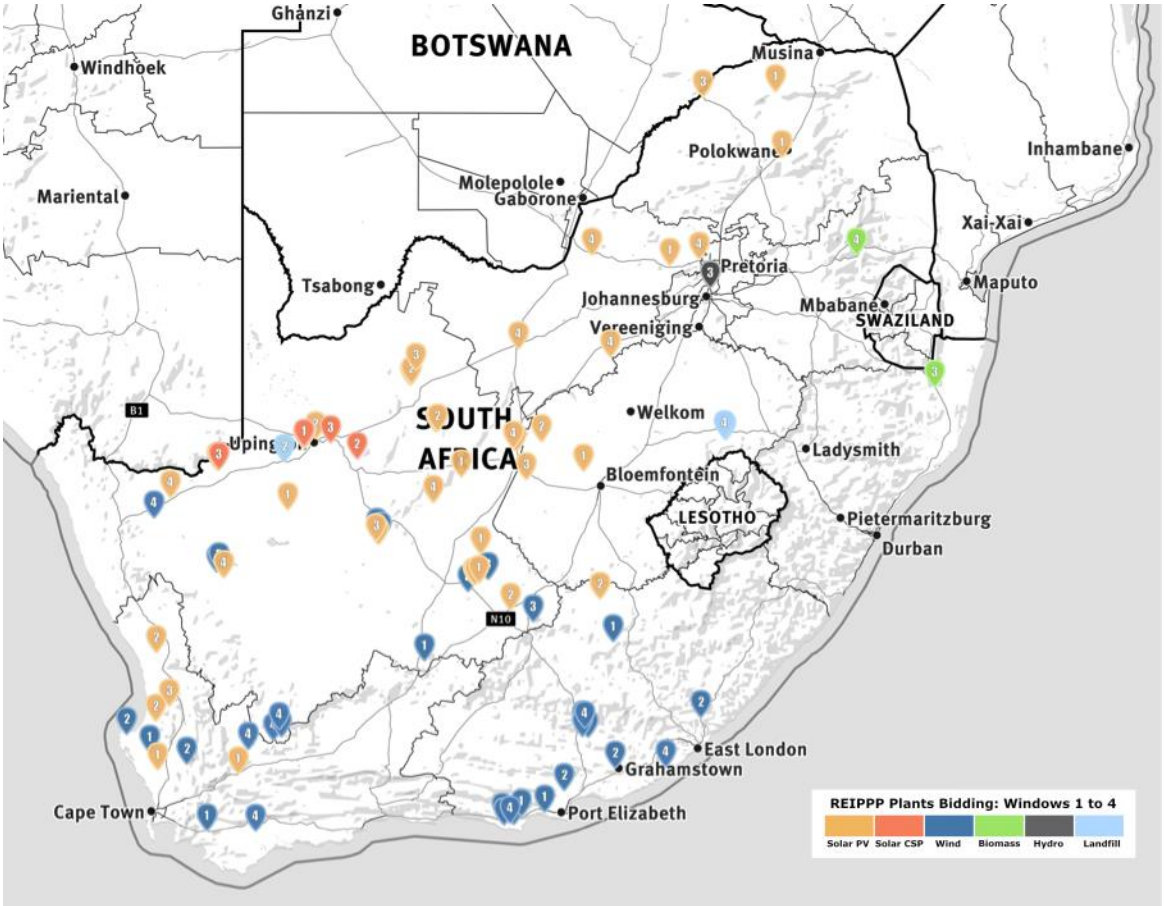
continued

85	Waainek	Onshore Wind	Grahamstown	23.4	Window 2	Construction
86	Waterloo Solar Park	Solar	Vryburg	750	Window 4	Approvals, planning and financing
87	Wesley – Ciskeo Wind Farm	Onshore Wind	Peddie	33.0	Window 4	Approvals, planning and financing
88	West Coast 1	Onshore Wind	Vredenburg	90.8	Window 2	Partially Operational
89	Witkop Solar Park	Solar	Polokwane	30.0	Window 1	Fully Operational
90	Xina CSP South Africa	Concentrated Solar Thermal	Pofadder	100.0	Window 3	Awaiting Construction (Approved and financed)
91	Zeerust	Solar	Zeerust	75.0	Window 4	Approvals, planning and financing

Source: *Energy Blog*, 2015

Appendix B: Map of renewable energy plants across RSA

Figure 1. Map of Renewable Energy Plants across RSA



Source: *Energy Blog*, 2015