RESEARCH REPORT

VTT-R-07599-13

Development of Namibian energy sector

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Confidentiality: Public

Report's title Development of Namibian energy sector	
Customer, contact person, address Ministry for Foreign Affairs of Finland	**Order reference** -
Project name Energy Policy, Regulatory Framework and Energy Future of Namibia	**Project number/Short name** 75708/ENENAMI
Author(s) Miika Rämä, Esa Pursiheimo, Tomi Lindroos, Kati Koponen	**Pages** 68/-
Keywords Energy policy, energy system, Namibia	**Report identification code** VTT-R-07599-13

Summary

Namibia is at crossroads concerning the development of its energy system. The current reliance on imported electricity is clearly not sustainable as neighbouring countries are also experiencing difficulties in securing their own electricity supply. Although a substantial import of petroleum products will continue for the foreseeable future, the utilisation of domestic resources, both renewable and fossil, is important to improve the degree of self-sufficiency. Information on past, current and future state of the energy system is essential for decision making. Currently information is scattered and common practices of compiling and publicly reporting the key numbers are missing. These challenges can be alleviated by establishing national energy statistics and by assigning responsibilities for the maintenance of these statistics as well as utilising tools and concepts such as energy system modelling.

This report is part of a three year cooperation project between VTT Technical Research Centre of Finland and the Ministry of Mines and Energy of Namibia entitled "Energy Policy, Regulatory Framework and Energy Future of Namibia" which ran from 2011 to 2013. It details the energy statistics collected and compiled for the period 2000 to 2011 as one of the essential steps towards the review and updating of the country's energy policy, which is enshrined in the White Paper on Energy Policy of 1998. This is the first national energy statistics for Namibia and future compilations are expected to build on this effort. The said White Paper set a number of targets and initiatives for the development of energy in Namibia, and many studies and projects have been carried out towards fulfilment of the policy objectives. Further, the reports of projects and studies relevant for the review of Namibia's energy policy are also here catalogued for future reference. Namibian energy stakeholders also received training on an energy systems model developed by VTT for use by Namibia while formulating its energy policy in the near future, fulfilling the capacity building component of the cooperation project. The results on a series of representative scenarios with low, medium and high growth estimations are also given.

Confidentiality	Public

Espoo 15.11.2013

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Distribution (customer and VTT)

Ministry for Foreign Affairs of Finland (1)
Ministry of Mines and Energy of Namibia (1)
VTT Technical Research Centre of Finland (1)

Preface

This research report is part of the project “Energy Policy, Regulatory Framework and Energy Future of Namibia” that took place between May 2011 and December 2013. The key objectives for the project were to build capacity within the Ministry of Mines and Energy of Namibia (MME) and to support the Ministry in the task of updating the energy policy of the nation. The project originated from a visit to Finland in October 2009 by Hon. Erkki Nghimtina, then Minister of Mines and Energy of Namibia, during which mining and energy related issues were discussed. The Ministry for Foreign Affairs of Finland (MFA) received a letter from the MME in February 2010 after which VTT Technical Research Centre of Finland was contacted and following reciprocal visits between the two organisations and careful planning for the possible cooperation, project was started in May 2010 after a positive funding decision by the MFA.

The rationale for this report is to present the main findings of the project and to provide an updated starting point for any study on the Namibian energy system either by the MME themselves or any new cooperation partner, especially geared towards a review of the now 15 year old, outdated energy policy.

Work during the project was carried out in close cooperation with the Energy Directorate of the MME and main stakeholders of the energy sector in Namibia. The project included five extended missions to Namibia, including a fact finding mission in June 2010 at the initiation phase of the project, and a seminar event planned for November 2013 in which the main results of the cooperation were presented.

The Project Board monitoring the progress during the cooperation consisted of the Ministry of Mines and Energy Permanent Secretary Mr. Joseph Iita, later replaced by Permanent Secretary Mr. Kahijoro Kahuure., Team Leader and Principal Scientist Mr. Kari Sipilä from VTT, and Chargé d'affaires Asko Luukkanen, later replaced by Counsellor Antti Piispanen from the Embassy of Finland in Windhoek as a representative of MFA of Finland. In addition, Project Manager and Research Scientist Miika Rämä from VTT and Director Selma-Penna Utonih from MME acted as rapporteurs and secretaries for the Board.

I would like to acknowledge the project funder Ministry for Foreign Affairs of Finland; it is very clear that a need for similar projects exists in Namibia and elsewhere. The Embassy of Finland in Windhoek also more than deserves credit for supporting the project all the way from planning phase to the very end.

Compliments are also in order to the main stakeholders involved in the project: Electricity Control Board, Renewable Energy and Energy Efficiency Institute, NamPower, and NAMCOR. I thank all the people involved in the project in the aforementioned organisations for the patience, support and numerous fruitful conversations.

Most importantly, on behalf of the whole project team in VTT, I would like to thank Mrs. Selma-Penna Utonih and her staff in the Energy Directorate of the Ministry of Mines and Energy for the interest and unwavering support for the project. I hope results achieved will benefit the work of the Directorate of Energy and the Ministry in both the short and long term.

City of Espoo 15.11.2013

Miika Rämä

Contents

Abbreviations

CBEND	Combating Bush Encroachment for Namibia's Development
CCGT	Combined Cycle Gas Turbine
CDM	Clean development mechanism
CSP	Concentrating solar power
DRF	Desert Research Foundation
ECB	Electricity Control Board
EE	Energy efficiency
EFF	Energy for future
EMP	Environmental Management Plan or Energy Management Program
EPC	Engineering, Procurement and Construction
FEED	Front-End Engineering & Design
FID	Final Investment Decision
FPS	Floating Production System
GBCNA	Green Building Council of Namibia
GEF	Global Environment Facility
ICI	Institutional Cooperation Instrument
IEA	International Energy Agency
IPP	Independent power producer
LCC	Life cycle costing
MFA	Ministry for Foreign Affairs of Finland
MME	Ministry of Mines and Energy of Namibia
NAMCOR	National Petroleum Corporation of Namibia
NAMREP	Namibia Renewable Energy Programme
NDP	National Development Plan
NEF	National Energy Fund
NEI	Namibia Energy Institute
NIRP	National Integrated Resource Plan
NPC	National Planning Commission
NREP	National Rural Electrification Programme
NSA	Namibia Statistics Agency
OGEMP	Off-grid Energisation Master Plan
PPA	Power Purchase Agreement
PV	Photovoltaic solar power
RE	Renewable energy
REDMP	Rural Electrification Distribution Master Plan
REECAP	Renewable Energy and Energy Efficiency Capacity Building Programme
REEEI	Renewable Energy and Energy Efficiency Institute
REFAD	Renewable Energy for African Development
REFIT	Renewable Energy Feed-in Tariffs
SADC	Southern African Development Community
SAPP	South African Power Pool
SET	Solat energy technology
SFM	Sustainable forest management
SHS	Solar home system
SOLTRAIN	Southern African Solar Thermal Training and Demonstration Initiative
STCS	Short Term Critical Supply
SWH	Solar water heater
TIMES	The Integrated Markal Efom System (model)
UNDP	United Nations Development Programme
WEC	World Energy Council

Units

%	Per cent
CO_2	Carbon dioxide
ha	hectar
J	Joule
m^2	square meter
t	tonne
toe	tonne of oil equivalent
Tcf	Trillion cubic feet
V	Volt
W	Watt
Wh	Watt hour
y	Year
N$	Namibian dollars
US$	United State dollar

Metric prefixes

k	Kilo 10^3
M	Mega 10^6
G	Giga 10^9
T	Tera 10^{12}
P	Peta 10^{15}

Conversion table

	TJ	Mtoe	GWh	Tcf
TJ	1	$2.388 \cdot 10^{-5}$	0.278	$9.52 \cdot 10^5$
Mtoe	$4.1868 \cdot 10^4$	1	11630	0.0399
GWh	3.6	$8.6 \cdot 10^{-5}$	1	$4.37 \cdot 10^{-6}$
Tcf	$1.05 \cdot 10^6$	25.1	$2.29 \cdot 10^5$	1

TJ = Terajoule,
Mtoe = Mega (million) tonnes of oil equivalent
GWh = Giga Watt hour
Tcf = Tera (trillion) cubic feet

1. Introduction

The purpose of this document is to report the main results of a cooperation project between the Ministry of Mines and Energy of Namibia (MME) and VTT Technological Research Centre of Finland (VTT) called “Energy Policy, Regulatory Framework and Energy Future of Namibia”.

VTT has had a long term role in Finnish climate and energy policy decision making at the highest level. The core competence of Energy Systems knowledge centre within the organisation of VTT is the evaluation of technologies as a solution to energy related challenges from technical, economic and environmental points of view.

The project was funded by the Ministry for Foreign Affairs of Finland (MFA) utilising the Institutional Cooperation Instrument (ICI) that enables governmental offices and institutions to participate in development cooperation. The main objective in an ICI funded projects is to build capacity within the partner organisation. The projects are always based on local needs and initiatives and should have strong ownership in the partner organisation. This kind of cooperation provides a solid platform for the participating organisations to share information and to learn from each other.

The motivation behind the project was the perceived need by the MME and the Namibian energy sector in general to update the energy policy of the country, originally presented as the White Paper on Energy Policy in 1998. While the paper provides a basis to guide the development of the Namibian energy sector, it was considered to be outdated both by the Ministry and the major stakeholders. Also the operational environment for the energy industry has undeniably experienced major changes during the last decade. The primary energy consumption has approximately doubled since the White Paper and reliance on neighbouring countries, especially South Africa, to provide for the electricity needs of Namibia is more of a liability than before. The utilisation of domestic energy sources, both renewable and fossil is generating significant interest and is finally attracting concrete investments into the country.

Energy policy development is a continuous process and the current project is but a single piece contributing to this endeavour. As stated earlier, the overall objective is to improve the capacity of the MME to meet with challenges related to policy development now and in the future. The work towards this objective is reported in the present document. The current chapter gives an introduction to the Namibian energy system and the main stakeholders operating in the country with more detailed information available within the following three chapters. The document consists of three main chapters, each presenting an individual, yet closely related topic in detail. These topics are energy statistics as a basis for decision making (Chapter 2), energy system modelling as a tool for energy policy development (Chapter 3) and general observations concerning the development of the Namibian energy system (Chapter 4) as a literature review of significant studies and reports concerning this topic.

This report aims both to present the work done during the project as extensively as possible and to provide useful material for the Ministry of Mines and Energy and/or any institution working towards the development of the Namibian energy sector. The topics within the document are discussed from an energy system point of view. Legislation and regulative issues are mostly out of scope of this study.

The contents of the report have been discussed and revised in during a study tour to Finland in November 2013 with all major stakeholders represented in the delegation.

1.1 Namibian energy sector

The primary energy consumption of Namibia has been growing 3.5 % annually on average and electricity consumption 5.6 %, although yearly growth rates vary significantly from year to another. During 2000-2010 the total growth in primary energy has been 38% and for electricity, 79 %. At the same time, e.g. the electricity production capacity has increased very little. The growth during this period has been almost solely fuelled by imported energy in form of electricity and petroleum products. This raises concerns on the sustainability of the development in the future as well as on self-sufficiency issues, both of which are highlighted already in White Paper of 1998 as policy goals to serve as the framework for the policy currently in place.

The electricity supply of Namibia leans strongly on imported electricity (65 % in 2011). The interconnector capacity currently stands at 900 MW, consisting of a 600 MW connection to South African system and the 300 MW Caprivi Link in northeast linking the Namibian system with the Zambian grid, which comes with an option to for 300 MW increase in capacity when Phase 2 of the project is realised. The rest of the electricity supply is provided in practice by the Ruacana 332 MW hydro power plant located on the northern boundary river between Namibia and Angola. The plant consists of three 80 MW turbines and a fourth newly commissioned 92 MW unit. During 2014, the runners of three older turbines will be replaced, increasing the capacity by 15 MW to a total of 347 MW. There are also two diesel plants (Paratus and newly built Anixas) in the town of Walvis Bay (24 MW and 22 MW) and a coal fired condensing plant, Van Eck, in the capital Windhoek. The coal plant has four units rated 40 MW each, but currently in practice the maximum electricity output is a fraction of the total capacity, about 50 MW. The plant is currently undergoing refurbishment, to be completed in 2014, after which at least a capacity of 90 MW is guaranteed. Nevertheless the plant will remain as a peak power station. In addition to these, a small pilot plant utilising a widely available domestic biomass fuel, invader bush, is located about two hundred kilometres north of the capital. The capacity of the plant is 250 kW. Basic information on these power generation plants in Namibia can be found in Table 1 below.

The peak demand for electricity in Namibia has grown 5.8 % a year on average since 2000 and reached 580 MW in 2011.

Table 1. Existing power production plants in Namibia.

Power plant	Type	Built	Capacity
Ruacana	Hydro power station	1978	322 MW (347 MW in 2014)
Paratus	Diesel power station	1976	24 MW
Anixas	Diesel power station	2011	22 MW
Van Eck	Coal-fired power plant	1973	120 MW (50 MW)
CBEND	Small scale biomass plant	2010	0.25 MW
Tsumkwe	PV - diesel hybrid	2011	200kWp PV +300kW diesel

Electricity supply situation will remain critical in Namibia for the coming years until a new base load power plant is commissioned as similar challenges exist also in neighbouring countries. The new base load plant commissioning is envisioned to take place in mid-2017 in the form of the Kudu power station exploiting the Kudu gas field located off-shore in southern Namibia. The capacity of the planned power station is a nominal 800 MW capacity Combined Cycle Gas Turbine (CCGT), half of which will be sold outside the country through long term power purchase agreements. The mid-case gas reserves is estimated to be c. 1 Tcf (~1 000 PJ), which will provide fuel for the power plant for approximately 15 years of operation. Other option for a new base load power plant would have been a coal-fired power station in Arandis

area, but following a resolution by the Government declaring Kudu as a national priority project the option was put on hold.

Other significant medium to long term projects concerning the electricity sector are Baynes hydro power project and ZIZABONA project aiming to connect transmission grids of Zimbabwe, Zambia, Botswana and Namibia directly in order to provide flexibility and capacity for the transmission system of the SADC region. According to initial studies, Baynes hydro power would have a capacity of 600 MW although this amount of generation poses challenges to the existing transmission system in the area. Also unlike the Ruacana station, Baynes is planned to have reservoir of about 0.5 TWh enabling 800 hours of full capacity production.

As evident, the most challenging years are upon Namibia until new large scale power generation capacity comes online. The national power utility NamPower is carrying out Short Term Critical Supply project (STCS) to maintain electricity supply for the country. This project includes the previously mentioned Van Eck refurbishment and runners replacement in Ruacana, but also coordinated DSM measures, negotiation of power purchase agreements with both regional utilities and independent power producers in Namibia and acquisition of emergency diesel generators if necessary.

While the conventional power production technologies are utilised both in long and short term as a solution for the current situation, renewable power production will play a part in energy system in years to come as well. Basically all of the independent power producers are based on one of the three renewable energy technologies; biomass, solar and wind. These sources of energy are abundant in Namibia, especially the first two. Although unevenly distributed in the country, theoretical biomass potential consisting of invader bush species is huge; estimations of 40 TWh/a have been made. Namibia is also one of the most attractive places in the world to make use of the solar energy with insolation figures around 6 kWh/m^2/day on average. Even though wind resources are not exceptional on a global perspective, they are nevertheless good especially on the coast where annual average wind speeds are estimated between 6 to 12 m/s. Electricity Control Board (ECB) has granted licenses for 19 IPPs; one (1) 44 MW wind farm, thirteen (13) for solar plants (PV), one (1) for CSP and four (4) thermal plants.

Nuclear power has also been a topic of public discussion in Namibia as a potential technology for electricity generation due to the vast resources of uranium in the country. The capacity building in order to enable this possibility in the future is underway, but remains a long term target. With all the current plans concerning investments on electricity production already in motion and the relatively small demand for electricity compared to electricity output of a typical nuclear unit, a possible Namibian nuclear power plant does not seem feasible and is at any case decades away from being realised even if not taking into account the topic of nuclear waste management which is in the end the sole responsibility of each nation utilising nuclear power. It also needs to be noted that uranium mining alone does not equal self-sufficiency no matter the scale of mining as enrichment facilities are also needed in order to produce fuel for nuclear plants.

The locations of both current and future production plants is illustrated in Figure 1 below and information on the future projects is compiled into Table 2.

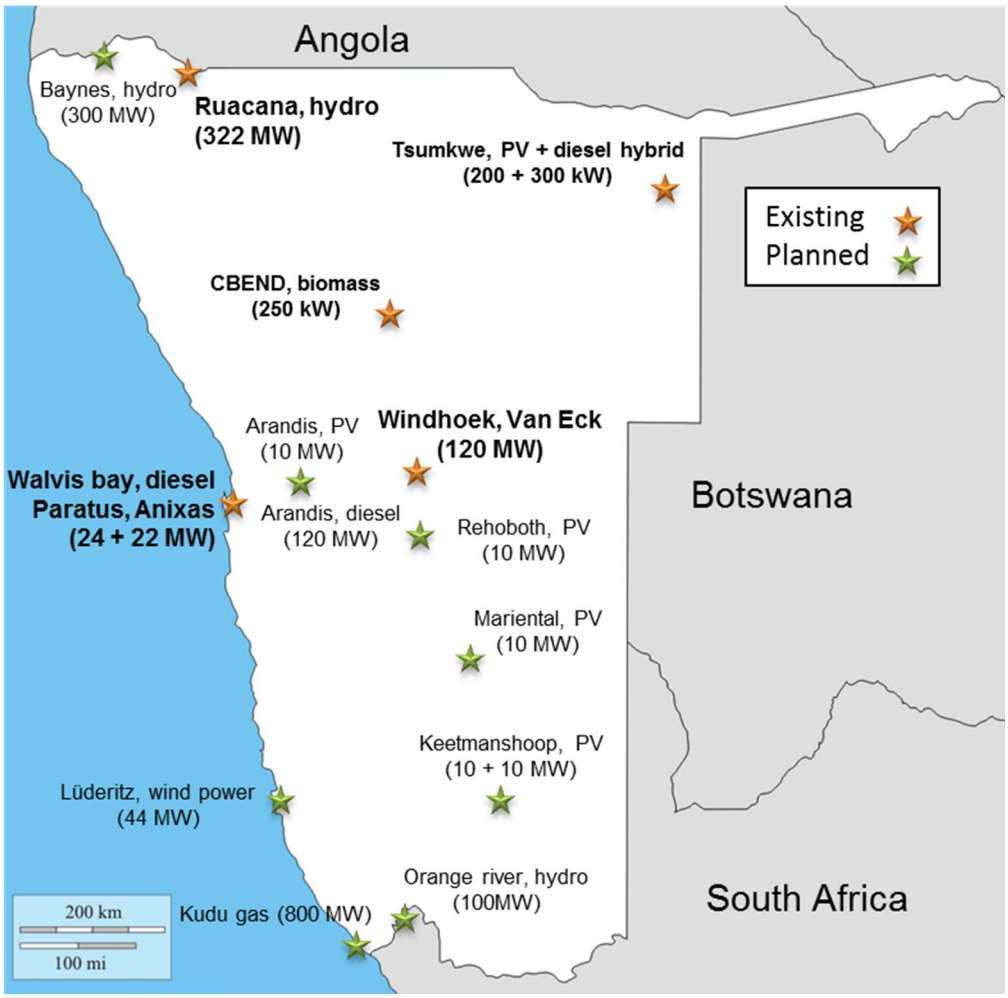

Figure 1. Locations of current (bolded text) and potential future production plants.[1]

Table 2. Possible future projects to increase electricity production capacity.

Power plant	Type	Online (estimation)	Capacity
Kudu	Gas-fired power station	Mid-2017	800 MW
Baynes	Hydro power station	2022	300 MW[2]
Wind power	Wind farm	2016	44 MW
Solar power (PV)	PV plants	2017	5 x 10 MW
Solar power (CSP)[3]	CSP plant	2017	50 MW
Orange river	Numerous small scale hydro plants	-	100 MW
Arandis Power	Heavy fuel oil	2015	120 MW

One peculiarity on the Namibian electricity sector is the structure of the consumption. Mining sector as one of the main consumers of electricity increases (or decreases) its share in step loads of significant size rather than gradually over time. This makes the long term forecasts of the electricity demand difficult or inaccurate. Flexibility through interconnector capacity and dialog with the mining sector stakeholders can help in mitigating this challenge.

[1] Background map from d-maps.com (http://d-maps.com/carte.php?num_car=1176&lang=en)
[2] Total capacity of 600 MW is shared by Namibia and Angola, effective capacity being 300 MW.
[3] Location to be selected

Although the electricity demand is increasing due to the economic development of the country, especially through industrial activity in the mining sector, petroleum products easily make up most of the energy consumption in Namibia. The share of oil products of the total energy supply is been around 70 % for the last decade, 66 % in 2011. The bulk of the energy consumption is due to the transportation sector, more specifically road transport.

1.2 Main stakeholders

The most important stakeholders in the Namibian energy sector are the Ministry of Mines and Energy (MME), Electricity Control Board (ECB), NamPower, NAMCOR, Renewable Energy and Energy Efficiency Institute (REEEI) and National Planning Commission (NPC).

MME is the responsible ministry in matters of energy in Namibia and its mission is to ensure the reliable, affordable and sustainable energy supply for the country by taking advantage of the domestic natural resources while supporting the nation’s socio-economic development. More practical responsibilities also include petroleum product price equalisation, administration related to petroleum exploration licenses as well as export and import control of petroleum products. Planning, prioritising and implementing rural electrification and administration of Solar Revolving Fund, establish to stimulate renewable energy use in rural areas, fall under the diverse list of responsibilities of the Ministry.

ECB is a statutory regulatory authority established in 2000 under the Electricity Act 2 of 2000; which has subsequently been repealed by the Electricity Act, 4 of 2007; the latter Act having expanded the ECB mandate and core responsibilities. The core mandate of the ECB is to exercise control over the electricity supply industry with the main responsibility of regulating electricity generation, transmission, distribution, supply, import and export in Namibia through setting tariffs and issuance of licenses. To ensure the endowment of Namibia's energy resources are available to present and future generations by considering Namibia’s economic, environmental and social responsibility. The enabling legislation is being reviewed and updated to transform the ECB into an Energy Regulator.

NamPower, the national electricity utility, is a state-owned company with a mandate to generate, trade, transmit, import, export and distribute electricity. The utility is responsible for the expansion of the generation capacity national power grid. Through the Directorate of Energy, NamPower is partly responsible for rural electrification.

In order to catalyse development, NamPower remains committed to its objective of availability, affordability and accessibility of electricity to at least 80% of all Namibians within the next ten years.

Distributors, the distribution industry comprises of Regional Electricity Distributors (REDs), Local Authorities and Regional Councils who are responsible for distribution and supply of electricity. The owners of a RED (its shareholders) are the participating stakeholders – i.e. the local authorities, regional councils and NamPower which stakeholders transferred their assets and/or customers to the RED in exchange for shareholding.

NAMCOR's main business is to ensure the optimal exploitation of Namibia's petroleum resources and meaningful Namibian participation in resulting business developments in petroleum related exploration activities.

Upstream NAMCOR's main business is to ensure the optimum exploitation of Namibia’s petroleum resources and meaningful Namibian participation in resulting business developments in petroleum related exploration activities. The company also acts as advisor to the Ministry of Mines and Energy and assists it in monitoring the exploration activities of licensees. This is an activity that requires the active selling or promotion of Namibian acreage to local and international oil exploration and production companies. Having identified prospects with potential for hydrocarbons and having carried out all necessary geological

work required, such acreages are offered to local and international oil companies by holding promotional events and by attending important international oil and gas promotion conferences.

Since 2003, NAMCOR has played a significant role in the importation of petroleum products for Namibia.

REEEI is a national institute established by the Ministry of Mines and Energy, and hosted by the Polytechnic of Namibia. It was officially launched in 2006. Its mandate is to promote renewable energy and energy efficiency understanding and uptake in Namibia through research and development, the collection and dissemination of information on renewable energy and energy efficiency technologies and practices, as well as providing respective advisory services. In December 2012, the Government of the Republic of Namibia authorised the transformation of REEEI into Namibia Energy Institute, with an expanded mandate that covers nuclear, electricity and petroleum (oil & gas), besides the current REEE functions. The institute works in close co-operation with the MME. Currently REEEI is undergoing a transformation approved by the Cabinet in 2012 into a general energy office called Namibia Energy Institute (NEI).

NPC is an organisation established by the constitution of Namibia charged with responsibility of planning national priorities and directing Namibia in the path of development. The NPC periodically produces National Development Plans (NDP) to outline the strategy for working towards the goals of sustainable economic growth, equity, social harmony and balanced progress. These plans and the general work of the NPC are often cross-cutting with development of the energy sector of Namibia and thus is part of the framework of things to be taken into consideration.

2. Energy statistics

Energy statistics contain aggregated information about the supply and consumption of energy products. Reliable statistics form a base of an information source about the energy system. Statistics are also a key tool when studying the characteristics of the system or projecting the future development. The importance of Namibian energy statistics was highlighted already in the White Paper on Energy Policy. In general, most statistics were collected, but by different institutes and stakeholders. Apart from these individual sectoral statistics, there was no general energy statistics.

In this project, information was collected from different national sources and compiled into a first version of the energy statistics of the Namibia. These statistics can be used for domestic policy purposes and for international reports, e.g. for IEA statistics division.

The energy statistics collected here contain three sections: input sheets, an energy balance and time series. The input sheets are designed for easy maintenance and upkeep. The energy balance is an overview of statistics of one year, and is presented in the IEA format to make it compatible with international statistics. The time series presents the development of each sector.

Energy statistics include 8 sectors (energy supply, electricity, industry, transportation, residential, commercial, agriculture and fishing) and 9 energy carriers (gasoline, diesel, jet kerosene, other oil products, coal, natural gas, biomass, charcoal and electricity). In total, there are 95 annual input parameters. Statistics are automated as much as possible. They calculate the balance and time series from the input numbers.

In the following chapters the energy statistics of Namibia are presented, a plan for the upkeep is proposed and an estimate of the required annual work given. It is recommended to upkeep and to improve the statistics according to one of the options in this proposal or any further facilitated design.

2.1 Energy supply and consumption

Figure 2 shows the total primary energy supply in Namibia from 2000 to 2011. Oil products are the largest energy source with a share of around 70 %. Second largest energy source is imported electricity (~15 %). These figures include both imports and exports and show that Namibian is a net importer. After these two groups comes domestic hydropower, imported coal and produced biomass. The biomass figure is missing the domestic biomass consumption as there were no estimates available. Quite likely, the share of biomass would be considerably high.

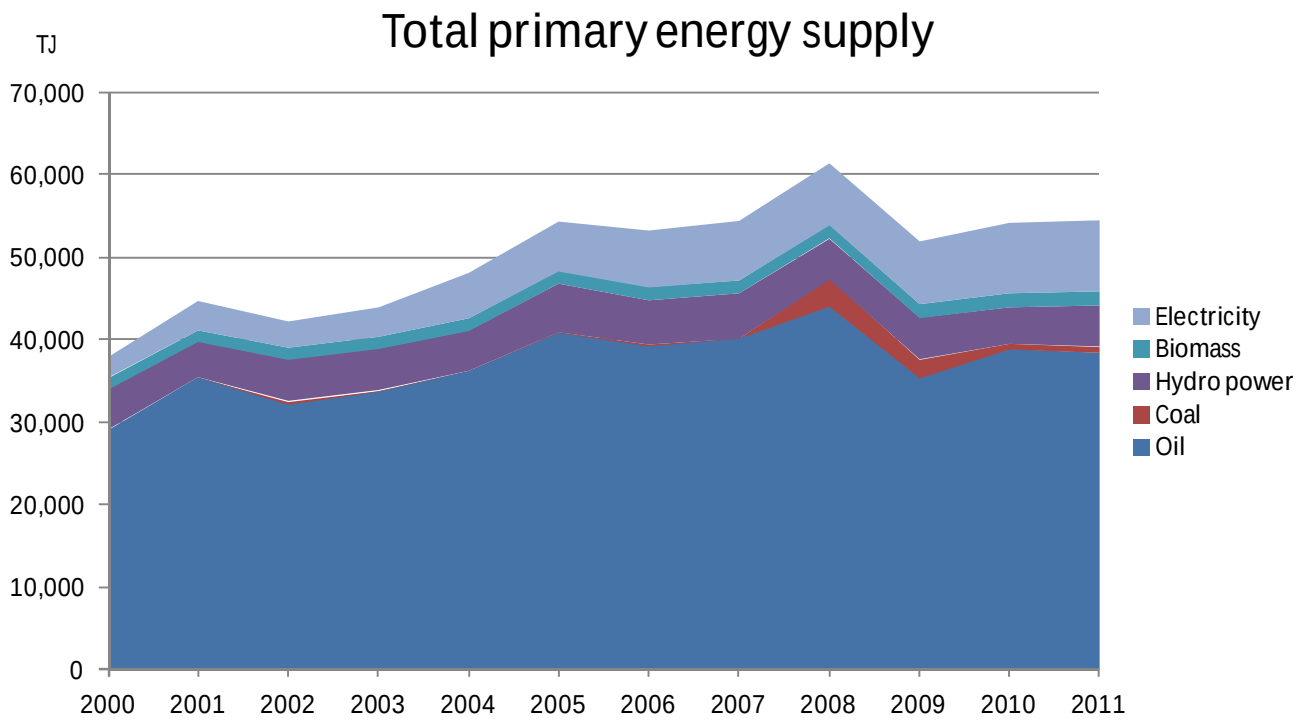

Figure 2. Total primary energy supply increased steadily between 2000 and 2005. After that the energy supply has remained roughly on the same level. In the year 2008 there was a peak in the imports of oil and in 2009 there was a drop as the storages were probably quite full after the record high level of imports. Statistics are presented in terajoule (TJ) to be able to compare different energy products.

Supply figures are based on customs import and export statistics. Namibian custom classifies imported and exported goods according to the international Combined Nomenclature or CN classification. This classification is very detailed. In most cases, the consumption information is not available with similar level of detail. In the energy statistics, imports and exports are aggregated to more general categories.

Figure 3 shows the amount of imported oil products in TJ. Customs provide the amounts in kilograms and Namibian dollars. Different CN categories are summed in an additional imports and exports calculating tool provided with statistics. Oil products are added to 8 oil products: gasoline, diesel, jet fuels, heavy fuel oil, LPG, illuminating paraffins, lubricants and bitumen. The largest increase has been in the amount of imported diesel. In monetary terms, the customs value of imports was about 4000 million N$ in 2011.

Figure 4 presents a similar graph for the exports of oil products. The data from customs didn't have any exports before the year 2008. This may be due to a change in the custom processes or data reporting methods. In general, the exports of oil products are roughly 10 % of the imports.

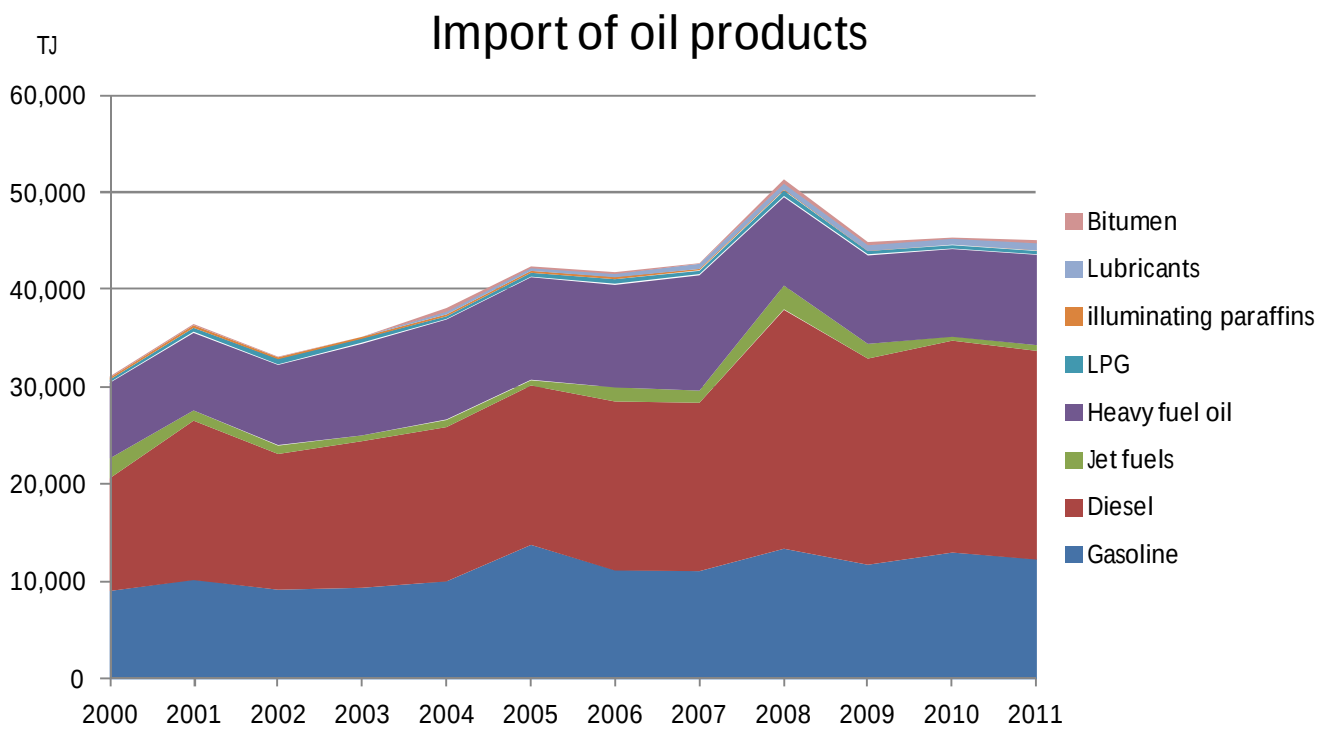

Figure 3. Import of oil products in terajoules (TJ) between 2000 and 2011. The largest increase has been in the amount of diesel fuel. The figure does not include the exports which are presented in Figure 4. According to the Customs, the value of the imports of the oil products was 4000 million N$ in 2011.

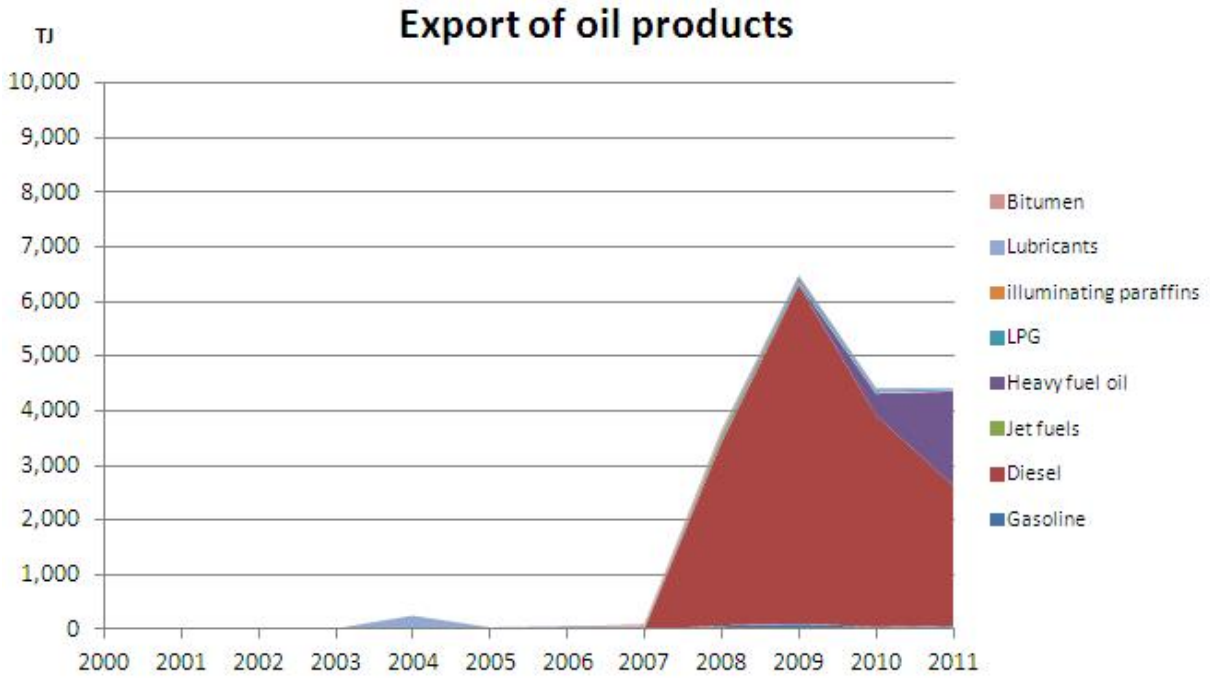

Figure 4 - Export of oil products in terajoules (TJ) between 2000 and 2011. There was no data from 2000 to 2008. The level of exports between 2008 and 2011 was roughly 10 % of the imports.

Figure 5 presents the energy consumption of oil, coal, biomass and electricity by sector. During the years 2008 to 2011 about three quarters of the oil products were consumed in road transport. In addition, some smaller amounts of oil were used in rail and sea transport. Second largest oil consuming sector was fishing and third was industry. Industry consumes about 60 % of the electricity while about 20 % is consumed in residential sector and about 15 % in public and commercial sector.

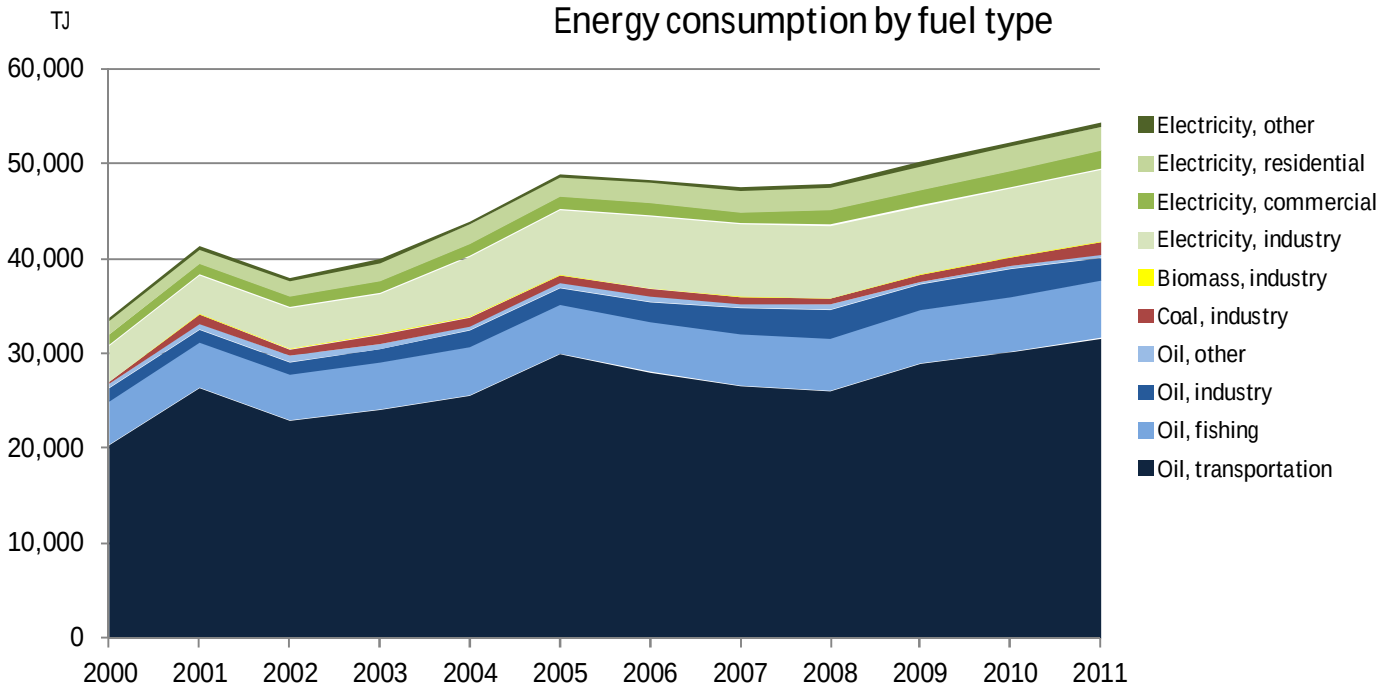

Figure 5. Total energy consumption by fuel type.

Energy consumption figures are accumulated from the domestic information sources such as sales from pumping stations. In the year 2008 the supply was much higher than the consumption. After this, during the years 2009 to 2011 the consumption was slightly higher than the supply. One possible explanation could be reserves accumulated during 2008. Other possible explanations are inaccurate consumption estimates from non-road transport sources or difference with the methods of import and export statistics.

The supply and consumption of oil products are within 10 % of each other, i.e. not in balance. This requires improvement especially as oil is the largest energy product in Namibia. One possible approach would be to check the methods of Customs and organize a consumption survey for oil product delivering companies. The biggest imbalance was in coal supply and consumption. In general, the supply of coal was 30 to 70 % less than consumption. Either a big proportion of coal imports is not accounted for or alternatively the consumption estimates from NamPower and mining companies are incorrect.

2.2 Electricity supply and consumption

Electricity statistics are an essential part of energy statistics. Currently, most of electricity statistics are managed by Electricity Control Board (ECB). Some smaller amounts of information on wind, solar and biomass based generation were provided by the Renewable Energy and Energy Efficiency Institute (REEEI). The current situation of electricity statistics is considerably better than with other energy sources.

Figure 6 presents the electricity supply situation of Namibia from 2000 to 2011. The consumption has almost doubled since 2000 and almost all of the new demand has been satisfied with imports. During the years 2012 and 2013 some new domestic capacity was built and larger project such as Baynes hydropower and Kudu gas power plant were decided.

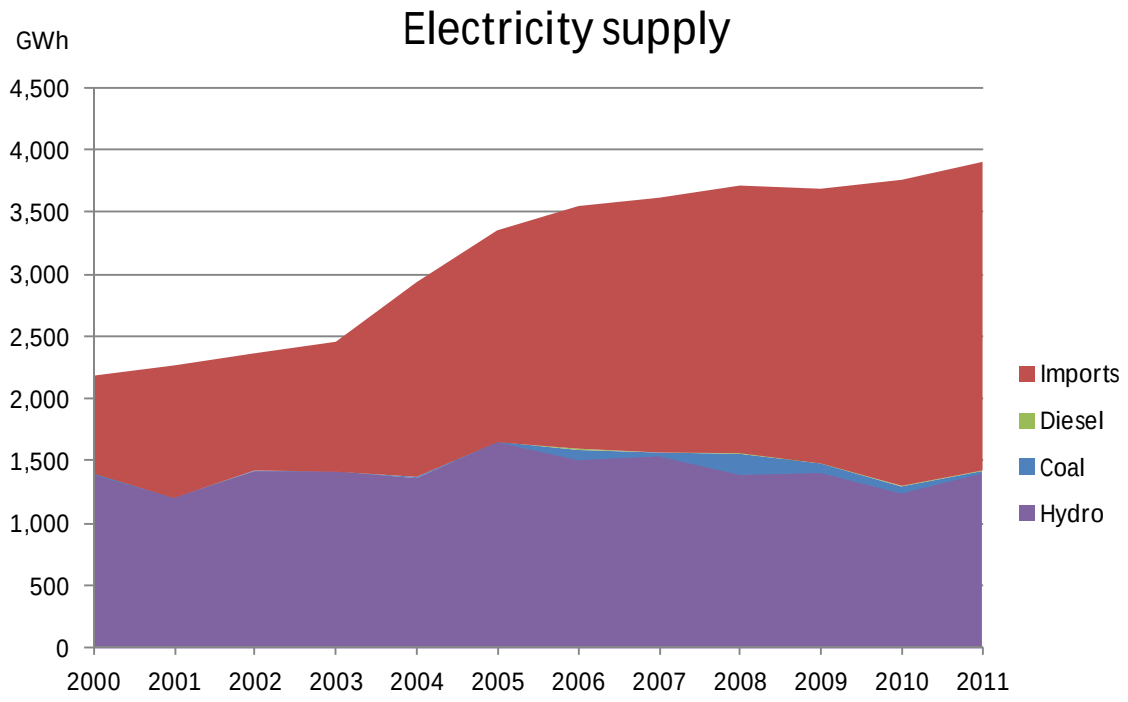

Figure 6. Electricity supply in Namibia between 2000 to 2011 in GWh. Imports don't include the exports. Electricity exports are presented under electricity consumption.

Namibia has a target to increase the share of renewable energy in the electricity generation. The statistics software package includes an automated section which calculates the share of renewable generation. There are four different categories:

1) all renewable electricity generation capacity on grid
2) Only wind, solar PV, solar CSP and biomass on grid
3) all renewable electricity generation capacity on grid + off grid
4) Only wind, solar PV, solar CSP and biomass on grid + off grid

If the hydropower is included, the share of renewable capacity was 67 % in 2012. If the hydropower is excluded, the share of wind, solar and biomass capacity was 0.1 %. If we include the off grid instalments, the share of wind, solar and biomass increases to 0.4 %. Fossil fuel based capacity is used less than hydropower. In 2011 more than 98 % of all produced electricity was from hydropower.

Figure 7 shows the imports and exports of the electricity from 2000 to 2011. Until 2008 the biggest share of imports was from South Africa. In the recent years, larger amount of imports have been from Zimbabwe and Zambia. Throughout the period, exports have been around 3 % of the imports. STEM stands for Short Term Energy Market operating within South African Power Pool (SAPP).

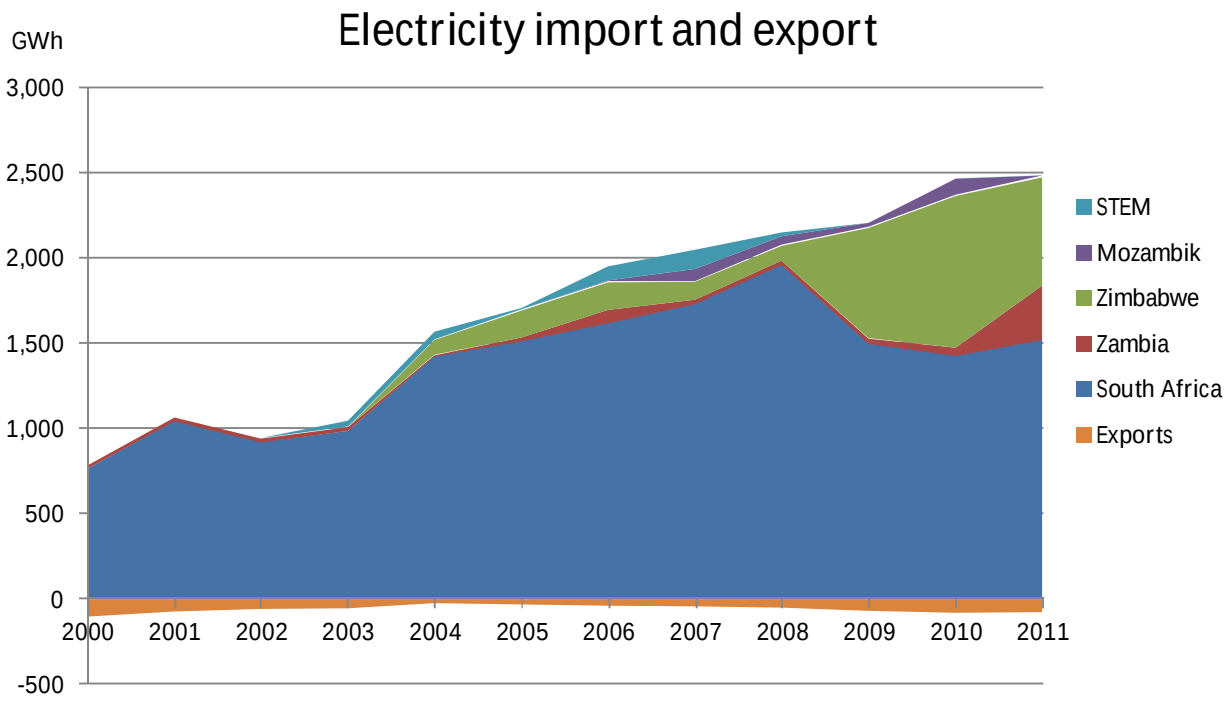

Figure 7. Imports and exports of electricity between 2000 and 2011.

Figure 8 presents the consumption of the electricity by sector. Category industry refers to industrial companies which receive the power directly from the Nampower. Orange river and Skorpion mining companies receive their electricity directly from Eskom from South Africa.

Namibia's peak power demand has been rising steadily since 2000. Peak power demand is reached during the winter when the need for heating is the greatest. Figure 9 presents the steady growth of peak power demand which has been around 4 % annually if Skorpion mining company is excluded. In 2004 there was a larger increase of about 80 MW when the Skorpion zinc mine and refinery started operating.

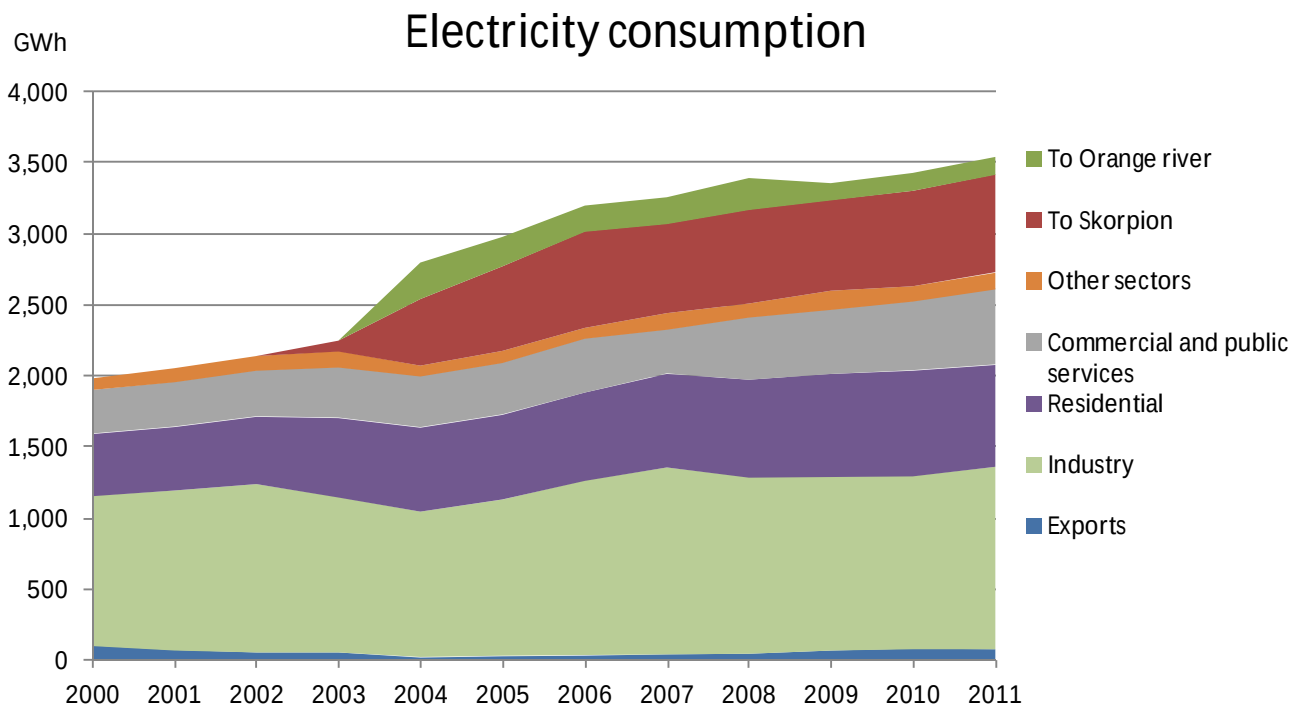

Figure 8. Electricity consumption by sector. Industry refers to industry where the power is delivered by Nampower. Orange river and Skorpion receive their electricity directly from South Africa.

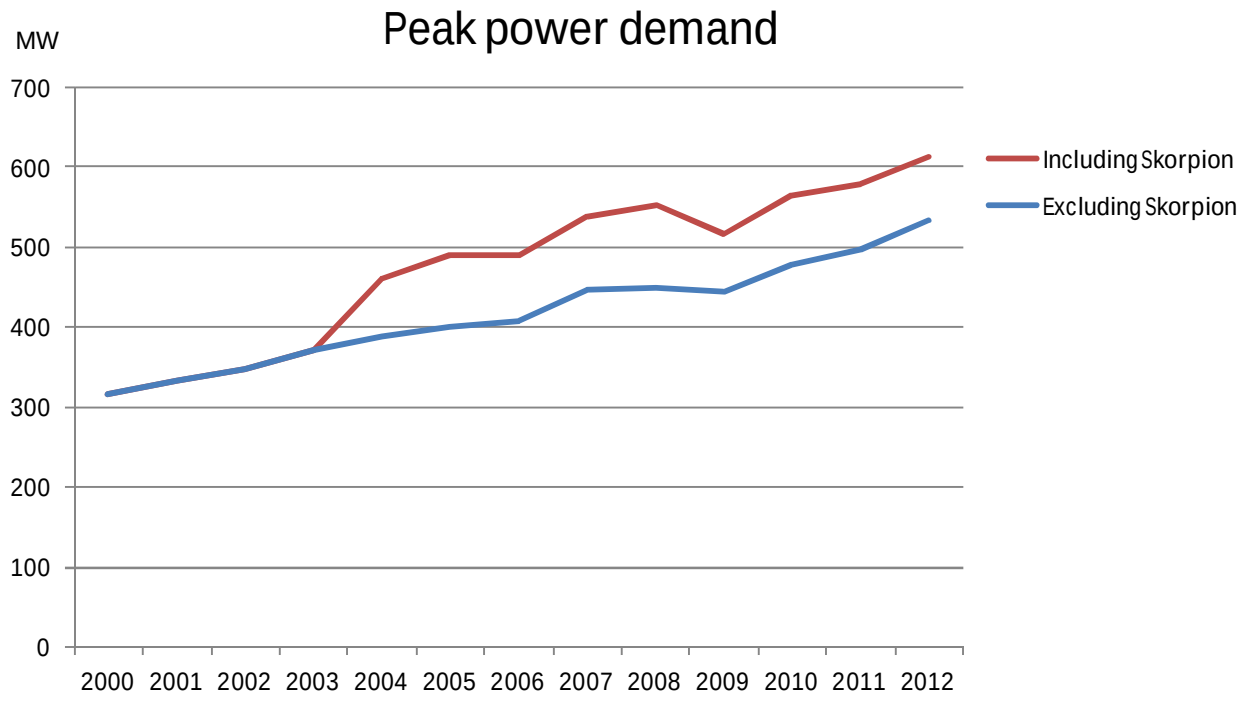

Figure 9. Peak power demand in Namibia between 2000 to 2011. The peak power demand is presented with and without Skorpion Zinc mine and refinery.

2.3 CO_2 emissions from energy use

Most of the energy is consumed in the transport sector and most of the Namibia's energy sector's CO_2 emissions come from transportation. The second largest CO_2 emission source is fishing followed by industry, electricity generation and others. According to energy statistics and Figure 10, the total CO_2 emissions from the energy use were 2800 $ktCO_2$ in 2011. The amount CO_2 emissions from energy have been increasing by approximately 4 % per year.

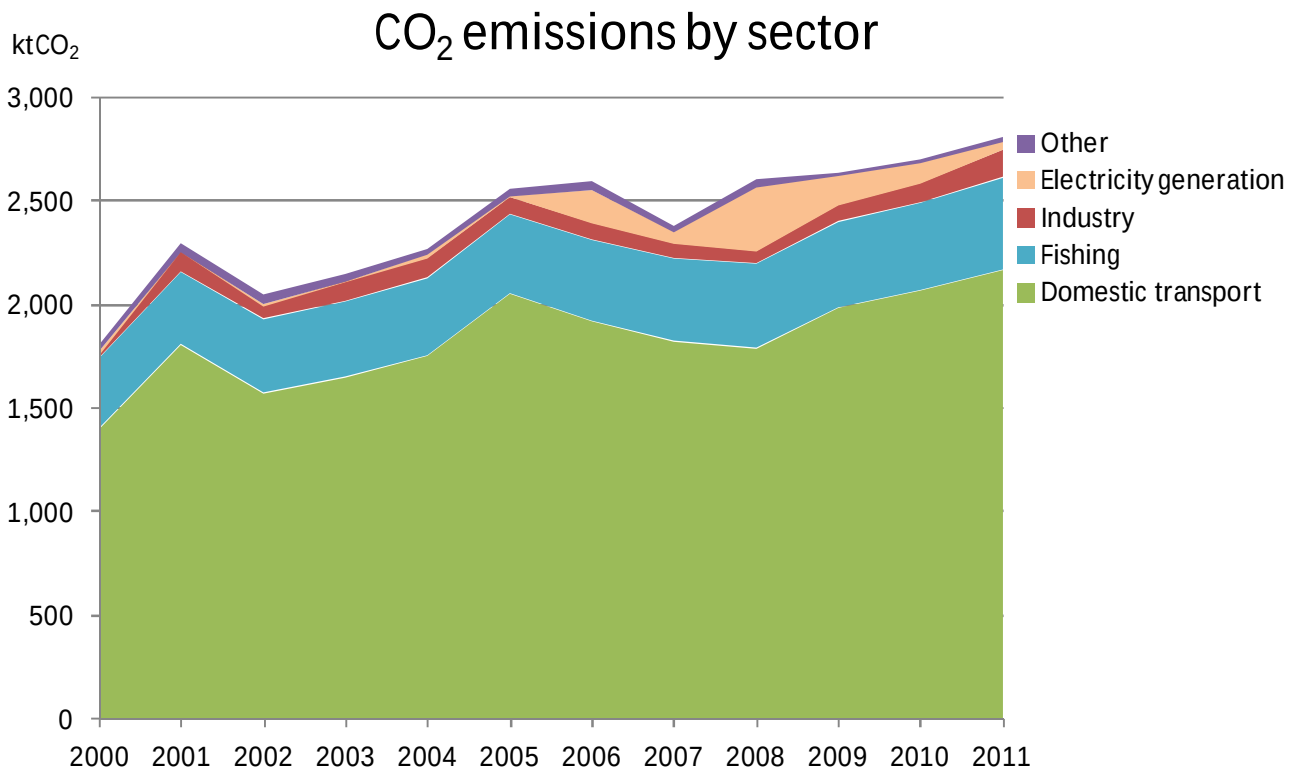

Figure 10. Sectoral CO_2 emissions from the energy consumption in the Namibia in 2000 to 2011. International transportation is excluded from this graph.

Figure 11 presents the energy consumption by sector. The CO_2 emissions from electricity generation are accounted for in the electricity generation sector. From imported electricity, the emissions are accounted in the exporting country. Industry's CO_2 emissions are relatively small because most of the industry's energy consumption is electricity in the current version of the statistics.

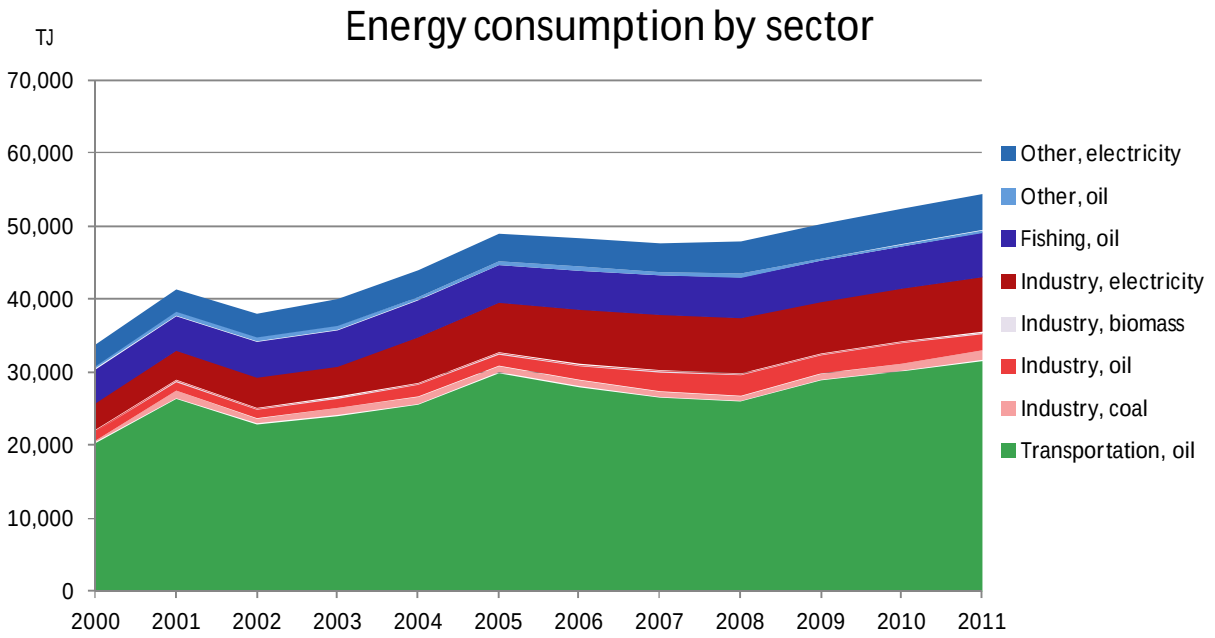

Figure 11. Final energy consumption by sector in Namibia in 2000 to 2011. International transportation is excluded from this graph.

2.4 Resource estimate and recommended future actions

The energy statistics are easy to update. Most of the input numbers are collected already for other purposes and it is relatively quick work to gather them from different institutes and update the energy statistics. It is estimated that annual update of the statistics requires a month of work during the first years when the learning process and documentation requires some additional work. After the personnel are fluent with the current version of the statistics, the upkeep should take only a week.

Currently there are several missing numbers and imprecise estimates. It requires more work to improve the quality of the statistics. When new information sources or estimates become available, they should be included to the statistics. This requires that personnel fully understand how the statistics work.

VTT Technical Research Centre of Finland organized a training period for the Ministry and stakeholders concerning the statistics as part of the cooperation project. Additionally, International Energy Agency (IEA) provides also training for the statistics. During the last years, Ministry of Mines and Energy has already participated in the IEA's training.

It is highly recommended that

- Ministry and stakeholders commit to the annual upkeep and improvement of the energy statistics, responsibilities are defined and funding granted
- personnel from the ministry and stakeholders regularly participate to further training to improve their skills with the energy statistics
- in the long run, the upkeep and development of the energy statistics should be designated to the Namibia Statistics Agency (NSA)[4]
- Law on statistics is prepared; companies are required to submit data and confidentiality of data is guaranteed

[4] http://www.nsa.org.na/

3. Energy system modelling

The chapter on energy system modelling will give a description of the model to familiarise the reader to the concept of energy system modelling and to present the scenarios selected for the study, explain the results of the modelling exercise in detail and finally discuss options for additional studies.

3.1 Model description

The future development of Namibian energy system has been projected in this document by utilising a specific Namibian energy system model constructed by VTT. The Namibian energy system model is based on TIMES (The Integrated Markal Efom System) modelling system developed in the IEA ETSAP Programme[5]. This model describes the Namibian energy system as a whole, not just electricity consumption and production, but also entire energy consumption and supply of residential, commercial, industrial and transport sectors, including upstream energy supply and transactions of energy with neighbouring countries. Time scale of the model is within years 2008-2030 with milestone years at intervals of 5 years, furthermore, each milestone year is divided into three seasons (winter, intermediate and summer) and each season is divided into several daily timeslices in order to model peak load situations.

Basically, TIMES based energy system model finds cost-optimal future development of the energy system, that is, of the entire region including neighbouring countries. TIMES model features vast technology library for each sector with parameters such as efficiencies, investment costs etc. assembled in cooperation with international energy technology experts. The model chooses optimally from this technology selection, however, taking into account several country-specific or policy based assumptions and constraints inserted into the model. Trade in terms of energy commodities between Namibia and its neighbouring countries is defined endogenously, that is, volumes and prices of trade are based on supply and demand conditions in each country instead of using fixed prices or volumes.

In the model Namibian energy system is defined in great detail, based on updated energy statistics, whereas neighbouring countries, South Africa, Angola and Botswana are inserted into the model in a more robust manner by using existing IEA energy statistics. Projections for future development in terms of energy use in each sector is based on projections of GDP and population utilised as model drivers, however, development of mining sector is structured in the model based on estimated production volumes of different mining sectors.

3.2 Namibian energy scenarios

3.2.1 Scenario descriptions

Scenarios for Namibian energy system development analysed by TIMES model are based on combination of quantitative and qualitative options. Different projections for GDP and population constitute the quantitative element of the scenario building. Low, medium and high growth scenarios in terms of GDP and population are explained in the following chapter.

In addition to quantitative scenario elements described above, scenarios can also be differentiated by qualitative elements. In the case of Namibia, one important decision in terms of energy system is potential utilisation of Kudu gas field. In terms of scenario building, there are two options:

[5] Loulou, R. Remme. U., Kanudia, A., Lehtilä, A. & Glodstein, G. 2005. Documentation for the TIMES Model. Energy Technology Systems Analysis Programme (ETSAP).

1. Kudu gas field is utilised and 800 MW gas fired power plant is built in 2020 in order to produce electricity from Kudu gas for 20 years. By taking into account estimates for efficiencies and availability factors of best available technology NGCC (natural gas combined cycle) power plant, annual supply of 35 PJ can be defined for Kudu gas field. Additional investments in electricity production capacity are allowed in the model if necessary. Operation of NGCC power plant is not constrained in any way, i.e., annual utilisation rate depends on the cost-efficiency in terms of electricity demand and/or export to neighbouring countries. Production cost for Kudu gas is assumed to be at level of 70 N$/GJ.

2. Kudu gas field is not utilised and energy system model can find cost-optimal investment plan in terms of electricity production for Namibia.

By combining these quantitative and qualitative elements in scenario building, 6 different pathways for development of Namibian energy system can be defined:

1. **LOW**: Scenario for low growth without utilisation of Kudu gas field.
2. **LOW KUDU**: Scenario for low growth with utilisation of Kudu gas field.
3. **MEDIUM**: Scenario for medium growth without utilisation of Kudu gas field.
4. **MEDIUM KUDU**: Scenario for medium growth with utilisation of Kudu gas field.
5. **HIGH**: Scenario for high growth without utilisation of Kudu gas field.
6. **HIGH KUDU**: Scenario for high growth with utilisation of Kudu gas field.

Model results based on these 6 different scenarios provide required variation in order to paint a picture of uncertainties surrounding Namibian energy system development. It has to be emphasised that scenario results based on model calculations are not predictions of the future, but these numerical results provide several equally probable and reasonable pathways towards the future.

3.2.2 Economic drivers

GDP and population illustrated in Figure 12 and Figure 13 are based on estimates from the Ministry of Finance and the National Planning Commission. GDP and population projections are used in the model as drivers and as basis for other drivers, constituting main development of Namibian energy consumption. For example, use of personal vehicles is based on development of GDP per capita, whereas commercial trucking is based on GDP growth. It has to be noted that Namibian growth scenarios do not reflect to neighbouring countries, that is, growth in South Africa, Angola and Botswana is set to reference projections based on IEA estimates used in the energy system model.

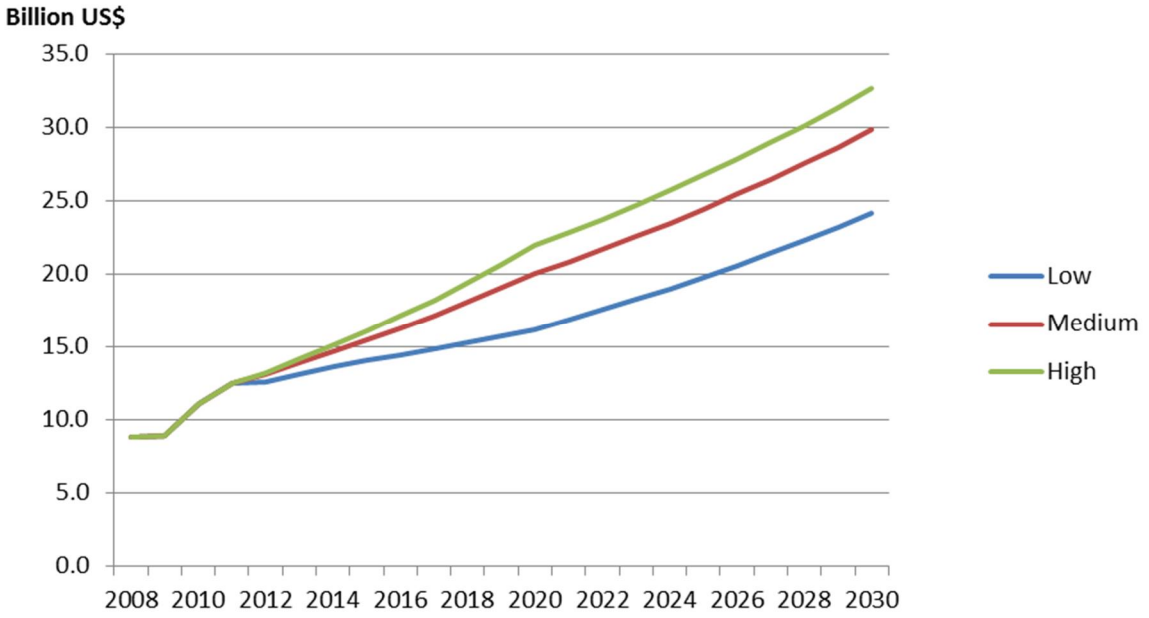

Figure 12. Development of GDP in all scenarios.

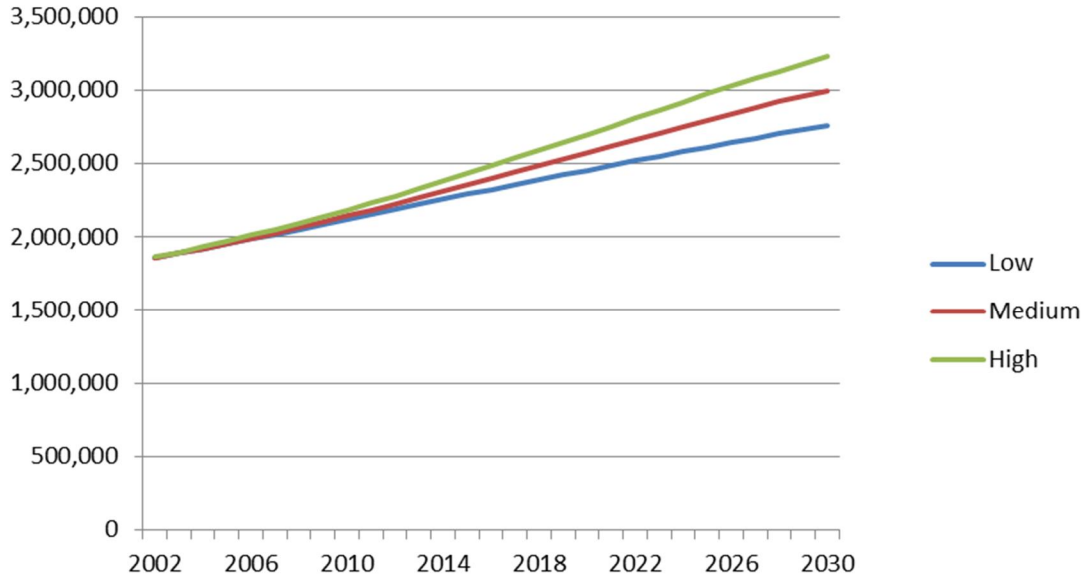

Figure 13. Population growth in all scenarios.

3.2.3 Mining industry

Production volumes of the mining sector, including copper production in Namibian Custom Smelters, are based on spot load projections of mining activity for each scenario provided by National Planning Commission in the National Integrated Resource Plan (NIRP) . By using these electricity spot load figures and energy consumption estimates from mining sector actors combined with production volume statistics, projections for mining activity were obtained for scenario purposes. Furthermore, in the case of uranium mining specific electricity consumption factors were varied by milestone years due to changes in uranium processing methods.

3.2.3.1 Uranium

Uranium mining is the only mining sector for which NIRP provides production volume scenarios in addition to electricity consumption scenarios. Furthermore, these scenarios differentiate in terms of uranium processing which results in different specific electricity consumption values for each scenario. Production volume and electricity consumption scenarios and calculated specific electricity consumption values are represented in Table 3. In addition to electricity consumption, data from two uranium mining companies indicating oil based fuel consumption in operation was used in order to estimate specific diesel oil consumption of 0.31 PJ/kt.

Table 3. Production volume, electricity consumption and specific electricity consumption of uranium mining during model years 2008-2030.

Uranium						
ktUO/y	2008	2010	2015	2020	2025	2030
LOW	5.119	5.306	10.506	10.506	7.306	7.306
MEDIUM	5.119	5.306	18.056	18.056	14.856	14.856
HIGH	5.119	5.306	18.056	24.056	20.856	20.856
GWh	2008	2010	2015	2020	2025	2030
LOW	306.3	317.5	724.8	724.8	448.9	448.9
MEDIUM	306.3	317.5	1049.4	1049.4	773.4	773.4
HIGH	306.3	317.5	1347.0	1956.7	1680.7	1680.7
PJ/kt	2008	2010	2015	2020	2025	2030
LOW	0.215	0.215	0.248	0.248	0.221	0.221
MEDIUM	0.215	0.215	0.209	0.209	0.187	0.187
HIGH	0.215	0.215	0.269	0.293	0.290	0.290

3.2.3.2 Diamonds

Diamond mining production volumes are available in statistics[6] for years 2008-2010 and electricity consumption can be obtained from NIRP for year 2008. By using specific electricity consumption calculated from these values and electricity consumption scenarios from NIRP, production volume scenarios for future years illustrated in Table 4 can be obtained. No variation between scenarios has been assumed here. In addition, data from individual diamond mining company indicating oil based fuel consumption in operation was used in order to estimate specific diesel oil consumption of 1.69 PJ/t.

[6] Chamber of mines of Namibia - Annual Review 2011/2012

Table 4. Production volume, electricity consumption and specific electricity consumption of diamond mining during model years 2008-2030.

Diamonds						
t	2008	2010	2015	2020	2025	2030
ALL	0.635	0.490	0.889	0.889	0.889	0.889
GWh	2008	2010	2015	2020	2025	2030
ALL	46.0	35.5	64.4	64.4	64.4	64.4
PJ/t	2008	2010	2015	2020	2025	2030
ALL	0.261	0.261	0.261	0.261	0.261	0.261

3.2.3.3 Gold

Gold mining production volumes are available in statistics and electricity consumption in NIRP for year 2008. By using specific electricity consumption calculated from these values and electricity consumption scenarios from NIRP, production volume scenarios for future years illustrated in Table 5 can be used in model.

Table 5. Production volume, electricity consumption and specific electricity consumption of gold mining during model years 2008-2030.

Gold						
t	2008	2010	2015	2020	2025	2030
LOW	2.120	2.683	6.775	6.775	6.775	6.775
MEDIUM	2.120	2.683	6.775	6.775	6.775	6.775
HIGH	2.120	2.683	18.225	18.225	18.225	18.225
GWh	2008	2010	2015	2020	2025	2030
LOW	38.8	49.1	124.0	124.0	124.0	124.0
MEDIUM	38.8	49.1	124.0	124.0	124.0	124.0
HIGH	38.8	49.1	333.6	333.6	333.6	333.6
PJ/t	2008	2010	2015	2020	2025	2030
ALL	0.066	0.066	0.066	0.066	0.066	0.066

3.2.3.4 Zinc

Zinc related mining activity in Namibia can be divided into two separate categories: zinc concentrate mining and Skorpion mining company based zinc processing. There are no scenarios concerning Skorpion activity available and therefore in the energy system model current production level of 145 kt (special high grade zinc) and current specific electricity consumption of 15.96 PJ/Mt were used.

Similarly, there are no scenarios for zinc concentrate mining and therefore production level of 2010 was used for further model years as stated in Table 6. In addition, electricity consumption of Rosh Pinah zinc mining activity calculated from NIRP was used in order to estimate for specific electricity consumption.

Table 6. Production volume, electricity consumption and specific electricity consumption of zinc mining during model years 2008-2030.

Zinc concentrate						
Mt	2008	2010	2015	2020	2025	2030
ALL	0.094	0.101	0.101	0.101	0.101	0.101
GWh	2008	2010	2015	2020	2025	2030
ALL	36.0	38.6	38.6	38.6	38.6	38.6
PJ/Mt	2008	2010	2015	2020	2025	2030
ALL	1.377	1.377	1.377	1.377	1.377	1.377

3.2.3.5 Copper

As in the case of zinc, copper mining activity can be divided into two separate categories: copper concentrate mining and Namibia Custom Smelter based copper processing. There are scenarios for copper concentrate mining in NIRP illustrated in Table 7. There are merely electricity consumption figures available in NIRP, however by using production volume statistics for year 2008 and these electricity consumption figures, specific electricity consumption for copper concentrate mining can be obtained. By using this parameter production volume estimates of Table 7 were calculated. It is evident that due to market situation copper mining was not profitable in year 2010.

Table 7. Production volume, electricity consumption and specific electricity consumption of copper mining during model years 2008-2030.

Copper concentrate						
kt	2008	2010	2015	2020	2025	2030
LOW	8.354	0.000	10.417	10.417	10.417	10.417
MEDIUM	8.354	0.000	10.417	10.417	10.417	10.417
HIGH	8.354	0.000	47.920	47.920	47.920	47.920
GWh	2008	2010	2015	2020	2025	2030
LOW	31.6	0.0	39.4	39.4	39.4	39.4
MEDIUM	31.6	0.0	39.4	39.4	39.4	39.4
HIGH	31.6	0.0	181.3	181.3	181.3	181.3
PJ/kt	2008	2010	2015	2020	2025	2030
ALL	0.014	0.014	0.014	0.014	0.014	0.014

Tsumeb based Namibia Custom Smelter consumes electricity and coal in copper processing. NIRP merely provides electricity consumption estimates for years from 2015 and production volumes for years 2008-2010 are available in statistics. Therefore, specific electricity consumption of 5.38 PJ/Mt provided by Namibia Custom Smelter[7] must be used in the model in order to calculate production volume for future years as stated in Table 8. Furthermore, specific coal consumption of 36.14 PJ/Mt from same reference was used resulting in annual coal consumption of 0.599 PJ in year 2008.

[7] www.dundeeprecious.com/English/sustainability/our-environment/energy-and-raw-materials-use/default.aspx

Table 8. Production volume, electricity consumption and specific electricity consumption of copper processing during model years 2008-2030.

Copper						
Mt	2008	2010	2015	2020	2025	2030
ALL	0.017	0.025	0.105	0.105	0.105	0.105
GWh	2008	2010	2015	2020	2025	2030
ALL	24.8	37.4	156.3	156.3	156.3	156.3
PJ/Mt	2008	2010	2015	2020	2025	2030
ALL	5.380	5.380	5.380	5.380	5.380	5.380

3.2.3.6 Iron ore

There is no activity in terms of iron ore mining currently in Namibia. However, in all the scenarios of NIRP there are electricity loads allocated to iron ore mining. Furthermore, the actor planning iron ore operations in Namibia estimates annual production of 2 Mt of iron ore[8]. There are no estimates or existing data for specific electricity consumption for Namibian iron ore mining and therefore electricity load and annual production estimates are used in order to calculate this consumption parameter for energy system model purposes.

Table 9. Production volume, electricity consumption and specific electricity consumption of iron ore mining during model years 2008-2030.

Iron ore						
Mt	2008	2010	2015	2020	2025	2030
ALL	0.000	0.000	2.000	2.000	2.000	2.000
GWh	2008	2010	2015	2020	2025	2030
ALL	0.0	0.0	249.7	249.7	249.7	249.7
PJ/Mt	2008	2010	2015	2020	2025	2030
ALL	0.449	0.449	0.449	0.449	0.449	0.449

3.2.3.7 Other mining

Other mining sector consists of salt and other mineral related mining activity. NIRP provides electricity consumption data concerning other mining activity. By combining these electricity consumption figures with production volume statistics from year 2008 specific electricity consumption was calculated.

Table 10. Production volume, electricity consumption and specific electricity consumption of other mining activity mining during model years 2008-2030.

Other mining						
Mt	2008	2010	2015	2020	2025	2030
LOW	0.732	0.896	0.896	0.896	0.896	0.896
MEDIUM	0.732	0.896	0.896	0.896	0.896	0.896
HIGH	0.732	0.896	2.206	2.206	2.206	2.206
GWh	2008	2010	2015	2020	2025	2030
LOW	69.7	85.4	85.4	85.4	85.4	85.4
MEDIUM	69.7	85.4	85.4	85.4	85.4	85.4
HIGH	69.7	85.4	210.2	210.2	210.2	210.2
PJ/Mt	2008	2010	2015	2020	2025	2030
ALL	0.343	0.343	0.343	0.343	0.343	0.343

[8] www.deepyellow.com.au/shiyela-iron-project-september-2010.html

3.2.4 Other sectors

In the Namibian energy system model other industrial activity than mining activity described above is defined as electricity consumption dependent on development of economic driver based on GDP. In the model base year 2008 electricity consumption of other industrial sector calculated from NIRP and Namibian energy statistics is 2.49 PJ.

Development of energy end use in residential and commercial sectors is based on several drivers depending on end use type. For example, electricity consumption in residential sector is divided by end use types, such as lighting, hot water, cooking etc. Shares of end use types in electricity consumption of residential and commercial sectors are based on average African parameters used in the model. Base year energy consumption values of these sectors as well as agriculture and fishing sectors are based on Namibian energy statistics.

Transport sector is driver based as well and end use is divided by personal vehicles, freight trucks, trains and aviation. Base year values for road transport are calculated by using pump statistics for total consumption of gasoline and diesel oil provided by National Energy Fund (NEF) combined with transport volume and vehicle stock statistics[9] and average mileage values for vehicles.

3.2.5 Other scenario definitions and model assumptions

In addition to scenario assumptions stated above, there are several assumptions and constraints set to the energy system model in order to describe policy measures and country-specific features common to each scenario. In the following, the most important assumptions are explained:

- Baynes hydro plant is built in 2020 with electricity production capacity of 300 MW (Namibian share of the hydro plant). Inflow data for Baynes is based on average Ruacana flow figures; however Baynes plant is able to control production inside the model season due to reservoir. Other investments in hydro power are restrained in the model.

- Cement production in Ohorongo Cement Plant is assumed to be 500 000 t in year 2015 and 700 000 t in year 2020 and further. Cement plant can use only coal or heavy fuel oil in cement kilns. Model uses technical parameters for general cement production plant available in the TIMES model technology library.

- Load curves for energy end-use are modelled by fitting statistical Namibian load curves into model timeslices also considering seasonal differences.

- Options for domestic production of biofuels, e.g., biodiesel or ethanol, and production of synthetic fuels are disabled in the model for the timeframe of 2008-2030.

- Improving energy efficiency measures are included in each sector of the technology library.

- Import and export capacities to neighbouring countries in terms of electricity remain at the current level. Import and export prices are defined endogenously in the model.

[9] Namibia energy review for UNFCCC, Ministry of Environment and tourism, 2007

3.3 Results from the model in detail

TIMES energy system model of Namibia was run for each scenario with results analysed from years 2015-2030 (years 2008 and 2010 in result figures are from statistics). It has to be noted that the Namibian energy system model includes other African regions and therefore development of these countries optimised by the model affect Namibian results illustrated here. For example, optimal investment decisions in South African electricity infrastructure affect cost effectiveness of Namibian electricity via export and import. It needs to be understood that while the model provides a solid platform to investigate the development of the Namibian energy system, the results should not be considered as accurate and absolute predictions of the future.

In Figure 14 Namibian electricity consumption divided into main sectors is illustrated. It is evident that high scenario results in significantly increased electricity consumption with more than doubled consumption in year 2030. Main factor behind this increase is high mining activity in that scenario. Also, electricity consumption of other industry sectors increases notably. Losses are higher in Kudu scenarios in 2030, since natural gas based electricity is exported to neighbouring countries.

In Figure 15 electricity production in Namibia divided by production type, including import and export, is illustrated. In Kudu scenarios production mix differs greatly from non-Kudu scenarios, since in Kudu scenarios investment of 800 MW natural gas fired power plant is fixed. It is evident that in absence of utilisation of Kudu gas, investment on coal based electricity production mixed with wind power from year 2020 is optimal according to the model. Utilisation rate of natural gas power plant is not at maximum level during years 2020-2025 in low and medium scenarios, since domestic consumption is at relatively low level compared to the production capacity and cost effectiveness of natural gas based electricity is high enough to be exported in large volumes. This relative cost effectiveness of natural gas based electricity depends on several issues in the model such as power plant investments in neighbouring countries and global market prices of competitive fuels. In year 2030 natural gas based electricity is exported mostly to South Africa. In all scenarios import dependency of Namibian energy system decreases significantly. One might notice the absence of solar power in the results presented here; see Chapter 3.4 for the explanation why this does not appear in the scenarios.

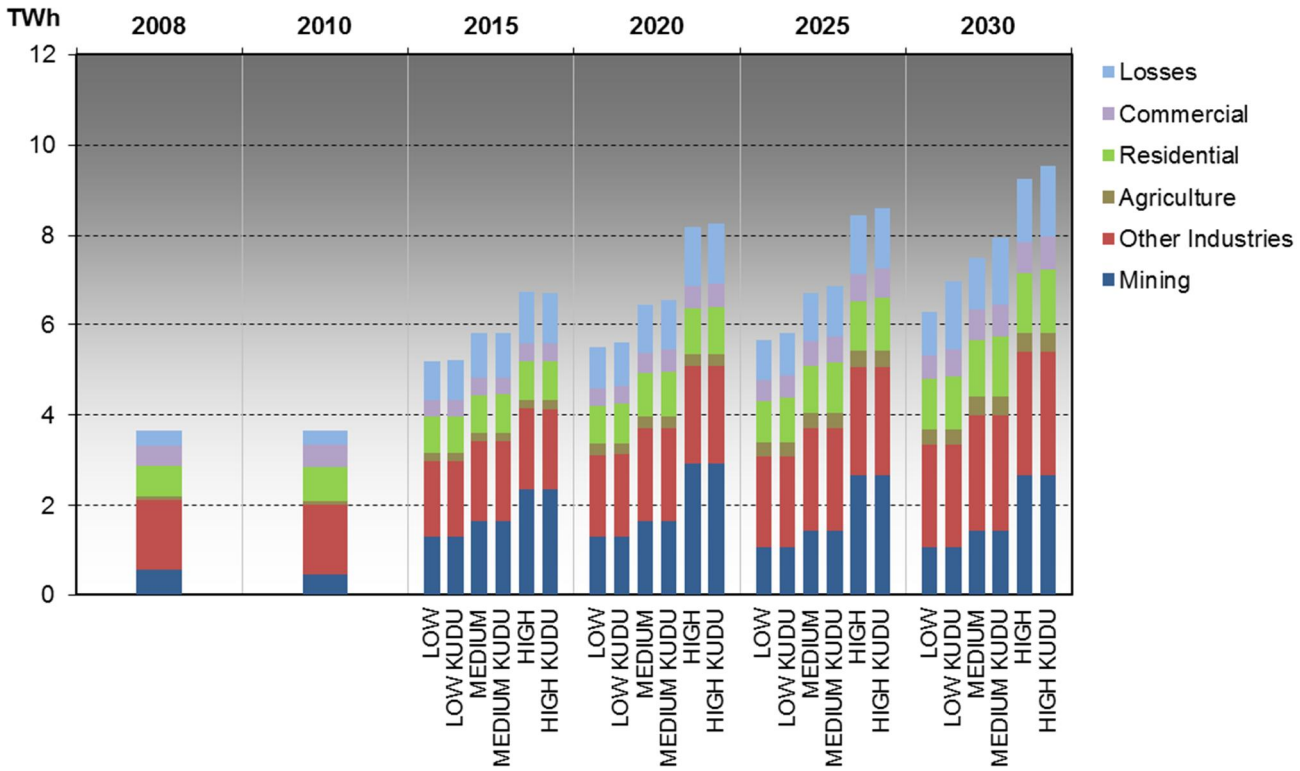

Figure 14. Electricity consumption in scenarios in years 2008-2030 divided by sectors.

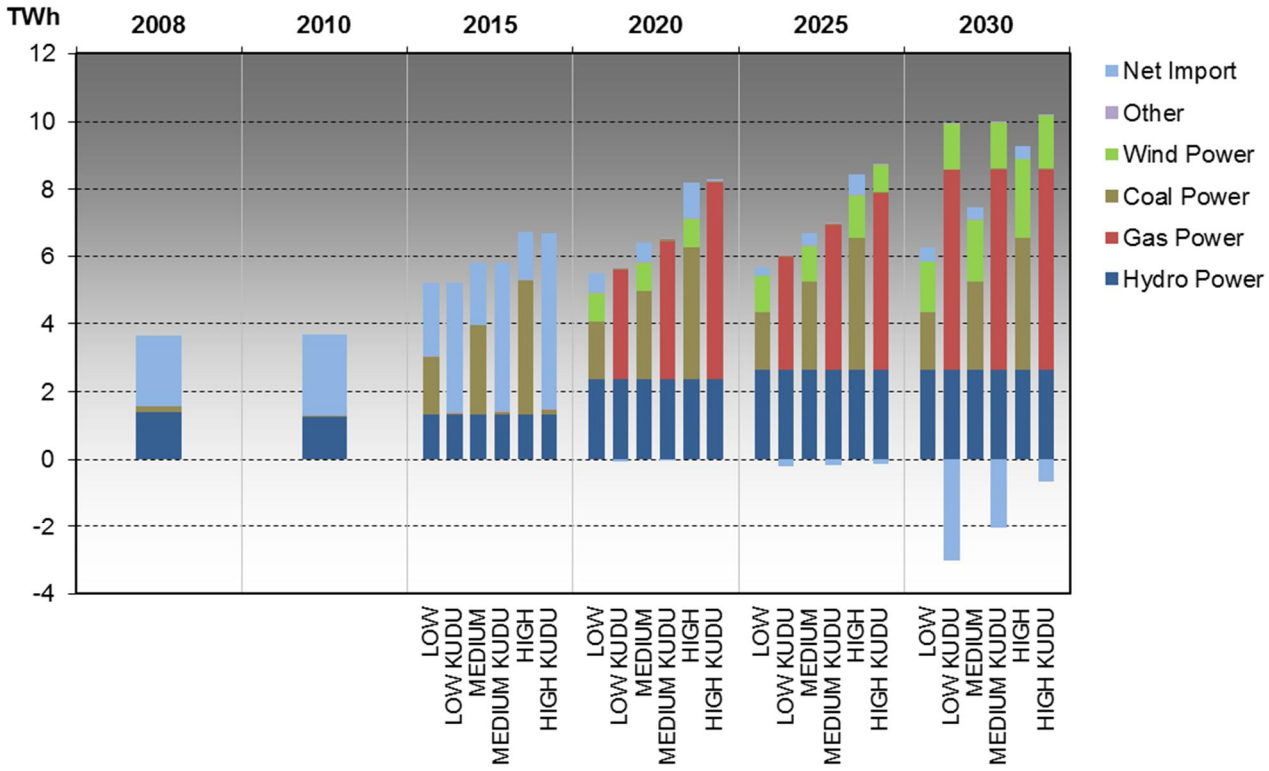

Figure 15. Electricity production in scenarios in years 2008-2030 divided by production technologies including import.

In Figure 16 primary energy consumption of Namibia is illustrated. Evidently, economic drivers and growing mining sector increase energy consumption significantly in Namibia. Also, shift from imported electricity to domestic electricity generation affects primary energy consumption increasingly. However, in the case of Kudu scenarios domestic content of primary energy is relatively high. In Figure 17 consumption of oil products is examined in greater detail. Decrease of gasoline consumption is due to the shift of vehicle stock to diesel fuelled cars and improvements on mileage. Furthermore, growing mining sector generates increased oil based fuel consumption in that sector.

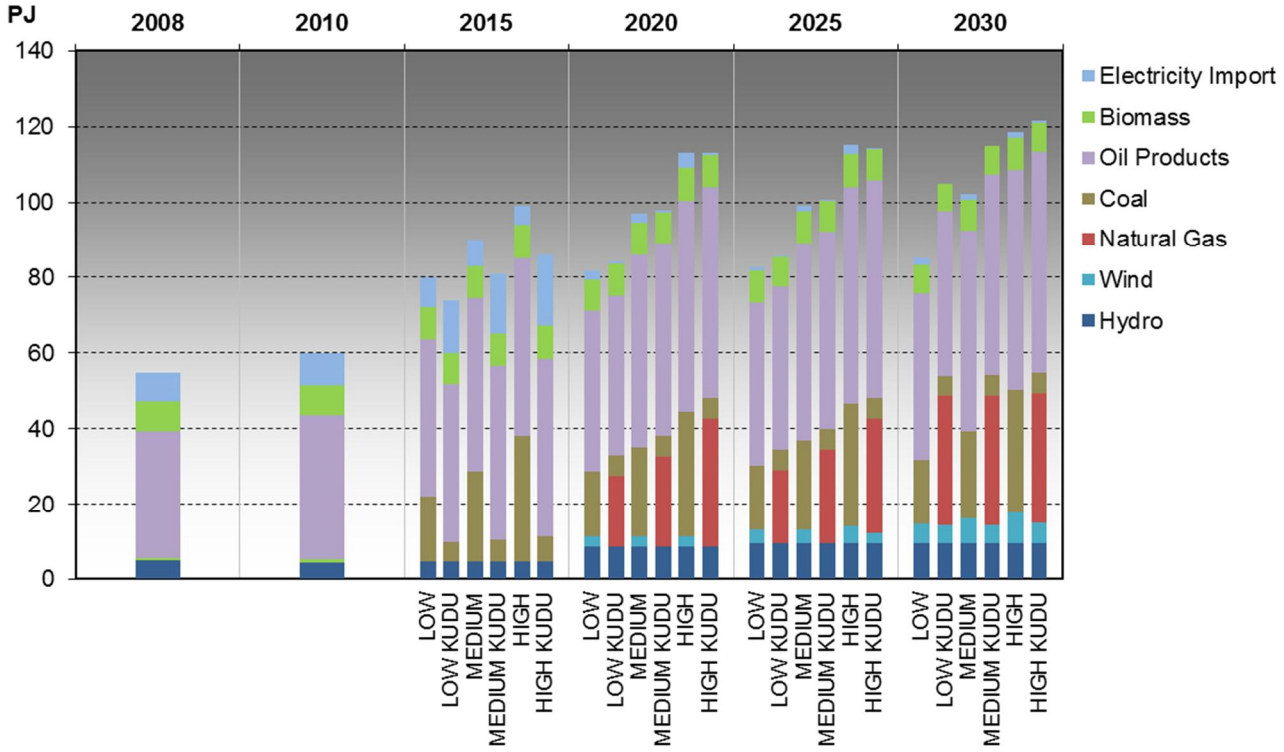

Figure 16. Primary energy consumption in scenarios in years 2008-2030.

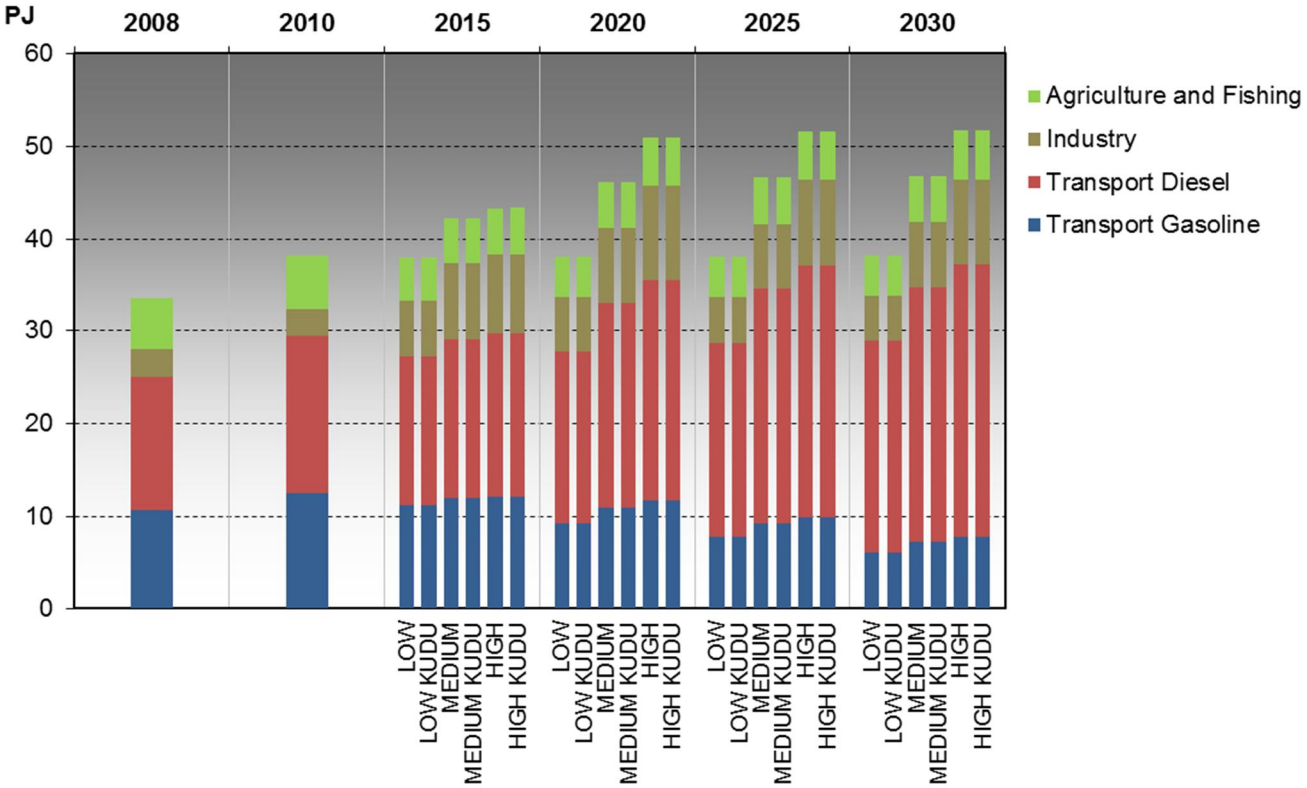

Figure 17. Consumption of oil based fuels in scenarios in years 2008-2030.

In Figure 18 development of total CO_2 emissions of Namibia is illustrated. It has to be noted that this graph includes CO_2 emissions from energy, industrial, transport, residential, commercial and agricultural sector but it does not include other greenhouse gases such as methane or nitrous oxides. Obviously, general increasing trend of emissions is congruent with primary energy consumption of Figure 16, since majority of primary energy is based on fossil fuels. However, it is interesting to notice how introduction of Kudu gas affects emissions. In the low and medium scenarios emissions of Kudu case surpass emissions of non-Kudu case in year 2030. Main reason for this occurrence can be found in Figure 15 where difference between these cases in terms of electricity export is evident. That is, in the case of Kudu, Namibia produces emissions for electricity consumed in South Africa, whereas in the non-Kudu case coal power is generated in order to cover domestic demand only. Therefore, excessive production affects more to emissions than higher specific emission factor of coal. Another factor behind growing emissions is growing consumption of oil based fuels depicted in Figure 17, although this concerns only medium and high scenarios.

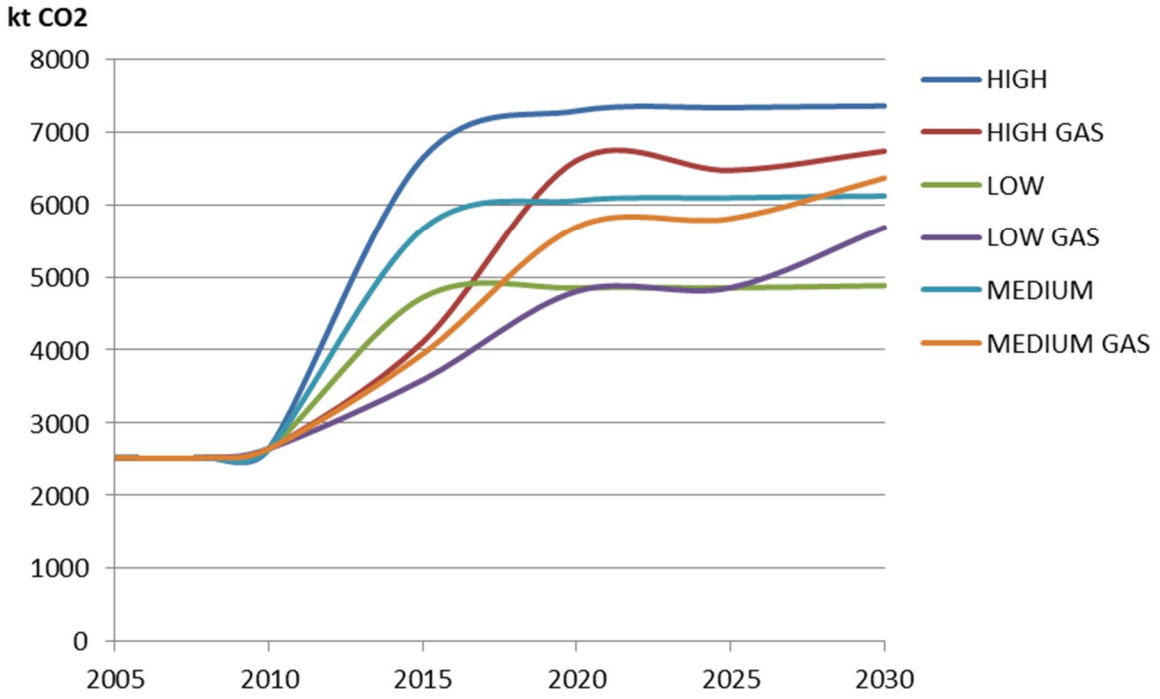

Figure 18. Total CO_2 emissions in scenarios in years 2005-2030.

3.4 Possibilities for further studies

TIMES energy system model of Namibia provided by VTT enables Namibian policy makers to perform with relative ease several feasible and reasonable pathways towards the future of Namibian energy system. Main direction of further studies should be aimed at varying economic drivers and volumes of mining sector of scenarios in order to probe different outlooks of economic background behind energy system.

Another direction for energy system modelling can be analysis of different available technologies in the same manner as Kudu was examined in scenarios defined above; some energy technologies can be excluded from the model or some technology investments can be fixed. Furthermore, TIMES energy system model enables setting of constraints for the system, such as e.g. upper limit for total emissions or share of renewables in electricity generation. These constraints and other scenario definitions are valuable tools for analysis supporting complex energy policy process.

Another important issue concerning future development of Namibian energy system is solar power. It has to be noted that results from energy system model represented above do not involve solar power, since model does not have solar power in the base year of 2008 and it does not find solar power to be cost-optimal from the energy system point of view with current scenario assumptions and parameters when compared to e.g. wind power. Furthermore, solar investments were not fixed or constrained in any way in scenario definitions. Therefore, further studies should be performed from the renewable energy source point of view: for example, obtaining enhanced data for wind and solar conditions in Namibia, setting fixed solar investments into the model, improving modelling structure and parameters for off-grid solar power etc. By setting the scenario definitions in terms of renewable energy and tweaking the model into more accurate version, TIMES energy system model enables all these cases of analysis with some effort.

4. Literature review and background information

A significant amount of studies and projects related to the Namibian energy sector have been carried out since the White Paper on Energy Policy was published in 1998. Many of these studies build on the policy statements given and address the challenges identified in the White Paper. This chapter aims to give an overview of the work accomplished at this point, offers comments on the progress made, and gives recommendations for reasonable next steps. Altogether 70 studies were found, most of which are available online and some of which are available on request. The studies are mostly accomplished between years 2005-2013.

The chapter includes description and evaluation of national documents such as the current Energy Policy and National Development Plans, a compilation of energy system related studies and major projects concerning the sector, but the emphasis is on the topic of renewable energy in Namibia. There are also a large amount of studies on energy efficiency, which is discussed in the chapter as well.

Each sub-chapter includes a table with titles, references and short descriptions of the summarised studies. The titles in the tables also include links to an internet address where the document or other source of information is located[10]. In the beginning of the chapters related to electrification, renewable energy and energy efficiency, the targets set in the White Paper are presented and the current status of the sector is reflected to these targets.

The listing of studies, documents and projects provides an excellent starting point for orientation to the Namibian energy sector and visualises the amount of work already carried out. All the material is also very useful in the process of updating the energy policy in Namibia. This report highlights some topics and points of interest, but it is up to the updated energy policy to prioritise and emphasise those issues that are considered the most important for Namibia, when technical, economic, social, and environmental aspects are taken into account.

As a conclusion of the literature review it can be said, that a significant amount of studies have been conducted especially related to the renewable energy sector and to the energy efficiency. Some of the studies give quite detailed propositions for actions that could be realised in Namibia, but some of them fail to give concrete propositions of actions needed on the way forward. Sometimes it also seems that there is a lack of coordination between the on-going projects and project partners, as several studies related to the same subject are made in a row. In future, it could be valuable to concentrate on concrete case studies, with very detailed and realistic plans for the implementation, instead of the general review studies. Also prioritisation of the study subjects would be beneficial. Attention could also be paid on the transparency and accessibility of the study results. At the moment it is sometimes challenging or even impossible to find e.g. the final reports of the projects. Therefore, this literature review is not complete, and also other, non-listed activities are certainly going on.

The main online data sources utilised are listed in Table 11. These internet sites contain the largest amount of information in one place, but reports can be found also from various other sources. Annual reports (

Table 12) of NAMCOR, NamPower and ECB also provide useful information about main activities during a year. These were not reported in the literature review.

[10] At the time this report was written in July 2013.

Table 11. Main online data sources utilised for literature review

Organisation	Internet site
Ministry of Mines and Energy	http://www.mme.gov.na/energy/renewable.htm
Renewable Energy and Energy Efficiency Institute (REEEI)	http://www.reeei.org.na/downloads.php http://www.reeei.org.na/projects.php
ECB	http://www.ecb.org.na/
Desert Research Foundation of Namibia	http://www.drfn.org.na/publications/reports/

Table 12. Useful annual reports

Organisation	Internet site
NamPower	http://www.nampower.com.na/pages/annual-report.asp
NAMCOR	http://www.NAMCOR.com.na/tags/annual-reports
ECB	http://www.ecb.org.na/?page_id=321

4.1 National documents

The White Paper on Energy Policy (1998) presents an extensive and all-around description of the Namibian energy sector, although being 15 years old some of the information is outdated. However, it is emblematic that many of the challenges remain the same today. The White Paper presents many initiatives that have led to concrete actions, e.g. the establishment of institutional and planning framework took form as founding of REEEI, the creation and resourcing of Electricity Board led to the founding of ECB. There are also a lot of issues highlighted for further study, e.g. the topic of rural electrification that have produced studies, plans and actual implementation since 1998. Many other similar examples exist and the White Paper can be considered successful in steering the development of the energy sector in general. However, the White Paper contains so many proposals that a systematic prioritisation of them would definitely have been necessary. Due to the lack of prioritisation, some important topics such as availability of transparent information in form of official and public statistics describing the key numbers on the energy system is still not available. Starting point for this task of creating such a system for Namibia is given in the Chapter 2.

In addition, the White Paper does not give concrete or quantified future forecasts on the development of the energy system. The forecasts are mainly presented as verbal descriptions and very few numbers are given on future estimates. This can be seen from the policy statements which are very general in nature and not many clear targets are set or rationalised. For example, the mining and manufacturing industry, essential for the development of the energy sector, is only described in the White Paper as “productive sector of the economy” and not profiled in much detail. Another topic worth mentioning is the renewable energy sources, which are discussed, and the objective of studying possibilities and promoting utilisation is stated. However, the resources are not described in detail, the

potential of each renewable source of energy is not calculated or evaluated, and no clear targets are set. The setting of more concrete and quantified targets to the energy sector should be done in the policy update, and the energy system modelling concept presented in Chapter 3 can provide tools, means and a solution for this task.

While not specifically focused on energy sector, the Vision 2030 document contains a framework description for long term national development and current National Development Plan III with more actual and practical depiction of development. It also provides important background information to be taken into account in the context of energy policy development. Ideally, the two processes would support each other, as an efficient and reliable energy system is a key element in development of any nation.

Table 13. General policy documents related to the Namibian energy sector.

Title	Reference	Description
GENERAL POLICY		
National Integrated Resource Plan (NIRP)	MME, Hatch 2011-2013	The objective of National Integrated Resource Plan is to identify the resources providing for the energy needs of Namibia in short and long term for the lowest reasonable cost. It is mostly focused on electricity supply, but also takes into account other energy sources when they have an effect on the electricity demand, e.g. DSM measures or when substituting electricity consumption with an alternative energy source. Report contains an extensive description of the electricity system in Namibia and the possible future developments and it consists of four separately documented tasks, the last completed in June 2013.
National development plan III (NDP3)	National Planning Commission 2008	National development plans monitor and plan the implementation of the development objectives of the nation in five year intervals. Starting from NDP3, Vision 2030 has provided a long term perspective as a basis for the plan creating a strong link between the two addressing a clear shortcoming of the previous development plans that focused more on immediate needs rather than on long term development of the nation as a whole. In the coming NDP4 more prioritising will be made in order to achieve more significant impact and results.
Electricity Act, 2007	Parliament of the Republic of Namibia, MME 2007	The objective of the Act was to establish the Electricity Control Board and provide for its powers and functions, as the electricity industry regulator, and provide for the requirements and conditions for obtaining licences for the provision of electricity, to provide for the powers and obligations of licencees, and to provide for incidental matters.
Vision 2030	Government of the Republic of Namibia 2004	Vision 2030 document describes a policy framework for long term national development with many important cross-cutting issues highlighted that need to be considered also in the development of the energy sector. The most important of these are good governance, sustainable development, economic growth and the environment.
White Paper on Energy Policy	MME 1998	White Paper of Energy Policy remains the effective policy declaration for the nation. The paper is based on the framework of goals effective governance, security of supply, social upliftment, investment and growth, economic competitiveness and efficiency and sustainability. Policy statements are made on energy demand and supply as well as important cross-cutting issues. In addition to the statements of a more general nature, the document puts forward a number of initiatives that have been addressed during the last 15 years and thus served the purpose of directing the development of the energy sector in Namibia.

National Integrated Resource Plan (NIRP) gives an up-to-date and accurate description of the electricity system of Namibia. It also contains information on other sources of energy and energy related measures when they have an impact on the electricity production or consumption in the country. The Plan provides a systematic and thorough approach to meeting the challenges in coming years and solidifies the status of ECB as the leading energy authority in Namibia. It provides information on the current situation of the energy sector, but far more importantly presents the options for future development of the system. Consisting or four separate reports, NIRP provides clearly the most extensive and factual compilation of information concerning the important electricity sector.

4.2 Energy system

The energy system, especially the electricity sector has been a topic in number of studies. Most include technical and economical discussion and some also take into account the policy and regulative framework in place.

Table 14 below lists and describes the studies, papers or reviews on specific subjects. Two documents should be highlighted; Review of electricity policy in Namibia and Energy policy scenarios from present to year 2050. First provides a cross section of the Namibian electricity sector with interesting insight from leading Namibian players, and second provides a set of reasonable scenarios concerning possible paths of development for the energy system.

Table 14. Documents related to the development of the Namibian energy system.

ENERGY SYSTEM		
Development of an Electricity Support Mechanism for Namibia, Report 1: Rationale and Options[11]	ECB, EMCON 2013	The report presents the rational for the electricity support mechanism in Namibia, and identifies approaches to enhance access and affordability of electricity for low-income consumers. It is the first of several outputs of an in-depth study commissioned by the ECB aiming to devise a national support mechanism that benefits low-income electricity users.
Review of Net Metering Practices - Final Report	ECB, CAMCO 2013	A project was launched to assess the application of net metering and developing net metering rules for rooftop and inverter based solar photovoltaic (PV) and micro wind energy converters, based on recent studies within Namibia that indicate the potential role that small-scale renewable energy technologies could play with regard to Namibia's power supply. Net metering has become a policy option to support the use of renewable energy technologies and incentivise increased distributed generation. Net metering is generally a renewable energy incentive that is consumer based and as such the size of systems installed is usually small with a general size limit of less than 1 MW.
Review of electricity policy planning in Namibia	Ndhlukula 2009	The paper provides a review of the actions in Namibian energy sector and a review of the political situation.
Planning Power: Review of electricity policy in Namibia	Institute for Public Policy Research 2009	The document contains a review of the electricity policy and general situation in the Namibian electricity sector. It includes analyses by electricity sector experts and interviews with leading players in the electricity industry of the nation.
Electricity Supply and Demand Management Options for Namibia. A Technical and	EMCON Consulting Group 2008	The study was aimed to determine whether Namibia can meet its electricity demands, to identify generation and demand management options within the context of the White Paper, and to determine the role that renewable resources could

[11] Available on request from ECB.

Economic Evaluation.		play. Eight different electricity generation scenarios were studied.
Energy policy scenarios for Namibia from present time to year 2050	Consulting Services Africa 2007	This study is part of a larger international project initiated by the World Energy Council (WEC). It presents the envisaged impact that the four WEC's energy policy scenarios would have on the Namibian economy and its energy sector. Particular attention is paid to the availability, accessibility, and acceptability of energy resources. The four scenarios are defined by two variables: the level of engagement by the Namibian government, and the level of co-operation between Namibia and regional and international governments and organisations. In addition, the climate change mitigation possibilities by government and the private sector are studied. The project included a study of the following eight speciality areas within the energy sector: Non-electrical stationary end-use technologies, Electrical stationary end-use technologies, Mobility technologies, Electricity generation, Energy supply systems, Energy price drivers, Investment and funding in the energy sector, Climate change.
An empirical analysis of energy demand in Namibia	De Vita et al. 2006	Unique database of end-user local energy data and the Autoregressive Distributed Lag (ARDL) bounds testing approach to co-integration are used for estimating the long-run elasticities of the Namibian energy demand function at both aggregated level and by type of energy (electricity, petrol and diesel) for the period 1980-2002.

4.2.1 Petroleum sector

A limited amount of public (online) data is found related to the Namibian petroleum sector. However, the internet site of the MME provides a presentation of the petroleum upstream and downstream activities[12]. Currently, the upstream and downstream activities within the Ministry have been combined into a new Directorate called Petroleum Affairs. More information can be also found from the annual reports of NAMCOR and oil companies.

Concerning the downstream activities, White Paper on Energy policy states that Namibia is indeed depended on imports as many other nations. This creates a security of supply issue that can be alleviated through diversifying the supply. Currently, the Private Oil Companies are bringing into the country 100% importation of petroleum products. The role of affordable fuels is seen as a necessary factor for economic growth. Due to the vast distances between economic centres in Namibia, a strong dependence on transport fuels exists.

There is the National Energy Fund (NEF) which was established or governed by the Petroleum Products and Energy Act 1990 and as amended in 1994, 2003, and 2004. Its main responsibility is the price equalisation of petroleum products in Namibia. NEF received its income from levies on fuel price on a monthly basis. NEF is also responsible for the road subsidy for transporters delivering fuel to far outlying rural areas. The objective of price adjustments is to adjust the price in such a manner that the monthly unit over/under recoveries incurred during the previous month are cleared and that the Namibian Dollar value of the cumulative 'Slate' balances at the end of the previous month are kept within the predetermined level.

The Government of the Republic of Namibia invites international oil companies to apply for petroleum exploration licenses in Namibia, under the Open Licensing System which was adopted in 1999. Companies can now apply at any time for acreage.

[12] http://www.mme.gov.na/energy/fuels.htm and http://www.mme.gov.na/energy/upstream.htm

Exploration profile has increased and we now have a total of 50 licences issued to local and international oil companies. Oil and gas explorations work is continues with international exploration companies still showing interest in Namibia. National oil company (NAMCOR) and local companies team up with international companies to search for oil and gas in Namibia. 25 wells were drilled in offshore Namibia. The total quantity of 2D seismic data of 123509 kilometres and the quantity of 3D seismic data of 27792 square kilometres have been acquired so far.

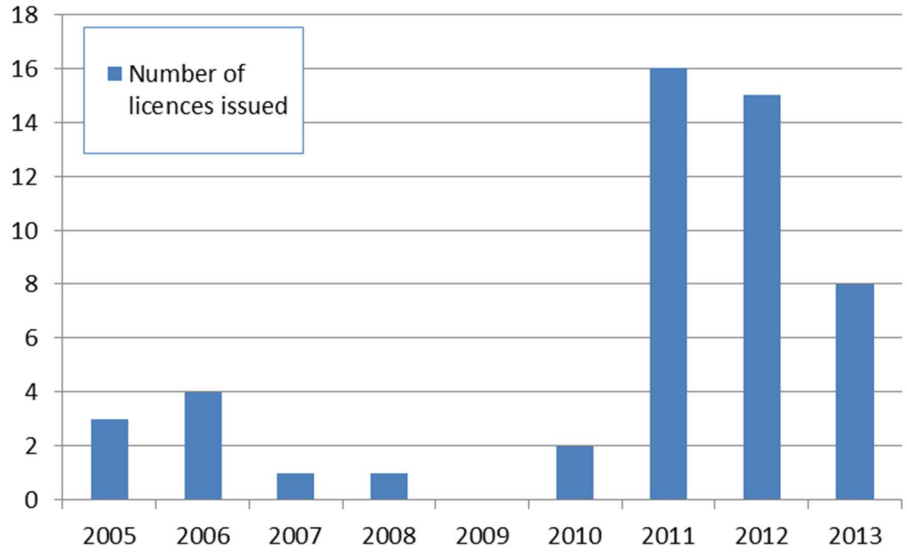

Figure 19. Number of licences issued through an Open Licensing Regime (NAMCOR 2013)

Table 15. Documents related to the development of the petroleum sector.

PETROLEUM SECTOR		
Future Perspective of Oil & Gas Exploration in Namibia[13]	NAMCOR 2013 (Manfriedt Muundjua)	A conference presentation on the current developments of the oil licencing and exploration activities in Namibia. An update of the Kudu project.

4.2.2 Major projects

Both Kudu gas to power and Baynes hydro power can certainly be considered as major projects due to the large production capacities planned and their significant effect on the electricity supply balance of Namibia. While the plans for hydro power in Baynes include a reservoir, the production capacity will still include seasonal variations whereas Kudu gas on will operate as a base load power plant for the country most of the year.

Baynes hydro power is a bilateral project between Governments of Angola and Namibia with currently on-going negotiations. In order to support decision making, both an environmental and social impact assessment and a techno-economical study are carried out. The final investment decision is yet to be made, but it has been estimated that Baynes could be online in 2018.

On the Kudu gas to power project, a significant step was made in March 2013 when the national utility company NamPower and upstream parties signed a Project Development Agreement, to ensure that each aspect proceeds through engineering and design to a Final

[13] Available on request (Manfriedt Muundjua, NAMCOR)

Investment Decision (FID) in a defined and coordinated manner. All parties are not target to make FID by mid-2014.

The upstream development concept envisages horizontal subsea wells being tied back to a Floating Production System ("FPS"), for processing of the gas to the required specification for pipeline export to KPS. Front-End Engineering & Design ("FEED") studies are underway, expected to be completed early 2014. Simultaneously, NamPower is in the process of securing an Engineering, Procurement and Construction ("EPC") contract for KPS, and appointing a coordinating bank to help raise their project finance.

Although estimations and evaluations of both projects are present in many studies, not many public documents are currently available dedicated to the projects. The Table 16 includes a link to the official NamPower web pages as an information source, independent evaluation of the Kudu project and web link to ERM pages with information and documents related to the environmental and social impact assessment.

Table 16. Major projects in the Namibian energy sector.

MAJOR PROJECTS		
Kudu Gas to Power Project	NamPower 2013	NamPower as the national utility of Namibia and the key stakeholder in Kudu Gas to Power Project publishes the current status of this nationally significant undertaking. Although a topic present in a number of studies done during part years, the most up-to-date information should be available from NamPower now that the project is gaining momentum for real.
The Kudu gas field offshore Namibia – a viable project or just stranded gas?	CEPMLP Annual Review (Beukes) 2012	A paper investigating the reasons for Kudu project not being realised at this point despite of the economic benefits for Namibia. Options for the implementation are discussed and viability of the project in general is evaluated.
Baynes Hydro Power Project Environmental and Social Impact Assessment (ESIA)	Environmental Resources Management (ERM) 2013	In support of decision making by both Namibian and Angolan governments concerning the Baynes hydro power project, an environmental and social impact assessment is done by ERM. The results of the study in parallel to techno-economic investigation by a Brazilian consortium of engineers will be utilised in making of the final investment decision on the implementation of the project.

4.2.3 Electrification

Electrification and especially rural electrification are long term targets for Namibia. The White Paper pays special attention to the topic as electrification is seen as nationally important objective and has potential to become the driving force behind economic development. It is also identified that as Namibia is a vast, sparsely populated country, many rural areas will never be connected to the national grid due to high costs associated in required investment and maintenance. Policy states that while electrification effort will continue through grid extension where economically viable, renewable energy based solutions to provide electricity access will be made available for more remote off-grid areas as well. A target of increasing rural electrification from about 9 % in 1998 to 25 % by year 2010 was set in the White Paper, and recommendation towards the founding of a dedicated electrification fund to address the financial challenges of rural electrification were made. Currently, funding is provided within MME budget and supplemented by the electricity levy.

Between 1990 and 2000, rural electrification was carried out under National Rural Electrification Programme (NREP) after which Rural Electrification Distribution Master Plan (REDMP) was completed in 2000, supplemented in 2005 to steer the effort and updated in 2010. In this master plan the off-grid areas where grid connection was evaluated to be

economically unfeasible in foreseeable future were identified. Securing electricity supply for these areas was planned in the Off-grid Energisation Master Plan (OGEMP) for Namibia. This plan introduces a concept of energy shops; locations were information and equipment is available, not just concerning electricity, but other energy solutions such as efficient wood stoves as well. The shops are established both in rural and urban areas with exact locations planned carefully according to population and household density in order to maximise the benefit and offer the services to as large groups of people as possible in each region of Namibia. The network of the energy shops has been expanded yearly. Currently there are 13 energy shops and a 20 year plan is to have 180 shops in total. The rural electrification effort is overseen and coordinated by the MME.

According to the International Energy Agency World Energy Outlook electricity access in 2010 was 23 % for rural – a close achievement of the white paper's target – and 78 % for urban areas. The total electrification rate in Namibia was 44 %. These figures are consistent with the Income and Expenditure Survey of 2012 (NPC).

Table 17. Documents related to electrification and electricity supply in Namibia.

ELECTRIFICATION AND ELECTRICITY SUPPLY		
Rural Electricity Distribution Master Plan for Namibia[14]	MME, EMCON 2010	The Rural Electricity Distribution Master Plan (REDMP) for Namibia was originally introduced in 2000, and was conceptualised and developed as part of the Government's policy agenda to guide the social upliftment of especially poor, rural communities and economic development of the nation. It is reviewed and updated every 5 years. The latest iteration of the master plan is the 2010 REDMP, which aims to: establish the status quo with regards to the planned versus achieved electrification of rural communities from 2005 up until 2010, to establish rural electrification targets and priorities for the next 20 years, and to establish a structured methodology and approach to derive a rural electrification master plan for achieving the 20-year targets. The scope of this Master Plan is restricted to grid electrification only, thus complimenting the Off-grid Energisation Plan.
Guidelines for the establishment of Energy Shops in Namibia	Desert Research Foundation of Namibia (DRFN Energy Desk) 2008	The guidelines are supporting the implementation of the Off-grid Energisation Master Plan for Namibia by providing guidelines for launching and maintaining a national roll-out programme of Energy Shops. A work plan and cost estimates are provided.
Off-grid energisation master plan for Namibia (OGEMP)	Consulting Service Africa 2007	The aim of the OGEMP is to provide access to appropriate energy technologies to everyone living or working in off-grid, pre-grid and "grey" areas. The plan proposes the establishment of Energy Shops and recommends a broad range of energy technologies and appliances to be sold through energy shops. Also a credit finance system provided via an OGEMP revolving fund is proposed. The study presents cost estimates and a plan for the establishment of the Energy Shops.
Rural Electrification Master Plan	EMCON Consulting Group 2000	Short description of the main electrification master plan project by EMCON Consulting Group.

4.3 Renewable energy

Already in the White Paper (1998), the significant renewable energy resources in Namibia were recognised, but also a gap was identified between the renewable resources and their

[14] Available on request from MME.

exploitation. This gap existed due to several reasons, such as the novelty of renewable energy sector, lack of an adequate institutional framework and energy planning, constrains in human resources and public awareness. Also the need for life-cycle costing of renewable energy technologies was identified. Consequently, the White Paper (1998) set several goals for promoting the production and use of renewable energy in Namibia, such as establishment of an adequate institutional and planning framework, development of human resources and public awareness, creation of suitable financing systems, improving access to renewable energy sources, particularly in rural electrification, rural water supply and solar housing and water heating.

Since the publication of the White Paper, several projects and programmes related to renewable energy have been initiated and conducted in co-operation with the government, private sector and development organisations. The first development programme for renewable energy in Namibia started already before the launch of White Paper, in 1996, when the Government launched the first solar revolving fund under the Home Power Project with support from Renewable Energy for African Development (REFAD), a US-based development organization. This programme granted loans to interested rural households for the purchase of photovoltaic solar home systems, and was the first attempt to address the financing barriers associated with renewable energy technologies. The following big programme was the Namibia Renewable Energy Programme (NAMREP) supported by the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP). During this programme several studies were made in order to identify the barriers to solar technology in Namibia, and to give recommendations related to capacity building, institutions and policy, public awareness, and financial and technical questions. (Ndhlukula 2009)

Another important achievement of the NAMREP was the publication of the “Strategic action plan for the implementation of renewable energy policies as outlined in the Namibian White Paper” in 2006. The Strategic action plan listed the main development objectives for the renewable energy sector in Namibia (Table 18). The objectives have been successful in steering the operation of REEEI. Strategic aims, policy statements and recommended activities were listed for all the development objectives. The action plan also identified wide lists of technical studies, actions and improvements necessary to be conducted regarding the renewable energy, electrification and capacity building needs in Namibia. Many of the actions proposed within NAMREP have also been implemented in practice.

Table 18. Strategic Action Plan Development Objectives, loosely prioritised (NAMREP 2006).

Priority	Development objective
1	Enhanced capacity of the renewable energy and energy efficiency sector
2	Improved renewable energy and energy efficiency knowledge base
3	Broadened awareness of renewable energy and energy efficiency
4	Equal playing field for renewable energy
5	Improved financial mechanisms for renewable energy technologies
6	Improved security of energy supply
7	Enhanced institutional coordination and integration
8	Improved access to energy
9	Sustainable development

The first objective of the action plan was to establish the Renewable Energy and Energy Efficiency Institute (REEEI) in order to increase the institutional and human resources capacity within the renewable energy sector, to conduct research and promote renewable energy and energy efficiency. This objective was achieved in 2006, when REEEI was established with cooperation agreement between the Polytechnic of Namibia and the Ministry of Mines and Energy (MME). After its establishment, REEEI took responsibility of some of

the actions from the Strategic action plan. At the moment, several studies and actions listed in the action plan have been accomplished and put into action, but there are still propositions, that have not been implemented. An updated version of the Action plan could still serve as a good basis for the development of the renewable sector in Namibia, and would be a good starting point for the formulation of Namibia's renewable energy policy.

The literature review pointed out that during the last years several projects and studies related to the renewable energy sector have been conducted in Namibia. The projects related to solar energy, wind power and bioenergy, and the current situation of the sector are discussed more in detail in the following chapters 4.3.1 - 4.3.5. Table 19 presents the literature found concerning the renewable energy sector in general.

In Namibia, hydro power is often not mentioned when talking about the renewable energy sector even though hydro power is classified as a renewable energy source. The fact is that basically all electricity produced within the country comes from Ruacana hydro power plant making the Namibian electricity production almost 100 % renewable. However, here the discussion focuses on the other potential forms of the renewable energy in Namibia.

Table 19. General studies on renewable energy sector in Namibia.

RENEWABLE ENERGY		
Renewable energy feed-in tariff (REFIT) for Namibia	ECB, Nexant, Inc. 2013	The scope of the study is to propose Renewable Energy Feed-in Tariffs (REFITs) along with associated Regulations that would create an environment conducive to mobilizing Independent Private Producers (IPPs) and their investors into Namibia's electricity sector.
Namibia's energy future - A case for renewables	VO Consulting, Konrad Adenauer Stiftung (KAS) 2012	The study is an overview of the different aspects of Namibia's energy future, especially electricity sector, and of the role that renewable energies as well as energy efficiency measures could play. The study aims to contribute to the political and business decision making, and to the discussion of media, planners, environmentalists, scientists and the population at large.
Renewable Energy transition for a sustainable future in Namibia	Le Fol 2012	The Master Thesis analyses the Namibian energy system at both the institutional and technological levels in order to understand which policy framework could sustain a renewable energy transition. The Multi-level Perspective is used to examine thoroughly the Namibian energy regime and recommend energy policy. In addition, different degree of renewable integration and institutional changes are tested with a long term energy scenario analysis simulated with LEAP. The thesis shows that high renewable energy deployment powers a sustainable future in Namibia.
Development of procurement mechanisms for renewable energy resources in Namibia[15]	REEEI, ECB 2010	This report provides background and introductory information on Namibia's Electricity Supply Industry covering the important players and applicable rules and regulations; gives recommendations of the instruments and regulatory framework that Namibia must adopt to promote; and gives an overview over the specific costs of different renewable energy technologies (RETs).
Renewable energy development in the Namibian context	Elombo et al. 2010	The current electricity situation in Namibia is discussed. Capacity expansion of electricity generation is needed in order to meet the country's increasing electricity needs. A discussion of the efforts made by the Namibian national power utility, NamPower and the country's government are presented, followed by an abbreviated review of on-going wind energy projects in the country

[15] Available on request from ECB.

Renewable energy baseline survey (REECAP)	Desert Research Foundation of Namibia 2008	The report presents a baseline survey of renewable energy use in select localities Namibian rural and peri-urban households conducted in June and July 2007. The study also assessed the most prevalent energy sources used, the monthly expenditure incurred, and gathered data on the most common services used by un-electrified households, and the associated costs for these services.
Energy-related Impacts of Climate Change in Rural Namibian Households	Bradley-Cook 2008	The report identifies the most likely energy-related impacts of climate change in rural Namibian households. It also synthesizes the most recent climate projections for Namibia with information and previous research about energy and energy services in the context of rural households and livelihoods. The climate change impacts on each energy use are highlighted and presented with a range of adaptation measures and strategies that would minimize the impact of these measures.
Development of a regulatory framework for renewable energy and energy efficiency within the electricity sector	Consulting Service Africa 2007	The primary objective of the project is to recommend the essential elements of a regulatory framework for renewable energy and energy efficiency in Namibia. General recommendations with implementation plans (three legal acts and a number of different regulations) are proposed.
Namibia energy review for the UNFCCC	Capôco et al. 2007	The main components of the energy review are: Assessment of the costs and benefits of fuel switching for motor vehicles, facilitation of the adoption of alternative energy technology, potential for building local entrepreneurship for CDM projects, investigation of the potential for incorporation of more efficient lighting and energy use technologies in public and private buildings, afforestation and agro-forestry in relation to climate change.
Strategic Action Plan for the implementation of renewable energy policies as outlined in the Namibian white paper on energy policy	NAMREP 2006	The Renewable Energy Strategic Action Plan was developed based on the policy statements of the White Paper on Energy Policy (1998). The action plan reports the sector's policy and mission statements, the formulated objectives, and the developing strategies and specific actions to achieve the objectives.

4.3.1 Solar energy

The significant solar resources in Namibia were highlighted in the White Paper (1998). The potential of solar energy to contribute to basic electricity services in remote areas, such as water pumping, water desalination and electricity generation was stated, and the solar energy was hoped to contribute to the goal of social upliftment. Decentralised options for rural electrification were also seen as a possibility to cheaper solutions compared to extension of the grid over long distances, and they were hoped to improve the security of supply. However, it was stated that the resources were virtually unused and not even solar water heating was in use. The policy paper highlighted the need for feasibility studies, and measurements of solar resources. The White Paper presented two direct policy statements related to solar energy:

- *"Government will promote the use of photovoltaic pumps and solar stills to supply water of sufficient quality and quantity for human consumption in off-grid areas, where this is appropriate and cost-effective."*

- *"As government believes that solar water heating can make an important contribution to rational use of energy in Namibia, it will analyse the economic savings which can*

be attained through wider use of solar water heaters and develop appropriate promotion strategies."

As mentioned earlier, the studies on solar energy in Namibia started already before the launch of the White Paper. Later, in the NAMREP programme several studies were conducted, for example a baseline study for "Barrier Removal to Namibian Renewable Energy Program" (Consulting Service Africa 2005), and an "Assessment of duties and taxes" (Price Waterhouse Cooper 2005) related to solar technology in Namibia. Also the cost efficiency of the solar water heaters was studied in the "Assessment of feasibility for the replacement of electrical water heaters with solar water heaters" and the policy target for applying the life cycle costing method were partly met by creating the "Comparative Solar Water Heater Life Cycle Costing Tool for Namibia" (by Emcon Consulting Group 2005).

Recently the studies on solar energy have focused on the concentrating solar power (CSP) technology. A study called "Pre-feasibility study for the establishment of a pre-commercial concentrated solar power plant in Namibia" was done to support the establishment of a CSP plant in Namibia (REEEI, GESTO 2012). The study includes an assessment of the solar resources, and proposes five potential sites for the plant: Ausnek, Kokerboom, Hochland, Skorpion and Gerus. Also, the possibility to use hybrid systems, e.g. combining the Kudu gas power plant with the CSP technology to provide the required base-load station for Namibia, has been discussed. In addition, a project called Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN) focusing on solar thermal systems was launched in 2009, and aims to provide training of solar thermal technology service providers, establishing a solar thermal technology platform for Namibia, and the SADC region, and flag ship demonstration systems in chosen regions of respective countries. The Programme runs in four countries: South Africa, Mozambique, Zimbabwe, and Namibia where it is managed by REEEI.

Despite the large amount of studies conducted, no big scale investments on solar power plants connected to grid have yet been realised. However, development towards increased use of off-gird solar energy has taken place. For example, the Solar Revolving Fund (SRF) was launched in 2006, and administered by private companies, and re-launched in 2011 under the management of the MME Renewable Energy section. The SRF is a credit facility established and administered by MME to stimulate demand for the utilization of solar energy technologies in the rural areas, especially for communities living in off-grid areas, but also to urban clients. The SRF is an element of the Off-Grid Energisation Master Plan for Namibia (OGEMP) whose objective is to provide access to appropriate energy technologies to rural areas. The loans can be applied for installing applications such as solar water pumps, solar home system, solar water heaters, and solar cookers/stoves. The access to renewable energy technologies and solar energy systems is also improved by the establishment of Energy shops. The Energy shops are located in different regions and their primary function is to stock and sell suitable and approved energy products and compatible appliances. The shops also provide information on the financing mechanisms. The first energy shop was launched at 2011, in Mariental, in the Hardap Region. In addition, the use of solar water heating has been increasing and there is a Cabinet directive that requires that for all new public buildings, and existing public buildings without water heaters the hot water requirement should be met through solar water heaters, and any existing public buildings with electric geysers should replace them with solar water heaters[16] if maintenance requires new geysers. Figure 20 shows the growth of installed solar technologies from 2004 to 2010 (data from REEEI).

[16] http://solarthermalworld.org/content/namibia-solar-water-heaters-mandatory-public-buildings [Accessed: 9.7.2013]

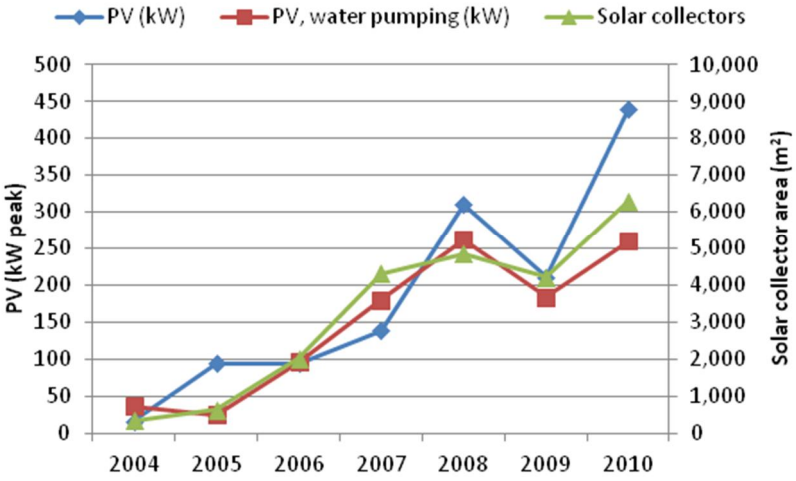

Figure 20. Annually installed PV, PV for water pumping capacity and solar collector area (data from REEEI).

The Tsumkwe Energy project in the remote area of Tsumkwe (Otjozondjupa Region) seems to remain the only pilot off-grid minigrid project with hybrid system including diesel electricity generators and 200 kW solar PV, with 1500-2000 kWh battery storage capacity and 11kV mini-grid. It provides electricity to the public institutions (school, clinic and police station) and households. However, the Tsumkwe project relies mainly on foreign aids (70%), its business viability has not been proven yet, and currently there is no political incentive to this type of approach (Le Fol 2012).

The interest of independent power producers (IPPs) on solar energy production has been rising. The ECB has granted licences for thirteen (13) solar plants (PV) at different sites in the country. The first project is expected to be in service by January 2014. In the ECB annual report of 2012 (ECB 2012) they reported on several licences applied for installing solar energy systems or hybrid systems. The conditional licences were granted for PV installations of 10-30 MW at several locations. NamPower is negotiating with the IPPs, and states, that some of the potential IPPs are not ready to accept the political risks related to the investments, such as change of law or de-linking of the Namibian dollar from the South African Rand (NamPower 2013).

Currently the ECB is responsible for the introduction of IPPs into the Namibian energy sector and clear investment framework with instructions and templates for is available at ECB website[17]. Also the Namibian legislation concerning IPPs and new energy technologies is under development. A list of licences given to IPPs can be found from Appendix I (containing also other than solar energy projects).

[17] http://www.ecb.org.na/?page_id=321

Table 20. Documents related to solar energy in Namibia.

Title	Reference	Description
SOLAR ENERGY		
Pre- feasibility study for the establishment of a pre- commercial concentrated solar power plant in Namibia	REEEI, GESTO Energy Consulting et al. 2012	The pre-feasibility study was done for the establishment of a pre-commercial solar power plant in Namibia. Several points were studied: overview of the Namibian energy sector, assessment of the solar resources, site selection and environmental analysis (top 5 sites chosen), CSP technology review, plant layout and basic engineering for the sites, the role of CSP in the Namibian energy sector.
Irradiation measurements on ground (A presentation)	CSP Services 2012	Guidelines for making irradiation measurements.
Guidelines for Procurement, Calibration and Installation of Meteorological Stations	CSP Services 2012	Guidelines for making irradiation measurements, details on the equipment and procedure.
Lights on the Horizon: A Socioeconomic Impact Evaluation of Rural Electrification in Tsumkwe, Namibia	Ashton et al. 2012	The report presents a socioeconomic impact evaluation of the Tsumkwe Energy Project, which implemented the largest solar diesel hybrid system in southern Africa and is a pilot study for developing future rural electrification projects. The report presents a set of recommendations, opportunities, and lessons learnt for the future development of Tsumkwe.
SOLTRAIN II Project Document	Austrian Development Agency 2012	The project document for the SOLTRAIN II Project (2012-2016), following the SOLTRAIN project (2009-2012) presents the goal to contribute to the switch from a fossil fuel based energy supply to a sustainable energy supply system based on renewable energies. The technical focus of the project is on solar thermal systems, and the project includes awareness campaigns, implementation of Centres of Competence for solar thermal applications and Solar Thermal Technology Platforms at educational institutions as well as extensive training courses ranging from practical hands-on training to University level courses. In order to increase the awareness on different applications of solar thermal technologies, flag ship demonstration systems will be installed.
Concentrating Solar Power Technology Transfer for Electricity Generation in Namibia (CSP TT) NAM (A project proposal)	GEF (Global environmental facility) 2011	The proposed project aims to increase the share of renewable energies in the Namibian energy mix by developing the necessary technological framework and conditions for the successful transfer and deployment of CSP technology for on-grid power generation, thereby reducing greenhouse gas emissions. The final aim is to get debt financing from banks for the construction of Namibia's first 50 MW CSP plant.
Simulation of solar radiation components and daily optimum slopes in the coastal and continental areas of some SADC countries (abstract)	Monowe & Nijegorodov 2010	The solar radiation conditions are studied in Namibia (4 synoptic stations), South Africa (5 synoptic stations), Mozambique (21 synoptic stations) and Botswana (9 synoptic stations). It is concluded that continental areas are more convenient for utilisation of solar energy using solar devices with concentrators (middle-temperature and high-temperature Rankine cycles), while at coastal areas flat-plate collectors and PV-arrays are preferable. It is found out that the range of optimum slopes for SADC countries studied is from +30° to -62°.
Tsumkwe Energy Fact Sheet	Desert Research Foundation of Namibia 2008	The fact sheet presents shortly the Tsumkwe Energy project in Tsumkwe, Namibia with hybrid system of diesel electricity generators and 100-150 kWp solar PV, with 1500-2000 kWh battery storage capacity and 11kV mini-grid.

First Cost Reduction Strategies for renewable energy products and services	SK Holdings (PTY) Ltd 2006	The study presents a strategy and action plan for the economical sourcing of Renewable Energy Technology products. The strategy discusses on topics, such as: market regulation, empowerment of technicians, revision of Solar Revolving Fund repayment terms, tax exemption of all solar-related products, establishment of a manufacturing plant, augmentation of public awareness, decentralisation of the administrative functions of the Solar Revolving Fund, decentralisation of stock availability.
Code of Practice and Register of Products for Namibian Solar Energy Technologies	Emcon Consulting Group and Tinda ESI Consultants cc 2006	The report presents a consultancy for the establishment of a Register of Recommended Products and for the drafting /adoption of Codes of Practice. Both tasks address three Solar Energy Technology (SET) areas, being Solar Home Systems (SHS), Solar PV Water Pumping Systems (PVP) and Solar Water Heaters (SWH).
RET-projects coordination framework amongst public institutions	Consulting Service Africa 2006	The project was launched after visiting several buildings operated by line Ministries (schools, hostels, clinics, etc.) that were located in off-grid areas and have solar energy technology (SET) installations. The PMU noted that approximately 60% of those installations were not operating for one reason or another. Based on these alarming findings, the PMU identified the need for new and improved SET project co-ordination mechanisms amongst public institutions. Fourteen recommendations were presented, related to awareness rising, life cycle costing, standardisation, maintenance and capacity building.
Sustainable Energy Supply in your Hands	Consulting Service Africa 2005	The booklet promotes sustainable energy supply and energy efficiency for Namibia. Its presents the most common solar energy technologies: solar water pump, solar home system, solar water heater, and solar cooker.
Assessment of feasibility for the replacement of electrical water heaters with solar water heaters	Emcon Consulting Group 2005	The study represents a review of the solar water heater (SWH) industry in Namibia, and its development since the studies done in 1999. The main barriers to an increased uptake in SWH technology are still financial (high capital cost with low electricity tariffs) coupled with a lack of awareness. Indications are that users of SWH are generally very satisfied with the technology. The study gives further recommendations on the quality of the systems, life cycle costing, and on the need of new studies/demonstrations.
Comparative Solar Water Heater Life Cycle Costing Tool for Namibia	Emcon Consulting Group 2005	A life cycle costing (LCC) tool was developed as part of the feasibility assessment project. Example results are reported in the report above. Tool is available to be downloaded.
Baseline Study: Barrier Removal to Namibian Renewable Energy Program (NAMREP)	Consulting Service Africa 2005	The Baseline Study includes demographic information, regional profiles, and identification of key programmes, policies and projects regarding the national energy sector and solar technology. It also identifies the barriers to solar technology in Namibia, and gives recommendations related to capacity building, institutions and policy, public awareness, and financial and technical questions.
UNDP/GEF/MME barrier removal to Namibian renewable energy programme (NAMREP) - Assessment of duties and taxes	Price Waterhouse Cooper 2005	The study gives recommendations on duties and taxes in the renewable energy sector, concerning the solar energy. Instruments such as custom duties, zero-rating of VAT, subsidization policy, tax incentives, and financial assistant of technicians are discussed.

4.3.2 Bioenergy[18]

The White Paper (1998) discusses only on small scale biomass use related to bioenergy. At the time, biomass was the main fuel of rural and peri-urban households, and contributed approximately 10% to Namibia's total net energy consumption. The problem of over exploitation of biomass resources was already recognised, and it was noted that the resources were unevenly distributed. Therefore, the more efficient use of biomass and possibility to transport biomass / charcoal to the areas of need was taken as an objective. The White Paper also indicated the need for a "biomass strategy". The policy statements directly related to bioenergy (biomass use) were:

- *"As a basis for future policy development, government will investigate the feasibility of charcoal production and/or wood transport to areas of need."*
- *"Government will investigate the status and use of biomass in the different regions of Namibia in order to determine which rural people are most affected by woodland depletion, as well as the nature of the problems experienced by rural people. This investigation will form the basis of a national biomass strategy which aims to address the problems experienced by rural people in the different regions."*
- *"Government will promote fuel-efficient cooking technologies in rural areas."*
- *"Government will establish an appropriate inter-Ministerial mechanism to ensure that rural people's wood fuel needs are integrated into the Directorate of Forestry policies and practice, especially with regard to the management and control of forests, as well as to woodlot and commercial, communal and farm forest strategies."*

Also the Strategic action plan (2006) emphasised the need of technical studies related to biomass. It suggested finalising the biomass strategy, using biomass management tool to control biomass resources, and conducting studies on biomass transportation and charcoal production. However, at the moment, no such a document as "Biomass strategy" for Namibia could be found online.

The current situation of the biomass use in Namibian households is not clear, as the CENSUS 2011 data has not yet been published[19]. At the time of CENSUS study in 2001, 70% of Namibians in total and 90% of the rural population used wood or charcoal from wood for cooking. Almost 50% of population used wood or charcoal for heating (when 30% of population did not use heating at all). Since then, the non-renewable cooking paraffins have also been introduced as an energy efficient alternative for wood and wood-based fuels, especially in areas suffering from deforestation.

Since 2001, the charcoal production from wood has been growing significantly in Namibia, and has become an important industrial sector. The estimates of charcoal production quantities vary between 50 000 – 120 000 tonnes per year depending on the source[20]. The charcoal is mainly exported to Europe and South Africa for leisure use, but also used in Namibia. However, it is unclear, if the policy targets to more even distribution of biomass by charcoal transportation have been met. The charcoal industry can be considered to have both positive and negative impacts. At the moment, the charcoal production has become an

[18] *Here bioenergy refers to energy (electricity, heat) or energy sources (e.g. charcoal, biofuel) produced from biomass material.*

[19] http://www.npc.gov.na/npc/census_data.html [Accessed: 10.7.2013]

[20] http://www.namibiansun.com/content/national-news/charcoal-industry-under-fire [Accessed: 10.7.2013]

important economic activity providing work for many people. It also helps to fight the invader bush problem, as the wood material should originate from invader bush clearing. However, there seems to be a lot of problems with labour conditions, as the position of workers is not well defined and the working conditions are very hard (Dieckmann & Muduva 2010). It is also problematic that the workers are being paid per kilogramme or per tonne of wood harvested, which makes the workers to select the thick and massive tree trunks instead of bushes, even though the trees should be protected. Also, the charcoal is often produced in simple steel kilns, so several veld fires have been caused due to charcoal production.

The bush encroachment problem creates possibilities also for larger scale bioenergy production in Namibia. The study made by Leinonen (2007) was the first study on the costs and potential to use invader bush for larger scale energy production in Namibia. The bioenergy production from invader bush was seen as a tool for fighting the bush encroachment problem, as larger scale harvesting of invader bush could deliberate land for farming (Leinonen 2007). More recently, the use of invader bush for larger scale energy production has been promoted in the CBEND (Combating Bush Encroachment for Namibia's Development) pilot project, where the first bush to electricity demonstration plant (250 kW) has been installed. The technology used is wood gasification and the fuel source is a variety of encroacher bush species. The project was funded by the European Union (N$ 14 million), and implemented by Desert Research Foundation of Namibia. It was also the first project to negotiate a Power Purchase Agreement (PPA) with NamPower. Based on this experience, also guidelines for independent power producers to establish themselves in Namibia have been written (Robert Schultz 2011). However, there were problems with the grid connection for the plant due to the low power factor of the connecting line in 2012 (Le Fol 2012).

Figure 21. Invader bush plant (CBEND) in Otavi area.

The manual harvesting of invader bush is problematic and hinders its larger scale use of for energy purposes. Leinonen (2007) proposed and tested a mechanized production chain. Later, in the Energy for Future project (by Energy for Future (Pty) Ltd), the mechanical harvesting has also been tested (Colin Christian & Associates CC Environmental Consultant 2010). The aim of the project was to use invader bush harvesting as a long term option to provide supplementary fuel to the Ohorongo Cement Plant. The Ohorongo plant is fully equipped to replace up to 100% of coal with alternative fuels such as wood chips in its kiln[21]. Some environmental concerns on the mechanical harvesting rose during the project, for

[21] http://www.ohorongo-cement.com/product/process.php [Accessed: 11.7.2013]

example protected plant species can be damaged due to bad visibility during the harvesting the, the animals can be killed, and the soil quality can be affected.

Also other biomass opportunities have been studied in Namibia. The possibilities to produce biogas from reed in the Fish River has been studied (DRFN 2009), and currently two small scale CDM projects on biogas production on land fill and water treatment plant have been launched (UNFCCC 2012). A Roadmap for bio-oil-energy has been done by the Ministry of Agriculture, Water and Forestry (Coetzee 2006). The roadmap proposed the cultivation of jatropha in Caprivi and Kavango regions in Namibia, as it was seen as the most suitable biofuel option. At 2010, a strategic environmental assessment was done and the overall findings indicated that there were significant risks associated with the establishment of a Jatropha based biofuel industry in Namibia, due to the overly optimistic assumptions regarding yield, viability and climate change mitigation potential. At 2011 it was informed that Namibian government had made a decision to stop the planting of large-scale Jatropha plantations for biofuel production in the Kavango and Caprivi regions, due to negative impact on food security and land tenure, loss of access to communal land and low financial viability[22] (theBioenergysite 2011).

Based on the results of the literature review, the development of the larger scale bioenergy concepts has been slow, and instead the smaller scale charcoal production has developed significantly. However, the experiences gained form the CBEND project can serve as a good starting point for the further development of larger scale plants. The case with jatropha cultivation shows the importance of the environmental assessment of the bioenergy projects, in order to avoid unsustainable decisions. The environmental assessment should always be done before implementation of the bioenergy projects, already in the planning phase, as the bioenergy projects can have significant impacts e.g. on land use and access to land, food and feed production, water resources, soil quality, and biodiversity. It would also be very useful to get public information on the biomass resources in Namibia.

Table 21. Documents related to bioenergy in Namibia.

Title	Reference	Description
BIOENERGY		
Clean development mechanism project design document form (cdm-ssc-pdd) - Methane recovery and power generation at the Kupferberg Landfill in Namibia	UNFCCC 2012	The CDM project aims to reduce the GHG emissions emitted at the landfill through methane capture, combustion, and utilisation. The project will be implemented in a phased approach: -Phase 1: The installation and commissioning of a gas extraction and flaring system - Phase 2: The possible installation of a gas-to-electricity generation system, once the total extraction potential has been proven when the flare is operational. Electricity will be generated using an internal combustion engine exported to the municipal 11kV network via a step-up transformer and switchgear.
Clean development mechanism project design document form (cdm-ssc-pdd) - Power generation from biogas in Windhoek, Namibia	UNFCCC 2012	The CDM project aims to reduce greenhouse gas emissions at the Gammams' Water Care Works through methane recovery and renewable electricity and heat generation. It is expected that a total of 245kW of electricity will be generated, and will be used onsite, thereby replacing the electricity that is currently sourced from a predominantly coal-fired grid. The engines are also expected to generate a total of 494 kW of thermal energy to be used to maintain the required temperature in the anaerobic digesters.

[22] http://www.thebioenergysite.com/news/8861/namibia-blocks-biodiesel-jatropha-plantations [Accessed 15.7.2013]

Recirculation of biogas residue to agricultural land in Namibia– Risks and potentials in full utilization of organic waste	Nehrenheim et al. 2011	The study aims at evaluating the potential for some three planned biogas projects in Namibia at early stage, especially regarding the management of the biogas residue. In this processes, a first screening of the potential biogas substrate in the southern part of Namibia (south of Windhoek) was conducted. Moreover, the paper aims to point out the potentials in using organic waste for biogas production and thereafter recycling the nutrient rich residue to the farmland of Namibia.
A forest research strategy for Namibia 2011-2015	Ministry of Agriculture, Water and Forestry 2011	The strategy addresses issues associated with sustainable forest management (SFM), especially the key drivers of deforestation and forest degradation, and core SFM issues such as natural and artificial regeneration (tree planting) of commercially exploited species. Linked to these is also the issue of value-addition to forest products, which is currently performing below its potential.
Guidelines for independent power producers	DRFN, Schultz 2011	The guidelines comprise the core information relevant for an Independent Power Producer (IPP) to establish itself in Namibia. The information has been drawn from experiences gained in the implementation of the CBEND Project from 2007 to 2010 by the DRFN. The information is kept general in order to be applicable to any type of IPP.
Waste Management Report	DRFN, Schultz 2011	The CBEND Waste Management Report investigates the different waste materials produced at the 250 kW wood gasification plant in terms of their possible toxicity, disposal options and alternative use opportunities.
CBEND Project fact sheet	Desert Research Foundation of Namibia (DRFN) 2007-2010	The CBEND proof-of-concept project will procure and install one ~0.25 MW bush-to-electricity power generating plant in northern Namibia. Fuel for the power plant will be derived from harvested invader bush (with emphasis on bush thinning rather than clearing) and electricity produced will be supplied to the national grid. The technology considered is wood gasification.
Strategic environmental assessment (SEA) for biofuel production in the Caprivi and Kavango regions of Namibia	van Zyl & Barbour 2010	The foreign and local investors have shown increased interest in large-scale cultivation of Jatropha for biodiesel production in the north-eastern communal areas of Namibia, so the SEA has been made to evaluate the environmental impacts of cultivations. The overall finding of the SEA indicates that under current conditions there are significant risks associated with the establishment of a Jatropha based biofuel industry in Namibia, specifically large-scale production (areas in excess of 500 ha). These risks are linked to significantly overly optimistic assumptions regarding yield, viability and CDM potential. In addition, the climatic and soil conditions in north-eastern Namibia cannot be regarded as ideal for the establishment of Jatropha. These risks are to some extent reduced by the small-scale homestead model contrasted with larger scale production.
Bioenergy value chains in Namibia: Institutional challenges for rural development and food security	Herrmann & Brüntrup 2010	This paper elaborates on the potentials and risks of bioenergy production in Namibia and the institutions and policies shaping them. Existing and emerging value chains based on the conversion of Jatropha curcas into straight vegetable oil and biodiesel and of woody shrubs (bush) into charcoal, pellets, and woodgas are analysed in terms of their viability and impacts on rural development and food security. Bioenergy value chains can have large positive impacts, but extremely high expectations, unclear land rights, delegated negotiation power, communication infrastructure, long procedures and government anxieties can combine to a politically and socially explosive mix. The paper identifies gaps in the institutional and policy framework and proposes solutions for improvement around the policy areas of food security, agriculture, labour, land, output markets and value chain coordination.

Namibia's Black Gold? – Charcoal Production, Practices and Implications	Dieckmann & Muduva 2010	The aim of the study is to make a contribution to a comprehensive picture on the charcoal industry in Namibia. The special focus lies at an assessment of the status of charcoal workers in order to develop recommendations which aim at more regulation in the industry.
Energy for Future: Bush-to-Fuel Project – Environmental management plan	Colin Christian & Associates CC Environmental Consultant 2010	Energy for Future (Pty) Ltd (EFF), which is part of the Schwenk Group in Germany and Namibia, is offering a service to farmers to cut encroacher bush for use as fuel in the new Ohorongo Cement plant near Otavi. The Environmental Management Plan (EMP) is intended to translate the findings and recommendations of the Environmental Impact Assessment into practical measures that can be implemented on all bush cutting sites.
Energy for Future: Bush-to-Fuel Project – Environmental impact assessment	Colin Christian & Associates CC Environmental Consultant 2010	Energy for Future (EFF) proposed the bush cutting project as a long term option to provide supplementary fuel to the Ohorongo Cement Plant. The EIA process dealt with following topics: review of the available literature, compilation of a legal & policy register by a legal specialist, consultations with the relevant authorities, public participation amongst the affected farm owners, GIS mapping to exclude environmentally sensitive areas, and specialist desktop studies on flora, fauna and birds.
Fuelwood scarcity, energy substitution, and rural livelihoods in Namibia	Palmer & MacGregor 2009	The study discusses on the household fuelwood demand by using data originally collected for Namibia's forest resource accounts and by using a non-separable household model. The substitution between fuelwood collected from open access forest resources, cow dung, and fuelwood purchased from the market are analysed. The households' reactions to economic scarcity and availability of forest stocks are studied.
Biogas Production from Common Reed in Mariental – A pre-feasibility study	Desert Research Foundation of Namibia (DRFN) 2009	The study aims to find ways to utilize reeds in the Fish River near Mariental. These reeds are seen as a major contributor to the decreasing water carrying capacity of the river, and a likely cause of increased risk of flooding. In the study, biogas production is analysed with respect to local conditions. The prospective biogas utilization options are compared to a scenario which follows the current method of spraying and burning, and one of integrated river management without energy production. It is shown how the different scenarios contribute to the aims of the REEDS project.
Wood chip production technology and costs for fuel in Namibia	Leinonen 2007	The technology and economy to use (invader) bush biomass for power production in Namibia is evaluated. The current production costs of bush chips at the power plant are calculated, and the possibilities to mechanize production technology and to decrease the wood chip production costs are discussed. Feasibility studies are done for utilization of wood chips for power generation in 5, 10 and 20 MW electric power plants and for power generation in Van Eck coal fired power plant in Windhoek. Field tests are made at Cheetah Conservation Farm (CCF) in Otjiwarongo region. A new mechanized wood chip production chain is designed.
A national bio-oil-energy roadmap for Namibia	Coetzee 2006	An article compiled by Marina E. Coetzee from the original Roadmap for bio-oil-energy by Kruger, F., Crafford, J., Oliver, G., Roos, C., Engels, S. The article summarizes information form the roadmap on alternative bioenergy pathways, suitable oil crops for Namibia, suitable locations, and production systems. It also summarises the recommendations of the roadmap, recommending the cultivation of Jatropha in Namibia.

4.3.3 Wind power

The White Paper (1998) recognised the potential of wind power, especially in coastal areas. Wind power was also considered suitable for small scale applications as water pumping, desalination and electricity generation in remote areas. The need for mapping of the wind resources was mentioned, but no concrete policy statements were given.

In 2008-2009 the REEEI embarked on a Wind Energy Resource Assessment Project and to date are measuring wind energy data at 11 sites along the west coast and southern part of Namibia, in collaboration with NamPower and MTC. Data is planned to be collected for 5 years.

It seems that there is not much literature or project reports available related to wind energy in Namibia, and that no specific programmes related to wind energy have taken place. Only few public case studies on grid integration of wind energy by Elombo (2010) were found.

There is currently one wind turbine (220 kW) installed in Namibia, which feeds the distribution grid in Erongo Region (Le Fol). Also several stand-alone 1 kW turbines are installed around the country and used for water pumping and electricity generation for farms (WEC 2007). There is currently a single valid licence granted by ECB for a 44 MW wind farm in Lüderitz.

Table 22. Documents related to wind power in Namibia.

Title	Reference	Description
WIND POWER		
Grid integration of wind energy: A case study on a typical sub-transmission network in Namibia	Elombo et al. 2010	A case study on the transient performance of a typical sub-transmission network in Namibia in relation to grid integration of wind energy is presented. The focus is on the relative impact of two wind generator technologies; direct-driven synchronous generator and doubly-fed induction generator. Also the impact of automatic voltage regulation is investigated.
Impacts of grid integration of wind energy in the Namibian power network	Elombo et al. 2010	The impact of grid integration of wind energy in the Namibian context, and the efforts made by the country's power utility, NamPower and the government in order to expand the generation capacity are discussed. A study case of the grid integration of wind energy on a typical sub-transmission network in Namibia is presented.

4.3.4 Current renewable energy installations

Currently, the share of renewable energy (other than hydro power) in the Namibian electricity production and use is negligible despite the policy efforts and several projects accomplished. However, small scale use of biomass is still common. The renewable energy presents around 12% of total energy supply, of which approximately 10% is hydro power and 2-3% bioenergy. Almost 100% of electricity produced in Namibia is produced by hydropower. *Table 23* summarises the current situation of renewable energy installations in Namibia.

Table 23.The known installed renewable energy capacity in Namibia.

Renewable energy source	Current situation
Hydropower	Ruacana 322MW, plans for 600MW Baynes hydropower plant of which 300 MW for Namibia, and for Orange river 100MW project.
Solar energy	6000m^2 of installed solar panels for water heating 450kW of PV, no CSP plants at present although initial studies made.
Hybrid solutions	Tsumkwe Energy project with 200 kW solar PV, 1500-2000 kWh battery storage capacity and 11kV mini-grid.
Bioenergy	CBEND 250 kW bush-to-electricity power plant online, growing charcoal production since 2001, current production 50 000-120 000 tonnes per year (partly for export).
Wind power	A 220 kW wind turbine in the Erongo Region, several 1 kW turbines, three locations selected for wind farms, not yet realised.

4.3.5 Current challenges

Since the publication of the White Paper (1998) a significant amount of studies and projects related to the renewable energy sector has been performed, but the development of the sector has been slow. It seems that the policy targets (e.g. of the White Paper) are often taken to research level, but the implementation of the research results takes place slowly. Several challenges related to the promotion of renewable energy have been identified by different studies. During the project in hand, also the MME identified some of the challenges related to the renewable energy sector:

- Outdated energy policy (White Paper 1998).
    - There is a need for realistic but achievable political targets for renewable energy for next 10-15 years.

- Lack of Capacity
    - Policy making process and enforcement of these policies
    - Research and Development capacity needed
    - Training facilities & training programmes needed
    - Public acceptance and awareness

- Incentives
    - Currently no incentive schemes are in place that can ensure private investment into renewable energy. Policy must come out clearly in what way government will support IPPs. Support such as tax breaks, guarantees etc. are needed.
    - Financing mechanisms for renewable energy technology procurement needs to be redefined. The needs of the rural energy poor are not properly addressed by financial mechanisms in place (SRF).
    - For the uptake of renewable energy technologies and energy efficiency in residential and commercial sectors incentives such rebates are needed.
    - Support is needed to stimulate the local manufacturing base due to the demand for renewable energy technologies that will be created by the renewable energy target.
    - Support is needed to the off-grid industry such as the suppliers and installers

The study by Le Fol (2012) lists also similar challenges, and in addition highlights the technical limitations in terms of grid integration and resource assessment, the poorly addressed energy planning, the high investment cost, and the lack of financing mechanisms to support investments. Also, the independent power producer (IPP) framework in place is not conducive to successful negotiations between IPPs and NamPower.

4.4 Energy Efficiency

In the White Paper (1998) the government recognised that the Namibian industry is energy intensive, and that energy should be used efficiently. The paper stated that the energy efficiency will be promoted through policies of better information collection and dissemination, and by conservation practices in households, buildings, transport and industry. There was several specific policy statements directly related to the energy efficiency:

- *Government will investigate the nature of energy end-use patterns in all sectors and use the data captured to monitor and assess energy efficiency in these sectors.*
- *Government will embark on national awareness campaigns to promote the efficient and sustainable use of energy in Namibia.*
- *Government will promote the use of energy-efficient appliances and the construction of thermally efficient buildings in the household sector.*
- *Government will encourage the application of building technologies and practices enhancing energy efficiency and conservation.*
- *Government will promote the application of energy efficiency and conservation measures in industry.*
- *Government will promote fuel saving measures in the transport sector.*
- *Government will establish an institutional base, with adequate human resources, to house and manage a programme on energy efficiency and energy conservation.*

Several of the policy statements have been put into actions since 1998. For example a Danish Government funded “Renewable Energy and Energy Efficiency Capacity Building Programme” (REEECAP), addressed the question of energy efficiency in Namibian housing and building sector during years 2006-2008 (Ndhlukula 2009). The project dealt with the problematic of how the energy efficiency could be included in the building codes and in the behaviour of the people, and assessed to what extent energy efficiency was incorporated in rural and peri-urban houses in Namibia. The main strategic focus was on enhanced capacity for both rural and urban decision makers in energy planning.

The work was continued in the NEEP project 2010-2013, which aimed at reducing Namibia’s energy-related GHG emissions through the nationwide adoption of energy-efficient technologies and practices in the commercial and residential building sector. The main goals of the programme were development of improved regulations, provision of auditing and energy marketing services, and strengthening of institutional capacity and awareness. The NEEP project also made efforts to establish the Green Building Council of Namibia (GBCNA) as a step towards promoting and facilitating green building practices in the country. The main task of the GBCNA is to develop and operate the Green Building Rating System and to promote and facilitate green building practices, technologies and operations in the construction and build environment (Curren et al. 2013).The study prepared by Camco Clean Energy, Saku Energy Enterprise (SEE) and Namibia Housing and Urban Development (Curren et al. 2013), presents a very recent review of the Namibian energy efficiency questions. The project reviews the existing Namibian National energy policy, building codes and building regulations and recommends amendments on how the building codes could be developed.

The literature review showed that several baseline studies on energy efficiency and reports related to the Namibian building codes have been made, and that the REEEI has taken a strong role in the energy efficiency questions in Namibia. The studies present a creditable amount of practical propositions on the amelioration of energy efficiency in housing in Namibia. In addition, the development of the sector is planned to be assessed in the annual national survey reports, since 2011. The results of the first Annual National Survey (2011) indicated that there exists some basic awareness of renewable energy and energy efficiency issues amongst the population, but that knowledge regarding the implementation and evaluation of appropriate measures was lacking. The survey gives a set of recommendations on a way forward. The next step seems to be the incorporation of the energy efficiency regulations to the national building codes. Currently the Namibian building code is being updated and energy efficiency and renewable energy regulation will be incorporated during the process. Some municipalities have already updated their building codes.

The literature review also showed that less attention has been put on energy efficiency of other sectors than housing, e.g. industry and transportation. These questions should also be raised to the political and public discussion, as the industry, transportation, and fishing are currently important energy consumers (see Figure 5 and Figure 11). However, actions have been carried out under the Energy Management Program (EMP) related to food industry and concrete production. Also energy audits have been made for some industrial buildings.

Table 24. Documents related to energy efficiency in Namibia.

ENERGY EFFICIENCY		
Revision of National Building Codes to Incorporate Renewable Energy Technologies and Energy Efficiency Principles - Background Review	Curren et al. 2013	The project reviews the existing Namibian National Energy Policy, Building Codes and/or National Building Regulations and recommends amendments in order to include energy efficiency (EE) and renewable energy (RE) aspects. The study also presents an overview of relevant international best practices and the ways forward for Namibian building codes. The next phase of the project is an extensive stakeholder consultation
Annual national survey on energy efficiency in buildings	REEEI, Lithon Project Consultants (Pty) Ltd 2011	The purpose of the study is to measure the effectiveness of energy efficiency initiatives in Namibia, specifically in the setting of new and existing residential and non-residential buildings. The survey measures the outcome and effectiveness of targeted interventions by a field study / questionnaires, and proposes solutions for further strategic planning.
Baseline Study on Energy Efficiency in Buildings in Namibia	EMCON, AGAVA Energy, VO Consulting 2011	The study aims to establish building energy benchmarks for buildings in Namibia and to identify and review energy efficiency standards with a view to making recommendations on appropriate energy efficiency approaches for Namibia. Energy benchmark is done for supermarkets, warehouse shops, offices, and hotels.
Namibia Energy Efficiency Programme (NEEP) in Buildings	MME, REEEI 2010	The NEEP in Buildings project is set against a background of rising electricity consumption in Namibia coupled with a growing power deficit in South Africa, the country's main energy supplier. Addressing this challenge requires a concerted effort to both increase the available electricity generation (supply-side) and ensure a more efficient utilization of the existing resources (demand-side). The NEEP project's objective is therefore the reduction of Namibia's energy-related GHG emissions through the nationwide adoption of energy-efficient technologies and practices in the commercial and residential building sector, with a focus on government office buildings, hospitals, hotels, schools and possibly a sample of residential buildings.
Revision of Namibian Building codes to incorporate Renewable Energy and Energy Efficiency (executive summary)	Sustainable Energy Africa, EMCON Consulting Group 2008	This report is the product of an extensive consultative and stakeholder process to determine, assess and recommend which EE and RE interventions could potentially be included in the Namibian Building Codes. The interventions are evaluated and suitable are chosen for Namibia.
Guidelines For Building In An Energy Efficient Manner	REEEI, Habitat Research & Development Centre (HRCD) 2008	The guideline document contains a technical instruction guide focussing on energy efficient building methods and measures in the housing environment. It aims to empower persons in the housing sector to construct energy efficient houses, and to mainstream energy efficiency in the housing sector of Namibia.
Energy Efficiency Baseline Survey for Rural, Peri-Urban and Urban Households (executive summary) (REECAP)	Consulting Services Africa (CSA) and the Desert Research Foundation of Namibia (DRFN) 2007	The summary presents the results of field study conducted by DRFN in 2007. The objective of the study was to assess to what extent energy efficiency is incorporated in rural and peri-urban houses in Namibia.
Energy efficiency in the tourism sector in Namibia	REEEI 2007	The project aimed to enhance energy efficiency (EE) in the tourism sector in Namibia, by making the tourism enterprises aware of the EE opportunities, and by rewarding those who were already implementing EE measures.

5. Conclusions and recommendations

This chapter presents the key conclusions and recommendations of the three sections of this report; the energy statistics of Namibia, the energy system modelling and the literature review.As a whole, the purpose of the report was to present the work done during the cooperation project between VTT and MME as extensively as possible in order to provide useful material for the Ministry or any institution working within the Namibian energy sector, e.g. concerning energy policy issues. The point of view is national energy system with legislation and regulative issues mostly out of scope of the report.

Energy statistics

During the project, the first version of the Namibian energy statistics was compiled, following the IEA format for the country specific energy statistics. The energy statistics are an integral part of decision making and thus also part of the development of a new energy policy for Namibia. Guidelines as well as a description on the current version of the proposed energy statistics is given in Chapter 2. Three clear actions are highly recommended as next steps concerning the statistics:

- Ministry and stakeholders commit to the annual upkeep and improvement of the energy statistics, responsibilities are defined and funding granted
- personnel from the ministry and stakeholders regularly participate to further training to improve their skills with the energy statistics
- in the long run, the upkeep and development of the energy statistics should be designated to the Namibia Statistics Agency (NSA)[23]
- Law on statistics is prepared; companies are required to submit data and confidentiality of data is guaranteed

Energy system modelling

The energy statistics enable a more systematic and detailed planning for the future energy system in Namibia. Based on these energy statistics, an energy system model has been developed for the Ministry of Mines and Energy as well as major stakeholders as a tool for investigating the development of the energy system of Namibia. The model helps the Namibian policy makers to study with relative ease several future pathways for Namibian energy system, and the most feasible and reasonable options can be chosen for further investigations. It can also help to understand the dynamics of energy system development and act as a tool for broad range of studies concerning the topic.

In this report, the energy system model is used to investigate scenarios with low, medium and high growth in line with estimations from NPC and Ministry of Finance used also in National Integrated Resource Plan (NIRP) by ECB. The scenarios are studied with and without the realisation of Kudu gas to power project. The results are analysed from 2015 to 2030 with years 2008 and 2010 presented as statistics. It must be noted that the electricity sector does not develop in a vacuum as the investment decisions and growth in neighbouring countries affects the outcome for Namibia as well. Electricity consumption in 2030 is forecasted to be 50 % to over 100 % higher than in 2010 depending on the growth scenario. This is mainly due to increased mining activity which continues to be the key element in predicting the electricity consumption. According to the modelling results, utilisation of Kudu gas power is not at maximum during 2020 to 2030. This is due to investments in neighbouring countries linked with global market prices for competitive fuels and the planned capacity as well as estimations on energy consumption in the countries in question. It is clear that keeping close eye on development in neighbouring countries is very important for

[23] http://www.nsa.org.na/

Namibia. All the modelled scenarios show improvement in self-sufficiency, indicating a clear goal for the development of the system in years to come.

Following actions are recommended as next steps concerning future modelling exercises:

- In order to enhance the accuracy of consumption forecasts utilised by the modelling, most effort should be focused on developments in the mining sector of Namibia.
- The modelling results can also be influenced by e.g. introducing constraints such as fixed investments in certain technology, limit for total emissions or share of renewables in electricity production.
- Special attention should be paid to renewable energy technologies solar, wind and biomass, and the corresponding resource definition.

Literature review and background information

In order to clarify the current state of the energy policy development in Namibia, a literature review was made related to the actions and developments since launch of the Energy Policy White Paper (1998).The review showed that a lot of research and project activity has been going on in the renewable energy and energy efficiency sector during last years (2005-2013). Thus, a lot of useful information is available for future policy updates. Some of the older documents, such as the "Strategic Action Plan for the implementation of renewable energy policies as outlined in the Namibian White Paper on energy policy" (Consulting Service Africa 2006), could be still used as a basis for a policy update, as many of its recommendations are still valid.

Also, the current state of the renewable energy installations in Namibia was summarized. It seems that despite the various studies made, the implementation of the larger scale solar, wind or bioenergy technologies has been fairly slow. The importance of the environmental and social assessment of the projects related to new renewable energy possibilities cannot be over emphasised, especially in the vulnerable conditions of Namibia. The environmental and social impacts should always be evaluated before launching new projects, as e.g. the bioenergy production can have significant impacts e.g. on land use and access to land, food and feed production, water resources, soil quality, and biodiversity.

Based on the literature review, several recommendations related to the energy policy studies can be given:

- The transparency of the project results and availability of the information would benefit all the actors of the sector. The data management could be developed for example in cooperation with REEEI.
- Public results on the resources (biomass and wind) are needed.
- In future, especially the studies on the renewable energy sector should give concrete propositions for future actions instead of general descriptions, and to concentrate on carrying out these actions.
- The studies and discussion on energy efficiency should also concentrate on industry and transportation sectors, which are significant energy consumers.
- The co-operation of Ministries and the different actors, and coordination of the on-going projects related to the energy sector is crucial in order to respond the challenges that the sector is facing and in order to establish the support systems needed for the future investments.
- An updated energy policy for Namibia would benefit the development of the energy sector by setting clear goals and targets in order to help possible investors to evaluate the future prospects. The challenges and actions should also be prioritised.

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Appendix A – IPPs licensed (November 2013)

Licensee	Type	Size (MW)	Suspensive conditions lapse	Date Issued	Validity period (yrs)	Location	Comments
Atlantic Coast Energy Company	Coal (pulverized)	700	31 Oct 14	1 Nov 07	25	Walvis Bay	
Vizion Energy Resources	Coal (CFB)	800	1 Oct 14	4 April 08	25	Walvis Bay	
Arandis Power	Diesel (HFO)	120	31 Oct 13	1 Nov 11	30	Arandis	
CBEND (Bush Energy Namibia)	Biomass	0.25	30 April 14	1 May 10	5	Farm Piere (Outjo district)	
Diaz Wind Power (Pty) Ltd	Wind	44	30 Nov 13	1 Apr 07	22	Luderitz	
GreeNam Electricity (Pty) Ltd	Solar	10	31 Aug 13	1 June 11	25	Keetmanshoop	
GreeNam Electricity (Pty) Ltd	Solar	10	31 May 14	1 June 11	25	Rehoboth	
GreeNam Electricity (Pty) Ltd	Solar	10	31 May 15	1 June 11	25	Mariental	
Uprise Investment (Pty) Ltd (Green continent)	Solar	10	30 Apr 13	1 May 12	25	Keetmanshoop	
Momentous Energy (Pty) Ltd	Solar	20	30 Apr 13	1 May 12	25	Keetmanshoop	License only approved for 10MW
NamEnergy Solar	Solar	30	30 Apr 13	1 May 12	25	Arandis	License only approved for 10MW
Namibia Solar World	Solar	40	30 Apr 13	1 May 12	25	Farm Quinta No. 976 (Gobabis)	License only approved for 10MW
Evofield Energy Holdings	Solar	30	30 Sept 2013	1 Oct 12	25	Farm Safier	License only approved for 10MW
Ark Industries Namibia	Biomass	16	31 Dec 13	1 Jan 13	30	Rehoboth	
Namibia Breweries Limited	Solar	1	31 Dec 13	1 Jan 13	25	Windhoek	Own consumption
OKA Investment	Solar	20	31 Jul 2014	1 Aug 13	25	Ondangwa	Private off-taker
Erongo Diagram Investment	Solar	5	31 Jul 2014	1 Aug 13	25	Arandis	Private off-taker
Africa Energy Corporation	Solar	4.9	31 Jul 2014	1 Aug 13	25	Walvis Bay	Private off-taker
Paramount Infrastructure Development	CSP	22	31 Aug 2014	1 Sep 13	25	Khorixas	