UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

INCORPORATING RENEWABLE ENERGY AS AN ALTERNATIVE SOURCE OF ENERGY IN THE EXTRACTIVE INDUSTRY: THE CASE OF NAMIBIA

By

IYALOO NDAPANDULA HAMULUNGU

Student number: u17256412

Submitted in partial fulfilment of the requirements for the degree

MAGISTER LEGUM (LLM) IN EXTRACTIVE INDUSTRY LAW IN AFRICA

prepared under the supervision of

Adv. Leonardus Gerber

Department of Public Law

University of Pretoria

2017

DECLARATION OF ORIGINALITY

UNIVERSITY OF PRETORIA

The Department of ……PUBLIC LAW…….. places great emphasis upon integrity and ethical conduct in the preparation of all written work submitted for academic evaluation.

While academic staff teach you about referencing techniques and how to avoid plagiarism, you too have a responsibility in this regard. If you are at any stage uncertain as to what is required, you should speak to your lecturer before any written work is submitted.

You are guilty of plagiarism if you copy something from another author's work (e.g. a book, an article or a website) without acknowledging the source and pass it off as your own. In effect, you are stealing something that belongs to someone else. This is not only the case when you copy work word-for-word (verbatim), but also when you submit someone else's work in a slightly altered form (paraphrase) or use a line of argument without acknowledging it. You are not allowed to use work previously produced by another student. You are also not allowed to let anybody copy your work with the intention of passing if off as his/her work.

Students who commit plagiarism will not be given any credit for plagiarised work. The matter may also be referred to the Disciplinary Committee (Students) for a ruling. Plagiarism is regarded as a serious contravention of the University's rules and can lead to expulsion from the University.

The declaration which follows must accompany all written work submitted while you are a student of the Department of ……PUBLIC LAW…….. No written work will be accepted unless the declaration has been completed and attached.

Full names of student: ……IYALOO NDAPANDULA HAMULUNGU……..

Student number: …… U17256412……..

Topic of work … INCORPORATING RENEWABLE ENERGY AS AN ALTERNATIVE SOURCE OF ENERGY IN THE EXTRACTIVE INDUSTRY: THE CASE OF NAMIBIA……..

Declaration

1. I understand what plagiarism is and am aware of the University's policy in this regard.

2. I declare that this ……MINI-DISSERTATION…… (e. g essay, report, project, assignment, dissertation, thesis, etc) is my own original work. Where other people's work has been used (either from a printed source, Internet or any other source), this has been properly acknowledged and referenced in accordance with departmental requirements.
3. I have not used work previously produced by another student or any other person to hand in as my own.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

SIGNATURE ……IYALOO NDAPANDULA HAMULUNGU……

DEDICATION

To my two daughters who are my daily reminder of all that is good in this world.

ACKNOWLEDGEMENTS

First of all, I would like to give thanks to my faithful God, who strengthens me.

I express special thanks:

- To Leon Gerber, my supervisor, for immediately seeing the potential of this research project, for his unwavering guidance and patience and insightful comments.
- To my family for their encouraging words, for their endless love and for always being there for me.
- To my friends for putting up with my late-night calls, for always being there to uplift my spirits whenever needed. I deeply value your support.

ABSTRACT

Energy is essential in the modern world, as it is required for the performance of various economic activities. Electricity, apart from liquid fuel, is one form of energy which is crucial for development, it is mostly generated from fossil fuels such as coal. The process of electricity generation from fossil fuels, however has negative implications for the environment, such as the depletion of the ozone layer through the emission of greenhouse gases. Moreover, despite the negative implications on the environment, fossil-based electricity is considered reliable and cheap in comparison to other sources of energy such as renewables.

Several economic activities require large amounts of energy in their operations and processes, an example of this type of economic activity is mining. However, some mines are located far from the main grid and are usually faced with power supply problems, it would be beneficial for such mines to consider alternative energy sources such as renewable energy. In addition, using renewable energy in the mining sector has other benefits such as the lower emissions of greenhouse gases.

The research investigates the potential incorporation of renewable energy as an alternative source of energy into the Namibian mining sector. The rationale behind this research is that Namibia has some uncertainty regarding security of supply when it comes to electricity, considering that it exports majority of its electricity supply from the Southern African Power Pool.

The research ascribes to the theories of reasoned action and the renewable energy transition. Furthermore, several business models befitting use for RE projects were identified and discussed, the research suggests that the type of business model to be used is largely determined by the geography as well as the jurisdiction. The investigation reveals that the business model suitable for use in the Namibian mining industry for RE projects is the net metering model, this is because Namibia has published net metering rates.

Lastly, the investigation revealed that there is great potential for the incorporation of renewable energy into the Namibian mining sector due to the fact that Namibia is richly endowed with a good solar regime and windy coastal areas. However, despite this, there are several challenges that may hinder the successful incorporation of RE into the mining sector. The challenges were categorised as economical, political, technical as well as social.

KEYWORDS

Mining

Energy

Renewable energy

Electricity

Business models

Fossil fuels

GHG emissions

Namibia

TABLE OF CONTENTS

LIST OF ACRONYMS

BOOT	-	build-own-operate-transfer
BOO	-	build-own-operate
BOT	-	build-own-transfer
CAPEX	-	capital expenditure
ECB	-	Electricity Control Board
EPC	-	procurement and construction
GHI	-	global horizontal irradiance
IEA	-	International Energy Agency
IPCC	-	Intergovernmental Panel on Climate Change
IPP	-	independent power producer
ISO	-	International Standards Organisation
MME	-	Ministry of Mines and Energy
NDPs	-	National Development Plans
NAMPOWER	-	Namibia Power Corporation
NAMREP	-	Namibia Renewable Energy Programme
NIRP	-	National Integrated Resource Plan
NPC	-	Namibia Planning Commission
PPA		power-purchases agreement
PPPs	-	public-private partnerships
PV	-	photovoltaic
RE	-	renewable energy
REDs	-	regional electricity distributors

REEEI	-	Renewable Energy and Energy Efficiency Institute
RES	-	renewable energy sources
RET	-	renewable energy technologies
SAPP	-	Southern African Power Pool
SPC	-	special purpose company
SPV	-	special purpose vehicle

UNITS OF MEASURE

MWh	-	megawatt-hour
TWh	-	terawatt-hour
MW	-	megawatt
KW	-	kilowatt

CHAPTER ONE - RESEARCH OVERVIEW

1.1. Background and introduction

Energy is an essential aspect of the modern world,[1] accordingly, it is critical for economic and social development.[2] However, with the increasing world population and trends of urbanisation,[3] the demand for energy is also expected to increase.[4] It is submitted that global energy demand patterns are not sustainable,[5] which begs the question that what can be done to improve this trajectory?

A substantial proportion of the electricity generation is dominated by fossil fuels,[6] which is associated with emissions which cause local, regional and global environmental problems.[7] When fossil fuels are burned, they omit greenhouse gases. The generation of electricity is a major cause of greenhouse gases emissions in the atmosphere.[8] Carbon dioxide forms part of these gases which are very harmful to the planet.[9] These greenhouse gases cause a rise in the atmospheric temperatures.[10] All these factors lead to a negative change in the global climate.[11]

---

[1] R Prakash & I K Bhat, 'Energy, economics and environmental impacts of renewable energy systems*' Renew. Sustainable Energy Rev. Reviews* 13:9 (2009) at 2716.

[2] N Wohlgemuth & F Missfeldt, 'The Kyoto mechanisms and the prospects for renewable energy technologies' *Solar Energy* 69:4 (2000) at 305.

[3] B C McLellan et al., 'Renewable energy in the minerals industry: a review of global potential*' J. Clean Prod.* 32 (2012) at 32.

[4] Prakash (n 1) at 2716.

[5] Wohlgemuth & Missfeldt (n 2) at 305.

[6] D von Oertzen, 'Green Energy in Namibia' Electricity Control Board 1 (2009) at 2.

[7] Wohlgemuth & Missfeldt (n 2) at 305.

[8] D Popp, I Hascic & N Medhi, 'Technology and the diffusion of renewable energy' *Energy Econ.* 33:4 (2011) at 648-662.

[9] Von Oertzen (n 6) at 2.

[10] Ibid.

[11] Ibid.

Kirschke states that mining requires large quantities of energy, including the mining of base metals such as copper, lead, nickel, zinc, tin, aluminium and iron ore to precious metals such as platinum, gold and silver or fertilisers such as phosphate or fossil fuels such as coal.[12] The extent of energy usage indicated in literature shows that the average percentage of annual electricity costs for members of the Energy Intensive Users Group of Southern Africa has increased from 7 per cent in 2007 to 20 per cent in 2014, and it is worth noting that 47 per cent of these members are mining companies.[13]

In addition, mines located in remote areas struggle with power supply and therefore rely on diesel generators.[14] Incorporating renewable energy (RE) into the mining operations can be one way of mitigating the emissions from the industry and may prove cost-effective as well as solve power supply problems for remote mines.[15] Furthermore, the report by the Global Cleantech Center states that many of the world's mining companies are facing increased pressure from governments, local communities and other stakeholders to carry out their operations in a sustainable manner.[16] Against this background, mining companies can start looking at renewable energy as an alternative to meet their power needs and also to make their activities environmentally safe.[17]

Renewable energy is a promising alternative solution because it is environmentally safe.[18] Associated benefits of using renewable energy technologies include lower carbon dioxide emissions.[19] It is affirmed in the 'Intergovernmental Panel on Climate Change (IPCC) Special Report

---

[12] J Kirschke, 'Energy urgency: Why the global mining industry is embracing renewables' available at <http://nextbillion.net/energy-urgency-why-the-global-mining-industry-is-embracing-renewables/> accessed 30 April 2017.

[13] R G Votteler & A C Brent, 'A literature review on the potential of renewable electricity sources for mining operations in South Africa' *J. Energy South Afr.* 27:2 (2016) at 1.

[14] F Boyse et al., 'Implementing renewable energy for off-grid operations.' *Carbon War Room, Washington DC* (2014) at 5.

[15] Renewables, Global Status Report, (2014) at 22.

[16] Global Cleantech Center, 'Mining: the growing role of renewable energy', (2014).

[17] M Van Wyngaardt, 'Mining companies relying more on renewable energy' available at <www.miningweekly.com/article/mining-companies-relying-more-on-renewable-energy-2016-07-27> accessed 30 April 2017.

[18] A Demirbas, 'Global Renewable Energy Projections' *Energy Sources, Part B* 4:2 (2009) at 218.

[19] Global Cleantech Center (n 16).

on Renewable Energy Sources and Climate Change Mitigation' that renewable energy may, if implemented properly, contribute to social and economic development, energy access, a secure energy supply, and reducing negative impacts on the environment and health.[20] This is especially true when viewed in the context of mining, using renewable energy in mining operations not only will lower the energy costs of a mining company, it will also benefit the immediate community in the form of job creation, access to power and reduced GHG emissions. Making use of renewable energy also influences the social 'licence to operate' of the mining company in the community where it operates.[21] Furthermore, renewable energy technologies could also be an asset to the local communities after the mine closes down, because they plant will be left behind for the benefit of the local community.

1.2. Aims and objectives

1.2.1. Research aim

- To investigate the challenges of incorporating renewable energy in the Namibian extractives industry.

1.2.2. Research objectives

The objectives of the research are to:

- to examine the potential for using renewable electricity as an alternative energy in the Namibian mining sector
- to investigate energy demand and consumption in Namibia
- to identify any limitations to the successful incorporation of renewable electricity in the Namibian mining industry as an alternative source of energy; and
- to recommend business models that may be used for renewable energy projects

[20] O Edenhofer et al., (eds.) *Renewable energy sources and climate change mitigation: Special report of the intergovernmental panel on climate change* 2011 Cambridge University Press at 7.

[21] Global Cleantech Center (n 16).

1.3. Research questions

Varun et al. points out that electricity generation plants that utilise coal are known to have the highest carbon dioxide emissions per kWh, but are still widely used due to their low cost of electricity generation and high availability of raw material.[22] Painuly reports that the International Energy Agency estimates that, without new policy initiatives, fossil fuels will account for more than 90% of total primary energy demand in 2020.[23] Namibia imports the majority of its electricity supply from South Africa and other neighbouring countries such as Zimbabwe, which is generated using coal. There is sufficient potential for renewable energy technologies (RET) in general. However, a country such as Namibia, richly endowed with renewable energy sources, is not making sufficient use of such resources.

Accordingly, this research investigates the prospects of incorporating renewable energy, such as solar and wind power, into the Namibian mining industry as an alternative source of electricity; with the research in essence considering the challenges that are likely to be faced in taking on such an initiative.

1.3.1. Primary question

The broad research question which the research seeks to answer is as follows:

- What are the challenges of incorporating renewable energy in the Namibian extractives industry?

1.3.2. Secondary research questions

In the course of answering the main research question, the following secondary questions are also answered:

- What is/are theory/theories underpinning the use of renewable energy?
- What does renewable energy imply?
- What is the state of energy demand and consumption in Namibia?

---

[22] Prakash (n 1) at 2717.

[23] J P Painuly, 'Barriers to renewable energy penetration; a framework for analysis' *Renew. Energy* 24:1 (2001) at 74.

- Is there a potential for renewable energy as an alternative source of energy in Namibia?
- What are the challenges associated with incorporating renewable energy into the Namibian mining industry?
- What business models may be used in RE projects in the mining sector?

1.4. Proposed methodology and limitations

1.4.1. Methodology

The study concentrates on Namibia in the form of an in-depth country study. The research utilises a qualitative method in the form of pure desktop study of domestic, regional and international instruments to accomplish the research aims. Furthermore, scholarly articles are utilised in the course of answering the research questions. Given the scope of the scholarly sources, it is important to note that the terms 'mining sector' and 'extractive industry' will be used interchangeably for the purposes of this study.

1.4.2. Research parameters

The scope of the study is limited to the potential incorporation of renewable energy into the Namibian extractives industry. This research does not consider electricity generation in general nor does it consider energy use in other sectors of the economy. It is limited to the challenges that may be faced in the incorporation of renewable energy into the extractives industry as an alternative energy source.

The author acknowledges certain limitations to the study including that renewable energy cannot compete with grid power on an equal footing. Furthermore, the statistical data on the consumption of energy in Namibia is limited, with the data accordingly limited to that available till 2007.

1.5. Relevance of study

The research is important in that it will contribute to the body of literature available on this subject with the aim that this will give some clarity that projects of this kind are not too far-fetched for mining corporations to take on. There have been many studies focusing on renewable energy in general, but limited studies on this specific subject exist in Namibia. This study endeavours to shed some light on

the use of renewable energy in the mining sector to supplement non-renewable energy in the pursuit of making mining an environmentally friendly and sustainable activity, as well as to cut operational costs of mining companies.

1.6. Chapter overview

The study comprises six chapters. Chapter Two discusses the theory or the various theories to which this research ascribes to, including the reasoned action theory and the renewable energy transition theory. Business models are also briefly discussed in chapter two.

Chapter Three deals with the concept of renewable energy in that it seeks to define renewable energy as a generic term as well as explore the potential of renewable energy in Namibia. The purpose of Chapter Three is to create the context in which the research will be carried out. The chapter also provides the profile of energy consumption and demand in Namibia.

Chapter Four examines the energy framework as well as stakeholders in this particular energy sector. This chapter further investigates the challenges associated with the use of renewable energy. Lastly, the chapter provides a few illustrations of mines that have realised renewable energy projects as an alternative in their operations, as well as those mines that are in the process of implementing renewables into their energy mix.

Chapter Five presents an evaluation of the theories identified in chapter two and the business models that were identified in Chapter Two.

Chapter Six presents the research conclusion and. recommendations for addressing the challenges identified.

CHAPTER TWO - THEORETICAL FRAMEWORK

2.1. Introduction

The purpose of this chapter is to provide a theoretical lens through which the research will be understood and interpreted. Two theories to which the research ascribes have been identified. The discussion examines the behavioural factors affecting the decisions of the mining companies to use renewable energy as an alternative in their operations. Accordingly, the chapter is divided in two parts. The first part considers the theories, in particular the reasoned action theory and the contributions by different scholars to the theory. It further aims to explain the behaviour and perceptions of firms regarding the use of renewable electricity. The theory of renewable energy transition theory is also addressed in the first part of this chapter. The second part addresses the various business models that are available for use in renewable energy projects by mining companies.

2.2. Theories

2.2.1. Reasoned action theory

The theory of reasoned action originates from social psychology and explains how and why attitude affects behaviour (conduct).[24] The reasoned action theory is based on the premise that people (or organisations) consider the consequences of alternative behaviours before engaging in them and, with subsequent behaviours connected with the desired outcomes.[25] This argument, if interpreted in relation to the incorporation of renewable energy in the mining industry, means that, before mining companies consider alternating fossil-based electricity with renewable-based electricity, they will weigh the pros and cons of using renewable-based electricity. The mining company will consequently

[24] H Y Feng, 'Key factors influencing users' intentions of adopting renewable energy technologies' *Academic Research International* 2:2 (2012) at 157.

[25] H K Bang et al., 'Consumer concern, knowledge, belief, and attitude toward renewable energy: an application of the reasoned action theory' *Psychology & Marketing* 17:6 (2000) at 453.

follow the path that presents more benefits. These benefits may include tax benefits associated with using renewable-based electricity, if there are such incentives in the particular jurisdiction. Secondly, these benefits may include government subsidies. Thirdly, these benefits may also be reduced costs of the technology required to harness renewable energy.

Moreover, in order to bring about the favourable conditions that will support the use of renewable energy, all the relevant stakeholders need to work together. Masini and Menichetti further postulate that cooperation between public and private actors is needed: policy makers need to develop incentives to encourage investment in clean energy and the private actors, such as mining companies, need to raise the required financial resources for the incorporation of renewable energy in the sector.[26]

In terms of the reasoned action theory, the behaviours are determined by the intention to perform the desired action.[27] The behavioural intent is, in turn, determined by two factors, namely (1) attitude towards the behaviour and (2) the social pressure to perform the behaviour.[28] In other words, if the attitude of the mining company towards renewable energy is that renewable energy as an alternative will probably increase the operational costs of the mining company, then it is unlikely that such a company will follow the renewable route.

On the other hand, if the attitude of the mining company towards the use of renewable energy is such that the use of renewable energy does not impact on the environment negatively and that the use of renewable energy is likely to result in the positive certification, for example, from the International Standards Organisation (ISO) Technical Committee 207,[29] it is possible that the mining company will be in favour of incorporating renewable energy as an alternative source of energy. Another aspect which may affect the perception of the mining company towards the use of renewable

---

[26] A Masini & E Menichetti, 'The impact of behavioural factors in the renewable energy investment decision making process: conceptual framework and empirical findings' *Energy Policy 40* (2012) at 29.

[27] Bang et al (n 25) at 453.

[28] Ibid.

[29] The ISO 14000 family of standards provides practical tools for companies and organizations of all kinds looking to manage their environmental responsibilities. ISO 14001:2015 and its supporting standards such as ISO 14006:2011 focus on environmental systems to achieve this. The ISO 14000 family of standards are developed by ISO Technical Committee ISO/TC 207 and its various subcommittees. (ISO 14000 family - Environmental management available at <www.iso.org/iso-14001-environmental-management.html> accessed 20 June (2017).

energy is the pressure from international organisations to carry out their operations in a sustainable manner, such as an increased pressure placed on countries by institutions such as the IPCC to reduce carbon dioxide emissions.

2.2.2. Renewable energy transition theory

Sustainable energy transition involves the extensive deployment of clean energy such as wind or solar power to reduce the environmental burden on the national economy.[30] The theory of renewable energy transition is best understood from the contributions to literature by Gregory C. Unruh. Unruh argues that industrial economies have become locked into fossil fuel-based technological systems through a path-dependent process.[31] This process, according to him, is driven by technological and institutional increasing returns to scale.[32] This condition is termed 'carbon lock-in'.[33] This system, purports Unruh, arises through a combination of systematic forces which preserve fossil-based infrastructures regardless of the environmental externalities.[34] Modern societies have increasingly become more dependent on fossil fuels for producing electricity than they have relied on renewable energy.

According to Fischer and Newell, sustainable energy transition will not take place without support from the government in the form of binding constraints on carbon emissions, either through direct regulation or by using price instruments. Therefore, sustainable energy can be considered fundamentally political.[35] In essence, public support is required to break carbon lock-in.[36] Public support is defined as policies that give individuals and companies incentives to deploy clean energy.[37]

---

[30] R Beddoe et al., 'Overcoming systemic roadblocks to sustainability: the evolutionary redesign of worldviews, institutions, and technologies.' *Proceedings of the National Academy of Sciences* 106:8 (2009) at 2483.

[31] G C Unruh, 'Understanding carbon lock-in' *Energy Policy* 28:12 (2000) at 817.

[32] Ibid.

[33] Ibid at 818.

[34] Ibid.

[35] C Fischer and R G Newell, 'Environmental and technology policies for climate mitigation.' *J. Environ. Econ. Manag.* 55:2 (2008) at 142.

[36] Unruh (n 31) at 819.

[37] M Aklin & J Urpelainen, 'Political competition, path dependence, and the strategy of sustainable energy transitions' *Am. J. Political Sci.* 57:3 (2013) at 645.

Aklin and Urpelanien posit that as the capacity of public support increases, so does the number of clean energy producers and if the profitability of using clean energy increases, so does the number of clean energy utilities.[38] These writers further argue that when governments make use of positive reinforcement for political gain; they interpret positive reinforcement as a political mechanism.[39] Accordingly, it is submitted that the arguments advanced by Aklin and Urpelanien have some basis in modern societies or governments, as the level of political will to decarbonise the energy sector effectively determines the extent of renewable energy technology deployment. Furthermore, the political will of a particular government will necessarily manifest itself in the policies that are passed by that government.

2.3. Different business models to be used in RE projects

In order for renewable energy projects to be undertaken in the mining sector, several business models may be utilised. Business models provide a structure for business investments regarding the form, design, implementation, management and incorporate critical financial service and monitoring features.[40] The type of business model is determined by the local conditions, regulatory environment, fiscal regime, institutional framework and the support mechanisms in place.[41] It is important to note that, although business models may be categorised in theory, in practice they often take a hybrid form.[42] Nevertheless, the business models identified for the deployment of renewable energy projects can be characterised as follows:

---

[38] Aklin & Urpelanien (n 37) at 645.

[39] Ibid.

[40] 'Business models to realise the potential of renewable energy and energy efficiency in the greater Mekong subregion' available at <www.adb.org/sites/default/files/publication/161889/business-models-renewable-energy-gms.pdf> accessed 31 July 2017.

[41] Ibid.

[42] Ibid.

2.3.1. Public-Private Partnerships (PPPs)

In PPPs, a contract between a public-sector authority and a private entity is concluded in terms of which the private party provides a service (e.g. electricity supply), which would normally be considered to fall within the remit of the public sector.[43] The risks are identified and allocated to the party that has better mitigation measures to deal with such risks, [44] which is usually the private entity. The private party thus bears most of the financial, technical and operating burden,[45] therefore putting the private sector's expertise and skills to use in a public infrastructure project.[46] One particular feature of the PPPs is the long-term nature of the partnership relationship between the public-sector body and the private entity, commonly up to 10 years.[47]

Common PPPs models are:[48]

- build-own-operate-transfer (BOOT) model[49]
- build-own-operate (BOO) model[50]
- build-own-transfer (BOT) model[51]

---

[43] 'Business models to realise the potential of renewable energy and energy efficiency in the greater Mekong subregion' (n 40).

[44] R Osei-Kyei & A P Chan, 'Review of studies on the critical success factors for public–private partnership (PPP) projects from 1990 to 2013.' *Int. J. Proj. Manage.* 33:6 (2015) at 1336.

[45] 'Business models to realise the potential of renewable energy and energy efficiency in the greater Mekong subregion' (n 40).

[46] Osei-Kyei & Chan (n 44) at 1336.

[47] Ibid.

[48] 'Business models to realise the potential of renewable energy and energy efficiency in the greater Mekong subregion' (n 40).

[49] The acronym BOOT is often used interchangeably with BOT or build-own-operate-transfer.

[50] Typically, under the BOO model the private sector entity finances, builds, owns and operates an infrastructure facility effectively in perpetuity. (See D Grimsey & MK Lewis 'Evaluating the risks of public private partnerships for infrastructure projects' *Int. J. Proj. Manage.* 20 (2002) at 109).

[51] In a BOT project, the public sector grantor grants to a private company the right to develop and operate a facility or system for a certain period in what would otherwise be a public sector project, the operator generally obtains its revenue through a fee charged to the utility/government instead of tariffs charged to the consumers, these projects are sometimes referred to as concessions (see Concessions, Build-Operate-Transfer (BOT) and Design-Build-Operate (DBO) Projects available at <https://ppp.worldbank.org/public-private-partnership/agreements/concessions-bots-dbos> accessed 05 October 2017.)

PPPs usually involve the creation of a special-purpose company or special-purpose vehicle for the project development, maintenance and operation for a contracted period of time. A contract will be concluded between the special purpose company (SPC) or special purpose vehicle (SPV) and the government, as well as with the contractors, to build the facility.[52]

PPPs has the benefit of sharing financial risks and rewards between the public sector and private sector bodies. [53] However, despite this advantage PPPs carry an inherent conflict between the public sector's need to demonstrate the value for money versus the private sector's need for robust revenue streams to support the financing arrangements.[54] Furthermore, PPPs are only feasible if a reliable, long-term revenue stream can be established.[55]

2.3.2. Self-generation

This model may be implemented in two ways; one option involves the mining firm developing, financing and operating the power supply project on its own land. Within this context, the mining firm could potentially enter into a sub-contract with an independent constructor.[56] In the alternative, the mining firm leases the land to an independent company (usually an independent power producer (IPP)) that will manage the development, financing and operation of the project, in part or in whole.[57] The IPP then sells electricity to the mine.

This model has the advantage that only a few actors are involved in the project.[58] The disadvantage is that it requires high initial investment cost.[59] Furthermore, this model is often beneficial only in the long term. For the IPP, they run the risk of being committed to only one client

---

[52] 'Business models to realise the potential of renewable energy and energy efficiency in the greater Mekong subregion' (n 40)

[53] D Grimsey & M K Lewis 'Evaluating the risks of public private partnerships for infrastructure projects' *Int. J. Proj. Manage.* 20 (2002) at 109.

[54] Ibid.

[55] Ibid.

[56] Boyse (n 14) at 7.

[57] Ibid.

[58] Votteler & Brent (n 13) at 15.

[59] Ibid.

(the mine).[60] In the case of commodity prices plummeting, the risk is that if the mine closes down the IPP faces a situation of revenue loss.

2.3.3. Industrial pooling

In terms of this model, a group of industrial corporations, which have mining operations located in proximity to each other, enter into a long-term power-purchase agreement (PPA) with a shared generation plant.[61]

The project can be realised by using combined financial investments and a sub-contractor to build the plant,[62] with the aim of developing a renewable energy plant to reduce energy costs.[63] The model can be undertaken in two ways: the first option is to develop, finance and operate distributed renewable energy assets on one of the firms' land, usually through a sub-contract with an external constructor.[64] The second option is: the consortium of mining companies may lease the designated land to an independent company which will oversee the development, financing and operation of the system.[65]

The advantages of this model include the creation of economies of scale as well as opportunities for increased renewable penetration through the expansion of a micro-grid.[66] However, there is a downside to it: mining companies may be reluctant to enter into joint capital ventures with their competitors.[67] Furthermore, as mining have diverse interests as well as differing project lifespans, it can prove difficult to achieve such a joint venture.

---

[60] Votteler & Brent (n 13) at 15.

[61] 'Alternative energy in mining' German Cooperation; Deutsche Gesellschaft für Internationale Zusammenarbeit; *South African Institute of International Affairs* (2014) available at <https://www.saiia.org.za/special-publications-series/607-sadc-business-barriers-case-3-alternative-energy-in-mining/file> accessed 01 August 2017.

[62] Votteler & Brent (n 13) at 15.

[63] Boyse (n 14) at 19.

[64] Ibid.

[65] Ibid.

[66] Ibid.

[67] Ibid.

2.3.4. Net metering

Net metering is a billing mechanism that credits solar energy users for the electricity they add to the grid.[68] This model may be utilised by a single mining firm that is connected to the main grid.[69] In this scenario, the mining company is already purchasing electricity from the national electricity supplier, however credit is received any surplus solar energy which has been fed into the main grid.

However, the implementation of this model is aimed at reducing the electricity cost by developing a renewable plant and to avoid potential supply disruptions or price uncertainties.[70] Any surplus energy generated by the renewable plant is then ideally sold to the national supplier.[71] Net metering does not require any special equipment, electric meters are used in such a way that they are able to run in either direction. The electricity utility would only need to use accounting procedures and policies.[72]

The advantage of this model is that it creates additional revenue for the operator of the plant.[73] Moreover, no electricity goes to waste because all the electricity generated from renewable sources is used, [74] It also encourages the use of renewable energy and has the benefit of reduced electricity expense. A disadvantage of this model is that the private entity is tied to the grid and is still dependent on the grid to an extent, furthermore, should the net-metering policy be changed the private entity could find itself owing the utility although enough electricity was produced to meet all its needs.[75] Namibia recently published rates applicable under the net metering schemes; the rates are applicable

[68] 'A brief introduction to net metering' available at <www.conserve-energy-future.com> accessed 05 October 2017.

[69] Votteler & Brent (n 13) at 15.

[70] Boyse (n 14) at 19.

[71] Ibid.

[72] 'Net metering' available at <www.netzeroguide.com> accessed 05 October 2017.

[73] Boyse (n 14) at 19.

[74] Ibid.

[75] 'Net metering' (n 72).

to PV systems installed under the schemes of up to 500 kVa.[76], making this business model suitable for use in Namibia.

2.3.5. Self-generation and powering townships

This model is often used by off-grid mines which depend on diesel generators for their power supply.[77] The surrounding communities or townships located near the mine would be connected via the mini-grid through an own investment or an IPP.[78] The surrounding communities and townships obtain government support to run on a transmission line.[79] The benefit that this holds for a mine operating through this model, is a reduction in electricity expense through tax rebates, costs and subsidies.[80] This business model helps with rural electrification in cases where the mine is located in remote areas. The approach used here for the renewable energy project is that the mine employs a sub-contractor to install the plant or, alternatively, an IPP would be used.[81]

The advantage of using this model is that the mine could sell unused electricity to the surrounding community creating extra revenue.[82] A disadvantage is that the procedure to obtain the required permits from the electricity authority, the environmental ministry and the land management authority could be lengthy and challenging.[83] For example, in Namibia a mine which is embarking on this type of business model would need to obtain the necessary permit for renewable electricity generation from the Electricity Control Board (ECB), with the final decision resting with the Ministry of Mines and Energy. Secondly, the mine would have to obtain an additional clearance from the Ministry of Environment, whereby an environmental impact assessment would have to be carried out. Lastly, the mine would most likely need to obtain the necessary permits for zoning or rezoning.

---

[76] 'Namibia publishes tariffs for net-metering' <www.pv-magazine.com/2017/03/20/namibia-publishes-tariffs-for-net-metering/> accessed 05 August 17.

[77] Votteler & Brent (n 13) at 16.

[78] Ibid.

[79] 'Alternative energy in mining' (n 61).

[80] Votteler & Brent (n 13) at 16.

[81] Ibid.

[82] Ibid.

[83] Ibid.

2.4. Conclusion

This chapter discussed the reasoned theory and the renewable energy transition theory. The reasoned action theory attempts to explain the behaviour or attitudes of mining companies towards renewable energy. The research shows that these attitudes towards renewable energy may be influenced by a number of factors, including the consequences of undertaking a certain course of action.

The support or lack thereof, from the government or relevant public institutions in any given jurisdiction may influence the firm's decision regarding a more sustainable energy source, such as wind or solar power. In addition, there is hardly any precedent for large-scale deployment of renewable energy technology. This, in turn, may serve as a deterrent to the use of renewable as opposed to fossil-based electricity. Social pressure also plays a role regarding the renewable energy; it may emanate from organisations such as the IPCC on governments to reduce their carbon emissions.

In turn, the renewable energy transition theory suggests that modern economies have become dependent on fossil fuels, a concept termed 'carbon lock-in' by Unruh. This process is driven by technological and institutional increasing returns to scale. Academic literature thus posits that sustainable energy transitions will not take place without the necessary government support in the form of regulatory responses such as constraints on carbon emissions. Lastly, the research showed that renewable energy transition theory underwrites the notion that political will can significantly influence the use of renewable energy.

In light of the above, the author submits that the business model which a mining company may use in the renewable plant is largely determined by the location, jurisdiction and the availability of funds. The mining company may choose to develop the project itself or it may enter into a contract with an IPP.

The following chapter examines the concept renewable energy in greater detail.

CHAPTER THREE - CONTEXTUALISATION

3.1. Introduction

Having examined the behavioural theories and business models, which can find application in the context of renewable energy incorporation into the mining sectors, it is clear that governmental support plays an important role in promoting the use of renewable energy. This support may be in many forms, but typically include incentives, subsidies or policies.

The pivotal aim of this chapter is to provide a contextualisation of renewable energy, particularly the extent of Namibia's potential for the use of renewable energy. It further contemplates the consumption of energy in the mining sector that may hinder its incorporation of renewables in the sector.

As it is important to determine what constitutes 'renewable energy' in the context of this research, the chapter firstly discusses the term renewable energy in a broader sense, in particular, what constitutes this kind of energy for the purposes of this research. Although there are various types of renewable energy sources, for purposes of this research the emphasis is placed on solar and wind power.

The chapter continues by secondly exploring the potential for incorporating renewable energy in the extractive industry as an alternative source of energy for operations and processing in Namibia, before concluding with a discussion on energy demand and consumption in the mining sector.

3.2. What is renewable energy?

Firstly, it is imperative that the terms energy and electricity are unpacked before defining renewable energy this is in order to create some clarity regarding the similarity or the difference between the two terms. Energy comes in many different forms: such as electricity, direct sun heat, nuclear and

many more.[84] The term energy refers to heat and power, but can also be used to refer to fuels such as diesel and petrol.[85]

Electricity, on the other hand, denotes an energy carrier applicable to various forms of human activities, be they industrial production, household use, agriculture, commerce for running machines, lighting or heating.[86] Electrical energy is a high-quality form of energy.[87]

Energy sources have been divided into three classes: namely, fossil fuels, renewable energy sources and nuclear energy sources. Renewable energy sources are often regarded as alternative energy sources.[88]

The International Energy Agency (IEA) defines renewable energy in its report as follows:

> *Renewable energy is energy that is derived from natural processes that are replenished constantly. There are various forms of renewable energy, deriving directly or indirectly from the sun, or from heat generated deep within the earth. They include energy generated from solar, wind, biomass, geothermal, hydropower and ocean resources, solid biomass, biogas and liquid biofuels.*[89]

---

[84] National Planning Commission, 'Energy demand and forecasting in Namibia' (2013) available at <www.npc.gov.na/?wpfb_dl=229> accessed 27 July 2017.

[85] International Energy Agency (2004), Energy Statistics Manual, OECD Publishing, Paris available at <http://dx.doi.org/10.1787/9789264033986-en> at 17.

[86] Ibid at 39.

[87] D Von Oertzen, 'Namibia's Energy Future: A Case for Renewables' *Konrad Adenauer Stiftung* (2012) at 16.

[88] A Demirbaş 'Global renewable energy resources' *Energy Sources*, *Part A: Recovery, Utilization, and Environmental Effects,* 28:8 (2006) at 789.

[89] International Eneryg Agency (2004), *Energy Statistics Manual,* OECD Publishing, Paris available at <http://dx.doi.org/10.1787/9789264033986-en> at 115.

Quaschning points out that energy may be renewable if it is infinite within a timeframe relevant for humanity.[90] While the IEA has identified a number of types of renewable energy sources,[91] these sources will be limited to solar and wind in this research, as indicated above. Renewable energy commodities are derived from the current or recent flows of the available solar or gravitational energy.[92] Renewable energy is clean in that it produces lower levels of greenhouse gases compared to fossil fuels, inexhaustible and occurs naturally in the environment.[93] Furthermore, renewable energy is cheaper than conventional energy in the sense that it is naturally available.[94] Broadly speaking, the potential of renewable energy technologies is extensive, though it may be limited by geography and the climate, for example, the availability of wind or sun in a certain region.[95]

Of all the types of renewable energy, solar power has arguably attracted most attention as a promising option to be used in industries.[96] According to Timilsina et al., solar energy refers to sources of energy that can be directly attributed to the light of the sun or the heat that sunlight generates.[97] Solangi states that solar energy can be exploited through solar thermal and solar photovoltaic (PV) routes for various applications.[98] Photovoltaic modules are solid-state devices that convert sunlight directly into electricity with no rotating equipment.[99] They are highly reliable and require little maintenance, although at the time of writing it can only be manufacture at a high

---

[90] V Quaschning, *Understanding Renewable Energy Systems* (2016) Routledge at 21.

[91] S Karekezi & W Kithyoma, 'Renewable energy development' *Workshop on African Energy Experts on Operationalizing the NEPAD Energy Initiative*, June 2003 at 789.

[92] International Energy Agency (n 85) at 18.

[93] Demirbaş (n 88) at 779.

[94] T B Johansson et al., 'Renewable fuels and electricity for a growing world economy: defining and achieving potential' in T B Johansson et al. (eds) *Renewable Energy: Sources for Fuels and Electricity* (1993) at 1.

[95] Wohlgemuth & Missfeldt (n 2) at 307.

[96] S Mekhilef, R Saidur & A Safari, 'A review on solar energy use in industries' *Renew. Sustainable Energy Rev.* 15:4 (2011) at 1778.

[97] G R Timilsina et al., 'Solar energy: Markets, economics and policies' *Renew. Sustainable Energy Rev.* 16:1 (2012) at 450.

[98] K H Solangi et al., 'A review on global solar energy policy' *Renew. Sustainable Energy Rev.* 15:4 (2011) at 2161.

[99] Von Oertzen, 'Namibia's Energy Future (n 87) at 21.

costs.[100] Solar thermal technologies make use of the sun energy directly for heating, cooking and drying.[101]

Wind energy may be converted into electrical power,[102] particularly through the use of wind turbines.[103] In the context of Namibia, wind is present predominantly in the coastal areas of Namibia due to the presence of the South Atlantic Anticyclone off the coast and is less prevalent inland.[104] This makes the coastal more viable wind farm projects than inland areas.

Since most nations and international organisations are encouraging the use of renewable energy, as opposed to fossil-based energy sources, renewable energy is gaining momentum since most nations and international organisations are encouraging the use of renewable energy instead of fossil-based energy sources in the quest to save the planet. Renewables are featured in the United Nation Climate Change Convention because of the role played by fossil fuels in the GHG emissions into the atmosphere.[105] The Kyoto Protocol is an international agreement that sets emission reduction targets which binds its parties,[106] with the aim of combatting global warming by reducing greenhouse gas emissions caused by industrial activity.[107] The exploitation of renewable energy sources (RES) forms an integral part of the effort to reduce the negative impacts brought about by using fossil fuels and to confront the risks associated with climate change.[108] Namibia ratified the

---

[100] Von Oertzen, 'Namibia's Energy Future (n 87) at 21.

[101] Karekezi & Kithyoma (n 91) at 14.

[102] Chiguvare & Iileka (n 104) at 27.

[103] D Dusmanescu, 'Solar energy potential as support for sustainable development of Romanian economy.' *Renewable and Alternative Energy: Concepts, Methodologies, Tools, and Applications*, IGI Global, (2017) at 413.

[104] Z Chiguvare & H Iileka, 'Challenges and opportunities for increased energy access in Sub-Saharan Africa, with special reference to Namibia' in O C Ruppel & B Althusmann (eds) *Perspectives on Energy Security and Renewable Energies in Sub-Saharan Africa* (2015) at 27.

[105] Karekezi & Kithyoma (n 91) at 6.

[106] United Nations, *Kyoto Protocol to the United Nations Framework Convention on Climate Change* (1998).

[107] The Kyoto Protocol was established in 1997 in Kyoto, Japan. It is linked to the United Nations Framework Convention on Climate Change. Article 2 of the UNFCCC sets out its objective which is the stabilization of the concentration of greenhouse gas emissions in the atmosphere at a level that will prevent dangerous anthropogenic interference with the climate system. (Karekezi and Kithyoma (n 91)).

[108] S Mirasgedis et al., 'The role of renewable energy sources within the framework of the Kyoto Protocol: the case of Greece' *Renew. Sustainable Energy Rev.* 6:3 (2002) at 249.

Kyoto protocol.[109] In view of the above, mining contributes to the GHG emissions through the use of energy in its operations and processes, it is submitted that it is imperative for mining sector to incorporate renewable energy as an alternative source of energy.

3.3. Energy supply and consumption in Namibia

3.3.1. Energy supply

Namibia has a diversified energy supply which includes a combination of hydro-electric and coal-fired power plants. These include the Ruacana hydro-electric power station located on the northern boundary river between Namibia and Angola; the coal-fired Van Eck station in Windhoek; and the Paratus and Anixas diesel plants, which are both located in Walvis Bay.[110] The Ruacana power station depends on water flow and weather conditions.[111] This means that in the absence of sufficient water flow, enough electricity cannot be generated and fed into the national grid.[112] The Van Eck coal-fired power station was not operative during 2013.[113] Against this backdrop, Namibia relies mainly on imported electricity for its supply,[114] from the Southern African Power Pool (SAPP).[115] It is worth noting that electrical energy constitutes less than one-third of Namibia's total annual energy consumption, with the other two-thirds comprising liquid fuel and diesel, followed by gas. [116]

---

[109] Namibia ratified the Kyoto Protocol on the 4th of September 2003 and South Africa ratified the protocol on the 31st of July 2002 (Karekezi and Kithyoma (n 91)).

[110] Von Oertzen, 'Namibia's Energy Future' (n 87) at 24.

[111] National Planning Commission 'Energy Demand and forecasting in Namibia' (n 84).

[112] Dusmanescu (n 103) at 14.

[113] Ibid at 24.

[114] M Rämä, et al. '*Development of Namibian energy sector*' (2013) Research Report VTT at 66.

[115] SAPP was created in 1995 when the ministers responsible for energy in the SADC region signed a memorandum of understanding, with the aim of optimising the use of available energy resources and supporting one another during emergencies. SAPP comprises of members such as NamPower (Namibia), Eskom (South Africa), ZESCO (Zambia) and Zimbabwe Electricity Supply Authority among others. (available at <https://www.usea.org/sites/default/files/event-/SAPP%20Overview.pdf> accessed 9 Oct. 2017)

[116] Dusmanescu (n 103) at 11.

Table 1: Power production plants in Namibia

Power plant	Type	Built	Capacity
Ruacana	Hydro power station	1978	322 MW (347 MW in 2014)
Anixas	Diesel power station	1976	24 MW
Paratus	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

Source: M. Rämä, M. et al. *Development of Namibian energy sector* (2013) Research Report VTT

3.3.2. Energy consumption

Economic activities heavily rely on energy and Namibia is no exception.[117] The mining sector is a major end-user of electricity in Namibia.[118] It therefore follows that the growth of the mining and other Industrial sectors will inevitably result in an increased electricity consumption, which in turn will necessitate more domestic electricity generation within Namibia.[119]

In 2007, the country's per capita energy consumption amounted to 7.5 MWh, which indicates an economy that is energy intensive.[120] The total energy consumption in 2007 was 15 TWh, of which 3.5

[117] National Planning Commission 'Energy Demand and forecasting in Namibia' (n 84).

[118] P Smit 'Namibia's mining growth to boost demand for electricity' *Creamer Media* (2010) available at <www.engineeringnews.co.za/print-version/namibias-mining-growth-to-boost-demand-for-electricity-2010-12-03-1> accessed 27 July 2017.

[119] Ibid.

[120] D von Oertzen, 'Namibian national issues report on the key sector of energy with a focus on mitigation' *Desert Research Foundation of Namibia* (2010) at 4.

TWh was electricity consumption. This energy intensity can be attributed to various sectors of the economy, with mining as one of the dominant sectors that are highly dependent on energy.[121]

In 2013, Namibia's primary energy consumption was estimated to be growing at 3.5 per cent annually on average and electricity consumption at 5.6 per cent.[122]

3.4. The potential for renewable energy in Namibia

Generally, there is a growing potential for renewable energy sources to meet the world's demand for energy such as solar and wind.[123] Given the price fluctuation of oil and gas, renewable energy sources are becoming increasingly attractive.[124] The economics and policy mechanisms needed for renewable energy markets are evolving as well.[125] Namibia is no exception, it needs to revisit its key energy policies to determine whether there is a need for a paradigm shift.

3.4.1. Solar energy

Renewable energy from solar sources is particularly attractive because it is safe from price volatility, it is available in large supply and it is eligible for support from bilateral and multi-lateral institutions that advocate for low-carbon energy production.[126]

Namibia's solar regime is among the best in the world and thus has good potential for solar projects.[127] It is estimated at an insolation of 2 200 kWh/m^2/a, with little cloud cover. The global horizontal irradiance (GHI) is the principal climatic indicator which was used to determine the

---

[121] Von Oertzen, 'Namibian national issues report' (n 120) at 4.

[122] Rämä (n 114) at 66.

[123] A K Akella, 'Social, economical and environmental impacts of renewable energy systems', 2009, 34, *Renew. Energy* at 390.

[124] Ibid.

[125] McLellan (n 3) at 42.

[126] U Deichmann et al., 'The economics of renewable energy expansion in rural Sub-Saharan Africa.' *Energy Policy* 39:1 (2011) at 217.

[127] Von Oertzen, 'Namibian national issues report' (n 120) at 4.

technical potential for solar PV in Namibia.[128] Namibia experiences more than 300 days of sunshine every year.[129] The areas with a high GHI are found mostly in the western parts of Namibia.[130]

Despite the apparent attraction for use in the Namibian mining sector, it is not without limitation. It appears that dust from mining operations may limit the use of the solar PV. Furthermore, due to the variations in the solar radiation, solar power may require complimentary power sources in order to ensure consistent capacity.[131] The footprint of the infrastructure required for optimal use is also extensive, thus rendering solar PV units more suitable for use in remote locations.[132]

3.4.2. Wind energy

Namibia is considered to have a long coastline, as it measures up to 1,572 kilometres.[133] As such, there is an opportunity for sufficient wind to be harvested and put to good use.[134]

Since the 1980s, Luderitz has been pinpointed as an area where wind power generation would be most economical.[135] The Ministry of Mines and Energy and German Technical Cooperation carried out a wind assessment project in 1996 for the region of Luderitz and Walvis Bay on the coast of Namibia.[136] This project found that the two areas have a potential for producing wind power.[137] The Southern African Power Pool (SAPP) estimates Namibia's potential for wind energy at between 27.201 MW and 36 TWh per year.[138] In addition, the area around Luderitz is enveloped by strong

---

[128] Chiguvare & Iileka (n 104) at 27.

[129] KPMG Global Mining Institute 'Namibia: country mining guide' available at <https://assets.kpmg.com/content/dam/kpmg/pdf/2014/09/namibia-mining-guide.pdf> accessed 26 July 2017.

[130] Chiguvare & Iileka (n 104) at 27.

[131] McLellan (n 3) at 42.

[132] Ibid.

[133] National Planning Commission 'Energy Demand and forecasting in Namibia (n 84).

[134] Ibid.

[135] H Schutt, '100% decentralised, renewable energy for Namibia' in O C Ruppel & B. Althusmann (eds), *Perspectives on Energy Security and Renewable Energies in Sub-Saharan Africa* (2015) at 47.

[136] Chiguvare & Iileka (n 104) at 27.

[137] Ibid.

[138] Ibid.

south-westerly winds in summer and 'berg' winds during winter, making it one of the windiest places on Earth.[139]

There are numerous wind energy sites with installed capacity of up to 100 MW.[140] There is currently one wind turbine installed in Namibia, which has a capacity of 220 KW and feeds the distribution grid in the Erongo region. New technologies such as vertical axis wind turbines are also available which enables the generation of electricity on small-scale level at lower wind speeds.[141]

However, as wind is mostly abundant in mountainous or coastal areas and thus largely location-bound, it may not match most mine locations.[142]

3.5. Conclusion

Renewable energy can be defined in several ways. However, important aspects of its definition in general, is that it is finite and it is replenished constantly. The forms of renewable energy investigated in this chapter are solar and wind.

The first renewable energy source is that of solar energy, which may be tapped through either solar thermal, or solar photovoltaic routes. The second source includes wind power which can be captured through the use of turbines.

The chapter has further shown that the total global energy, the mining sector accounts for 11 per cent and 15 per cent of the total electricity usage. There are limited statistics indicating the electrical energy use in Namibia, however, from the available data, it can be seen that the Namibian economy is one that is energy-intensive, but that there is a great potential for renewable energy in Namibia. Namibia's solar regime is among the best in the world, whilst wind power generation appears promising, despite some challenges.

---

[139] I Davidson, H Muashekele & N Mukapuli, 'Benguela Community/UNAM Wind Power Demonstration Project:experiences in implementation' *JEPE* (2014) 8:6.

[140] Von Oertzen, 'Namibian national issues report' (n 120).

[141] KPMG Global Mining Institute (n 129) at 47.

[142] McLellan (n 3) at 42.

Although, there are opportunities for the use of renewable energy in Namibia, these give rise to several challenges. These challenges will be discussed in detail in Chapter Four.

CHAPTER FOUR - CHALLENGES OF USING RENEWABLE ENERGY AS AN ALTERNATIVE SOURCE OF ENERGY IN THE NAMIBIAN EXTRACTIVES INDUSTRY

4.1. Introduction

Having defined renewable energy and discussed Namibia's renewable energy potential in the last chapter, this chapter focuses on the challenges that hinder the incorporation of renewable energy into the Namibian mining sector. The challenges are categorised as economic, political, social and technical.

Accordingly, this chapter starts with an explanation of the energy framework in Namibia, followed by a discussion of the various stakeholders in the energy sector. The chapter will conclude with an in-depth analysis and discussion of the challenges.

4.2. Energy framework of Namibia

4.2.1. White Paper on Energy Policy

The White Paper on Energy was published by the Namibia Energy Policy Committee in May 1998.[143] The White Paper is the only one of its kind in the Namibian electricity supply industry, however, the ECB has recently tendered for selection of a consultant to assist the Energy Policy Committee with review and updating of the 1998 White Paper.[144] It has six goals which serve as its framework:[145]

- Effective governance
- Security of supply
- Social upliftment
- Investment and growth

---

[143] Ministry of Mines and Energy "Namibia electricity supply industry national integrated resource plan review and update" 2016.

[144] Ibid.

[145] *White Paper on Energy Policy* (Government of Namibia, 1998).

- Economic competitiveness and efficiency
- Sustainability

Section 3 of the White Paper addresses the topic of renewable energy which illustrates the government's undertaking to promote the use of renewable energy. The policy aims to address issues related to the planning and institutional promotion of renewable energy sources as well as creating public awareness and suitable financing systems. The White Paper guides the tariff structures and price determinants by the ECB.[146] Furthermore, the White Paper shows that the government is committed to ensuring that energy demand by the productive sectors of the economy continues to be met through reliable competitively-priced energy.[147] The policy outlines the different roles and functions of industry participants and lays the basic legal and fiscal criteria.[148]

In line with its commitment to promoting renewable energy as per the White Paper on Energy Policy, the Namibian government launched the Namibia Renewable Energy Programme (NAMREP) Phase I in 2003 and in 2007, Phase II was launched.[149] The aim of NAMREP is to remove barriers to the delivery of renewable energy.[150] One of the projects of NAMREP is the implementation of the Regulatory Framework for Renewable and Energy Efficiency within the electricity sector.[151]

4.2.2. Legislative framework

The electricity industry in Namibia is regulated through the provisions of the Electricity Act, 2000 that came into force on 12 July 2000. It gives statutory credence to the electricity sector in Namibia.[152] It gives power to the Electricity Control Board for the application and granting of electricity

---

[146] J Kapika & A Eberhard, *Power-sector reform and regulation in Africa: lessons from Kenya, Tanzania, Uganda, Zambia, Namibia and Ghana,* HSRC Press (2013) at 183.

[147] M van der Berg & P Koep, 'Mining and energy' in O C Ruppel and K. Ruppel-Schlichting (eds) *Environmental Law and Policy in Namibia*, 3rd Ed. (2016) at 228.

[148] Ibid.

[149] Ibid at 230.

[150] Ibid.

[151] Ibid.

[152] J Kisting, 'Opportunities in the renewable energy sector in Namibia.' *Baobab Equity Management (Pty) Ltd, Namibia, Final Report* (2008) at 29.

generation licences.[153] The Act also provides guidelines for the application of electricity generation licenses.

However, the Act had its shortcomings; it made no provision for the promulgation of technical codes (grid codes), market rules and pricing meant for the protection of private investment.[154] It became necessary that the Act should be flexible to accommodate the evolving market structure.[155] As a consequence, the Act was repealed and the Electricity Act of 2007 was passed.

In terms of the Electricity Act of 2007, any person engaged in the generation, transmission, distribution, supply, import or export of electricity must obtain a license from the ECB for such operations.[156] However, the final decision whether a licence will be granted lies with the Minister of Mines and Energy.[157]

The Act permits third-party access to the transmission network and allows potential choice for bulk consumers.[158]

4.2.4. National Integrated Resource Plan, 2012

The NIRP is a 20-year electricity development plan.[159] The plan came about as a result of a collaboration between the ECB and the World Bank.[160] The Ministry of Mines and Energy is the custodian of the plan. The NIRP focuses only on electricity; it does not deal with the overall energy needs of Namibia.[161] The NIRP is one of the documents which support IPPs (the other two being the

---

[153] Kisting (n 152).

[154] Kapika & Eberhard (n 146) at 175.

[155] Ibid.

[156] The World Bank Group & Electricity Control Board of Namibia *National Integrated Resource Plan Draft Report - Development and Analysis of Policy Implementation Scenarios* (2012).

[157] Ibid.

[158] Ibid.

[159] National Planning Commission 'Energy Demand and forecasting in Namibia' (n 84).

[160] N A Renkhoff 'Namibia towards a conducive regulatory framework in renewable energy law and regulation' in O C Ruppel & K Ruppel-Schlichting (eds) *Environmental Law and Policy in Namibia*, 3rd Ed. (2016) at 251.

[161] The World Bank Group & Electricity Control Board of Namibia (n 156).

RE Procurement Mechanisms and the IPP and Investment Market Framework.[162] It is a crucial tool for planning for the Namibian electricity industry.[163] It endeavours to provide an indication of Namibia's electricity demand and how this demand can be catered for, as well as the cost of supply.[164] The NIRP assesses the power supply development options for Namibia to meet consumer needs, including renewable energy.[165]

4.2.3. Vision 2030

Namibia's development plans and strategies to achieve its national goals are codified in 'The Vision 2030' which was adopted in 2004.[166] The long-term objectives are to be achieved through five-year successive National Development Plans (NDPs) until the target year 2030. The NDPs will contain the goals and intermediate targets milestones that will eventually lead to the realisation of Vision 2030.[167] As Namibia moves closer to its target date (2030) to achieve its goal of providing electricity access by 2030, the need to find and harness new sources of energy arises. Renewable energy is a solution which will aid the achievement of the Vision 2030.

4.3. Participants in the energy sector

There are several stakeholders in the Namibian energy sector, these are accordingly discussed below in more detail:

---

[162] IRP available at <http://www.irena.org/DocumentDownloads/events/2013/October/IRP%20NAMIBIA%20Muyambo%20130927.pdf > accessed 10 Oct. 2017.

[163] IRP available at <http://www.irena.org/DocumentDownloads/events/2013/October/IRP%20NAMIBIA%20Muyambo%20130927.pdf > accessed 10 Oct. 2017.

[164] The World Bank Group & Electricity Control Board of Namibia (n 156).

[165] *National Renewable Energy Policy for Namibia* available at <www.n-big.org/files/National-Renewable-Energy-Policy-for-Namibia_DRAFT-June-13-1.pdf> accessed 30 July 2017.

[166] *Vision 2030 Overview* available at <www.gov.na/vision-2030 accessed> 31 July 2017.

[167] O C Ruppel 'Environmental law in Namibia: an overview' in O C Ruppel & K Ruppel-Schlichting (eds) *Environmental Law and Policy in Namibia*, 3rd Ed. (2016) at 32.

4.3.1. Ministry of Mines and Energy

The Ministry of Mines and Energy (hereinafter the MME) is a policy maker of the energy sector, and is the custodian of the energy sector of Namibia.[168] The MME's mission is to ensure the reliable, affordable and sustainable energy supply for the country,[169] it is committed to exploring domestic natural resources while supporting the socio-economic development of the country.[170] It further has the responsibility of planning and procurement of additional capacity to address any deficit in the electricity generated domestically.[171] The MME has introduced a revolving fund to support solar energy usage for off-grid purposes to lower the threshold for RE investment.[172]

4.3.2. Electricity Control Board

The ECB is the statutory regulatory body established by the Electricity Act 2 of 2000 which has since been repealed by the Electricity Act 4 of 2007. Under the Electricity Act of 2007, the mandate and core responsibilities of the ECB have been expanded.[173] This mandate involves supervising control over the electricity supply industry which includes renewable energy.[174] The ECB is responsible for regulating electricity generation, transmission, distribution, supply, import and export in Namibia by setting tariffs and issuing licences.[175]

4.3.3. Namibia Power Corporation (NamPower)

NamPower is a state-owned entity, which is responsible for the distribution of electricity to mines, farms and local authorities where the regional electricity distributors (REDs) are not operational.[176] NamPower is the owner and operator of transmission and generation assets in Namibia as well as

---

[168] Von Oertzen 'Namibia's Energy Future' (n 87) at 17.

[169] Rämä (n 114) at 67.

[170] Ibid.

[171] 'Renewable energy: Investing in Africa- Namibia' available at <www.clydeco.com/uploads/Blogs/offshore/files/Energy_profile_-_Namibia.pdf> accessed 02 August 2017.

[172] 'Namibia-EEP Africa' available at <eepafrica.org/projects/namibia> accessed 05 October 2017.

[173] Renkhoff 'Namibia towards a conducive regulatory framework' (n 160) at 239.

[174] Rämä (n 114) at 67.

[175] Ibid.

[176] 'Renewable energy: Investing in Africa (n 171).

the owner of the REDs.[177] This situation results in a monopoly in the electricity sector regarding the transmission, generation and trading sectors governed by NamPower.[178] In regard to renewable energy, NamPower has approved the Renewable Energy Policy Paper which states that its target for the renewable is 10% of the total installed capacity. [179]

NamPower created the REDs which are responsible for the distribution and supply of electricity, in line with the Electricity Act.[180] By 2012, three REDs were operational: Northern RED (NORED), Central RED (CENORED) and Erongo RED.[181] In addition to the REDs, the City of Windhoek (CoW) is also a distributor.

4.3.5. Renewable Energy and Energy Efficiency Institute (REEEI)

The REEEI is a joint venture initiative between the Polytechnic of Namibia and the Ministry of Mines and Energy. It was established in 2006 with a mandate is to gather information on renewable energy and energy efficiency technologies and practices.[182]

The REEEI ran a programme from 2006 to 2008; - the Renewable Energy and Energy Efficiency Capacity Building Programme (REEECAP).[183] REEECAP's objective was to increase the use of renewable energy and energy efficiency measures in order to promote sustainable development in Namibia.[184] In 2012, the REEEI was transformed into the Namibia Energy Institute (NEI), with government authorisation,[185] and was launched on 20 May 2014. Whilst NEI does not necessarily

[177] 'Renewable energy: Investing in Africa (n 171).

[178] Ibid.

[179] 'Namibia-EEP Africa' (n 172).

[180] Von Oertzen, 'Namibia's Energy Future' (n 87) at 17.

[181] Ibid at 17.

[182] 'Renewable Energy & Energy Efficiency Institute (REEEI)' <www.pciaonline.org/node/211> accessed 02 August 2017.

[183] Ibid.

[184] Ibid.

[185] Rämä (n 114) at 67.

engage as a market actor, it has the role in supporting RE technologies through research and development.[186]

4.3.6. Namibia Planning Commission (NPC)

The NPC was established by the Namibian constitution. Its responsibility is to plan national priorities and direct Namibia in the path of development.[187] The NPC periodically publishes the NDPs. The work of the NPC usually cross-cuts with the development of the energy sector which strategically involves renewable energy.[188]

4.4. Challenges associated with using renewable energy technologies in the extractive industry

Several challenges have been identified below as hindering or slowing down the penetration of renewable energy into the Namibian extractive industry. They will be addressed in much more detail.

4.4.1. Economic challenges

Despite the increasing number of solar PV plants in Namibia, there is no legislation which addresses the compensation of a private owner of a solar PV which feeding into the grid.[189] The lack of legislation which addresses compensation for private owners could potentially lower the extent to which private owners feed into the grid.

There is a high upfront capital cost of renewable resources equipment which is limiting the potential infiltration of renewables into the energy market.[190] Furthermore, the lack of financing

[186] Renkhoff 'Namibia towards a conducive regulatory framework' (n 160) at 242.

[187] Rämä (n 114) at 67.

[188] Ibid.

[189] Chiguvare & Iileka (n 104) at 27.

[190] Rämä (n 114) at 57.

mechanisms for renewable energy technology procurement is in urgent need of review.[191] There is also limited foreign investment in the Namibia energy sector.[192]

There are no incentive schemes in place to ensure private investment in renewable energy in Namibia such as in the form of tax breaks or guarantees.[193] Government policy (White Paper) is not clear on its support for renewable energy,.[194] Guarantee mechanisms are not conducive to enhance confidence in the purchase of some of the technologies, such as solar energy equipment.[195] Furthermore, there are little or no financial incentives for local renewable energy entrepreneurs to bulk procure, sell, install and maintain renewable energy technologies.[196]

Duties and taxes are considered to be one of the factors hindering the expansion of RE projects in Namibia.[197] The imposition of duties and taxes contribute to the already high costs of renewable energy technologies as opposed to other energy generation technologies.[198] Value Added Tax (VAT)[199] is payable on all imports of solar energy products in Namibia.[200] If these are imported from other SACU member countries, [201] custom duties are not payable; however, VAT is still payable.[202]

---

[191] Rämä (n 114) at 57.

[192] Von Oertzen, 'Namibian national issues report' (n 120*)* at 4.

[193] Rämä (n 114) at 57.

[194] Ibid.

[195] Kisting (n 152) at 27.

[196] Ibid.

[197] Ibid at 30.

[198] Ibid.

[199] The essence of the VAT is that it is levied on all transactions and is credited against the trader's sales, it bears only on final consumption, if the crediting chain is unbroken. (M Keen & B Lockwood, 'The value added tax: its causes and consequences' *J. Dev. Econ.* 92:2 (2010) at 139.)

[200] Kisting (n 152) at 30.

[201] SACU is a customs union established in 1910, which consist of five members; namely Botswana, Namibia, South Africa, Lesotho and Swaziland. (retrieved from <http://www.sacu.int/> accessed 02 August 2017.)

[202] Kisting (n 152) at 30.

4.4.2. Political/legal challenges

The current Namibian energy policy is outdated and does not reflect the needs of contemporary societal requirements[203] As an example the White Paper on Energy was formulated in 1998. Current targets are arguably not realistic or achievable, which necessitates drastic revision.[204] As De Jongh posits the energy sector is the basis of a stable economy and, as such, it may be subjected to political intervention by governments as a means to control volatility in the economy.[205] At present there is a distinct lack of appropriate policy and regulatory regimes that support renewable energy, thus acting as an inherent barrier to entry into the market.[206]

Besides the direct financial support or incentives, such as tax breaks or subsidies which the government can provide to IPPs or mining companies, the government could establish a policy framework which allows alternative energy companies to either sell energy independently or feed excess electricity back into the main grid.[207] For example in Namibia, NamPower is the main power utility which controls the generation, transmission and supply of electricity in Namibia and any IPP which aspires to feed electricity into the main grid has to enter into a PPA with NamPower. Potential power providers depend on the electricity prices which NamPower deems fit and the conditions NamPower attaches to the purchase of the electricity.[208]

4.4.3. Technical challenges

Lack of technical expertise has been identified as a challenge to renewable energy.[209] Furthermore, there is a need for research and development as well as training facilities and programmes.[210]

---

[203] Rämä (n 114) at 56.

[204] Ibid.

[205] D De Jongh, D Ghoorah & A Makina, 'South African renewable energy investment barriers: an investor perspective' *JESA* 25:2 (2014) at 16.

[206] Chiguvare & Iileka (n 104) at 29.

[207] 'Alternative energy in mining' (n 61).

[208] Kisting (n 152) at 27.

[209] Rämä (n 114) at 56.

[210] Ibid.

Namibia's technology and engineering skills base is inadequate and is highly dependent on foreign expertise.[211]

4.4.4. Social challenges

Public acceptance and awareness was quoted among the challenges to the widespread use of renewables.[212] Wustenhagen, Wolsink and Burer distinguished three dimensions of social acceptance: namely, socio-political acceptance, community acceptance and market acceptance.[213]

Socio-political acceptance is acceptance broadly. It involves the societal acceptance of policies and technologies.[214] Socio-political acceptance at the general level also concerns acceptance by key stakeholders and policy actors of effective policies.[215] Community acceptance refers to the specific decision of placement decisions and RE projects by local stakeholders such as residents and local authorities.[216] Community acceptance has a time dimension feature attached to it.[217] Social acceptance can also be interpreted as social acceptance of an innovation. The focus is not just consumers but also on investors.[218] This involves the issue of intra-firm acceptance of RE innovation, for example, large firms are said to be subject to path dependencies when it comes to their investment behaviours.[219]

---

[211]Von Oertzen, 'Namibian national issues report' (n 120) at 2.

[212] Rämä (n 114) at 56.

[213] R Wüstenhagen, M Wolsink & M J Bürer, 'Social acceptance of renewable energy innovation: an introduction to the concept' *Energy Policy* 35:5 (2007) at 2684.

[214] Ibid.

[215] Ibid at 2685.

[216] Ibid.

[217] Ibid.

[218] Ibid.

[219] Ibid at 2686.

4.5. Realised renewable energy projects in mining operations

Though few in number, a number of mining companies are implementing renewable energy into their energy mix or are in the process of integrating it in the near future. The following examples include particular mines that are using, or beginning with the construction of RE plants:

4.5.1. Cronimet Chrome Mining SA's Thabazimbi Mine

Cronimet owns and manages a PV plant at its site in Limpopo.[220] Cronimet Chrome SA is a subsidiary of Cronimet Mining AG, based in Switzerland. The company acquired rights to develop the Zwartkop Chrome mine near Thabazimbi.[221] The mine is located off-grid and therefore cannot access the power grid.[222] Under the business-as-usual approach, the mine would have to rely on diesel to meet its power needs.[223] The volatility in diesel prices, coupled with sustained decreases in the price of solar panels encouraged Cronimet to explore the feasibility of developing an on-site PV plant for the Zimbi mine, considering the good solar irradiation received at the mine's location.[224]

The mine chose to follow the self-generation model. It managed the development, financing and the operation of the solar-diesel hybrid system on its own land, in partnership with Solea Renewables Ltd, a South African-registered engineering, procurement and construction (EPC) firm.[225]

The mine obtained a loan from the Deutsche Bank and German Reconstruction Credit Institute to cover the US$ 2.66 million in capital expenditure (CAPEX) required for the construction of the

[220] 'Alternative energy in mining' (n 61).

[221] Ibid.

[222] Boyse (n 14) at 23.

[223] Ibid.

[224] Ibid.

[225] Ibid.

plant.[226] Though the plant was completed in 2012, at the time it was not considered to be cost-effective nor technologically feasible.[227]

The benefits of the plant include GHG savings to the mining operations. The use of solar power also allows Cronimet to save in diesel costs. Cronimet has since acquired Solea Renewables, the engineering firm which oversaw the construction of the solar PV plant at Cronimet's mine at Thabazimbi. The firm is now called Cronimet Mining Solutions GmbH.[228]

4.5.2. IAMGOLD's Essakane mine in Burkina Faso

A 15-year power purchase agreement was signed between IAMGOLD Essakane SA Gold mine and EREN Renewable Energy (EREN RE) and its partner African Energy Management Platform (AEMP) for a solar farm.[229] This project which involves an investment of more than US$ 20 million will allow the mine to reduce its fuel consumption and carbon emissions.[230]

The mine is off-grid and relies solely on carbon-intensive diesel power. The solar plant is expected to be commissioned by the end of 2017.[231] The project is expected to reduce the mine's fuel consumption by approximately 6 million litres per year and reduce its annual carbon emissions by close to 8 500 tons.[232] The project will sell electricity from the solar plant to IAMGOLD Essakane for the duration of the power purchase agreement.[233]

---

[226] Boyse (n 14) at 23.

[227] Ibid.

[228] Ibid at 25.

[229] 'New renewable energy for mine project – IAMGOLD Essakane to benefit from largest hybrid plant in Africa' available at <http://energyandmines.com/2017/03/new-renewable-energy-for-mine-project-iamgold-essakane-to-benefit-from-largest-hybrid-plant-in-africa/> accessed 08 August 2017.

[230] Ibid.

[231] Ibid.

[232] Ibid.

[233] Ibid.

4.6. Conclusion

The chapter discussed the energy framework of Namibia. The research suggests that the Namibian White Paper on Energy Policy is outdated. It has also been found that the electricity supply industry of Namibia is monopolistic: owned and controlled by the government-owned entity that is NamPower. It has been established that the electricity regulating body, ECB's mandate has been expanded with the repeal of the Electricity Act of 2000 by the Electricity Act of 2007.

Challenges to the introduction of renewable energy have been identified as economic, political or legal, technical and social. It can therefore be concluded that, although Namibia has made a positive response to the adoption of RE in its energy sector, there remains significant work to be done in order to improve investor appetite for the introduction or expansion of renewables, particularly in the mining sector. Th findings further suggest that financing schemes for RE technology are lacking. Although the Namibian energy policy clearly sets out its support for the promotion of RE, there are no incentives such as tax breaks for the RE projects or the removal of subsidies for conventional energy, in order to create a level playing field for both RE and conventional energy. Competitiveness in the energy sector could be improved, by doing away with the current monopolistic situation. The examples of the realised projects illustrate that the use of renewable energy in an operational mining environment is not only possible, but an operational necessity.

In the next chapter, the research findings will be consolidated and analysed in order to come up with suitable recommendations.

CHAPTER FIVE - EVALUATION OF FINDINGS AND RECOMMENDATIONS

5.1. Introduction

The energy framework in Namibia as well as the stakeholders in the energy sector was discussed earlier in this study[234]. The previous chapter expanded by considering the challenges associated with the use of renewable energy.

The current chapter consolidates findings from the previous chapters, and provides an evaluation of the findings of the same. As such, the chapter applies the theoretical models identified in Chapter Two together with the available business models in order to determine viable option for use in the Namibian mining sector.

5.2. Evaluation of research findings

Looking back at the theories discussed in Chapter Two above, one finds merit in what these theories posit.[235] Firstly, the theory of reasoned action argues that governmental support is crucial in pushing the renewable energy agenda, it therefore warrants the argument that cooperation between public and private actors is important.[236] The government has the means to advocate for the renewable energy transition, or rather, the increased use of renewable energy as an alternative in the extractives industry. The government may do this by exercising its power in the form of a legislative response which creates a positive environment for private investment in renewable energy.

The theory of renewable energy transition speculates that the modern industrial economies are characterised by what Unruh terms 'carbon lock-in'.[237] This phenomenon results from modern industrial economies being trapped in a path-dependency process. Systematic forces promote path-

---

[234] See *infra* at 32.

[235] See *infra* at 16.

[236] Masini and Menichetti (n 26).

[237] Unruh (n 31).

dependency by preserving fossil-based infrastructures rather than renewable energy.[238] The theory postulates that this happens despite the environmental afflictions which are associated with the use of coal to generate electricity.[239]

The theory posits that governmental support is necessary to break carbon lock-in. It further calls for binding constraints on carbon emissions through direct regulation or price instruments.[240] Both theories argue for governmental support, which can be in the form of policies.[241] In Namibia, the government does have policies and programmes in place that call for the promotion of renewable energy, however, most of these are in the form of non-penalising initiatives.[242]

The various business models that may be used by mining companies in order to develop their RE projects are largely dependent on the location, or more specifically the geography, as well as the regulatory framework in the particular jurisdiction.[243] Against this backdrop, in considering the regulatory framework of Namibia, one finds that self-generation, net-metering and the self-generation and powering townships model may be feasible in Namibia.[244]

The use of PPPs will not be unfamiliar to mining companies because governments have used infrastructure development arrangements in the form of PPPs. In most cases, mining companies enter into these forms of arrangements with local governments. PPPs are used by the state to procure those infrastructures that are deemed important by the state. The government enters into an agreement with a private entity such as a mining company to build, develop and finance the

---

[238] Unruh (n 31).

[239] Unruh (n 31).

[240] Fischer and Newell (n 35).

[241] Policy measures may be direct or indirect, direct measures refer to policies that specifically target the local manufacturing industry development while indirect measures are policies that support the use of renewable energy in general and thereby creating an environment suitable for local manufacturing of RE technologies and equipment. A form of a direct measure would be local content requirements such as requiring the use of locally manufactured technology in domestic RE projects, financial and tax incentives, favourable custom duties, research and development (R&D) and export credit assistance. (J I Lewis & R H Wiser, 'Fostering a renewable energy technology industry: an international comparison of wind industry policy support mechanisms' *Energy Policy* 35:3 (2007) at 1851.)

[242] See *infra* at 36.

[243] See *infra* at 19.

[244] See *infra* at 21.

infrastructure as agreed. Thus, applying PPPs to the development of RE projects will bring mutual benefits for the mining company, for the community and for the host government. For the mining company, the PPPs have the advantage that the use of RE as an alternative energy source will reduce its energy expenses, whether the mine is connected to the grid or not. For the government, this model would have the implication that it is able to reach its electrification targets for remote and rural areas. For the community, the use of the PPP model entails that the RE plant will be a legacy asset which will be left behind after the mining operations have ceased. Furthermore, it is typical that PPPs are usually concluded for periods of up to 10 years, it is befitting most mines have a lifespan longer than 10 years. This therefore pinpoints the suitability of the model to mining operations.

The mining company may opt to develop the project itself or it may lease its land to an IPP to develop the project. Where the company opts to outsource the project, the creation of a special purpose company would be appropriate because mining companies are not in the business of electricity generation. Therefore, it may be difficult for the mine to manage, develop and understand the implications of a renewable energy plant, apart from the revenue opportunity.

The model of industrial pooling may tend to be problematic for different competitors to enter into a business. This may thus prove frustrating for the development of the project. In addition, applying this model in the Namibian mining sector may not be viable, given that most mining sites are located far from one another, making it difficult to implement this model.

The definitions of renewable energy offered by this study have three aspects in common, that is: renewable energy is infinite, it is inexhaustible and it is continually replenished as it is used up.[245]

Namibia is abundantly endowed with renewable energy sources as shown in Chapter Three above, however, this potential remains untapped. The literature has shown that the areas of Lüderitz and Walvis Bay are suitable for wind energy projects. This became clear from the wind assessment projects carried out in 1996. In addition, Namibia has an excellent solar regime. However, despite the many associated benefits of using solar energy, it has been pointed out that the use of solar PV may require back-up, especially during the rainy season when sunlight is less likely.[246] Therefore, the mine or the IPP operating the plant may need to invest in the storage of solar energy. This situation may

[245] See *infra* at 26.

[246] See *infra* at 31.

warrant the use of hybrid systems[247] providing the mine with a diverse supply of energy. In this model, where one source fails, there is an alternative source of energy to back up the energy supply of the mine.

The coast of Namibia is proven to be sufficiently windy for a wind farm. However, it is also true that there are not that many mines in coastal Namibia, so it is possible that if a mine decides to use wind energy in their operations, it will not be an onsite project. However, most mine sites have access to solar sources, so where it is not possible to use wind projects, it is possible that solar projects can be developed. Whether the mining company will make use of an IPP or manage the development of the project itself depends on what is suitable for the particular mine. Factors such as the process of obtaining the necessary permits will also influence the decision on what business model will be used for the project. The possible revenue stream of the project will also influence this decision.

There are various renewable energy projects in Namibia, but there is no precedent for a mine in Namibia using renewable energy as an alternative source of energy. The author takes cognisance that renewables cannot compete with fossil fuels and it is difficult to use it as a base load, because fossil fuels are cheaper and more reliable than RE, and although RE is readily available, the technology required to harness on a large scale is costly.[248] This argument is directly in line with the path-dependency concept brought forth by the renewable energy transition theory in Chapter Two. Despite all the arguments against RE, the advocacy aimed at the use of RE is growing, with the increased support from international bodies such as the UN.

Although fossil fuels are satisfying most of Namibia's energy needs, this does not mean that Namibia should remain complacent; the country cannot get comfortable with having its energy demands met by SAPP, and what better way to start diversifying than with a sector considered to be energy-intensive and which happens to be the backbone of the country's economy? Although the statistical data which support this finding are scattered, the indications of the per capita energy consumption suggest that this is the case.

---

[247] For the purposes of this study, 'Hybrid systems' is used to illustrate the case where multiple sources of energy are used to supplement/augment each other, particularly as a preventative measure in case where one source of energy fails.

[248] See *infra* at 14.

The challenges to the successful incorporation of renewable energy into the mining sector were found to be economical, political/legal, social and technical. The legal challenges identified include the inadequacy of the White Paper on Energy Policy of 1998. The policy in its section 3 commits to the promotion of renewable energy. However, the policy is said to be outdated; it is more than ten years old. This is not suggesting that an outdated policy is ineffective *per se,* but the law and policy need to evolve with the changing needs of society. Policymakers can revisit the policy and set new targets which are realistic for the use of renewable energy. Policy review should also be able to remove the monopolistic situation in the energy sector to allow for other actors and to create a level playing field. This monopoly is characterised by the single-buyer model being used in the Namibian energy sector, which has the effect that only the state-owned utility has the mandate to trade in electricity. Whichever tariffs are set by the national utility are accepted by the electricity distributors in the energy industry. This does not indicate a healthy competition in the industry.

Currently, renewable energy feed-in tariffs (REFIT) are under development in Namibia. In addition, there is an interim REFIT programme. The research has shown that there are little or no financial incentives in Namibia whatsoever.[249] Furthermore, the research has shown that there is limited investment into the renewables. Therefore, the creation of some form of incentives will go a long way in attracting investment in this area.

Inadequate investment into the research and development of renewables was also quoted among the challenges to the incorporation of renewable energy into the mining sector. Mining companies are prone to be reluctant about the use of renewables in the sector, which illustrates carbon lock-in.[250] The level of technical capacity in Namibia is not acceptable, RE technologies and equipment are not manufactured in Namibia, which means that they have to be imported into the country subjecting them to custom duties, in turn escalating the already high costs of these technologies. The situation begs for skills transfer, which involves the training of locals in order to equip them with the required skills and expertise in RE technologies.

---

[249] Financial incentives take the form of low-interest loans for project financing or providing financial subsidies to RE. Tax incentives may take the form of tax credits or tax deductions, reduction of VAT, moreover a tax deduction can be made available for labour costs for RE plants in the mining operations. Lastly, financial and tax incentives can be provided to companies such as joint ventures between foreign and local companies to encourage international cooperation and to promote technology transfer. (Lewis & Wiser (n 241) at 1852.)

[250] See *infra* at 18.

Among the challenges which were identified were the social challenges. The perception towards renewable energy needs to be changed. Here, the focus is not just on consumers, but also on investors, as well as other key stakeholders.[251] In addition, large companies are said to have a low risk appetite when it comes to their investment decision, which suggests that they are prone to path dependency, therefore mining companies need to be convinced of the benefits of investing in RE.

5.3. Conclusion

The discussion applied the theories which were identified in Chapter Two above. The purpose of these theories was to provide a theoretical lens for the study. Both theories were used in an attempt to explain the behaviour or the factors that affect the decisions of firms regarding the use of renewable energy in their operations.

It appears from the different models discussed and evaluated that the appropriateness of the business model was influenced by the fiscal regime where the mining operations are located as well as the legislative instruments in place. It was also concluded that business models which would be most suitable in the Namibia mining sector are the self-generation, net-metering, and self-generation and powering townships. Namibia's current legislative framework has no net metering framework in place although they are under development.[252] Namibia does, however, have a REFIT interim programme in place. It was concluded that the use of industrial pooling may not be as effective as the other business models, because it involved different competitors working together and most mining company will be reluctant to conclude capital ventures with their competitors.

The evaluation also pointed to the fact that there is a monopoly in the Namibian energy sector, with a national utility which is owned by the government in complete control of the electricity sector. The government-owned utility controls the purchasing, distribution and transmission of electricity in Namibia. Therefore, there is a single-buyer model in Namibia. There is a need to change this in order to allow fair competition in the energy sector.

---

[251] See *infra* at 41.

[252] See *infra* at 21.

It was concluded that there is little private investment into the renewables and that the public perception towards renewables needs to change. It is not only the perception of consumers, but also the perception of policy makers. The White Paper was also found to be outdated and that the government needs to revisit it in order to set new realistic targets for the use of renewable energy.

Lastly, it was concluded that the level of capacity and engineering skills in Namibia is inadequate and that renewable energy technologies and equipment are being imported subjecting them to custom duties and taxes. These custom duties escalate the already high costs of renewable energy technologies.

CHAPTER SIX - CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

This chapter provides a summation of chapters two to five above and presents recommendations for challenges where they have been identified. The recommendations emanate from the evaluation in chapter five.

The theories attempt to explain the behaviour or attitudes towards renewable energy. These attitudes towards renewable energy may be influenced by a number of factors, including the consequences of engaging in the behaviour or, put simply, in undertaking a certain course of action. The lack of support from the government or public institution in any given jurisdiction, such as tax incentives or subsidies, may influence the firm's decision regarding a more sustainable energy source, such as wind or solar power. In addition, there is hardly any precedent for large-scale deployment of renewable energy technology. This is, in turn, may serve as a deterrent towards the use the use of renewable electricity as opposed to fossil-based electricity. Social pressure also plays a role regarding the renewable energy, social pressure may emanate from organisations such as the IPCC on governments to reduce their carbon emissions.

In Chapter Three the definition of renewable energy was discussed in order to create clarity and to create the context or the background of the research study. Renewable energy has several definitions; however, one important aspect of its definition is that it is infinite and it is replenished constantly. The forms of renewable energy investigated included solar and wind. The Kyoto Protocol is relevant to the energy debate because renewables are featured in the United Nations Climate Change Convention and the fact that Namibia is a signatory to the Kyoto Protocol and is thus bound by its emission reduction targets, of which RE is one way to fulfil its obligations under the protocol. Several authors have established that renewable energy has lower emissions of carbon dioxide compared to fossil fuels.

Mining sector accounts for 11 per cent and 15 per cent of the total electricity usage of the total global energy, this is due to its heavy operations and processes involved in mining. However, in the

Namibian case there are limited statistics indicating the electrical energy use in its mining sector; though the available data show that the Namibian economy is one that is energy-intensive.

There is increased potential for renewable energy given that Namibia's solar regime is among the best in the world, it would be fair to infer that harnessing this source of energy can be beneficial for the Namibian mining industry and thereby reducing the cost of electricity for mining companies and reducing the emissions from the mining sector. The use of renewable energy in the mining industry as an alternative source of electrical energy can best be achieved with the support from the government. This support can be in the form of policies that encourage the use of renewable energy.

Although, there are opportunities for the use of renewables in Namibia, challenges remain which hinder the expansion of the sector. These include political, economic, technical and social challenges. In order to determine the legal challenges associated with the incorporation of RE in Namibia, particularly the mining sector, chapter four reviewed the energy framework of Namibia. It was found that the cardinal policy paper on energy, the White Paper was outdated. The research further suggested that the monopolistic approach adopted by the government does create a conducive environment for IPP to enter the energy market. It has been established that the electricity regulating body, ECB's mandate has been expanded with the repeal of the Electricity Act of 2000 by the Electricity Act of 2007.

Namibia has made a positive response towards the adoption of RE in its energy sector, however a lot still has to be done regarding the improvement of investor appetite in RE. Although the Namibian energy policy clearly sets out its support for the promotion of RE, there are no incentives such as tax breaks for the RE projects or the removal of subsidies for conventional energy, in order to create a level playing field for both RE and conventional energy. Competitiveness in the energy sector could be better, by doing away with the monopolistic situation.

Chapter Five evaluated the findings of the research. The discussion applied the theories which were identified in Chapter Two. The purpose of these theories was to better understand what underpins the study. Both theories attempted to explain the behaviour or the factors that affect the decisions of firms regarding the use of renewable energy in their operations. The conclusion is that the business model applicable was influenced by the fiscal regime where the mining operations are located as well as the legislative instruments in place. It was also concluded that business models which would be most suitable in the Namibia mining sector are the self-generation, net-metering and

self-generation and powering townships. Namibia's current legislative framework has no net metering framework in place although they are under development. Namibia does, however, have a REFIT interim programme in place. It was concluded that the use of industrial pooling may not be as effective as the other business models, because it involved different competitors working together and most mining company will be reluctant to conclude capital ventures with their competitors.

The evaluation also pointed to the fact that there is a monopoly in the Namibian energy sector, with a national utility which is owned by the government completely in control of the electricity sector. The government-owned utility controls the purchasing, distribution and transmission of electricity in Namibia. Therefore, there is a single-buyer model in Namibia. There is a need to change this in order to allow fair competition in the energy sector.

It was concluded that there is little private investment into the renewables and that the public perception towards renewables needed to change. It is not only the perception of consumers, but also the perception of policy makers. The White Paper was also found to be outdated and that the government needs to revisit it in order to set new realistic targets for the use of renewable energy.

Lastly, it was submitted that the level of capacity and engineering skills in Namibia is inadequate and that renewable energy technologies and equipment are being imported subjecting them to custom duties and taxes. These custom duties escalate the already high costs of renewable energy technologies.

6.2. Recommendations

In answering the main research question, the following observations are made:

- The challenges to the incorporation of RE in the mining sector are economic, political and legal, technical and social.
- There is an opportunity for using RE in the mining operations, however, this opportunity has not been explored yet. Currently there is no precedent for a mine in Namibia which uses RE as an alternative in its operations. This does not mean that Namibia should remain complacent.
- Local institutions are very hesitant to fund RE projects, they perceive these projects to be too risky because of the level of knowledge in the field of technology.

- The electricity demand will continue growing as the economy grows. Namibia cannot keep relying on imports from South Africa.

From the above, the following recommendations are made:

- Response in the form of legislation is needed. The government can act as an enabler by establishing policies which encourage and support the use of RE. The role which the government can play in promoting the use of RE is by setting a target in its policies which is achievable. In order to achieve this, the government can prescribe a percentage of electricity generation which should come from RE with a set timeframe. Furthermore, the government can also consider promulgating a white paper on RE. The white paper on RE would deal with all the issues that are incidental to the use of RE.
- There is a need to establish regulatory and institutional frameworks which create a competitive environment for both conventional and renewable energy to achieve a diverse energy supply for Namibia which is sustainable.
- The Namibian energy sector is need of liberisation and privatisation. The policy objectives need to be balanced with regulatory and legal provisions. Energy reforms provide opportunities to remove the emphasis placed on carbon-emitting electricity sourcing.[253]
- Mining companies need to change their perception of the use of RE in mining operations instead of relying only on electricity or diesel for off-grid operations. Mining companies should also consider the real benefits of using RE as an alternative source of energy. Namibia's energy future is dependent on RE sources and, as mining companies are among the major consumers of energy, it provides both an opportunity and a good starting point to invest in RE.
- More provision should be made to provide engineering skills and training to locals, instead of relying on foreign expertise. Mining companies that are looking to incorporate RE may have to invest more resources in training locals.

Clearly the incorporation of RE in the mining sector has numerous benefits not only for the mining company using it but also for the surrounding community because they will access to electricity and lastly for Namibia, because incorporating RE into the mining sector will reduce GHG emissions from

[253] Y Oke, 'The pathway to energy liberation in Nigeria: lessons for Namibia' in O C. Ruppel & B Althusmann (eds) *Perspectives on Energy Security and Renewable Energies in Sub-Saharan Africa* (2015) at 57.

the mining sector. However, despite these benefits, the challenges which have been identified to hinder the successful incorporation of RE in mining will have to be addressed in order to enable the harnessing of this source of energy.

BIBLIOGRAPHY

Primary sources

International instruments:

United Nations, Kyoto Protocol to the United Nations Framework Convention on Climate Change, (1998)

Namibian statutes:

White Paper on Energy Policy (Government of Namibia, 1998)

Electricity Act 4 of 2007

Electricity Act 2 of 2000

Secondary sources

Books:

Quaschning, V, *Understanding renewable energy systems* (Routledge 2016)

Chapters in Books:

Chiguvare, Z & Iileka, H, 'Challenges and opportunities for increased energy access in Sub-Saharan Africa, with special reference to Namibia' in Ruppel, OC & Althusmann, B (eds), *Perspectives on Energy Security and Renewable Energies in Sub-Saharan Africa* (2015)

Johansson, TB et al., 1993, 'Renewable fuels and electricity for a growing world economy: defining and achieving potential' in Johansson, TB et al. (eds), *Renewable Energy: Sources for Fuels and Electricity* (1993)

Oke, Y, 'The pathway to energy liberation in Nigeria: lessons for Namibia' in Ruppel, OC & Althusmann, B (eds), *Perspectives on Energy Security and Renewable Energies in Sub-Saharan Africa* (2015)

Renkhoff, NA, 'Namibia towards a conducive regulatory framework in renewable energy law and regulation' in Ruppel, OC and Ruppel-Schlichting, K (eds), *Environmental Law and Policy in Namibia*, 3rd ed. (2016)

Ruppel, OC 'Environmental Law in Namibia: an overview' in Ruppel, OC and Ruppel-Schlichting, K (eds), *Environmental Law and Policy in Namibia*, 3rd ed. (2016)

Schutt, H, '100% Decentralised, renewable energy for Namibia' in Ruppel, OC & Althusmann, B (eds), *Perspectives on Energy Security and Renewable Energies in Sub-Saharan Africa*, (2015)

Van der Berg, M & Koep, P, 'Mining and Energy' in Ruppel, OC & Ruppel-Schlichting, K (eds), *Environmental Law and Policy in Namibia*, 3rd ed. (2016)

Articles:

Akella, AK, Saini, RP & Sharma, MP, 'Social, economical and environmental impacts of renewable energy systems' *Renewable Energy* (2009) 34:2

Aklin, M & Urpelainen, J, 'Political competition, path dependence, and the strategy of sustainable energy transitions' *American Journal of Political Science* (2013) 57:3

Bang, HK et al., 'Consumer concern, knowledge, belief, and attitude toward renewable energy: An application of the reasoned action theory.' *Psychology & Marketing* (2000) 17:6

Davidson, I, Muashekele, H & Mukapuli, N, 'Benguela Community/UNAM Wind Power Demonstration Project-Experiences in Implementation' *Journal of Energy and Power Engineering* (2014) 8:6

Deichmann, U et al., 'The economics of renewable energy expansion in rural Sub-Saharan Africa.' *Energy Policy* (2011) 39:1

De Jongh, D, Ghoorah, D & Makina, A, 'South African renewable energy investment barriers: an investor perspective' *Journal of Energy in Southern Africa* (2014) 25:2

Demirbas, A, 'Global renewable energy projections' *Energy Sources, Part B* (2009) 4:2

Grimsey, D & Lewis, MK, 'Evaluating the risks of public private partnerships for infrastructure projects' *International Journal of Project Management* (2002) 20

Lewis, JI & Wiser, RH, 'Fostering a renewable energy technology industry: an international comparison of wind industry policy support mechanisms' *Energy Policy* (2007) 35:3

Feng, HY, 'Key factors influencing users' intentions of adopting renewable energy technologies' *Academic Research International* (2012) 2:2

Fischer, C & Newell, RG, 'Environmental and technology policies for climate mitigation' *Journal of Environmental Economics and Management* (2008) 55:2

Masini, A & Menichetti, E, 'The impact of behavioural factors in the renewable energy investment decision making process: conceptual framework and empirical findings' *Energy Policy* (2012) 40

McLellan, BC et al., 'Renewable energy in the minerals industry: a review of global potential' *Journal of Cleaner Production* (2012) 32

Mekhilef, S, Saidur, R & Safari, A, 'A review on solar energy use in industries' *Renewable and Sustainable Energy Reviews* (2011) 15:4

Mirasgedis, S et al., 'The role of renewable energy sources within the framework of the Kyoto Protocol: the case of Greece' *Renewable and Sustainable Energy Reviews* (2002) 6:3

Osei-Kyei, R & Chan, AP, 'Review of studies on the critical success factors for public–private partnership (PPP) projects from 1990 to 2013' *International Journal of Project Management* (2015) 33:6

Painuly, JP, 'Barriers to renewable energy penetration: a framework for analysis' *Renewable Energy* (2001) 24:1

Popp, D, Hascic, H & Medhi, N, 'Technology and the diffusion of renewable energy' *Energy Economics* (2011) 33:4

Prakash, R & Bhat, IK, 'Energy, economics and environmental impacts of renewable energy systems' *Renewable and Sustainable Energy Reviews* (2009) 13:9

Solangi, KH et al., 'A review on global solar energy policy' *Renewable and Sustainable Energy Reviews* (2011) 15:4

Timilsina, GR et al., 'Solar energy: markets, economics and policies' *Renewable and Sustainable Energy Reviews* (2012) 16:1

Unruh, GC, 'Understanding carbon lock-in' *Energy Policy* (2000) 28:12

Votteler, RG & Brent, AC, 'A literature review on the potential of renewable electricity sources for mining operations in South Africa' *Journal of Energy in Southern Africa* (2016) 27:2

Wohlgemuth, N & Missfeldt, F, 'The Kyoto mechanisms and the prospects for renewable energy technologies' *Solar Energy* (2000) 69:4

Wüstenhagen, R, Wolsink, M & Bürer, MJ, 'Social acceptance of renewable energy innovation: an introduction to the concept' *Energy Policy* (2007) 35:5

Reports:

Beddoe, R et al., 'Overcoming systemic roadblocks to sustainability: the evolutionary redesign of worldviews, institutions, and technologies.' *Proceedings of the National Academy of Sciences* 106.8 (2009)

Boyse, F et al., *Implementing renewable energy for off-grid operations* Carbon War Room, Washington DC (2014)

Dusmanescu, D, 'Solar energy potential as support for sustainable development of Romanian economy' *Renewable and Alternative Energy: Concepts, Methodologies, Tools, and Applications*, (IGI Global 2017)

Edenhofer O et al. (eds), *Renewable energy sources and climate change mitigation: special report of the intergovernmental panel on climate change* Cambridge University Press (2011)

Global Cleantech Center, *Mining: the growing role of renewable energy* (2014)

Kapika, J & Eberhard, A, *Power-sector reform and regulation in Africa: lessons from Kenya, Tanzania, Uganda, Zambia, Namibia and Ghana*. HSRC Press (2013)

Karekezi, S & Kithyoma, W, 'Renewable energy development' *Workshop on African Energy Experts on Operationalizing the NEPAD Energy Initiative* (2003)

Kisting, J, 'Opportunities in the renewable energy sector in Namibia' *Baobab Equity Management (Pty) Ltd, Namibia, Final Report* (2008)

Rämä, M et al., '*Development of Namibian energy sector*' Research Report VTT (2013)

The World Bank Group & Electricity Control Board of Namibia, 'National Integrated Resource Plan Draft Report: development and analysis of policy implementation scenarios' (2012)

Von Oertzen, D, 'Namibian national issues report on the key sector of energy with a focus on mitigation' *Desert Research Foundation of Namibia* (2010)

Von Oertzen, D, *Green Energy in Namibia* Electricity Control Board 1 (2009)

Internet sources:

'Alternative energy in mining' German Cooperation; Deutsche Gesellschaft für Internationale Zusammenarbeit; *South African Institute of International Affairs* (2014) available at <www.saiia.org.za/special-publications-series/607-sadc-business-barriers-case-3-alternative-energy-in-mining/file> accessed 01 August 2017

'A brief introduction to net metering' available at <www.conserve-energy-future.com> accessed 05 October 2017

'Business models to realise the potential of renewable energy and energy efficiency in the greater Mekong subregion' available at <www.adb.org/sites/default/files/publication/161889/business-models-renewable-energy-gms.pdf> accessed 31 July2017

Concessions, Build-Operate-Transfer (BOT) and Design-Build-Operate (DBO) Projects available at <https://ppp.worldbank.org/public-private-partnership/agreements/concessions-bots-dbos> accessed 05 October 2017

International Energy Agency, Energy Statistics Manual, (OECD Publishing, Paris 2004) available at <http://dx.doi.org/10.1787/9789264033986-en>

IRP available at <http://www.irena.org/DocumentDownloads/events/2013/October/IRP%20NAMIBIA%20Muyambo%2020130927.pdf >

ISO 14000 family - Environmental management available at <www.iso.org/iso-14001-environmental-management.html>

Kirschke, J 'Energy urgency: why the global mining industry is embracing renewables' available at <http://nextbillion.net/energy-urgency-why-the-global-mining-industry-is-embracing-renewables/> accessed 30 April 2017

KPMG Global Mining Institute, 'Namibia: country mining guide' available at <https://assets.kpmg.com/content/dam/kpmg/pdf/2014/09/namibia-mining-guide.pdf accessed 26 July 2017

'Namibia-EEP Africa' available at <eepafrica.org/projects/namibia> accessed 05 October 2017

National Planning Commission, 'Energy demand and forecasting in Namibia' (2013) available at <www.npc.gov.na/?wpfb_dl=229> accessed 27 July 2017

'Net metering' available at <www.netzeroguide.com> accessed 05 October 2017

National Renewable Energy Policy for Namibia available at <www.n-big.org/files/National-Renewable-Energy-Policy-for-Namibia_DRAFT-June-13-1.pdf> accessed 02 August 2017

'New renewable energy for mine project – IAMGOLD Essakane to benefit from largest hybrid plant in Africa' available at <http://energyandmines.com/2017/03/new-renewable-energy-for-mine-project-iamgold-essakane-to-benefit-from-largest-hybrid-plant-in-africa/> accessed 08 August 2017

'Namibia publishes tariffs for net-metering' <//www.pv-magazine.com/2017/03/20/namibia-publishes-tariffs-for-net-metering/> accessed 05 August 17

'Renewable energy: Investing in Africa: Namibia' available at <www.clydeco.com/uploads/Blogs/offshore/files/Energy_profile_-_Namibia.pdf> accessed 02 August 2017

Smit, P, 'Namibia's mining growth to boost demand for electricity' *Creamer Media* (2010) available at <www.engineeringnews.co.za/print-version/namibias-mining-growth-to-boost-demand-for-electricity-2010-12-03-1> accessed 27 July 2017

Vision 2030 Overview available at <www.gov.na/vision-2030> accessed 31 July 2017

Van Wyngaardt, M, 'Mining companies relying more on renewable energy', available at <www.miningweekly.com/article/mining-companies-relying-more-on-renewable-energy-2016-07-27 accessed 30 April 2017

Thesis:

Wood, GC *Connecting the dots: a systemic approach to evaluating potential constraints to renewable electricity technology deployment to 2020 and beyond in the United Kingdom*. Thesis, University of Dundee, 2013.